REPUBLIC OF CROATIA
Ministry of Economy and
Sustainable Development

INTEGRATED NATIONAL ENERGY AND CLIMATE PLAN FOR THE REPUBLIC OF CROATIA FOR THE PERIOD 2021-2030

June 2023

CONTENTS

INTRODUCTION

In a Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank: A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, COM/2015/080 final of 25th February 2015, it has been noted that integrated management is needed to ensure that all energy-related activities at the Union, regional, national and local level contribute to the objectives of the Energy Union. The objectives will be achieved through five key dimensions of the Energy Union: *1. energy security, 2. an internal energy market, 3. energy efficiency, 4. decarbonisation and 5. research, innovation and competitiveness.*

The Conclusions of the European Council on the Governance of the Energy Union of 26th November 2015 recognized that the governance system of the Energy Union will be an essential tool for the efficient and effective construction of the Energy Union and the achievement of its objectives. The Conclusions stressed that the governance system should be based on the principles of integration of strategic planning and reporting on the implementation of climate and energy policy and on coordination between actors responsible for climate and energy policy, at EU, regional and national level.

Therefore, on 11th December 2018, Regulation (EU) 2018/1999 of the European Parliament and of the Council on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No. 663/2009 and (EC) No. 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No. 525/2013 of the European Parliament and of the Council (OJ L 328, 21. 12. 2018) has been adopted (hereinafter referred to as the Regulation on the Governance of the Energy Union and Climate Action). This Regulation stipulates the development of **integrated national energy and climate plans** for a ten-year period. The first Integrated Energy and Climate Plan should cover the period from 2021 to 2030.

The achievement of the objectives of the Energy Union is to be ensured through a combination of Union initiatives and consistent national policies set out in integrated national energy and climate plans.

The Integrated National Energy and Climate Plan for the period 2021-2030 builds on existing national strategies and plans. It provides an overview of the current energy system and the energy and climate policy. It also provides an overview of the national targets for each of the five key dimensions of the Energy Union and the appropriate policies and measures to achieve those targets, for which an analytical basis should be established. In the Integrated Energy and Climate Plan, particular attention should be paid to the targets to be achieved by 2030, which include the **reduction in greenhouse gas emissions**. **energy from renewable sources**, **energy efficiency** and **electricity interconnection**. It should be ensured that the Integrated Energy and Climate Plan is consistent with and contributes to the Sustainable Development Goals.

According to Article 14 of the Regulation on the Governance of the Energy Union and Climate Action, by 30th June 2023, each Member State shall submit to the Commission a draft update

of the last disclosed integrated national energy and climate plan, and by 30th June 2024, report to the Commission an update of its last disclosed integrated national energy and climate plan.

The Integrated National Energy and Climate Plan for the period 2021-2030, pursuant to Article 12 of the Act on the Strategic Planning and Development Management System of the Republic of Croatia (Official Gazette No. 123/17, 151/22) shall be adopted by the Government of the Republic of Croatia at the proposal of the Ministry of the Economy and Sustainable Development.

The table below includes the most important targets that the Plan sets for 2030.

Indicator	Target
Reduction in greenhouse gas emissions for the ETS sector, compared to 2005	-50,2 %
Reduction in greenhouse gas emissions for non-ETS sectors, compared to 2005	-16,7 %
Share of RES in gross final energy consumption	42,5 %
Share of RES in final energy consumption in transport	21,6 %
Primary energy consumption (total energy consumption without non-energy consumption)	340,9 PJ (8,14 Mtoe)
Final energy consumption	274,2 PJ (6,55 Mtoe)

SECTION A: NATIONAL PLAN

1 PLAN OVERVIEW AND ADOPTION PROCEDURE

1.1 Summary

i. The political, environmental, social and economic context of the plan

The Republic of Croatia is a member state of the European Union (EU) since 1st July 2013 and its energy and climate legislation is aligned with the relevant acquis communautaire. Also, the Republic of Croatia is a party to the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol – The Protocol to the United Nations Framework Convention on Climate Change and the Paris Agreement to the United Nations Framework Convention on Climate Change, Dec. 12, 2015, T.I.A.S. No. 16-1104. and regularly submits greenhouse gas inventory reports as well as national reports to the Secretariat of the Convention.

The 7th National Report of the Republic of Croatia under the United Nations Framework Convention on Climate Change was published in 2018. In addition to information on greenhouse gas emissions, it also contains conclusions on the current situation and trends of environmental, economic, and social developments, as well as recommendations for improving the implementation of environmental protection and sustainable development policies [1]. Emissions of major pollutants into the air (SO_2, NH_3, NO_X, NMHOS) compared to the baseline year 1990 show a general downward trend. Emissions of greenhouse gases are decreasing. According to the number and quantity of pollutants being released into water and/or sea, the largest load is borne by the water catchment area of the Sava River. There are still minefields ("mine-suspected areas") on the territory of Croatia.

Regarding the social context of the plan, the development of the regions of Croatia and population of the areas are uneven, with growing pressure on larger cities. The trend of departure from rural areas continues. Due to the emigration of a share of the working age population and the recovery of the economy, the dynamics of decrease in the unemployment rate is considerably faster than the dynamics foreseen in European estimates. The number of inhabitants of the Republic of Croatia is continuously decreasing, whereby the share of the population in the age group above 65 is increasing, at the detriment of decrease in highly active age groups.

Croatia currently has considerably lower rates of economic activity of the population than most EU countries. In the overall energy balance of Croatia, there is a significant dependence on oil, gas, and electricity import.

ii. Strategies that address the five dimensions of the Energy Union

The five dimensions of the Energy Union are decarbonisation, energy efficiency, energy security, the internal energy market and research, innovation, and competitiveness.

Four key strategies address the **dimension of decarbonisation**. **The Energy Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050** (hereinafter referred to as the Energy Development Strategy) [3] is an obligation under the Energy Act (OG Nos. 120/12, 14/14, 95/15, 102/15, 68/18). For the purposes of developing the Energy Development Strategy, analytical backgrounds have been prepared (the so-called Green Paper [2] and White Paper [4]) presented to the professional and interested public at the end of 2018 and the beginning of 2019. The analytical backgrounds contain elaborated targets for using renewable energy sources (RES), energy efficiency, the internal energy market and energy security. The Energy Development Strategy defines the optimal energy mix and development projects with the aim of ensuring the energy independence of the Republic of Croatia, with particular emphasis on strengthening the production of energy from renewable sources. Also, special attention is paid to the security of supply, sustainability, and competitiveness of the energy system. All the above aligns with the EU Directives' objectives in terms of reducing consumption, reducing greenhouse gas emissions, sustainability of energy development, competitiveness of the energy the system and a positive investment environment. The Long-Term Strategy to Encourage Investment in the Renovation of the National Building Stock of the Republic of Croatia by 2050 is crucial [1]for the use of renewable energy sources in building construction, which, through the nZEB request for new buildings and the renovation of existing buildings, includes the obligation to cover a substantial portion of primary energy for the building by using renewable energy sources at the location of the building or in its immediate vicinity.

The third strategic document for decarbonisation is **the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050** [5] (hereinafter referred to as the Low-Carbon Development Strategy). The preparation of the Low-Carbon Development Strategy and the Action Plan for the Implementation of the Low-Carbon Development Strategy for a period of five years is an obligation under the Act on Climate Change and Protection of the Ozon Layer (OG No. 127/19). The Draft of the Low-Carbon Development Strategy was prepared during 2017, when it was submitted for public debate, and refers to the sectors of energy, industry, transport, general consumption, agriculture, waste, and land use. The final adoption of the Draft of the Low-Carbon Development Strategy has been postponed aligning it with the Energy Development Strategy and the Croatian Parliament adopted it in 2021.

One of the objectives within the decarbonisation dimension is also adaptation to climate change, which is elaborated **in the Climate Change Adaptation Strategy in the Republic of Croatia until 2040 with an outlook to 2070** with the action plan (hereinafter referred to as the Adaptation Strategy [6]. The Adaptation Strategy was adopted by the Croatian Parliament in 2020.

[1]https://mpgi.gov.hr/o-ministarstvu/djelokrug-50/energetska-ucinkovitost-u-zgradarstvu/strateski-dokumenti-programi-i-projekti/dugorocna-strategija-obnove-nacionalnog-fonda-zgrada-do-2050-godine/9055

The key document for the energy efficiency dimension is the **Long-Term Strategy to Encourage Investment in the Renovation of the National Building Stock of the Republic of Croatia by 2050**, which promotes the need to invest in the building stock. The long-term strategy was adopted by the Government of the Republic of Croatia in December 2020 and aligns the reconstruction goals with the NECP in the light of demographic trends and activities of the construction sector, with noticeable trends of accelerated abandonment of the existing stock of buildings of inferior properties, with the gradual growth of new construction. The building energy renovation rate in the period until 2020 amounted to 0.7% per year, and the Strategy defines a gradual increase through the period 2021 – 2030 to 3%, with a ten-year average rate of 1.6%. An important element is the introduction of additional measurable indicators of energy renovation of buildings, which will strengthen the process of conversion of the stock into nearly zero-energy buildings, i.e., climate neutral.

The dimensions of energy security and the internal energy market have been elaborated within the framework of the Energy Development Strategy.

The national strategies relevant to the dimension of research, innovation and competitiveness are the Strategy of Education, Science and Technology [7] and the Smart Specialization Strategy until 2029, the adoption of which is expected during the 2nd quarter of 2023 [8]. Regarding these strategies, this document also outlines systematized measures expected to contribute to research, innovation and competitiveness of the Croatian economy in sectors relevant to the energy transition.

iii. Tabular representation of key objectives, policies and measures of the plan

The key objectives outlined in the Integrated Energy and Climate Plan are the reduction in greenhouse gas emissions for the Republic of Croatia for the year 2030, the increase of the share of RES in the gross final energy consumption and the increase in energy efficiency, expressed as consumption of primary energy and final consumption of energy.

The objective of reduction in greenhouse gas emissions for the Republic of Croatia for 2030 is set by Directive (EU) 2023/959 of the European Parliament and of the Council of 14th March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments (Text with EEA relevance.) (OJ L 130, 16 5 2023.), and Decision (EU) 2015/1814 and Regulation (EU) 2023/857 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, and Regulation (EU) 2018/1999 (Text with EEA relevance.), (OJ L 111, 26.4.2023), separately for participants in the emissions trading system (ETS sector) and for non-trading sectors (non-ETS sectors). They are shown in Table 1-1.

Table 1-1. The targets for 2030

Scope	Target for 2030 compared to 2005	Target for 2030 compared to 2005 according to the WAM scenario
ETS sector	-62 % (EU-wide target)	-50,2 %
Non-ETS sectors	-40 % (EU-wide target) -16,7 % (target for HR)	-16,7 %

Targets in 2030 are shown in Table 1-2.

Table 1-2. Estimated values of key indicators

	Target for 2030
Share of RES in the gross final energy consumption	42,5 %
Energy efficiency	
Primary energy consumption[2]	340,9 PJ
Final energy consumption	274,2 PJ

Measures relevant to individual dimensions of the Energy Union are shown in Table 1-3.

Most of the measures are also relevant to reporting on policies and measures to reduce emissions and on greenhouse gas estimates to the European Commission under Regulation (EU) 2018/1999 on the Governance of the Energy Union and to the United Nations Framework Convention on Climate Change (UNFCCC) within the framework of preparing national reports and biennial reports of the Republic of Croatia to the UNFCCC, so the table specifies both the abbreviation indicating the dimension of the Energy Union to which the measure primarily refers and the abbreviation used within the framework of the said reporting. Impacts on other dimensions of the Energy Union, adaptation to climate change and the circular economy are listed along with the description of each measure.

All measures under the Plan for which one of the EU funds is listed as a potential source of financing also include the possibility of financing from the EEA Financial Mechanism, the Norwegian Financial Mechanism, and the Swiss Croatian Cooperation Programme, provided that, in accordance with the legal framework of the said financial mechanisms, the costs financed under the said measures represent eligible costs.

[2] Primary energy consumption, according to EUROSTAT guidelines, is defined as total energy consumption less non-energy consumption

Table 1-3. Overview of measures

Abbreviation 1[3]	Abbreviation 2[4]	Name	Impact on other dimensions
Decarbonisation			
MS-1	MCC-1	Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change	2,3,4,5
MS-2	MCC-2	Supporting the establishment and capacity building of regional energy and climate agencies	2,3,4,5
MS-3	MCC-4	The EU Emissions Trading System	2,4
MS-4	MCC-6	Strategic planning at the regional and local level	2,3,4,5
MS-5	MCC-8	Establishing of Platform for Carbon Capture, Use and Storage	5
MS-6	MCC-9	Improving the sustainability of urban areas	2,3,5
MS-7	MCC-10	Establishing of Programme for Carbon Footprint Calculation and Reduction in Businesses and Public sector	2,3,4,5
MS-8	MCC-11	Establishing a Digital Platform for Bioeconomy	2,3,4,5
MS-9	MCC-12	Transformation of the bioeconomy sector	2,3,5
MS-10	MCC-13	Legal adjustments and technical bases for the introduction of hydrogen into the energy system	3,5
MS-11		Reducing an individual's carbon footprint by changing lifestyle habits	
MS-12		Collection and processing of biomass from agriculture, forestry, fishing and aquaculture	
MS-13		Removal of fossil fuel subsidies	
MS-14		Carbon removal certification	
IP-1	MIP-1	Reduction of clinker content in cement production	
IP-2	MIP-2	Limiting fluorinated greenhouse gas emissions	
IP-3	MIP-3	The gradual decrease in the number of fluorocarbons that can be placed on the market	
IP-4	MIP-4	Restricting and prohibiting the market placing of certain products and equipment	
GO-1	MWM-1	Preventing generation and reducing the amount of solid waste	
GO-2	MWM-2	Increasing the amount of separately collected and recycled solid waste	
GO-3	MWM-4	Reducing the amount of disposed biodegradable waste	
GO-4	MWM-3	Assuring a system for the treatment and use of landfill gas	

[3] According to the dimensions of the energy union

[4] According to the sectoral division in accordance with the IPCC methodology

GO-5		Reduction of food waste per the guidelines for the development of the bioeconomy	
GO-6		Circular economy measures to increase resource efficiency and the application of business models based on repair, recycling and recovery.	
POLJ-1	MAG-2	Improvement of livestock facilities and manure management systems	
POLJ-2	MAG-4	Anaerobic decomposition of manure and biogas production	
POLJ-3	MAG-6	Improvement and change of soil tillage system (reduced tillage)	
POLJ-4	MAG-7	Extension of crop rotation with higher involvement of legumes	
POLJ-5	MAG-8	Intensification of crop rotation using intermediate crops	
POLJ-6	MAG-9	Improvement of mineral fertiliser application methods	
POLJ-7	MAG-10	Improvement of organic fertiliser application methods	
POLJ-8	MAG-11	Agroforestry	
POLJ-9	MAG-12	Hydromelioration interventions and systems for protection against natural disasters	
POLJ-10	MAG-13	Introducing new cultivars, varieties, and species	
LUF-1	MLF-1	Development of the Maintenance plan of the National Information System for land in the Republic of Croatia	
LUF-2	MLF-2	Carbon accumulation in forests areas	
LUF-3	MLF-3	Reforestation works	
LUF-4	MLF-4	Manufacture and use of wood and wood products	
LUF-5	MLF-5	Agricultural land management	
LUF-6	MLF-6	Pasture management	
LUF-7	MLF-7	Implementation of technical projects and scientific research in the LULUCF sector	5
FUG-1	MEN-24	Refinery modernisation	2,3
FUG-2	MEN-25	Measures to increase energy efficiency by improving processes and process units	2,3
OIE-1	MEN-16	Information, education, and capacity building for RES use	2,3,4
OIE-2	MEN-17	Spatial planning requirements for using RES	
OIE-3	MEN-19	Development of the regulatory framework for RES use	4
OIE-4		RES use for the production of electricity	3,4,5
OIE-5		RES use for heating needs	3,4,5
OIE-6		Use of RES in district heating systems	3,4
OIE-7		Energy sharing and energy community	
TR-1	MTR-5	Regulatory instruments for encouraging a cleaner transport system	2
TR-2	MTR-6	Program of co-financing the purchase of new vehicles on alternative fuels and the development of infrastructure for alternative fuels in road transport	2

TR-3	MTR-9	Improving the public transport system and promoting sustainable integrated transport	2
TR-4	MTR-12	Encouraging the development of energy-efficient maritime transport and inland waterway transport	2, 3, 5
TR-5		Encouraging the development of energy-efficient railway transport	2, 3, 5
TR-6		Encouraging the development of energy-efficient air transport	2, 3, 5
TR-7	MTR-13	Development of the low-carbon fuel market	2, 3, 5
Energy efficiency			
ENU-1	MCC-14	Energy efficiency obligation system for suppliers	1
ENU-2	MEN-1	Promotion of decarbonisation and the application of the "energy efficiency first" principle in buildings	1,3,5
ENU-3	MEN-2	Energy renovation programme for multi-apartment buildings	1
ENU-4	MEN-3	Energy renovation programme for single-family houses	1
ENU-5	MEN-4	Energy renovation programme for public sector buildings	1
ENU-6	MEN-5	Energy renovation program for heritage buildings	1
ENU-7	MEN-7	Energy management system in the public sector	1
ENU-8	MEN-6	Energy renovation programme for public lighting	1
ENU-9	MCC-15	Green public procurement	1,5
ENU-10	MEN-8	Energy management system in the business (service & production) sector	1
ENU-11	MEN-10	Information about energy efficiency	1
ENU-12	MEN-11	Development of a framework to ensure adequate skills in the context of green jobs required for building renovation	1
ENU-13	MEN-12	The energy efficiency of the electricity transmission network	1,3
ENU-14	MEN-13	Reduction of losses in the distribution network and introduction of smart grids	1,3,4
ENU-15	MEN-14	Increasing efficiency of district heating systems	1,3,4
ENU-16	MEN-15	Increasing the efficiency of the gas transport network	1,3,4
ENU-17		Increasing energy efficiency and use of RES in manufacturing industries	1
ENU-18		Increasing the energy efficiency of public water supply, drainage and wastewater treatment systems	1
Energy security			
ES-1	MEN-21	Construction and use of energy storage facilities	1,2,4,5
ES-2		Improvement and control of EES	1,2,4,5
ES-3	MEN-22	Development and maintenance of district heating systems	1,2,4
ES-4	MEN-23	LNG Terminal capacity upgrade	4
ES-5		Security of natural gas supply for EU countries	

ES-6		Security of natural gas supply for the Western Balkans	4
ES-7		Construction and improvement of the management of the transport gas system	4
ES-8		Exploration of potential hydrocarbon deposits in Slavonia, the Dinarides and the Adriatic	
ES-9		Reducing the use of fossil fuels for heating needs in individual heating systems	1
ES-10		Cyber security	
Internal energy market			
UET-1	MEN-27	Development of the electricity transmission network	1,2,3,5
UET-2	MEN-28	Development of the gas transport network	1,2,3,5
UET-3		Equipping the transport gas system for the future possibility of transporting up to 100% hydrogen	
UET-4		Enabling the implementation of demand response pilot projects in the distribution network	
UET-5		Development of the national balancing market	
UET-6	MEN-29	Elaboration of the regulatory framework for active participation of customers in the electricity market	1,3
UET-7	MEN-30	Introduction of advanced metering and data management systems	1,3
UET-8	MEN-31	Adoption and implementation of the Programme for energy poverty alleviation	1,2,3,5
UET-9		Implementation of the Energy Poverty Suppression Program, including the use of renewable energy sources in residential buildings in subsidised areas and areas of special state care for the period 2023-2027	1,2,3,5
Research, innovation and competitiveness			
IIK-1	MCC-17	Establishment of an identification and monitoring system for the achievement of research, innovation, and competitiveness goals	
IIK-2	MCC-18	Establishment of systematic financing of research and development projects	
IIK-3	MCC-19	Supporting low-carbon entrepreneurship development	
IIK-4	MCC-20	Supporting knowledge and technology transfer from science to economy with a focus low-carbon technology	
IIK-5	MCC-21	Supporting further work of excellence centres active in the field of natural, technical, biotechnical, and biomedical sciences	
IIK-6	MCC-22	Capacity building for stimulating research and innovation and increasing competitiveness in the low-carbon economy	1,2,3,4

1.2 Overview of the current state of policies

i. The National Energy System and the context of the national plan policies

The basic indicators of the development of energy consumption and economic indicators such as:

- GDP - Gross Domestic Product
- TPES - Total Primary Energy Supply
- TFC - Total Final Energy Consumption
- GEC - Gross Electricity Consumption
- NEC - Net Electricity Consumption
- TPES/GDP - energy intensity of total primary energy consumed;
- GEC/GDP - energy intensity of gross electricity consumption;
- NEC/GDP - energy intensity of net electricity consumption;

for the Republic of Croatia from 2016 to 2021 are shown in Figure 1-1.

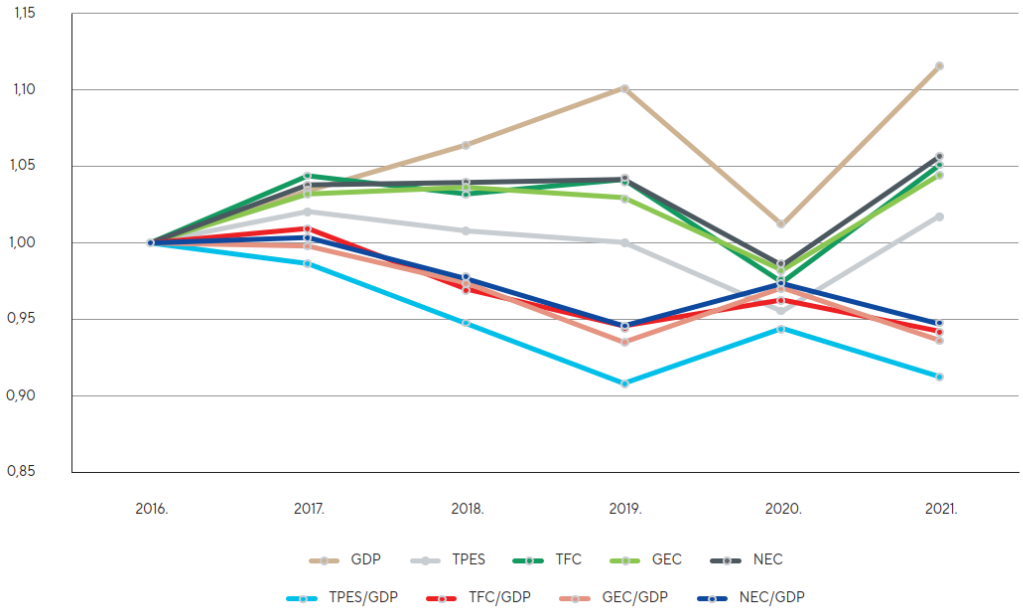


Figure 1-1. Basic indicators of energy consumption development and economic indicators for the Republic of Croatia in the period 2016-2021

During the period from 2016 to 2021, there was a trend of increase in GDP at an average annual rate of 2.2 percent. In the same period, total energy consumption increased at an average annual rate of 0.4, and final energy consumption at an average annual rate of 1 percent. There was an increase in electricity consumption, so total electricity consumption grew at an average annual rate of 0.9 percent and net electricity consumption at an average

annual rate of 1.1 percent. Losses of transmission and distribution of electricity also decreased at an average annual rate of 1.3 percent.

The **primary energy production** trends are shown in **Pogreška! Izvor reference nije p ronađen.**. During the six-year period from 2016 to 2021, primary energy production in Croatia decreased at an average annual rate of 1.6 percent. The upward trend was achieved in the production of energy from renewable sources, firewood and other solid biomass and thermal energy, while the production of other primary forms of energy (crude oil, natural gas and hydro power) achieved a downward trend.

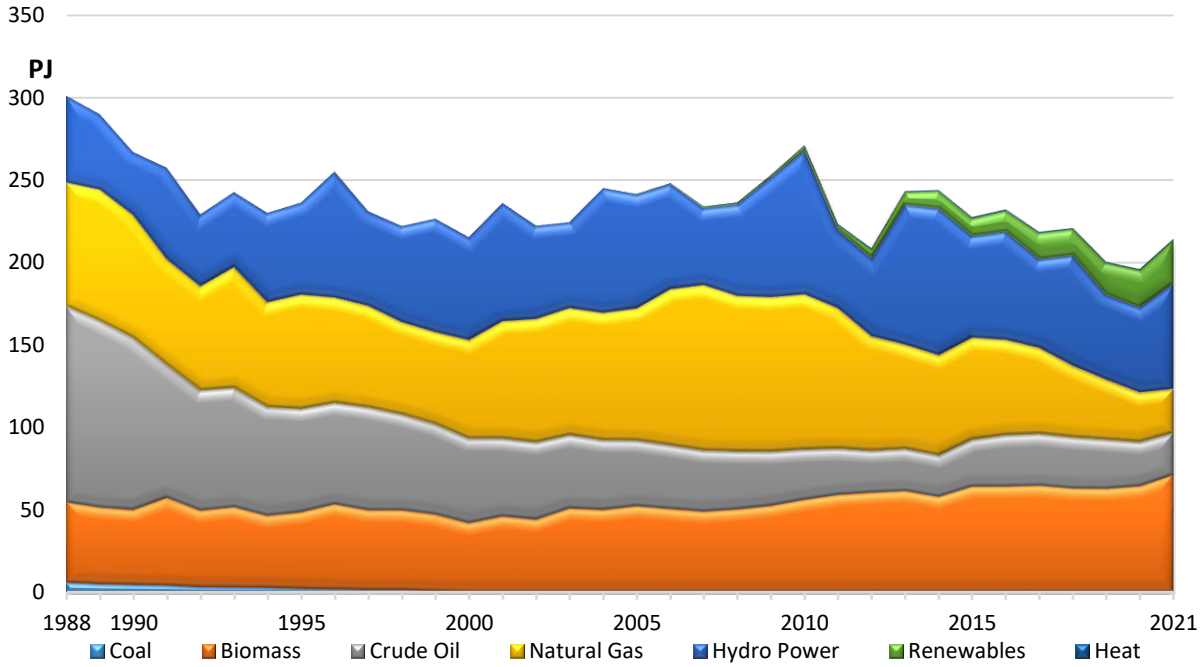


Figure 1-2. Primary energy production

Trends in **energy imports** until 2021 are shown in Figure 1-3.

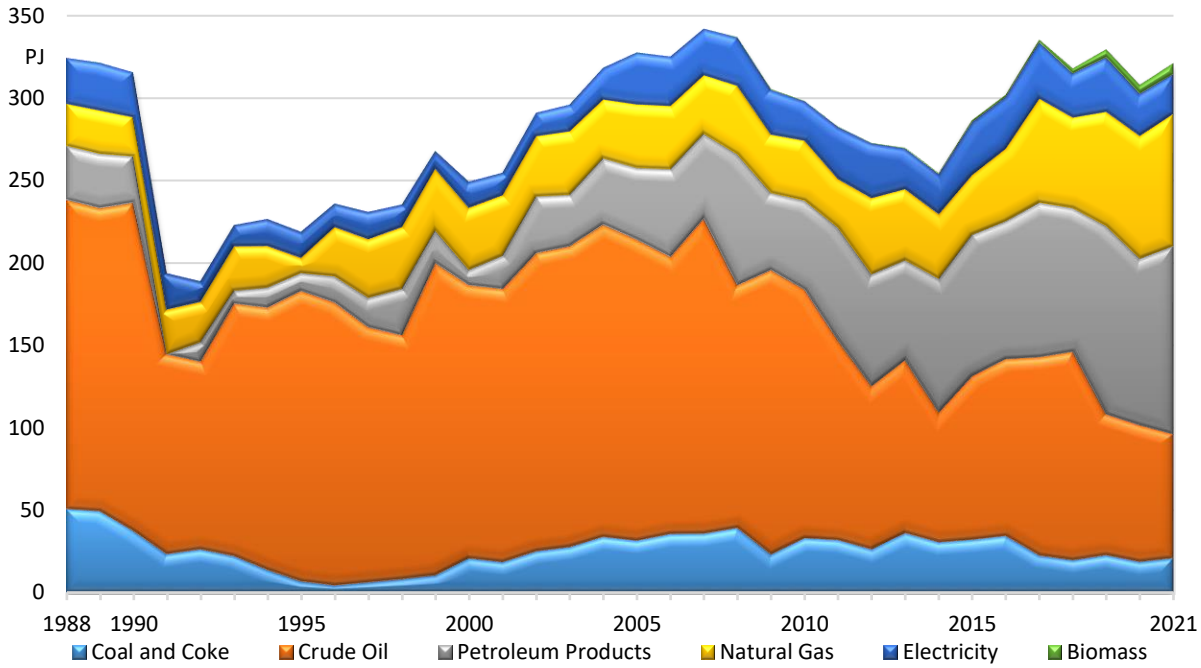


Figure 1-3. Import of energy to Croatia

During the period from 2016 to 2021, there was a trend of increase in import of energy to Croatia at an average annual rate of 1.2 percent. Certain changes in the structure of energy imports were achieved by increasing the share of petroleum products, natural gas and wood and biomass, while the shares of electricity, coal and coke and crude oil decreased.

In the said period, imports of wood and biomass increased at an average annual rate of 39.9 percent, imports of natural gas 12.7 percent and imports of petroleum products 6.4 percent. Coal and coke imports decreased by 9.4 percent, crude oil imports by 6.9 percent and electricity imports by 5.2 percent.

During the period from 2016 to 2021, total **primary energy consumption** increased at an average annual rate of 0.4 percent. During this period, the trend of reduction in the consumption of coal and coke, liquid fuels, hydro power, and electricity was achieved. The consumption of energy from wood and biomass, natural gas, renewable sources, and thermal energy increased (Figure 1-4).

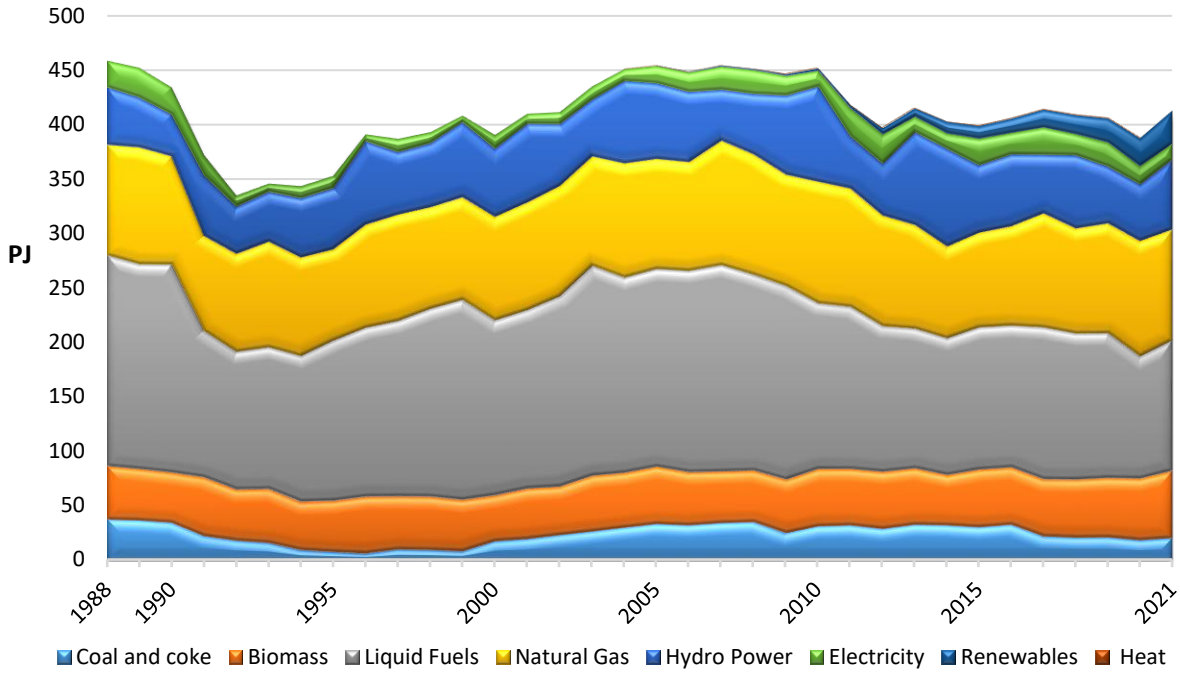


Figure 1-4. Total energy consumption

Energy legislation and climate legislation are aligned with the Acquis Communautaire. At the implementation level, energy, and climate fall within the competence of two ministries - the Ministry of the Economy and Sustainable Development and the Ministry of Physical Planning, Construction and State Assets.

The Republic of Croatia has adopted several documents related to energy that shape its strategic framework in this area.

In February 2020, the **Energy Development Strategy of the Republic of Croatia for 2030 with an outlook to 2050** was adopted, which is focused on the EU's goals of reducing greenhouse gas emissions, increasing the share of RES, energy efficiency, security, and quality of supply, as well as the development of the EU internal energy market, as well as available resources, energy infrastructure and the competitiveness of the economy and the energy sector.

In June 2021, the **Low Carbon Strategy** was adopted, which focuses on reducing greenhouse gas emissions and preventing an increase in their concentration in the atmosphere and consequently limiting the global temperature increase.

As part of **the National Development Strategy of the Republic of Croatia until 2030**, Strategic Objective 8 was defined. "Environmental and Energy Transition for Climate Neutrality".

To coordinate policies and measures for mitigation of and adaptation to climate change, in 2018 the Government of the Republic of Croatia adopted a decision on the establishment of the **Committee for intersectoral coordination for policy and measures of mitigation of and adaptation to climate change**. The Committee acts through the work of the Coordination Group and the Technical Working Group.

ii. Current energy and climate policies and measures relating to the five dimensions of the Energy Union

Dimension "Decarbonization"

The decarbonization dimension has two key elements

- emissions and elimination of emissions;
- renewable energy sources (RES).

The issue of climate change on a global scale is addressed by the United Nations Framework Convention on Climate Change (UNFCCC). The Republic of Croatia became a party to the UN Framework Convention on Climate Change (UNFCCC) in 1996, by passing the Act on its ratification in the Croatian Parliament (OG International Treaties, 2/96). The Republic of Croatia is a party to the Kyoto Protocol pursuant to the Act on the Ratification of the Kyoto Protocol along with the United Nations Framework Convention on Climate Change (International Treaties, OG No. 5/07) and the Act on the Ratification of the Doha Amendment to the Kyoto Protocol (International Treaties, OG No. 6/15) and the Paris Agreement, pursuant to the Act on the Ratification of the Paris Agreement (International Treaties OG No. 3/17).

During 2018, several new EU regulations were adopted, which regulate or restructure the field of climate change. This is why the adoption of a special Law on Climate Change and the Protection of the Ozone Layer (OG No. 127/19) has been initiated, which has been in force since 1st January 2020. The Act defines the competence and responsibility for climate change mitigation, climate change adaptation and protection of the ozone layer, climate change and ozone layer protection documents, monitoring and reporting on greenhouse gas emissions, greenhouse gas emission trading system, sectors outside the greenhouse gas emission trading system, ozone-depleting substances and fluorinated greenhouse gases, financing climate change mitigation, climate change adaptation and ozone layer protection, climate change and ozone layer protection information system, as well as other issues related to climate change mitigation, climate change adaptation and ozone layer protection.

The Republic of Croatia as a Party to the UN Framework Convention on Climate Change (UNFCCC) prepares and submits every four years a national report on climate change reporting on the implementation of the Convention's obligations. The most recent report is the Seventh National Report and the fourth biennial report[5] of the Republic of Croatia under the United Nations Framework Convention on Climate Change (UNFCCC) [].

In December 2019, the European Commission presented the European Green Deal that commits to achieving climate neutrality by 2050 and defines the decarbonisation of the energy system as key to achieving the 2030 and 2050 climate targets. In June 2021, the EU climate regulation was adopted, making the achievement of climate neutrality by 2050 legally binding, in line with the European Green Deal.

As part of the implementation of the Paris Agreement, the COP26 climate change conference (Glasgow, November 2021) was held, where the so-called Glasgow Climate Pact was adopted,

[5] https://www.haop.hr/sites/default/files/uploads/dokumenti/012_klima/dostava_podataka/Izvjesca/HRV_RoP_2019.pdf

which contains a series of decisions on intensified efforts to build resilience to climate change, reduce greenhouse gas emissions and ensure the necessary funding, and calls for the phasing out of fossil fuel subsidies and the consideration of further measures to reduce non-CO_2 emissions.

As a party to the Kyoto Protocol, the Republic of Croatia has set up a national system for monitoring greenhouse gas emissions in the country, and on an annual basis prepares the Greenhouse Gas Emissions Report and submits it to the UNFCCC Secretariat (by 15th April of the current year) and to the European Commission (by 15th January of the current year). The most recent Greenhouse Gas Inventory Report on the territory of the Republic of Croatia for the period 1990 -2021 (NIR 2023) was published in April 2023 [11].

In addition to these conventions, the key laws relevant to the dimension of Decarbonisation are:

- Act on Climate Change and Protection of the Ozone Layer (OG No. 127/19)
- Environmental Protection Act (OG Nos. 80/13, 153/13, 78/15, 12/18, 118/18),
- Air Protection Act (OG Nos. 127/19, 57/22)
- Energy Act (OG Nos. 120/12, 14/14, 95/15, 102/15, 68/18),
- Electricity Market Act (OG No. 111/21),
- Thermal Energy Market Act (OG No. 80/13, 14/14)
- Act on Renewable Energy Sources and High Effective Cogeneration (OG No. 138/21),
- Energy Efficiency Act (OG Nos. 127/14, 116/18, 25/20, 41/21)
- Act on Biofuels for Transport (OG Nos. 65/09, 145/10, 26/11, 144/12, 14/14, 94/18, 52/21),
- Act on the Deployment of Alternative Fuel Infrastructure (OG Nos. 120/16, 63/22),
- Act on the Environmental Protection and Energy Efficiency Fund (OG Nos. 107/03, 144/12),
- by-laws for implementation of those laws.

The strategic planning documents related to low-carbon development and the fight against climate change are:

- National Development Strategy of the Republic of Croatia until 2030 (OG No. 13/21),
- Energy Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050 (OG No. 25/20),
- Climate Change Adaptation Strategy in the Republic of Croatia for the period until 2040 with an outlook to 2070 (OG No. 46/20),
- Long-Term Strategy for the Renovation of the National Building Stock until 2050 (OG No. 140/20),
- Low Carbon Development Strategy (OG No. 63/21),

- Energy efficiency programme for the decarbonisation of the energy sector (MESD, 2021)
- Croatian Hydrogen Strategy until 2050 (OG No. 40/22).

In the **sector of building construction,** the Republic of Croatia is strongly committed to achieving an energy-efficient and decarbonised building stock by 2050. For the purposes of mobilizing all stakeholders in the process of building and renovating buildings to achieve the long-term target of reducing CO_2 emissions by 80% in the building construction sector by the end of 2050, the Ministry of Physical Planning, Construction and State Assets has initiated a Charter of Cooperation for the Decarbonisation of Buildings by 2050. The contents of the Charter include the achievement of energy and climate targets at the national and EU level through the decarbonisation of the building stock, renovation of buildings and construction of nearly zero energy buildings, which stresses the importance of further reduction in greenhouse gas emissions, increasing the share of renewable energy sources, improving energy security and introducing innovation and smart technologies that allow buildings to support the overall decarbonisation of the economy. The signing of the Charter encourages continuous cooperation on the development of the Long-Term Strategy for the Renovation of the National Building Stock and the transition to a nearly zero energy building standard (nZEB).

The signatories to the Charter support and promote the decarbonisation of buildings in their future activities, wherever possible. By the end of June 2022, 77 stakeholders from the business and public sectors signed the charter[6].

In **the transport sector**, the Republic of Croatia faces the problem of high dependence on petroleum products and the negative impact of transport on the environment. The share of electric passenger cars in the total number of registered passenger cars in Croatia is less than 0.3%, which indicates that the market for electric vehicles is still not sufficiently developed. Also, the hydrogen market in the transport sector has not been developed, and there is no publicly available infrastructure for the supply of hydrogen.

The Act on the Deployment of Alternative Fuel Infrastructure (OG Nos. 120/16, 63/22) stipulates that the joint framework of measures for market development regarding alternative fuels in the transport sector and for the deployment of adequate infrastructure is defined in the *National Policy Framework for Deployment of Alternative Fuel Infrastructure of the Republic of Croatia (NPF)*, which was first adopted in Croatia in 2017 (OG No. 34/17). It sets minimum targets for building alternative fuels infrastructure, including filling stations, joint technical specifications for filling and supply stations, user notification requirements, as well as measures needed to achieve national targets. All other issues relating to the deployment of alternative fuels infrastructure not regulated by the said Act or the NPF shall be governed by the regulations governing the areas of transport infrastructure, physical planning, spatial data infrastructure, construction, energy, energy efficiency, environmental protection, and laws establishing and defining the scope of activity of the Environmental Protection and Energy Efficiency Fund. The adoption of the new NPF is expected by 1st January 2024, which

[6] Source: https://mpgi.gov.hr/vijesti-8/odrzan-sesti-po-redu-otvoreni-dijalog-partnera-s-fokusom-na-inicijativu-obnova-zgrada/14669 (access date: 24th April 2023)

will set ambitious targets for the deployment of alternative fuels infrastructure in all transport modes. The initiative in question could lead to a significant increase in the share of vehicles powered by alternative energy sources and a faster development of the market for alternative fuels in Croatia.

Within the decarbonisation dimension, the **agricultural sector** plays an important role - both in the context of its own emissions and in the context of its contribution to the use of renewable sources. The Agriculture Strategy until 2030 (OG26/22) defines development needs, strategic goals, areas of intervention, implementation mechanisms and sources of financing. One of the strategic goals in the Agriculture Strategy until 2030 is "Strengthening the sustainability and resistance of agricultural production to climate change", within which one of the priorities is reducing vulnerability to climate change and encouraging production with low emissions. The current measures related to the Decarbonization dimension are shown in Table 1-4. The document in which the measure is planned is listed along with the name of each measure.

In the LULUCF sector, the largest sinks are realized in the category 'Forest land' (categorization methodology according to the IPCC). Forest land has an area of 49.3% of the total area of Croatia (according to the national classification). The LULUCF sector sinks account for 23.7% of national emissions. Forest management and afforestation as tree breeding work stipulated by forest management plans (FMP). There is relatively little suitable and available forest land for afforestation, which, like all other required forest works in the Forest Management Plans, must obtain a written consent of the ministry responsible for nature protection.

Table 1-4. Current measures within the dimension of "decarbonisation"

Name of the measure	Documents	Short description
Intersectoral policies and measures		
Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change	Act on Climate Change and Protection of the Ozone Layer (OG 127/19), the proposal for the Decision on the establishment of the Commission for Intersectoral Coordination for Policy and Measures for Mitigation and Adaptation to Climate Change from 2022	The commission is responsible for monitoring and evaluating the implementation and planning of policies and measures for mitigating and adapting to climate change in Croatia. Officials from competent state bodies were appointed to the Commission. The composition of the Commission, its tasks, and its working methods are determined by the Government of the Republic of Croatia on the proposal of the Ministry responsible for environmental protection.
Promoting the use of innovative information and communication technologies (ICTs) to reduce greenhouse gas emissions	Act on Climate Change and Protection of the Ozone Layer (OG 127/19) Act on Energy Efficiency (OG 127/14, 116/18, 25/20 and 41/21)	Innovative information and communication technologies are increasingly important in reducing greenhouse gas emissions and increasing energy efficiency. By intensifying their use in public administration, services and production processes, the productivity and efficiency of work will increase and, at the same time,

		reduce energy consumption and consequent greenhouse gas emissions. The measure is expected to increase innovative ICT use, monitor energy savings, and reduce greenhouse gas emissions.
European Union Emissions Trading System	Act on Climate Change and Protection of the Ozone Layer (OG 127/19), Regulation on the Method of Trading Greenhouse Gas Emission Units (OG 89/20) and Ordinance on the Method of Free Allocation of Emission Units to Plants and on Monitoring, Reporting and Verification of Reports on Greenhouse Gas Emissions from facilities and aircraft (OG 89/20)	Through the equal distribution of emission units, obligations to reduce emissions are distributed to system participants from all member states to contribute to the reduction of emissions at the EU level by at least 62% by 2030 compared to the 2005 level.
CO_2 emission tax for the non-ETS stationary sources	Regulation on unit fees, correction coefficients and detailed criteria and benchmarks for determining compensation for carbon dioxide emissions into the environment (Official Gazette 73/07, 48/09, 2/18, 46/21)	The Regulation on unit fees, correction coefficients and detailed criteria and standards for determining the fee for the emission of carbon dioxide into the environment (Official Gazette 73/07, 48/09, 2/18, 46/21) prescribes the obligation to pay the fee for the CO_2 emission for all stationary sources which emit more than 450 tons of CO_2 per year. Fee payers who invest in energy efficiency, RES, and other measures to reduce CO_2 emissions and other greenhouse gas emissions are charged a lower fee. The Environmental Protection and Energy Efficiency Fund is authorized to calculate and collect costs. From 2013 onwards, the obligation to pay the CO_2 emission fee applies only to sources the ETS does not cover.
Covenant of Mayors for Climate and Energy in the Republic of Croatia		The signatories of the Covenant support a joint vision for 2050: accelerating the decarbonisation of their territories, strengthening their capacity to adapt to the inevitable impact of climate change and allowing citizens to access safe, sustainable, and affordable energy. The Covenant encompasses 80 cities and municipalities, i.e., more than 2 million citizens of Croatia.
Charter of Decarbonisation of the National Building Stock by 2050		The signatories of the Charter are representatives of the state and local administration, the academic community and the professional public, the construction and energy sector and related industries who

		support and promote the decarbonization of buildings in their further activities, wherever possible. Through open partner dialogues, partners-Signatories of the Charter are encouraged to actively and continuously cooperate in creating and implementing the Long-Term Strategy for the Restoration of the National Building Fund and the transition to the nearly zero-energy building construction standard (nZEB).
RES		
Feed-in tariffs and a system of premiums to support the use of renewable energy sources in electricity generation and for highly efficient cogeneration	Act on renewable energy sources and high-efficiency cogeneration (OG 138/21) Act on the Electricity Market (Official Gazette 111/21)	The primary mechanism responsible for the previous development of RES was incentive prices (feed-in tariffs); The Law on RES and high-efficiency cogeneration introduced a premium incentive system.
Increased use of renewable energy sources and energy efficiency in the industrial sector	Act on renewable energy sources and high-efficiency cogeneration (OG 138/21) Act on Energy Efficiency (OG 127/14, 116/18, 25/20 and 41/21)	Use of available funds from the ESIF and from auctions of emission units in the EU ETS for the benefit of RES and energy efficiency in the industrial sector.
Promoting the use of renewable energy sources and energy efficiency through the Croatian Bank for Reconstruction and Development (CBRD)	Act on renewable energy sources and high-efficiency cogeneration (OG 138/21) Act on Energy Efficiency (OG 127/14, 116/18, 25/20 and 41/21)	The goal of the lending program for environmental protection, energy efficiency and RES projects is to realise investment projects aimed at environmental protection, improving energy efficiency, and encouraging the use of RES. Loans are intended for investments in land, construction facilities, equipment, and devices. The end users of the loan can be local and regional self-government units, communal companies, trading companies, artisans, and other legal entities.
Promoting the use of renewable energy sources and energy efficiency through the funds of the Environmental Protection and Energy Efficiency Fund	Act on renewable energy sources and high-efficiency cogeneration (OG 138/21) Act on Energy Efficiency (OG 127/14, 116/18, 25/20 and 41/21) Act on the Fund for Environmental Protection and Energy Efficiency (OG 107/03, 144/12)	Funds for financing are provided from the Fund's reliable income from environmental polluter fees, which include fees for carbon dioxide emissions, fees for burdening the environment with waste, fees for environmental users and special environmental fees for motor vehicles. RES projects for which the Fund for Environmental Protection and Energy Efficiency allocates funds include solar, wind, biomass, and energy from small hydroelectric plants and geothermal energy.

Implementation at the local level	Integrated national energy and climate plan for the period from 2021 to 2030	They are raising awareness about RES, with the expected result of behaviour change. The target groups are local authorities, interest groups, and the public.
Revitalization, construction and digitization of the energy sector and supporting infrastructure for the decarbonization of the energy sector	National Recovery and resilience plan 2021-2026	Accelerating investments in the development of the network in such a way that the existing electricity transmission and distribution system due to the increase in transmission capacity is revitalized, digitized, and upgraded with new capacities due to the increased needs in terms of RES by 2030.
Decarbonization of the heating system in the public sector	National Energy Efficiency Action Plan for the period 2022-2024	Replacement of heating systems that use solid and liquid fossil fuels by 2024 and co-financing for replacing natural gas with a new, more efficient system that uses RES. Also, encouragement and electrification of heating systems using heat pumps with mandatory production of electricity from photovoltaic systems on the building itself, connection of buildings to existing more efficient DHSs and development of new central heating systems to supply a more significant number of buildings.
Transport		
Providing information to consumers on the cost-effectiveness of fuel consumption and CO_2 emissions of new passenger cars	Rulebook on the availability of data to consumers on official fuel consumption and official specific CO_2 emissions of new passenger vehicles (OG 113/2021)	The purpose is to provide consumers with data on official fuel consumption and specific carbon dioxide emissions of new passenger vehicles intended for sale or leasing, enabling them to make an informed choice.
The obligation to use biofuels in transport	Act on Biofuels for Transport (OG 65/09, 145/10, 26/11, 144/12, 14/14, 94/18, 52/21)	This Act regulates the production, trade and storage of biofuels, the use of renewable energy sources in transport, the adoption of programs and plans to encourage the production and use of renewable energy sources in transport, the powers and responsibilities for determining and implementing policies to promote the production and use of renewable energy sources in transport, measures to encourage the production and use of renewable energy sources in transport, as well as to promote research and development of new, advanced biofuels that do not compete with crops for food and feed, and

		establish criteria for sustainability and saving greenhouse gas emissions for biofuels, liquid biofuels and biomass fuels.
Special environmental fee for motor vehicles	Decree on Amendments to the Decree on Unit Charges, Corrective Coefficients and Detailed Criteria and Benchmarks for Determining Special Environmental Charges for Motor Vehicles (Official Gazette 2/2021)	This Regulation prescribes unit charges and corrective coefficients based on which the special environmental charge for motor vehicles is calculated, as well as more detailed criteria and standards for determining the particular charge. A special fee is charged considering the type of engine and fuel, the working volume of the engine, the type of vehicle, CO_2 emissions and the age of the vehicle.
Special tax on motor vehicles	Act on Special Tax on Motor Vehicles (OG 15/13, 108/13, 115/16, 127/17, 121/19)	Based on the "polluter pays" principle, the calculation model is based on CO_2 emissions into the air from motor vehicles. The special tax is determined based on the selling or market price of the motor vehicle, CO_2 emissions expressed in grams per kilometre, engine volume in cubic centimetres and the level of greenhouse gas emissions. This special tax encourages the purchase of efficient vehicles and vehicles with lower greenhouse gas emissions.
Financial incentives for energy-efficient vehicles	National Policy Framework for the Deployment of Infrastructure and Development of Alternative Fuel Market in Transport (OG No. 34/17),	Subsidies for the purchase of alternative fuel vehicles through the allocation of grants have been introduced to increase the share of energy-efficient vehicles. These funds are paid from the revenues of the Environmental Protection and Energy Efficiency Fund realized through the sale of emission allowances in auctions and, among other things, by collecting a special environmental fee for motor vehicles.
Development of alternative fuels infrastructure	National Policy Framework for the Deployment of Infrastructure and Development of Alternative Fuel Market in Transport (OG No. 34/17), Act on Deployment of Alternative Fuels Infrastructure (OG No. 120/16, 63/22)	The co-financing incentive that follows the Directive on the deployment of the alternative fuels infrastructure, Act on Deployment of Alternative Fuels Infrastructure and National Policy Framework for the Deployment of Infrastructure and Development of Alternative Fuel Market in Transport (NPF) and promotes the construction of filling stations by the said documents.

Promotion of electromobility and establishment of charging infrastructure in buildings	Act on Construction (OG 153/13, 20/17, 39/19, 125/19)	The requirements for introducing electromobility by establishing charging infrastructure in buildings are applied to new and existing buildings.
Promotion of clean vehicles in public road transport	Act on promoting clean vehicles in road transport (OG 52/21). Ordinance on the obligation to report to the European Commission and minimum goals in procedures for the public procurement of vehicles for road transport (OG 86/2021).	It provides obligations of public contracting authorities to consider energy effects while procuring specific vehicles for road transport. It is to promote and encourage the market for clean and energy-efficient vehicles and increase the contribution of the transport sector to Union policies related to environmental protection, climate and energy and effects on the environment for the entire working life of the vehicle, including energy consumption and CO_2 emissions and emissions of certain pollutants.
Promoting integrated freight transport	Act on Combined Transport of Goods (OG No. 120/16) Ordinance on incentives for the combined transport of goods (OG 5/18)	The Ordinance provides incentives for the combined transport of goods by rail, inland waters or sea and the combined transport of goods on road sections.
Monitoring, reporting and verification of greenhouse gas emissions in the life cycle of liquid fuels	Rulebook on monitoring and reporting, the methodology for calculating greenhouse gas emissions during the lifetime of supplied fuels and energy and implementing projects to reduce emissions from oil and gas exploration and production (OG 131/2021).	Monitoring greenhouse gas emissions applies to fuels used to power road vehicles, non-road mobile machinery (including inland waterway vessels when not sailing at sea), tractors for agriculture and forestry, recreational vessels when not sailing at sea and electricity for use in road vehicles.
Industrial processes		
Reducing emissions of volatile organic compounds in the solvent utilization sector	Regulation on limit values for contents of volatile organic compounds in certain paints and varnishes used in construction and vehicle finishing (OG 86/21)	The regulation prescribes limit values for contents of volatile organic compounds which may be placed on the market. Developing and implementing a solvent management plan reduces volatile organic compounds emissions and carbon dioxide emissions.
Handling of substances that deplete the ozone layer and fluorinated greenhouse gases	Climate Change and Ozone Layer Protection Act (OG 127/19) and Regulation on Substances that Deplete the Ozone Layer and Fluorinated Greenhouse Gases (OG 83/21)	It is forbidden to release controlled substances and fluorinated greenhouse gases into the air while collecting, leakage testing, maintenance or servicing of appliances and equipment.
Technical and organizational measures for collection, reuse, recovery and destruction of controlled substances and fluorinated greenhouse gases	Act on Climate Change and Protection of the Ozone Layer (OG 127/19) and Regulation on Substances that Deplete the Ozone	This set of measures defines how the used controlled substances and fluorinated greenhouse gases in products and equipment must be

	Layer and Fluorinated Greenhouse Gases (OG 83/21)	collected, reused, recovered, or destroyed.
Capacity building and strengthening the knowledge of authorized repairers	Ordinance on the training of persons who carry out the activity of collecting, checking leaks, installing, and maintaining or servicing equipment and devices that contain substances that damage the ozone layer or fluorinated greenhouse gases or depend on them (OG 3/13, 47/14, 61/17, 127 /19) and the Law on Climate Change and Protection of the Ozone Layer (OG 127/19)	Education of authorized repairers on collecting and handling controlled substances and fluorinated greenhouse gases during device and equipment servicing.
Leakage detection of controlled substances and fluorinated greenhouse gases	Climate Change and Ozone Layer Protection Act (OG 127/19) and Regulation on Substances that Deplete the Ozone Layer and Fluorinated Greenhouse Gases (OG 83/21)	Technical measures to prevent or eliminate leakage of controlled substances and fluorinated greenhouse gases
A fee to cover the costs of collection, reuse, recovery and destruction of controlled substances and fluorinated greenhouse gases	Act on Climate Change and Protection of the Ozone Layer (O G127/19) and Regulation on Substances that Deplete the Ozone Layer and Fluorinated Greenhouse Gases (OG 83/21)	An entrepreneur who imports/introduces controlled substances and/or fluorinated greenhouse gases for placing on the market in the Republic of Croatia or for their own needs must pay a fee to the Environmental Protection and Energy Efficiency Fund. The cost is 0.20 EUR per kilogram of imported/introduced unused controlled substance and/or fluorinated greenhouse gas.
Waste management		
Preventing generation and reducing the amount of solid municipal waste	Waste Management Act (OG 84/21), Waste Management Plan of the Republic of Croatia for the period 2017 - 2022 (OG 3/17, 1/22)	This measure should be achieved by cleaner production, education, economic instruments, enforcement of regulations on integrated environmental protection requirements, and investing in modern technologies. Following the Act, quantitative targets and deadlines for reducing waste disposed to non-compliant landfills are defined.
Increasing the amount of separately collected and recycled solid municipal waste	Waste Management Act (OG 84/21), Waste Management Plan of the Republic of Croatia for the period 2017 - 2022 (OG 3/17, 1/22)	Quantitative goals and deadlines for increasing the amount of separately collected and recycled waste defined by the Law on Waste Management and the Waste Management Plan of the Republic of Croatia for the period 2017 - 2022 are incorporated into the measure. The goals of waste management are prescribed in order to encourage the transition to an economy that is

		more circular and in which the value of products, materials and resources is retained as long as possible, and the generation of waste is reduced to the minimum possible extent.
Methane flaring	Ordinance on waste landfills (OG 4/23), Ordinance on waste management (OG 106/22)	The Ordinance on Waste Landfills determines the operating conditions of the waste landfill, which reduce the possible harmful effects of the landfill on the environment. Landfill gas is collected from all landfills that receive biodegradable waste. The collected landfill gas should be processed and used. If the collected gas cannot be used to obtain energy, it should be burned.
Reducing the amount of disposed biodegradable municipal waste	Waste Management Act (OG 84/21), Waste Management Plan of the Republic of Croatia for the period 2017- 2022 (OG No. 3/17, 1/22)	The aim of the measure is to reduce the amount of biodegradable fraction of waste that is disposed of in landfills, thereby reducing the emission of methane produced by anaerobic processes of waste decomposition. The Waste Management Act stipulates that the maximum permitted mass of biodegradable municipal waste, the disposal of which can be allowed in a calendar year with all waste management permits in the Republic of Croatia, is 264,661 tons, which is 35% of the mass of biodegradable municipal waste produced in 1997.
Use of biogas for electricity and heat generation.	Low-carbon development strategy of the Republic of Croatia until 2030 with a view to 2050 (OG 63/21)	The measure is associated with the measure "Feed-in tariffs and premium system for the support of the use of renewable energy sources in electricity generation and for highly efficient cogeneration" in the section "Renewable energy sources".
Agriculture		
Changes in the diet of cattle and pigs and the quality of fodder	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Specific sub-measures within this group of measures related to the further improvement of animal husbandry, animal waste management systems, the level of production as well as their nutrition (digestibility): changing the ratio of certain types of forage in the diet, using fat supplements as an energy source, improving the quality of voluminous forage and improvement of the grazing system. These measures relate to potentially

		reducing methane and nitrogen compounds emissions from intestinal fermentation and animal waste management.
Changing the livestock breeding system	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Measures that achieve indirect effects on the reduction of greenhouse gas emissions refer to actions that increase the intensity of production (a more significant amount of animal products - milk, meat, eggs, etc., per animal and per unit of time), and thus indirectly affect the emission into the process of intestinal fermentation or from manure. Their effect largely depends on the livestock breeding system (technology).
Anaerobic manure decomposition and biogas production	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	By introducing a biogas plant, emission reduction is achieved by removing methane emissions from the disposal of used waste and producing electricity from renewable sources. The measure is related to the efforts encouraging the use of RES. Anaerobic digestion helps biogas plants reduce the source of readily degradable carbon in fertilizer applied to agricultural land, but also potentially reduces N_2O emissions from the nitrification process.
Improvement of breeding and selection program, health, and welfare of animals	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	This measure indirectly reduces methane and nitrous oxide emissions through breed improvements and enhancement of genetic potential. The breeding program is a set of selection procedures that achieve the genetic modification of individual species and breeds of animals to reduce methane emissions in dairy cows and increase production intensity.
Improvement of livestock facilities and animal waste management systems	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Covering the place for manure storage – creating a natural layer (crust) with natural (straw) or (porous) artificial material. This measure reduces the direct emission of methane and ammonia. However, to a lesser extent, it improves the process of nitrification (porous material) and causes a slight increase in nitrogen oxide emission.
Improvement of methods of application of mineral fertilizers	Low-carbon development strategy of the Republic of Croatia for the	This measure applies new slow-acting fertilizers suitable for growing crops (fertilizers coated with

	period up to 2030, with a view to 2050 (OG 63/21)	polymers). The research indicates the possibility of reducing the need for fertilizer application per hectare (due to lower nitrogen losses) with unchanged or increased income.
Hydromelioration interventions and disaster protection systems	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	The construction of drainage, irrigation and protection systems against floods, droughts and other natural disasters can reduce nutrient loss due to leaching and leaching, which results in a reduced need for nitrogen application.
Improvement and change of tillage system (reduced tillage)	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Tillage systems have a decisive influence on the parameters necessary for water storage in the soil, generally on water-air relations, water losses through evapotranspiration, the thermal state of the soil, and thus also on microbiological activity and soil respiration. The issue of reducing CO_2 emissions from agricultural soils in Croatia has not been sufficiently investigated in local conditions.
Expansion of crop rotation with greater participation of legumes	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Crop rotation is a system of crop production practised on arable land and represents a regular, spatial and temporal change of crops. The sowing of leguminous crops has multiple beneficial effects for agricultural soils; In this way, atmospheric nitrogen is bound, which is immediately used for protein synthesis, the risk of groundwater pollution with nitrates is prevented, the soil is enriched with organic matter, fertility is maintained, and certain crops (clover) can be effective in sequestering carbon in the soil.
Introduction of new cultivars, varieties and species	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	It encourages the development, education, and application of technologies at the national and regional level, facilitating the transition and adaptation of the entire production chain to produce new crops or enabling and encouraging the use of cultivars and varieties that are more resistant to drought and diseases and have a lower carbon footprint. Among other advantages, it aims to reduce the need to introduce nitrogen into the soil through fertilizers.

Improvement of methods of application of organic fertilizers	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Research on increasing carbon sequestration in the soil by improving the methodology of applying organic fertilizers. Organic fertilizers stimulate the activity of soil microbes much more strongly than mineral fertilizers, and with them, much less salt and acids are introduced into the soil.
Agroforestry	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	It defines the potential and benefits of various agroforestry technologies to increase carbon sequestration in the soil. Agroforestry includes technologies applied in forestry and agriculture to create higher productivity, economic justification, ecological acceptability, and sustainable land use.
Changing the way people eat	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	A significant reduction in emissions is due to less application of mineral fertilizers (and consequently fewer nitrogenous compounds) required for animal feed production, as well as to a decrease in methane emissions from intestinal fermentation of livestock. Additional benefits include significantly lower consumption of water and fuel in agricultural production.
Collection and processing of agricultural plantations and residues for use for energy purposes	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Optimization of the collection of pruned biomasses of permanent plantations, optimization of the collection of arable biomasses, production of safely available biomass, activation of poorer quality soil in the Republic of Croatia, ensuring a low-carbon energy source during the process of heat and/or electricity production (increasing the share of RES, reducing CO_2 emissions).
LULUCF		
Maintenance plan of the National Information System for land in the Republic of Croatia	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Ongoing activities: 1. Establish a unique land information system in the Republic of Croatia 2. An analysis project of all LULUCF land categories depending on the cover, land use and management practices used on each land and related emissions/outflows is being implemented to consider the potential of each of the storage areas within each LULUCF land

		category to reduce emissions, and increase outflows greenhouse gases 3. A project to strengthen projections in the LULUCF sector is being implemented The description of the above activities is in Chapter 3.
Carbon accumulation on the surfaces of existing forests	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21) Forest economic base of the area for the period 2016-2025	Implementation of activities that contribute to increasing the content of carbon stock in forests, especially in biomass storage, and the implementation of which ensures removals in a particular period that are greater than those defined by the reference level for forests (FRL). Realization occurs under the Forestry Economic Basis of the Area for 2016-2025.
Implementation of afforestation works	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21) Forest economic base of the area for the period 2016-2025	Afforestation in non-forest areas (in terms of the IPCC methodology) is an activity that generates outflows. The Republic of Croatia, due to nature protection regulations governing the establishment of Natura 2000 areas, is not able to dispose of all grassland areas (according to national rules: non-vegetated productive forest land) for reforestation purposes. Given that there are agricultural areas in the Republic of Croatia where production does not take place and which have been neglected for many years, the problem of these areas must be adequately addressed when creating the Land Management Strategy. It is necessary to evaluate the justification for converting these areas into forest areas by implementing afforestation. There is also a need to assess the effects of the afforestation of additional non-vegetated, productive forest land on fulfilling the obligations of the Republic of Croatia related to the use of renewable energy sources. It is necessary to create guidelines for further development based on the knowledge and experience gained through implementing afforestation activities.
Production and use of wood and wood products	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	By harmonizing available data and statistical reports, as well as new research, coordinate the information available for the needs of various

	Forest economic base of the area for the period 2016-2025	accounts to international organisations with the aim of more accurate, transparent, and high-quality reporting, but also to create a harmonised basis for adopting medium- and long-term strategies in the forestry and wood processing sector. It includes the mapping of forestry and wood industrial production. Encourage the use of wood products in traditional and new products to increase outflow and reduce greenhouse gas emissions in the storage of wood products. This also requires the regulation of the export of untreated and semi-processed wood, which encourages the development of the domestic wood industry, and the regulation of the export of energy wood increases the share of energy production from renewable sources, which fulfils the assumed international obligations. It is necessary to promote activities that generate outflows and ensure that wood products and wood for energy purposes are used in ways that contribute to meeting both EU goals by 2030 (reducing emissions and increasing the share of renewable sources in total energy consumption) and are helpful for the climate environment. It is necessary to create guidelines for further development based on the knowledge and experience gained through implementing this measure.
Management of agricultural land	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	This measure implements activities in managing areas for agricultural production in a way that contributes to reducing emissions. It is necessary to promote activities that benefit the climate and the environment and to create guidelines for further development based on the knowledge and experience gained through implementing this measure. Until now, implementation is realized through the Rural Development Program of the Republic of Croatia 2014-2020, i.e., the Agriculture Strategy.
Pasture management	Low-carbon development strategy of the Republic of Croatia for the	This measure implements activities in the management of pastures in a

	period up to 2030, with a view to 2050 (OG 63/21)	way that contributes to reducing emissions. It is necessary to promote activities that are beneficial for the climate and the environment and to create guidelines for further development based on the knowledge and experience gained through implementing this measure.
Implementation of technical projects and scientific research in the LULUCF sector	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Until 2030 and 2050, it is necessary to secure financial resources to implement technical and scientific projects in the LULUCF sector. Scientific projects should enable different models for moving to a higher level of the IPCC methodology (Tier 3) to determine the emissions/outflows of greenhouse gases as accurately as possible and consequently plan measures to reduce emissions and increase outflows.
Fugitive emissions		
Modernization of refineries	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	This measure implements investments in the modernization and improvement of production to maintain the competitiveness of refineries and reduce fugitive emissions from refineries.
Measures to increase energy efficiency by improving processes and process units	Low-carbon development strategy of the Republic of Croatia for the period up to 2030, with a view to 2050 (OG 63/21)	Increasing energy efficiency by implementing measures that reduce energy intensity through the more rational use of energy and raw materials and changes in production processes and equipment at pumping stations and in refineries, which contribute to reducing fugitive emissions.

Dimension 'Energy Efficiency'

Energy efficiency in the Republic of Croatia is regulated by:

- Energy Efficiency Act (OG Nos. 127/14, 116/18, 25/20, 32/21, 41/21),
- Building Act (OG Nos. 153/13, 20/17, 39/19, 125/19),
- Act on Protection against Light Pollution (OG No. 14/19),
- by-laws that follow from these Acts.

The national energy efficiency increases targets until 2020 and 2030 are defined in the Energy Efficiency Act. The 2030 targets are based on the first version of the NECP and are further set out in the National Energy Efficiency Action Plan (NAPEnU) for the period 2022-2024. The targets are expressed as the absolute amount of final energy consumption in 2030, which should amount to 286.9 PJ (6.85 Mtoe) or primary energy in 2030 344.4 PJ (8.23 Mtoe). The targets expressed as the absolute amount of primary and final energy consumption are shown in Figure 1-5.

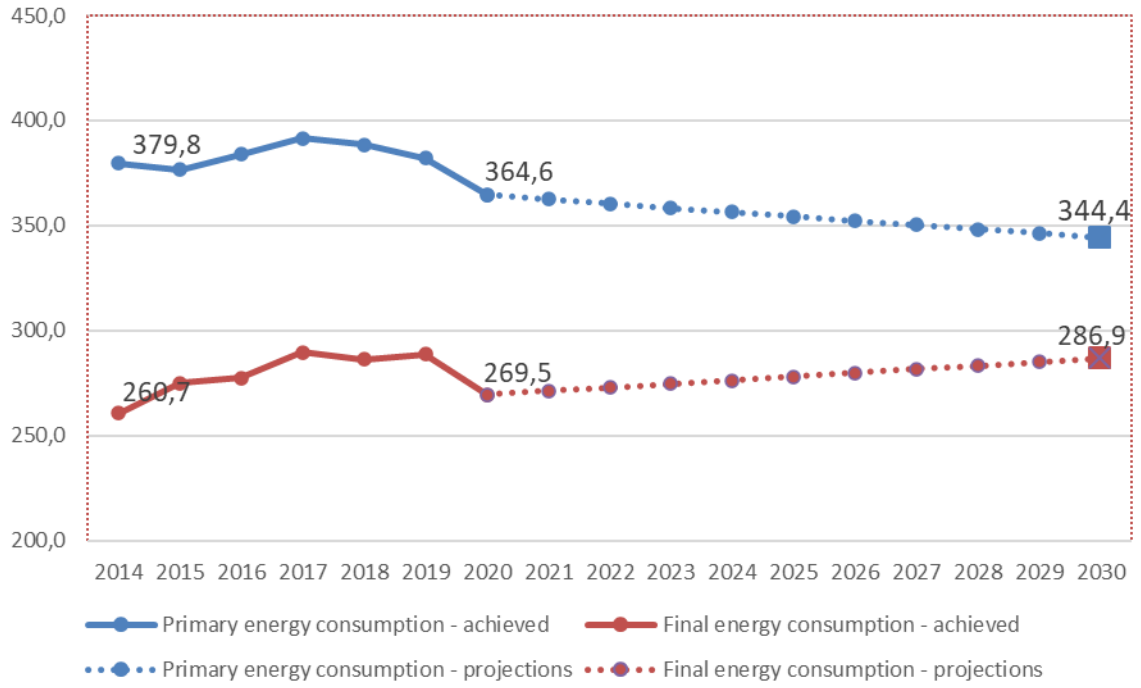


Figure 1-5. Indicative trend of achieved energy consumption from 2014 to 2020 and consumption projections from 2021 to 2030 with existing measures

Source: NAPEnU from 2022 to 2024

An overview of the regulatory measures defined in the aforementioned laws and relevant by-laws is shown in Table 1-5. The aforementioned laws and regulations in Croatia meet the requirements of the following EU directives:

- Directive 2012/27/EU of the European Parliament and of the Council of 25th October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (Text with EEA relevance (OJ L 315, 14th Nov 2012);
- Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency (Text with EEA relevance) (OJ L 328, 21st Dec 2018) - (hereinafter: the Energy Efficiency Directive);
- Directive 2010/31/EU of the European Parliament and of the Council of 19th May 2010 on the energy performance of buildings (recast) (OJ L 153, 18th Jun 2010.);
- Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency (Text with EEA relevance) (OJ L 156, 19th Jun 2018) (hereinafter: the Directive on Energy Performance of Buildings);
- Directive 2010/30/EU on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products, and Regulation 2017/1369 setting a framework for energy labelling and repealing Directive 2010/30/EU (Text with EEA relevance.) (OJ L 198, 28th Jul 2017);
- Directive 2009/125/EC of the European Parliament and of the Council of 21st October 2009 establishing a framework for setting eco-design requirements for energy-related products (recast) (Text with EEA relevance) (OJ L 285, 31st Oct 2009).

Table 1-5. Overview of existing regulatory measures for energy efficiency

Energy Efficiency Act
The obligation of the Government of the Republic of Croatia to adopt the National Energy Efficiency Action Plan for three years with measures to be implemented on the entire territory of the Republic of Croatia under the Integrated National Energy and Climate Plan (NECP), which defines alternative policy measures including measures to ensure the annual renovation of 3% of the total floor area of heated and/or cooled buildings owned and used by the central government.
The obligation of counties and large cities (> 35,000 inhabitants) to adopt (three-year) Action Plans and annual energy efficiency plans.
Energy efficiency obligation scheme for energy suppliers – encourages the implementation of energy efficiency measures in households affected by energy poverty or in social housing spaces.
Supplier's obligations to measure and account for consumption and to inform customers about past consumption, including comparison with the average normal or reference final customer from the same category of final customers.
The obligations of energy distributors are to enter data on metering and consumption of energy in the public sector monthly in the national Energy Management Information System (ISGE) and to provide individual meters to final customers.
The obligations of the Energy Regulatory Authority are to promote energy efficiency through tariffs and provide incentives to improve efficiency in the planning and operation of natural gas and electricity infrastructure.
The obligations of transmission and distribution system operators are to provide network access, transmission and distribution of electricity produced from high-efficiency cogeneration.
The obligations of large enterprises on implementing energy audits every four years introducing an energy management system - Ordinance on energy audit for large enterprises (OG 123/15, 5/20, 97/21).
The public sector must conduct energy audits of public lighting systems every five years and maintain and reconstruct public lighting in such a way as to reduce electricity consumption and meet other requirements prescribed by the Act on Protection against Light Pollution (OG 14/19) and the regulations arising from it.

The public sector must systematically manage energy, which implies the appointment of a responsible person for energy management, regular monitoring of energy consumption and the entry of data on energy consumption into the national information system for energy management (ISGE) - Ordinance on systematic energy management in the public sector (OG 18/15 and 06/16).
The obligation is to report all energy efficiency activities and realized savings in the national system for monitoring, measuring and verification of savings (SMiV) for the public sector, energy service providers and subsidy providers - Ordinance on the system for monitoring, measuring and verification of energy savings (OG 98/21, 30/22).
The competent ministries and the National Coordinating Body (NKT) are obligated to establish and run an energy efficiency platform - National Energy Efficiency Portal: https://www.enu.hr/.
Energy-related device labelling obligation - relevant EU regulations for individual groups of devices.
Regulation of energy services (energy performance contracts) in the public sector - Regulation on contracting and implementation of energy services in the public sector (OG 11/15)
It regulates the contracting of multi-apartment building energy services, and energy renovation works. It determines the adoption of a decision on energy renovation based on a simple majority of votes of co-owners, which is calculated by co-ownership parts.
The obligation is to use energy efficiency criteria in public procurement procedures for energy-related products - Ordinance on energy efficiency requirements in public procurement procedures (OG 70/15).
The obligation is to meet the requirements for eco-design of energy-related products when placed on the market - Ordinance establishing conditions for eco-design of energy-related products (OG 50/15).
Ordinances on conditions and criteria for determining the quality-of-service systems and works for certification of installers of renewable energy sources - photovoltaic systems (OG 56/15); solar thermal systems (OG 33/15, 56/15 and 12/17); smaller biomass boilers and stoves (OG 39/15, 56/15 and 12/17); shallow geothermal systems and heat pumps (OG 56/15 and 12/17).
Construction Act
Energy management and heat conservation are essential requirements for buildings - Technical regulation on rational energy use and thermal protection in buildings (OG 128/15, 70/18, 73/18, 86/18 and 102/20). Minimum energy performance of buildings, method of determining the energy performance of buildings, presentation of the technical, environmental, and economic feasibility of available high-efficiency alternative energy supply systems, equipping buildings with automation systems, and requirements for nearly zero-energy buildings.
The Government should adopt the Long-Term Strategy for the Renovation of the National Building Stock of the Republic of Croatia at the proposal of the Ministry responsible for the construction and update it every five years.
The Government should adopt energy renovation programs for buildings from 2021 to 2030 at the proposal of the ministry responsible for construction affairs.
The Government should adopt the Green Infrastructure Development Program from 2021 to 2030 at the proposal of the Ministry responsible for construction affairs.
The Government should adopt the Circular Management programme for spatial buildings from 2021 to 2030 at the proposal of the ministry responsible for construction affairs.
Promoting electromobility and establishing charging infrastructure in new buildings and buildings undergoing significant renovation for residential and non-residential buildings.
The obligation is to regularly inspect heating and cooling or air conditioning systems in buildings and energy certification of buildings. Ordinance on energy audit of buildings and energy certification (OG 88/17, 90/20, 1/21 and 45/21). Ordinance on the control of the energy certificate of the building and the report on regular inspection of heating systems and cooling systems or air conditioning in the building (OG 73/15 and 54/20). Ordinance on persons authorized for energy certification, an energy audit of buildings and regular inspection of heating systems and cooling or air conditioning systems in buildings (OG 73/15, 133/15, 60/20 and 78/21).
Act on Protection against Light Pollution
When planning, designing, constructing, maintaining, and reconstructing outdoor lighting, which is approved under the law governing construction, such technical solutions must be selected by the lighting project to ensure energy efficiency; local self-government units are obliged to adopt a lighting plan as well as an action

plan for the construction/reconstruction of lighting; the Ordinance prescribes energy efficiency criteria for lighting. Ordinance on the content, format, and manner of drafting a lighting plan and action plan for the construction and / or reconstruction of outdoor lighting (OG 22/23).

In addition to regulatory measures, other energy efficiency measures are being implemented in Croatia, according to three-year national action plans. The last NAPEnU was prepared for the period from 2022 to 2024. The measures from this NAPEnU implemented in Croatia at the time of preparation of this updated NECP are presented in Table 1-6. These are mainly measures of financial incentives by grant mechanisms or financial instruments from national sources (the Environmental Protection and Energy Efficiency Fund) and EU sources (National Recovery and Resilience Plan, European Regional Development Fund - ERDF).

Table 1-6. Overview of existing non-regulatory energy efficiency measures by sectors of final consumption (excluding transport)

Name of the measure	Category of measure	Short description
Households		
Energy renovation of multi-apartment buildings by 2030	Financial - ESCO model and grants	The Government of the Republic of Croatia adopted the program in December 2021, pursuant to the Construction Act. The program includes energy renovation of multi-apartment buildings damaged and multi-apartment damaged by the earthquake to reduce energy consumption and increase the safety and resilience of existing multi-apartment buildings to fire and earthquake. For the energy renovation of multi-apartment buildings undamaged in the C6 earthquake. NPOO initiatives: Renovation of buildings, i.e., investments C6.1. R1-I1 Energy renovation of buildings, allocation in the amount of EUR 39.8 million (HRK 300 million) was ensured, and in 2022 a call for allocation of funds was implemented. The ERDF has provided EUR 89 million in the form of a financial instrument for this programme. In addition, the FZOEU tool will be used based on the conclusion of the Government of the Republic of Croatia on measures to mitigate the energy crisis.
Program of energy renovation of family houses until 2030	Financial - Grants	The draft of this program has been drafted, but the Program has not yet been adopted. It envisages using FZOEU funds from the sale of allowances through grant auctions to owners of family houses.
An energy poverty curb programme involving the use of renewable energy sources in residential buildings in assisted areas and areas of special state concern for the period up to 2025	Financial - Grants	The program was adopted by the Government of the Republic of Croatia in December 2021. The goal of the Program is the energy renovation and installation of renewable energy sources in 387 residential buildings owned and managed by the Ministry of Physical Planning, Construction and State Assets. Funds for the implementation of the Program in the amount of around EUR 20 million (HRK 150 million) are provided from the NPOO, and other necessary funds are provided from the state budget. The program is fully implemented by the Ministry of Physical Planning, Construction and State Assets.
Public sector		

Energy renovation of public sector buildings by 2030	Financial - ESCO model and grants	The Government of the Republic of Croatia adopted the program in April 2022, pursuant to the Construction Act. NRRP secured grants of EUR 39.8 million (HRK 300 million), and EUR 33.2 million (HRK 250 million) was provided for the implementation of the renovation through the ESCO model through the direct allocation of funds to APN. Another EUR 150 million will be available from the ERDF as grants.
Energy renovation of buildings that have the status of cultural property by 2030	Financial - Grants	The Government of the Republic of Croatia adopted the program in December 2021, pursuant to the Construction Act. The funds are secured from the NRRP of EUR 39.8 million (HRK 300 million) as grants.
Systematic energy management in the public sector	Informative	The programme is implemented by the APN and is based on the public sector's obligation to systematic energy management; savings in this program are the result of organizational and information measures. In addition, APN started with implementing the Pilot Project to establish and implement systematic energy management and develop a new financing model, which extends the good practice of ISGE to residential buildings. For this pilot project, funds from the NRRP of EUR 1.6 million (HRK 12 million) have been secured.
Programme "Energy Efficient Public Lighting"	Financial - Affordable loans	The available funds from the ERDF to the OPCC 2014-2020 are HRK 152 million (EUR 20 million) for energy renovation of public lighting systems; the program is implemented through lending provided by HBOR; It is anticipated that the implementation of the projects under this program will be completed by the end of 2023.
"Green" Public Procurement	Voluntary agreements and cooperative instruments	The Government of the Republic of Croatia adopted it in 2021. Decision on green public procurement in central public procurement procedures (OG 49/2021) which set an obligation on the Central Office for Central Public Procurement to use green public procurement benchmarks to purchase green products and services. The goal is to have 75% of public procurement procedures with applied green public procurement standards in 2030.
Industry		
Increasing energy efficiency and use of RES in manufacturing industries	Financial - Grants Affordable loans	The aim is to support the implementation of energy efficiency measures and/or measures for the use of renewable energy sources that will lead to a reduction in the consumption of delivered energy in production facilities by at least 20% compared to the reference energy delivered by continuing co-financing with grants that started in the period OPCC 2014-2020. To this end, EUR 60.9 million (HRK 459 million) has been secured from the NRRP, and EUR 150 million will be additionally available as a financial instrument from the ERDF. Additional funds will also be provided from the Modernisation Fund.

In addition to the above measures, the existing documents define several measures aimed at providing information and education, which are shown in the Table below.

Table 1-7. Overview of existing intersectoral measures for energy efficiency

Name of the measure	Category of measure	Short description
Promoting nZEB standards of construction and renovation	Informative	This measure supports the legal obligation and includes educating and informing both the participants in the construction and the general public about the nZEB standard of construction and renovation.
Informative calculations	Regulatory Informative	Obligations of the supplier regarding measurement and calculation of consumption and informing customers about past consumption, which includes a comparison with the average normal or reference end customer from the same category of end customers of the supplier.
Awareness campaigns and promotion of energy services	Informative	Implementing targeted promotional campaigns related mainly to co-financing programmes for energy renovation of buildings and promoting energy services through the national energy efficiency portal; informing consumers about the duties of suppliers under the scheme of obligations.
Energy efficiency education	Educational	Establishment of a certification system and lifelong learning of construction workers about energy efficiency.
Integrated information system for monitoring energy efficiency	Informative - Monitoring the implementation and achieving energy savings	A comprehensive system for monitoring the performance of energy efficiency measures and verification of achieved savings.

In addition to the above measures all directed at the sectors of final energy consumption, the existing documents also define measures aimed at the energy infrastructure (generation, transmission and distribution of electricity and heat), as shown in Table 1-8. It should be noted that the Croatian Energy Regulatory Agency (CERA), based on the Energy Efficiency Act, is obliged to consider energy efficiency in relation to its decisions on the operation of gas and electricity infrastructure when carrying out regulatory tasks in accordance with the laws regulating the electricity market and the gas market, namely:

- to ensure the implementation of an assessment of the potential for increasing energy efficiency of the gas and electricity infrastructure, in particular regarding transmission, i.e. transport, distribution, load management, interoperability and connection of energy generation facilities, including possibilities of access for energy microgenerators and
- to identify specific measures and investments to introduce cost-effective energy efficiency improvements into grid infrastructure, including deadlines for their introduction.

To carry out the stipulated tasks, the CERA has ensured the preparation of the study "*Assessment of Potential for Increasing Energy Efficiency of the Electricity Infrastructure*" [].

The study has analysed measures that affect technical losses (decrease and increase), which are covered in the ten-year development plans for the transmission and distribution system.

These measures arise from the need to increase the safety of operations and to meet technical regulations, and related investments are too high to be justified exclusively by the savings that will be achieved by reducing losses. When prerequisites for introducing advanced technologies such as load management are created, the CERA will revise its assessment of potential for increasing energy efficiency of the electricity infrastructure and determine deadlines for the introduction of advanced measures.

Table 1-8. Overview of existing energy efficiency measures for energy infrastructure

Name of the measure	Category of the measure	Short description
Energy efficiency for decarbonisation of the energy sector	Heat production	The measure focuses on modernizing DHS production facilities by achieving diversification of thermal energy sources. Efforts to achieve this include replacing natural gas boilers with water/water heat pumps, high-efficiency natural gas cogeneration, industrial waste heat exploitation, energy utilisation of waste, solar energy utilisation, high-efficiency biomass cogeneration, biomass boiler rooms and geothermal energy utilization. A comprehensive assessment of the potential for efficient heating and cooling in Croatia has shown that the measure that is the most significant in terms of savings and requires public support is geothermal energy. EUR 29 million is foreseen for preparing geothermal energy projects in DHS through the Recovery and Resilience Mechanism.
Increasing the efficiency of the district heating system	Heat distribution	In the existing large district heating systems, a significant source of losses is the dilapidated distribution network, and this measure envisages the continuation of the replacement of hot water pipelines and steam pipelines with worn-out insulation of steel pipelines with new pre-insulated pipes and a technological shift towards the fourth generation of district heating. In smaller systems with boiler rooms, it is necessary to enable the reconstruction of boiler rooms, mainly by replacing them with high-efficiency cogeneration systems or systems that use heat pumps. The measure also envisages the development of new heating and cooling systems which use high-efficiency cogeneration or renewable energy sources. Given the provisions of Directive 2018/2002 on energy efficiency, and with the introduction of the obligation of individual measurement at the level of the final consumer, district heating systems have become systems with variable demand for heat energy, which requires the introduction of advanced metering systems as an additional step in the integration of different energy systems and increasing overall energy efficiency. Investments are insured by utility companies and against the use of ESI funds, according to OPCC 2014-2020, of EUR 80 million.
Loss reduction and transmission	Power grids	The current cost of losses in the transmission network of the Republic of Croatia amounts to about 2% of the transferred

network development		electricity, which is the amount at the level of other ENTSO-E transmission system operators. An essential characteristic of the Croatian transmission network, both from operational safety and support of market activities, as well as from losses, is a powerful connection with neighbouring power systems (interconnections). While on the one hand, this significantly increases the plant's safety; on the other hand, network losses increase due to transit. This measure implies the optimization of the topology of the transmission network and the reduction of losses, and the development of network capacity. According to the adopted amendments to the Energy Efficiency Act, in September 2021, the Ordinance on the system for monitoring, measuring and verification of savings (OG 41/2021) was adopted, according to which HOPS is obliged to implement measures to improve energy efficiency in the transmission network into the system for measuring, monitoring and verification of savings. In the period until 2030, HOPS will continue to implement measures related to the management of EES plants and actions associated with the development of the transmission network for optimal (safe and efficient) operation of the plant. In addition to the provision of funds by HOPS, this measure is proposed to program the use of ESI funds.
Reducing losses in the distribution power grid and introducing advanced grids	Power grids	The measure implies the reduction of losses in the distribution network and the introduction of advanced benchmarks for end consumers by the HEP-Distribution System Operator (HEP ODS). Until 2030, HEP-ODS will continue to carry out activities to reduce technical and non-technical losses in the distribution power grid. Detailed analysis will determine the causes of increased losses in certain network parts and priorities for implementing activities to reduce technical and non-technical losses. According to the adopted amendments to the Energy Efficiency Act in September 2021, the Ordinance on the system for monitoring, measuring and verification of savings (OG 41/2021) was adopted, according to which the DSO is obliged to achieve measures to improve energy efficiency in the distribution network into the system for measuring, monitoring and verification of savings. For the pilot project "Deployment of smart grids in pilot areas", HEP ODS was allocated EUR 20 million from ESI funds, according to OPCC.

Dimension "Energy security"

Key legislation relevant for the dimension of energy security:

- Energy Act (OG Nos. 120/12, 14/14, 102/15, 68/18),
- Electricity Market Act (OG No. 111/21),
- Gas Market Act (Official Gazette Nos. 18/18, 23/20,
- Oil and Petroleum Products Market Act (OG Nos. 19/14, 73/17, 96/19),
- Act on the Liquefied Natural Gas Terminal (OG No. 57/18),
- Act on the Regulation of Energy Activities (OG No. 120/12, 68/18),
- Act on Exploration and Exploitation of Hydrocarbons (OG Nos. 52/18, 52/19, 30/21).

The most important measures currently being implemented for the purpose of ensuring energy security are shown in Table 1-9.

Table 1-9. Existing measures to ensure energy security

Name of the measure	Documents	Short description
Preparing and publishing the report on the security of the electricity supply	Electricity Market Act (OG 111/21)	The Transmission System Operator and the Distribution System Operator shall, no later than 31st March of the current year, submit to the Agency for an opinion an annual report on the security of supply in the transmission system or the distribution system for the preceding calendar year. Based on these reports, the Ministry prepares its annual report on the security of electricity supply and expected electricity needs in the Republic of Croatia for the next ten-year period. The Agency, in cooperation with the Ministry, may, based on those reports, require transmission system operators, distribution system operators and other electricity entities to implement specific measures in case of the need to improve the security of the electricity supply.
Prescribing technical regulations, requirements and conditions for the safety and use of energy	Electricity Market Act (OG 111/21)	The Minister, with the prior approval of the Minister for Construction Affairs, prescribes technical regulations, requirements and conditions for the safety and use of energy for the protection of low-voltage networks and associated transformer stations,

		measures for the operation and maintenance of power plants, for the construction of overhead power lines with rated voltages from 1 kV to 400 kV, construction, use and maintenance of overhead power lines and power plants of rated AC voltage up to 1 kV and use and maintenance of low-voltage installations.
Preparation and publication of reports of the transport system operator	Gas Market Act (OG 18/18, 23/20)	The transmission system operator (PLINACRO d.o.o.) is obliged to prepare and submit a report for the previous year to HERA by 1st March of the current year, which must contain a report on the reliability, safety and efficiency of the transmission system, gas quality, quality of service, reliability of gas delivery, technical characteristics of the system, use of transmission system capacity, maintenance of system equipment and fulfilment of other duties and exercise of rights from this Act.
Plan of protection of the power system from significant disturbances	Amendments to the network codes of the transmission system (OG 128/2020)	HOPS) is responsible for the reliability and availability of the electricity supply system and the correct coordination of the generation, transmission, and distribution system, with responsibility for managing the electricity supply system and the system to achieve the safety of electricity delivery. HOPS prepares the Annual Report on the Security of Supply of the Croatian Power System, and the Croatian Energy Regulatory Agency approves it. All transmission system users implement the measures in the Defence Plan, which are mandatory for them. To ensure effective defence in cases of significant disruptions, but also to the system restoration plan, the transmission system operator shall adopt a System Defence Plan with technical and organisational measures taken to prevent the spread or exacerbation of disruptions in the transmission system to avoid disruption and system failure.

Intervention plan of measures for the protection of gas supply security of the Republic of Croatia	Decision on the adoption of the Intervention Plan on measures to protect the security of the gas supply of the Republic of Croatia (OG 127/22)	The intervention plan shall set out the procedures, roles and responsibilities of the competent authorities and any gas market participants involved in the event of disruption of soil supply. Furthermore, the Intervention Plan regulates measures to eliminate or mitigate the impact of disruptions in the gas supply, which includes ensuring a reliable and efficient supply of natural gas, the criteria and method of determining enough natural gas to provide a reliable supply of natural gas to protected customers, and the order in which natural gas supply is reduced or suspended to individual categories of customers in the event of a crisis.
Building and holding compulsory stocks of oil and petroleum products	Oil and Petroleum Products Market Act (OG 19/14, 73/17, 96/19)	The Hydrocarbon Agency (AZU), as the Central Authority in the Republic of Croatia for mandatory stocks of oil and petroleum products, is obliged to form stocks at least in the amount of 90 days of average daily net imports, i.e., intake or 61 days of average daily domestic consumption of petroleum products in the previous calendar year, whichever is higher. Mandatory supplies of oil and petroleum products are formed to secure the supply of oil and petroleum products in case of threat to the state's energy security due to extraordinary disruptions to the supply of oil and petroleum products markets.

Dimension "the Internal Energy Market"

Legislation relevant to the internal energy market includes laws regulating energy markets:

- Energy Act (OG Nos. 120/12, 14/14, 102/15, 68/18),
- Electricity Market Act (OG No. 111/21),
- Energy Efficiency Act (OG Nos. 127/14, 116/18, 25/20, 41/21)
- Act on Renewable Energy Sources and High Effective Cogeneration (OG No. 138/21)
- Thermal Energy Market Act (OG No. 80/13, 14/14)
- Gas Market Act (Official Gazette Nos. 18/18, 23/20,
- Oil and Petroleum Products Market Act (OG Nos. 19/14, 73/17, 96/19),
- Act on Biofuels for Transport (OG Nos. 65/09, 145/10, 26/11, 144/12, 14/14, 94/18, 52/21)
- Act on the Regulation of Energy Activities (OG No. 120/12, 68/18),
- Act on Exploration and Exploitation of Hydrocarbons (OG Nos. 52/18, 52/19, 30/21).

Regarding electricity interconnection, first of all, it is necessary to consider the EU target according to which the desired level of electricity interconnection is at least 15% compared to the installed power of power plants in the observed state by 2030. The transmission system in the territory of the Republic of Croatia already meets and exceeds that target many times over. The same applies if the existing electricity interconnection capacity is compared with the peak load of the system or the installed power of RES in the territory of the Republic of Croatia.

The most important measures regarding the energy transmission infrastructure are shown in Table 1-10.

Table 1-10. Existing measures for energy transmission infrastructure

Name of the measure	Documents	Short description
Preparation and implementation of electricity transmission grid development plans	Electricity Market Act (OG 111/21)	HOPS is an energy entity responsible for the transmission power grid's management, operation and management, maintenance, development, and construction. As the owner of the transmission network of 110 kV to 400 kV, HOPS is obliged to develop and adopt, with the prior consent of the Ministry of Economy and Sustainable Development and the approval of HERA. The updated ten-year transmission network development plan includes detailed investments in the subsequent three-year and one-year periods.
Preparation and implementation of power distribution grid development plans	Electricity Market Act (OG 111/21)	HEP ODS, designated as the distribution system operator for the territory of the Republic of Croatia for 50 years, is responsible for the

		operation and management, maintenance, development, and construction of the distribution network and is obliged every year to develop and adopt, with the prior approval of HERA, an updated ten-year distribution network development plan, including detailed investments in the next three-year and one-year period.
Preparation and implementation of gas transport system development plans	Gas Market Act (OG 18/18, 23/20)	The transmission system operator must develop a ten-year transmission system development plan per the Energy Development Strategy and the Energy Development Strategy Implementation Programme and submit it to HERA for approval every two years. The transmission system operator shall operate, maintain, and develop a safe, reliable, and efficient transmission system.

The level of power reserves in the production part of the electricity system (ES), in Croatia and in the neighbouring systems with which the Croatian ES is interconnected, enables safe and reliable system operation. The production and consumption of electricity by ES users within the synchronous area of continental Europe is continuously monitored in real time to maintain a stable frequency of the ES. Any imbalance is corrected by balancing mechanisms. Balancing mechanisms that activate energy from power reserves to maintain the frequency of the system after the occurrence of an imbalance in the system are:

- *Frequency Containment Reserve* (FCR)
- *Frequency Restoration Reserve with Automatic* Activation
- *Frequency Restoration Reserve with Manual Activation*
- *Replacement Reserve*

The current ES capacity is at a satisfactory level, with potential threats due to the lack of available domestic production capacity, which are currently compensated by high levels of cross-border exchanges, which makes the capacity and security of electricity supply dependent on the availability of cross-border transmission capacity and possibility of power generation in broader regional markets.

Flexibility can be defined as a change in the production pattern or power consumption due to a response to stimulus (price signal or activation) to provide ancillary services to the ES, most commonly to the system operator. A market research pilot project is currently underway regarding ensuring active power reserves of tertiary control through manageable consumption for the needs of CTSO. Within the framework of this project, by entering a

contractual relationship with CTSO for the provision of ancillary services of ensuring active power reserves of tertiary control, the end customer participates directly in the system balancing mechanism and receives a compensation defined by the contract. Manageable consumption units may be any devices whose consumption can be reduced at the request of the transmission system operator, and which are part of the end customer's facility, such as electric ovens, cold stores, pumps, compressors, and the like.

Ancillary services and services of flexibility that distribution network users provide to the distribution system operator are not currently used in the Republic of Croatia. The Distribution System Grid Code that came into effect in 2018 (OG No. 74/18) regulates new services that could be of use to the distribution system operator.

The establishment of the ECO balance group is regulated by the Act on Renewable Energy Sources and Highly Efficient Cogeneration (OG No. 138/21) and consists of electricity producers and other entities performing the activity of electricity generation, which are entitled to incentive pricing in accordance with the agreements on the purchase of electricity with the Croatian Energy Market Operator (CEMO).

Pursuant to the Act on Renewable Energy Sources and Highly Efficient Cogeneration, CEMO is designated as the head of the ECO balance group with the obligation to manage the ECO balance group, plan the production of electricity for the ECO balance group and sell the electricity produced by the members of the ECO balance group in the electricity market transparently and impartially.

Regarding consumer protection, competitiveness, and development of the retail electricity market, one of the key indicators is the rate of supplier switching by end customers. The rate of supplier switching by end customers in the entrepreneurship category is higher than in the household category. The main reason is the regulatory framework for public procurement, whereby specific end customers from the entrepreneurship category are obliged to regularly issue tenders for selection of the most favourable electricity supplier.

The basic prerequisite for enabling and developing energy management is the introduction of an advanced measurement system.

Measures in consumer protection are shown in Table 1-11.

Table 1-11. Existing consumer protection measures

Name of the measure	Documents	Short description
Informative calculations	Energy Efficiency Act (OG 127/14, 116/18, 25/20, 32/21, 41/21)	Supplier's obligations to measure and account for consumption and inform customers of prior consumption, including comparison with the average normal or reference final customer from the same category of final customers suppliers.
Obligations of the energy distributor to enter the data on energy measurement and consumption in the public sector into the National Information System for Energy Management (ISEM) monthly and provide individual meters to end customers	Energy Efficiency Act (OG 127/14, 116/18, 25/20, 32/21, 41/21)	Energy distributors shall ensure that, to the extent technically possible, financially justified and proportionate given potential energy savings, domestic energy and hot water final customers are provided with competitively priced individual meters that accurately reflect the actual energy consumption of final customers.

Existing measures to combat energy poverty are shown in Table 1-12**Pogreška! Izvor reference nije pronađen.**. The table shows the measures by which some progress or result has been achieved. In addition to the above, there are other measures, but these measures have not made progress and are therefore not included.

Table 1-12. Existing measures to eliminate energy poverty

Name of the measure	Documents	Short description
Compensation of energy costs of vulnerable customers	Regulation on criteria for acquiring the status of vulnerable energy customers from networked systems (OG No. 95/15); Regulation on Amendments to the Regulation on Criteria for Acquiring the Status of Vulnerable Buyers of Energy from Networked Systems (OG 31/22); Regulation on the monthly amount of compensation for vulnerable energy buyers, the method of participating in the settlement of the costs of energy users of the compensation and the actions of competent centers for social welfare (OG 140/15), which was replaced by: Regulation on the monthly amount of compensation for vulnerable energy buyers, the method of participating in the settlement of the costs of energy users of the compensation and the actions of the Croatian	Customers of electricity from the household category pay a supplement to the price of electricity. This supplement is charged by the supplier to the customers in accordance with the contract on the supply of the final customer and paid into the state budget. The funds thus collected are intended to finance vouchers for vulnerable customers. The changes in 2022 expanded the criteria for acquiring the status of an endangered customer, which increased the scope of this measure. The voucher for vulnerable customers amounted to HRK 200.00 until 2022, when, through

	Institute for Social Work (OG 31/22, 104/22, 31/23)	amendments to the Regulation on the monthly amount of compensation for vulnerable energy customers, this amount increased to HRK 400.00, and then to HRK 500.00. With the latest changes to the Regulation in 2023, the amount of vouchers applied from 1 April 2023 was determined. until 31.3.2024. year and it amounts to 70.00 euros.
An energy poverty curb programme involving the use of renewable energy sources in residential buildings in assisted areas and areas of particular state concern for the period 2021-2025	National Energy Efficiency Action Plan 2022-2024	Through this Program, it is planned to renovate 387 multi-apartment buildings in assisted areas and areas of special state concern.

Dimension "Research, Innovation and Competitiveness"

National documents relating to the dimension of "Research, Innovation and Competitiveness", which were considered in the preparation of the NECP 2019, are:

- Education, Science and Technology Strategy (OG No. 124/2013)
- Smart Specialization Strategy of the Republic of Croatia for the period from 2016 to 2020 (OG No. 32/2016)
- Innovation Promotion Strategy of the Republic of Croatia 2014-2020(OG No. 153/2014) and
- Research Infrastructure Development Plan in the Republic of Croatia (2016).

The development of policies relevant to this dimension is accompanied by the preparation and adoption of new documents, including e.g.

- the National Plan for the Development of the Education System until 2027 (OG No. 33/2023),
- Draft Smart Specialization Strategy until 2029, which is in the process of being adopted, and a public consultation was conducted in December 2022[7].

The legal framework defining scientific research and private and public investments in research, development and innovation includes, among others, the following acts:

- Scientific Activity and Higher Education Act (OG No. 119/2022)
- Act on Quality Assurance in Higher Education and Science (OG No. 151/2022)

[7] https://esavjetovanja.gov.hr/ECon/MainScreen?entityId=22750

- Investment Incentive Act (OG No. 63/22)
- Act on State Aid for Research and Development Projects (OG No. 64/18)
- Public Procurement Act (OG No. 120/16, 114/22) and
- Small Business Development Promotion Act (OG Nos. 29/02, 63/07, 53/12, 56/13, 121/16).

The Higher Education and Scientific Activity Act regulates the basic principles of performing higher education and scientific activities, establishment and operation of institutions, the process of hiring and promoting teachers, scientists and associates and their rights and obligations, basic issues of performing studies, the rights and obligations of students, performing scientific and professional activities, support and financing of these activities and supervision and misdemeanour sanctions.

The Act on Quality Assurance in Higher Education and Science regulates internal quality assurance and improvement of higher education institutions and scientific institutes, external quality evaluation of higher education institutions and scientific institutes and the organization and powers of the Agency for Science and Higher Education.

The Investment Incentive Act regulates the system of investment aid and timely realization of investment activities, with the aim of successful and scheduled realization of sustainable and technologically advanced investment projects of high added value in the territory of the Republic of Croatia. Aid relates to sustainable investment projects aimed at strengthening the competitive capacity in (i) manufacturing and processing activities, (ii) development and innovation activities, (iii) business support activities and (iv) high added value service activities.

Aid governed by the Investment Incentive Act relates to projects pursuing one or more of the following objectives:

- contribution to the green and digital transition of the economy of the Republic of Croatia
- contribution to a sustainable industry concept and advanced technological solutions of Industry 4.0.
- introduction of new equipment and modern technologies
- higher employment and training of employees
- development of products and services of higher added value
- enhancing entrepreneurial competitiveness
- balanced regional development of the Republic of Croatia
- economic activation of inactive assets owned by the Republic of Croatia
- productivity growth of economic operators in the Republic of Croatia.

The Act on State Aid for Research and Development Projects regulates requirements for granting state aid for research and development projects in the horizontal aid category for research and development, the competences of the bodies of the Republic of Croatia with regard to granting state aid for research and development projects, the procedure for determining the fulfilment of conditions for exercising rights, record keeping and reporting as

well as other issues related to the exercise of the right to aid for research and development projects. The purpose of the Act is to increase private sector investments in research and development, increase the number of entrepreneurs investing in research and development and foster cooperation between entrepreneurs and organizations for research and dissemination of knowledge in research and development projects, whereby research and development includes creative and systematic work undertaken for the purpose of increasing knowledge - including knowledge of humanity, culture and society - and developing new applications of existing knowledge. Research and development activities must include five basic criteria: **new knowledge** (as the objective of activity), **creative** (new concepts, ideas and methods that enhance existing knowledge), **uncertain in terms of outcome**, **systematic** (planned with secured funds and by recording outcomes) and **transferable** (outcomes are transferable as new knowledge) and/or **reproducible** (outcomes can be reproduced).

The Public Procurement Act defines one of the public procurement procedures as a "partnership for innovation". The public contracting authority may use partnership for innovation if it needs innovative goods, services, or works that cannot be realized through the supply of goods, services or works already available on the market. Partnership for innovation seeks to develop innovative goods, services or works and subsequently procure them, if they are consistent with performance levels and maximum costs agreed between the public contracting authority and participants. This instrument stimulates innovations that affect demand for innovation, while grants to enterprises affect the supply of innovation.

The National Recovery and Resilience Plan enables the implementation of innovative public procurement in the Republic of Croatia (investment of NPOO C2.9. R3 ***Innovative public procurement***). This will support the implementation of the new Smart Specialization Strategy until 2029, in the area of energy and climate, priority areas smart and clean energy, smart and green transport, sustainable and circular food and customized and integrated wood products[8] and related research and development.

The Small Business Development Promotion Act regulates the basis for the implementation of small business incentives, including grants for research, development and application of innovations and introduction of modern technologies.

In addition to the law, in December 2022 the Ministry of Science and Education adopted the National Guidelines for Technology and Knowledge Transfer (hereinafter: the Guidelines). The Guidelines offer recommendations and practical advice to offices for technology transfer (OTTs) and managers in research organizations to improve technology transfer and knowledge transfer activities and results. Their application should contribute to the effective use of the results of publicly funded research through proper management of intellectual property, through increased commercialization, the development of entrepreneurial culture and related skills in public scientific organizations, and for a more successful interaction between the public and business sectors, which is also extremely important for research and development activities in areas related to energy, climate and the like.

[8] As part of S3 until 2029, the following thematic priority areas are defined: (i) personalized health care, (ii) smart and clean energy, (iii) smart and green transport (iv) security and dual purpose – awareness, prevention, response, rehabilitation (v) sustainable and circular food, (vi) customized and integrated wood products and (vii) digital products and platforms.

Efficient infrastructure is needed to carry out research and development, in addition to human resources. The Scientific and Technological Forecasting project assessed the number of researchers in the field of Energy and Sustainable Environment of the Smart Specialization Strategy 2016-2020 to 800 researchers[9].

A proposal for a Research Infrastructure Development Plan in Croatia for the period until 2028 has been prepared and a public debate on the proposal has been conducted.[10] The plan follows up on the 2016 document and provides an overview of the national research infrastructure, including participation in international research organizations and infrastructures, parameters for its monitoring and basic criteria for selecting and financing future research, infrastructure projects and membership.

The institutional framework that supports the implementation of research, development and innovation, and enables aid and incentives in this area includes the Ministry of Science and Education and the Ministry of the Economy and Sustainable Development, which propose specific legal measures and incentives and are responsible for creating policies and implementing programs, reforms and measures defined in national strategic documents such as the National Development Strategy 2030, the National Recovery and Resilience Plan 2012-2026, the Smart Specialization Strategy and the like. This includes financing from the state budget and European Union funds (e.g., European Structural and Investment Funds, Recovery and Resilience Mechanism). The Ministry of the Economy and Sustainable Development financially supports research and development in the field of climate change mitigation and adaptation through auctions within the Emissions Trading System and through the Environmental Protection and Energy Efficiency Fund.

The Croatian Science Foundation provides support to scientific, higher education and technological programs aimed at the development of science, higher education, and technological development in the Republic of Croatia with the goal of ensuring social and economic development. The Act on the Croatian Science Foundation (OG No. 57/22), adopted in 2022, creates the preconditions for strengthening the capacity of the Foundation and more clearly defining its tasks in the field of implementation, coordination, development, monitoring and evaluation of research and development projects, thus creating a strong and independent system for selecting, financing, and monitoring research and development projects.

The Agency for Mobility and EU Programmes (AMPEU) promotes and implements decentralised activities of the European Union programmes and other international programmes in the fields of education and training, youth, science, and sport; Erasmus+ and the European Solidarity Corps (ESC) and supports the implementation of the EU Framework Programme for Research and Innovation Horizon Europe.

The Croatian Agency for Small Business, Innovation, and Investment (HAMAG-BICRO) provides support to entrepreneurs during all developmental phases of business ventures - from idea

[9] Institute of Economics (2022). ANALYTICAL REPORT ON SCIENTIFIC AND TECHNICAL MAPPING. Ministry of Science and Education - Conducted scientific and technological mapping within the project Scientific and Technological Prediction (gov.hr)

[10] (https://esavjetovanje.gov.hr/Documents/List/22083)

research and development to commercialization and placement on the market. Additional support to research, development and innovation is provided by the Croatian Chamber of Economy, which established the Innovation Council for Industry, and serves as a technical secretariat for the competitiveness cluster, as well as vocational chambers, the chamber of trades and crafts and entrepreneurial support institutions and innovation centres.

iii. Key issues of cross-border significance

Key issues of cross-border significance are the integration of energy markets, major infrastructure projects near the national border and cross-border infrastructure projects, international scientific and research cooperation related to the dimensions of the Energy Union, and other activities that may affect other EU Member States.

iv. Administrative structures for the implementation of national energy and climate policies

The umbrella institution for the implementation of national energy and climate policies is the Ministry of the Economy and Sustainable Development, its Energy Directorate and Directorate for climate, sustainable development and air, soil and light pollution protection, and the Institute for the Protection of the Environment and Nature.

The preparation and management of the GHG inventory in Croatia is the responsibility of the Ministry of the Economy and Sustainable Development, the national contact point under the UN Framework Convention on Climate Change (UNFCCC). The Institute for the Protection of the Environment and Nature within the Ministry of the Economy and Sustainable Development is responsible for organizing the preparation of the greenhouse gas inventory, collecting activity data, developing a quality assurance and quality control plan (QA/QC plan), implementing inventory quality assurance procedures, archiving data, keeping records and reporting on authorized legal entities participating in the flexible mechanisms of the Kyoto Protocol, selecting the authorized persons to prepare the inventory of greenhouse gases and ensuring access to data and documents for the purpose of technical inspections of the inventory. In addition, the Institute for the Protection of the Environment and Nature plays an important role in the administration of user accounts of Croatian participants in the EU Emissions Trading System (EU ETS).

The National Coordination Body for Energy Efficiency also operates within the MESD as a special organizational unit. It coordinates many stakeholders involved in defining, and more importantly, implementing the energy efficiency policy in Croatia, systematically monitors the implementation through the system of monitoring, measurement, and verification of energy savings, and prepares reports and informs the general public about plans, implemented measures and their effects.

In addition to the MESD, the Ministry of Physical Planning, Construction and State Assets also has an important role in the implementation of national energy and climate policies and is responsible for creating policies and measures to achieve the set energy savings targets in buildings. The Ministry of Physical Planning, Construction and State Assets prepares laws and regulations, strategies, and programmes in connection to long-term integral renovation of buildings: family houses, apartment buildings, commercial non-residential buildings, and

public sector buildings. The Ministry also performs activities as a Level 1 Intermediate Body for the use of ESI funds within the OPCC.

The Ministry of the Sea, Transport and Infrastructure is responsible for national policy, action plans and strategies related to the development of infrastructure to encourage the use of alternative fuels in transport and other measures to improve energy efficiency in transport.

At the implementation level, the Environmental Protection and Energy Efficiency Fund (EPEEF) plays an important role. The EPEEF is responsible for co-financing of measures defined in the national energy and climate plans, and acts as an intermediate body level 2 for the use of ESI funds under the Programme Competitiveness and Cohesion 2021 - 2027, in parts relevant to energy and climate. The EPEEF also allocates the funds collected from emissions through auctions in the EU market according to the Plan for the use of funds acquired from the sale of emission allowances through auctions in the Republic of Croatia. The EPEEF also manages the funds paid by energy suppliers in the event of failure to fulfil their obligations under Article 13 of the Energy Efficiency Act and is obliged to invest them in alternative measures.

In the area of energy efficiency, the Agency for Transactions and Brokerage in Real Property has an important role in the implementation of the energy renovation programme for public sector building on the energy service model and systematic energy management in the public-sector, all-in accordance with the powers defined by the Energy Efficiency Act (OG Nos. 127/14, 116/18, 25/20, 32/21, 41/21).

The Croatian Energy Regulatory Agency (CERA) regulates energy activities and is responsible for the improvement and implementation of by-laws, issuing licenses, setting, and changing tariffs, certifying the eligible producer status, etc.

The Hydrocarbon Agency provides operational support to competent bodies in activities of hydrocarbon exploration and exploitation, geothermal waters for energy purposes, underground storage of natural gas, as well as in permanent disposal of gases in geological structures and activities for ensuring compulsory stocks of oil and petroleum products.

The Croatian Energy Market Operator (CEMO) performs the public service of organizing the electricity and gas market and analysing and proposing measures for its improvement. It also performs tasks related to the system of incentives for electricity production from renewable energy sources and cogeneration, which involves collecting compensation from suppliers and calculating and allocating funds based on concluded contracts with eligible producers entitled to an incentive price.

The transmission/distribution system operators (CTSO/HEP-DSO) are responsible for transmission and distribution of electricity within the grid, the gas transmission network operator is PLINACRO d.o.o., whereas the oil storage system operator (JANAF) has the role of transport and storage of oil and petroleum products.

It should also be noted that energy suppliers are the stakeholders that will play a key role in achieving the targets of energy efficiency policy. Since 2019, suppliers have been required to achieve energy savings by investing in and stimulating energy efficiency improvements by end customers or by payments to the EPEEF.

1.3 Consultation and participation of national and EU entities and the outcome of consultation

i. Participation of the national parliament

In October 2019, a workshop organized by the Committee on European Affairs and the European Forum for Renewable Energy Sources (EUFORES) was held in the Croatian Parliament under the title: "The Clean Energy Package and the National Energy and Climate Plans - Outlook for Renewable Energies in Croatia" during which the Draft of the National Integrated Energy and Climate Plan was presented and discussed.

ii. Participation of local and regional bodies

Local and regional bodies participated in the preparation of the Draft of the National Integrated Energy and Climate Plan, but also in the preparation of all key strategic documents that served as the basis for the plan.

The local and regional bodies participated in consultative workshops organized within the framework of preparation of the Draft of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050, and via e-consultations at events organized within the public presentation of the Green Paper and the White Paper, and via e-consultations in the process of preparation of the Energy Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050.

Local and regional bodies also participated in a preliminary e-consultation in the process of preparation of the Draft of the National Integrated Energy and Climate Plan held in November and December 2018. The second round of workshops was organized upon the completion of all sections of the Draft in July 2019, as part of thematic cross-sectoral workshops open to all stakeholders. In October 2019, a meeting was organized with representatives of regional energy agencies, at which the Draft was presented and finalized, and then submitted for e-consultation. The e-consultation process is open to all stakeholders, including representatives of local and regional bodies.

In May 2023, a workshop was held for local and regional self-government units, which presented the draft of the revised Plan and discussed measures relevant to local and regional self-government units.

iii. Consultations with stakeholders, including social partners, and inclusion of civil society and the general public

During 2018 and 2019, the stakeholders, including social partners, civil society and the general public, actively participated in a series of consultative workshops organized within the framework of preparation of the Draft of the National Integrated Energy and Climate Plan, preparation of the Draft of the Low-Carbon Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050, at events organized within the public presentation of the Green Paper and the White Paper, which will serve as a basis for the preparation of the Energy Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050, and via e-consultations in the procedure of preparation of the draft and final version of the National

Integrated Energy and Climate Plan and the Energy Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050.

In particular, the stakeholders were actively involved in the workshops related to the preparation of the draft and completion of the final version of the National Integrated Energy and Climate Plan. The first round of workshops related to the preparation of the draft was organized in November 2018. The second round of workshops related to the preparation of the final version of the plan was organized in July 2019 (within thematic cross-sectoral workshops).

The first draft of the National Integrated Energy and Climate Plan was submitted for e-consultation during December 2018, when 90 comments were received. The revised draft of the plan was submitted for e-consultation in October 2019.

As part of the LIFE funded NECP Platform project, a multilevel climate and energy dialogue platform has been established. The platform brings together representatives of key stakeholders for the development of the Integrated Plan and includes relevant ministries, local and regional self-government, energy companies, research and academia sector, professional associations, and civil society organisations. The initial meeting of the platform, which was attended by 40 stakeholders, was held within the framework of the update of the Plan.

Also, in the period from March to June 2023, thematic workshops were held related to the update of the Integrated Plan (energy efficiency, renewable energy sources and transport, energy market and energy security, agriculture, LULUCF and waste and research, innovation, and competitiveness). More than 100 stakeholders from all relevant sectors participated in the workshops.

iv. Consultations with other member states

Consultation with other Member States took place at two levels:

- indirect presentation of the draft and final version of the plan;
- direct presentation of the draft and final version of the integrated energy and climate plan.

The text of the Draft of the National Integrated Energy and Climate Plan was translated into English, submitted to the European Commission, and published on the website of the MESD at the same time as the Croatian version of the Draft was submitted and was thus made available to all Member States, allowing indirect consultation with Member States.

There were also activities related to the direct presentation of the draft and the final version of the plan. The process of preparing the Draft of the Integrated Energy and Climate Plan was presented to representatives of the Energy Union member states at the meeting of the Technical Working Group on Energy and Climate held on 9th October 2018. The Republic of Croatia is one of the EU Member States that has expressed interest in participating in the work of the Energy Union bodies and is available to transfer its experiences in developing the Plan to the Member States of the Energy Union.

Also, Croatian representatives participated in a regional workshop held in Ljubljana in July 2019. This workshop was organized by the Ministry of Infrastructure of the Republic of

Slovenia, and was attended by representatives from Slovenia, Austria, Italy, Hungary, and Croatia. The aim of the workshop was to identify possible areas for cross-border and regional cooperation. Learn more about the results of regional cooperation in Chapter **"Regional cooperation on preparation of the plan 1.4"**.

v. Iterative procedure with the European Commission

Representatives of the MESD participated in the work and meetings of the Technical Working Group on National Energy and Climate Plans of the European Commission.

The first draft of the National Integrated Energy and Climate Plan was submitted to the European Commission at the end of December 2018.

After the draft was submitted to the European Commission, the text was further edited and amended in parts related to the evaluation of impact of measures and for the dimension of research, innovation, and competitiveness, which were underrepresented in the Draft.

During 2019, several bilateral meetings were held with the European Commission, which submitted its comments and recommendations on the draft of the national integrated energy and climate plan at the end of June 2019[11].

Recommendations and comments were largely adopted in the final text of the plan, and the Ministry of the Environment and Energy submitted to the European Commission replies to all the comments received.

The draft of the updated Plan was submitted to the European Commission within the deadline provided for in Regulation (EU) 2018/1999.

1.4 Regional cooperation on preparation of the plan

i. Elements that are subject to joint or coordinated planning with other member states

Elements of cross-border significance are:

- integration of energy markets,
- major infrastructure projects near the national border and cross-border infrastructure projects,
- international scientific and research cooperation related to the dimensions of the Energy Union, and
- other activities that may affect other EU Member States.

Key activities requiring coordinated planning with the neighbouring Member States were identified at a regional workshop held in Ljubljana in July 2019, organized by the Ministry of Infrastructure of the Republic of Slovenia. At that workshop, the Member States identified the

[11] https://ec.europa.eu/energy/sites/ener/files/documents/hr_rec_en.pdf

need and opportunity for further regional cooperation on topics covered by the Integrated Energy and Climate Plan and the Energy Union. Representatives of the competent ministries of Slovenia, Italy, Austria, Hungary, and Croatia participated in the workshop.

Some of the topics subject to joint or coordinated planning with other Member States are already being addressed at EU level. This primarily includes the integration of the energy market and the implementation of major infrastructure projects of common interest (PCI) funded by the Connecting Europe Facility (CEF).

On the other hand, scientific and research cooperation is a much broader topic, and further cooperation is needed here, mainly at the user level. The Horizon 2020 Framework Programme is of particular importance in this context and will continue as the Horizon Europe Framework Programme during the period covered by the plan.

Apart from the above, cooperation is also important in the implementation of projects and exchange of experiences, which needs special attention. Joint projects are of particular importance and, given the relatively low potential for individual Member States, will have a better implementation potential if the needs of several countries are combined (e.g., energy renovation of public or cultural property, etc.).

However, all these topics must serve to strengthen joint activities in the future, which should be primarily promoted through regional workshops that would present examples of good practice and serve as meeting points for professionals, institutions and companies that could conclude and implement future joint projects on topics covered by the integrated energy and climate plan and areas of the Energy Union.

ii. Explanation as to how regional cooperation is being considered within the plan

To establish regional cooperation on finalization and subsequent implementation of the plan, the first regional workshop organized by the Ministry of Infrastructure of the Republic of Slovenia was held in Ljubljana in July 2019. The workshop served as a basis for developing cooperation between Member States on the topics covered by the integrated energy and climate plan.

Regional cooperation is considered in the plan in two key segments:

- past cooperation;
- potential future cooperation.

The past cooperation was presented at the workshop in Ljubljana, where it was emphasized that the Republic of Croatia has a particularly good cooperation with the Republic of Slovenia and Hungary, in terms of establishment of the energy infrastructure, security of supply and integration of energy markets.

Potential future cooperation was also discussed at the regional workshop. It is primarily aimed at continuing the integration of energy markets and further strengthening of the cooperation between transmission system operators. It is particularly important to emphasize the need to collaborate in new and still underexplored areas and to encourage joint scientific and research work. In this context, the Republic of Croatia singled out issues such as hydrogen, battery development, and CO_2 capture and storage as particularly important, with the willingness to

extend cooperation to other areas in the future. The establishment of regional cooperation within the framework of the initiative "Clean Energy for the EU Islands", primarily with the Republic of Italy and other Mediterranean EU Member States, is also expected.

Also, upon completion of the National Integrated Energy and Climate Plan, the Republic of Croatia will make available to all EU Member States the text of the plan in Croatian and English and will be available for consultations on the contents of the document. This will further foster regional cooperation with already identified Member States and other interested Member States.

2 NATIONAL TARGETS

2.1 Dimension: decarbonization

2.1.1 Emissions and elimination of greenhouse gases

i. Elements referred to in Article 4, item (a), subitem 1

Croatia joins the EU in its efforts to contribute to other international goals, in particular the UN Sustainable Development Agenda, which defines 17 Sustainable Development Goals and the new Urban Agenda for the EU.

The European Union ratified the Paris Agreement and committed itself to reducing greenhouse gas emissions by at least 40% by 2030 compared to 1990 emissions. Croatia ratified the Paris Agreement in May 2017 (OG-IT 3/2017) and shares the common EU goal. This common EU objective is divided into two units, of which the first includes large sources of greenhouse gas emissions that are obligated parties of the European Emissions Trading System (ETS sector), and the second for non-ETS sectors, including other relatively smaller emission sources, such as: road and off-road transport (excluding air transport included in the ETS sector), small energy and industrial facilities not included in the ETS sector, households, services, agriculture, waste management, changes in land use and forestry.

The Republic of Croatia has set the following targets for reducing greenhouse gas emissions by 2030:

- In the ETS sector: at least 43% compared to 2005; with an annual reduction of the total EU quota of 2.2% for the period from 2021 to 2030 as defined by Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814 (Text with EEA relevance.) (OJ L 76, 19th Mar 2018) (the target for Croatia is indicative, and binding on the level of the EU ETS).
- For the non-ETS sectors, a common target of at least 30% reduction in emissions by 2030 compared to 2005 (Regulation (EU) 2018/842) has been set, and the commitments ranged from -40 to 0% for different EU Member States (-7% for Croatia).
- In accordance with Article 8, paragraph 3 of Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (Text with EEA relevance), PE/68/2017/REV/1 (OJ L 156, 19th Jun 2018) (LULUCF Regulation), the Republic of Croatia, like all other Member States of the European Union, had an obligation to develop the National Forestry Accounting Plan (NFAP) for the period from 2021 to 2025, which was submitted to the European Commission on 31st December 2018. The mentioned plan also proposes the Forest Reference Level (FRL) for the Republic of Croatia. In June 2019, the EC assessed the

said plans and made technical recommendations to Member States, including the Republic of Croatia.

In December 2019, the European Green Deal was announced, which is an initiative in the field of policies to ensure the EU's green transition with the goal of achieving climate neutrality by 2050. With the adoption of the European Climate Law in mid-2021, achieving climate neutrality by 2050 has become a legal obligation for the EU and its member states, which have thus committed to reducing net greenhouse gas emissions in the EU by at least 55% until 2030 compared to 1990 levels.

The 'Fit for 55% by 2030' legislative package (July 2021) transposes the Green Deal's political ambitions into European legislation through proposals to revise climate, energy and transport legislation and new legislative initiatives to bring EU regulations in line with its climate objectives. The legislative package includes the revision of the EU Emissions Trading System, the Carbon Border Adjustment Mechanism (CBAM), the revision of the regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry (LULUCF), standard values of CO_2 emissions for cars and vans, reduction of methane emissions in the energy sector, sustainable aviation fuels, greener marine fuels, alternative fuels infrastructure, the Social Climate Fund, renewable energy, energy efficiency, energy performance of buildings and energy taxation.

EU-ETS REFORM

Following the negotiations in December 2022, an agreement (EU institutions, member states) was reached on the reform of the existing ETS and the introduction of a new ETS system (ETS II) for road transport and buildings. On 18th April 2023 the Parliament adopted the reform of the EU's emissions trading system, including for aviation and maritime affairs, the new Carbon Border Adjustment Mechanism (CBAM) and established the Social Climate Fund.

Key elements of the ETS reform:

- The new 2030 ETS target: 62% (previously -43%) compared to 2005.
- New linear reduction factor: 4.3 percent from 2024 to 2027 and 4.4 percent from 2028 to 2030.
- Integration of maritime transport emissions into the EU ETS.
- The review of the ETS for aviation will phase out free quotas for the aviation sector by 2026 and promote the use of sustainable aviation fuels.
- The new ETS II for road transport and buildings will determine the price of greenhouse gas emissions from these sectors in 2027 (or 2028 if energy prices are extremely high).
- Emissions from waste incineration should be monitored from 2024 and included in the ETS from 2028 (Member States can push this through to 2030).
- Changing the rules on free allocations, i.e., phasing out free emissions to companies by 2034
- Rules for a new EU Carbon Border Adjustment Mechanism (CBAM), which aims to encourage non-EU countries to increase their climate ambitions and ensure that the EU and global climate efforts are not undermined by the relocation of the EU's

production to countries with less ambitious policies. CBAM covers materials such as iron, steel, cement, aluminium, fertilizers, electricity, hydrogen as well as indirect emissions under certain conditions. Importers would have to pay any price difference between the price of carbon paid in the country of production and the price of carbon emission allowances in the EU ETS. CBAM will be gradually introduced from 2026 to 2034 at the same rate as the phasing out of free emission allowances in the EU ETS

- Market Stability Reserve Reform: 24% of all ETS allowances will continue to be placed in the market stability reserve to address possible imbalances between supply and demand of allowances in the market
- Increasing the Innovation Fund and the Modernisation Fund
- Establishment of the European Social Climate Fund (SCF) to ensure that the climate transition is fair and socially inclusive. This will benefit beneficiaries who are particularly affected by energy and transport poverty.

The adoption of texts by the Council and publication in the Official Journal and entry into force are expected.

NON-ETS EMISSIONS

As regards the revision of the legislative framework on non-ETS greenhouse gas emissions, regulations have been adopted that will allow the EU to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. Regulation (EU) 2023/857 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/842 on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement, and Regulation (EU) 2018/1999 (ESR) sets stronger emission reduction targets for Member States to be achieved by 2030. Regulation (EU) 2023/839 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/841 as regards the scope, simplifying the reporting and compliance rules, and setting out the targets of the Member States for 2030, and Regulation (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review has strengthen the sector's contribution to the EU's overall 2030 climate ambitions. The regulations will enter into force upon signature and publication in the Official Journal.

The Effort Sharing Regulation (ESR) covers greenhouse gas emissions included in the EU target that are not covered by either the EU ETS or the LULUCF regulation. It includes CO_2 emissions and a significant proportion of non-CO_2 emissions. The revised ESR increases the 2030 greenhouse gas emission reduction target from 30% to 40% compared to 2005 levels. For the first time, all Member States must reduce these emissions by between 10% and 50%. The targets for each Member State by 2030 are based on GDP per capita and cost-effectiveness (16.7% for the Republic of Croatia, earlier 7%). Member States will also not be allowed to exceed their annual emission quota. The revised ESR strikes a balance between the need for Member States to be flexible in achieving their targets, while ensuring a just and socially equitable transition and the need to close legal loopholes and thus achieve the EU-wide emission reduction target. There are therefore limits on the number of allowances that Member States can keep from previous years, borrow in the coming years and trade with other Member States.

Land use, land-use change, and forestry (LULUCF) is one of the most important sectors in terms of contributing to meeting the EU's greenhouse gas emission reduction target. The revised LULUCF Regulation sets an overall EU level target of 310 million tonnes of CO_2 equivalent net removals in the LULUCF sector in 2030 (previously 225 million tonnes of CO_2e). In the period 2026-2030, each Member State will have a binding national 2030 target for increasing net greenhouse gas removals (for the Republic of Croatia: -593 $ktCO_2$), and all these targets together will lead to the achievement of a common EU target of 310 million tonnes of CO_2. In addition, each Member State undertakes to achieve the sum of net emissions and removals of greenhouse gases for the period 2026-2029 ('the 2026-2029 commitment'). The Regulation offers Member States flexible options that can help them achieve these objectives.

ii. Where applicable, other national targets consistent with the Paris Agreement and existing long-term strategies; where applicable, to contribute to the Union's long-term commitment to reducing greenhouse gas emissions, other goals, including sectoral and adaptation targets, if available

National targets for climate change adaptation

Adaptation measures that contribute to the decarbonisation dimension are elaborated in the Climate Change Adaptation Strategy in the Republic of Croatia for the period until 2040 with an outlook to 2070 with an action plan (OG No. 46/2020) [4].

The vision of the Climate Change Adaptation Strategy is "Republic of Croatia resilient to climate change", based on which the following goals have been set:

- to reduce the vulnerability of natural systems and society to the negative impacts of climate change,
- to increase the ability to recover from the effects of climate change,
- to exploit the potential positive effects that may also be due to climate change.

Increasing the resilience of vulnerable systems and reducing damage from natural disasters will also contribute to the long-term sustainable development of the Republic of Croatia.

When it comes to the environmental and climate ambition of the Common Agricultural Policy, it is important to highlight the contribution already made by the agricultural sector and the positive solutions implemented at the national and EU level, such as the introduction of good agricultural practices, improving agrotechnology, stimulating innovation in the sector, increasing the level of cooperation between scientific and research institutions, legislators, and manufacturers.

Climate change impacts on security of energy supply and adaptation measures are outlined in Chapters 2.3 and 3.3, which address the national targets for the energy security dimension and the measures needed to achieve them.

The National Development Strategy of the Republic of Croatia until 2030 (OG No. 13/2021) recognizes as a strategic goal the environmental and energy transition for climate neutrality (goal 8), which will be achieved through the reduction of emissions in the economy, transport and building construction as well. **The Low-Carbon Development Strategy of the Republic of Croatia until 2030 with an outlook to 2050 (OG No. 63/2021) focuses on** reducing greenhouse

gas emissions and preventing an increase in the concentration of greenhouse gases in the atmosphere and consequently limiting the global temperature increase. In accordance with the Strategy, the greenhouse gas emission reduction targets for 2030 and 2050 will be implemented in the Republic of Croatia within the political framework adopted by the European Union. The strategy applies to all sectors of the economy and human activity, and is particularly related to energy, industry, transport, agriculture, forestry, and waste management. The objectives of the Strategy are: achieving sustainable development based on knowledge and a competitive low-carbon economy and efficient use of resources, increasing security of energy supply, sustainability of energy supply, increasing energy availability and reducing energy dependence, solidarity by fulfilling the obligations of the Republic of Croatia under international treaties, within the framework of EU policy, as part of our historical responsibility and contribution to global goals and reducing air pollution and impact on health and quality of life of citizens.

About a hundred measures have been selected that can be applied to reduce emissions (technical and non-technical), in various sectors: electricity and heat production, fuel production and processing, transport, general consumption (households and services), industry, agriculture, land use, land use change and forestry, waste, product use and fugitive emissions.

2.1.2 Renewable energy

i. Elements referred to in Article 4, item (a), subitem 2

The indicative targets by 2030 are shown in the table below.

Table 2-1. Indicative national targets for RES shares until 2030

RES share, %	Achieved 2021	Targets 2030
In the gross final consumption of energy	31,7	42,5
In the final consumption of electricity	53,5	73,6
In the final consumption of energy for heating and cooling	38,0	47,1
In the final consumption of energy in transport	7,1	21,6

The figure below shows the trajectory of RES shares in the gross final consumption.

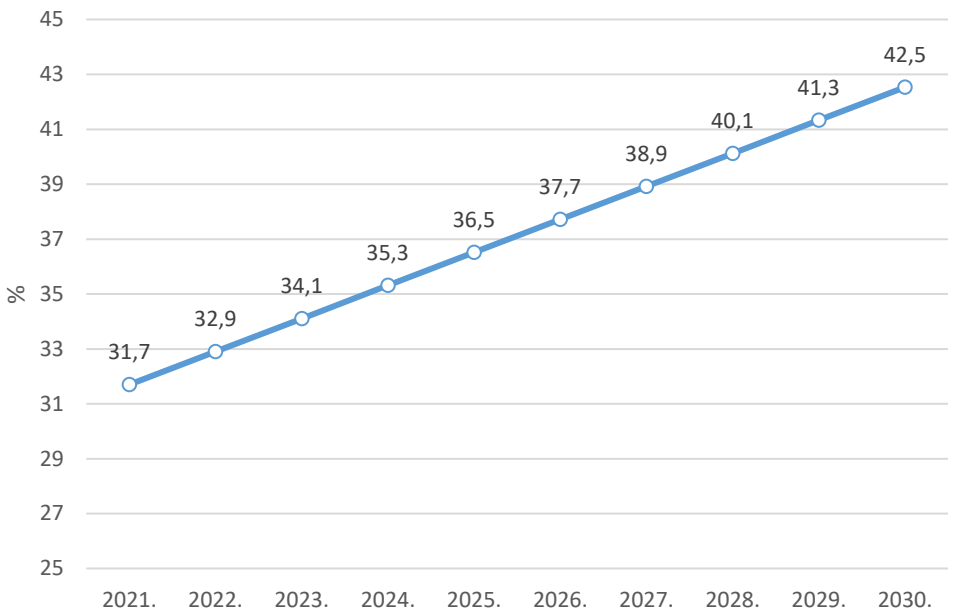


Figure 2-1. Indicative trajectory of RES shares in the gross final consumption of energy

ii. Estimated trajectories for the sectoral share of renewable energy in final energy consumption from 2021 to 2030 in the power, heating and cooling and transport sectors

The figures below show indicative RES shares in electricity (Figure 2-2), heating and cooling (Figure 2-3) and transport (Figure 2-4).

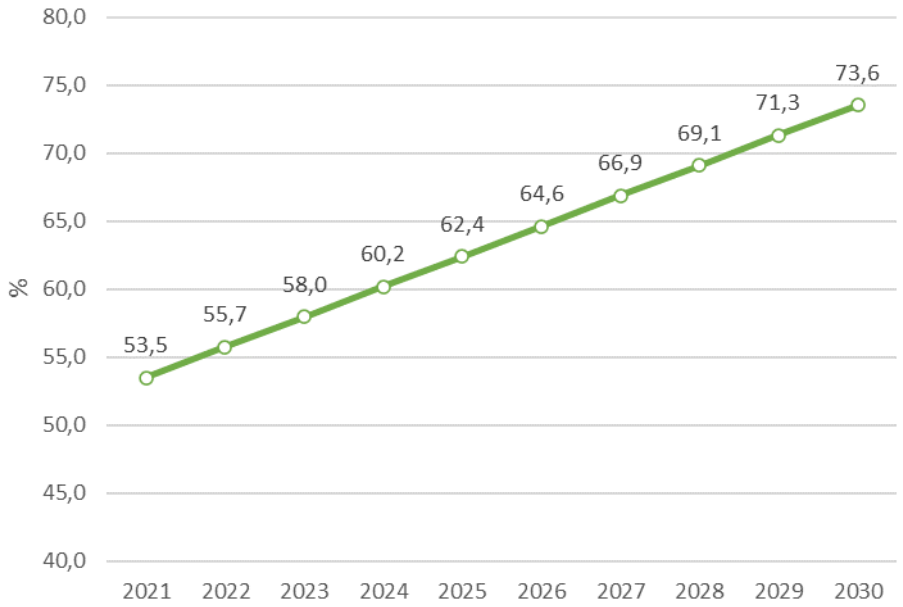


Figure 2-2 Indicative trajectories of RES share in electricity

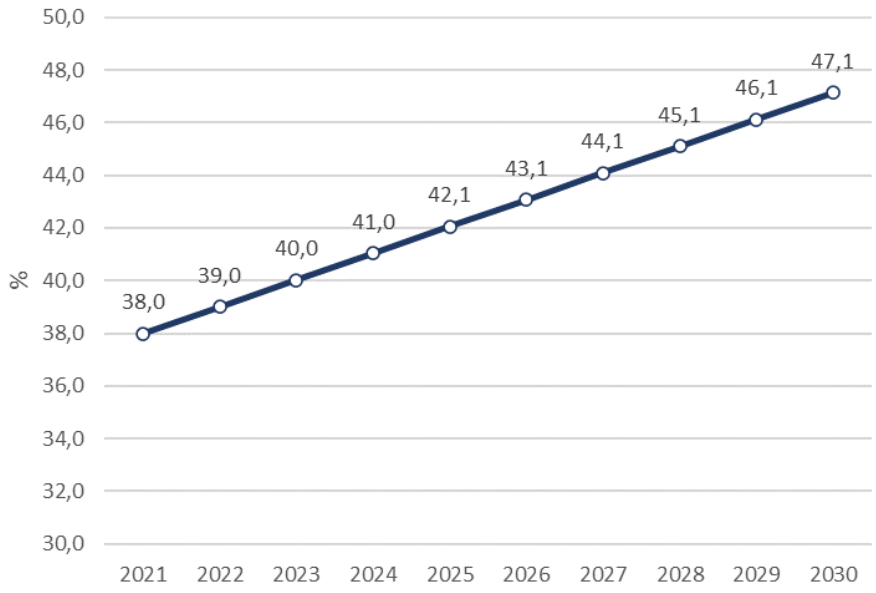


Figure 2-3. Indicative trajectories of RES share in heating and cooling

The efforts of the Republic of Croatia will be directed towards achieving the target regarding the RES share in heating and cooling, and the contributions of certain technologies can be expected to be higher or lower than estimated.

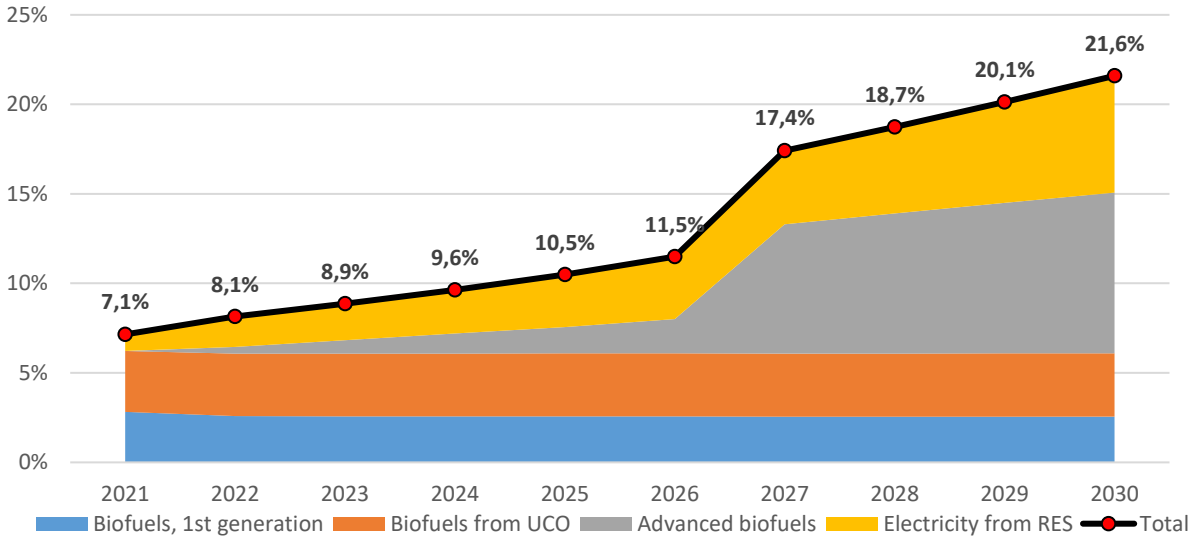


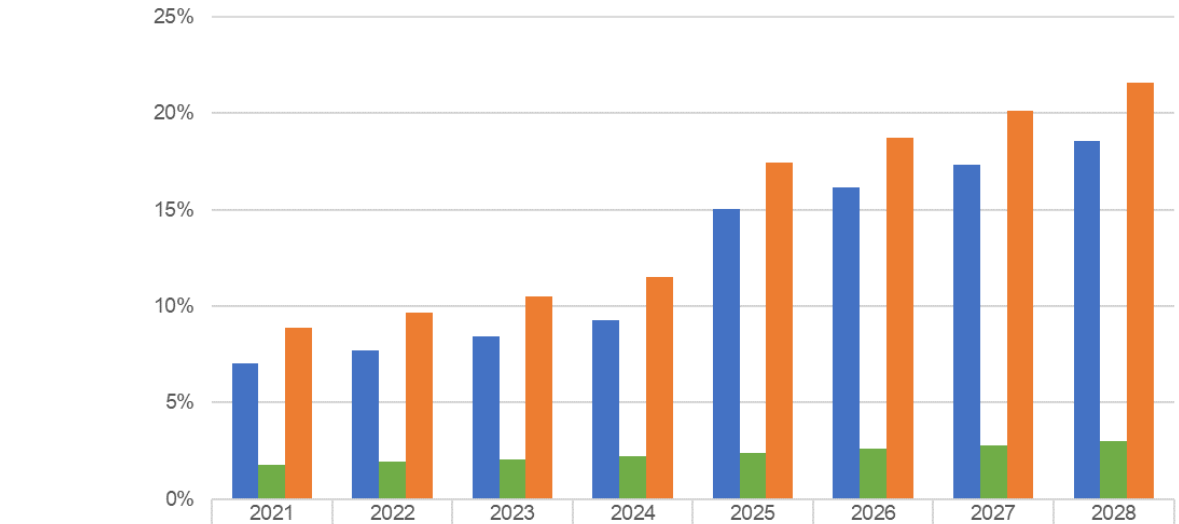
Figure 2-4. Indicative trajectories of RES share in transport

Regarding RES share in transport, the figure shows shares of electricity from RES, biofuels and advanced biofuels and biogas produced from the feedstocks listed in Annex IX, Part A of Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance.) (OJ L 328, 21st Dec 2018). It should be noted that the estimated contributions are the result of a simulation model and that deviations from the calculated values may be expected in the implementation. The efforts of the Republic of Croatia will be directed

towards achieving the goal regarding the share of RES in final consumption in transport, and the contributions of individual technologies can be expected to be higher or lower than presented here.

In order to meet the minimum National target for renewable energy in transport, the share of the obligation of the obliged entity to place renewable energy sources on the market in transport (share of obliged entities) is prescribed, i.e. the share that the distributors which place diesel fuel or motor gasoline for the propulsion of motor vehicles on the market are obliged to place on the market as part of the national target for renewable energy in transport, which, under a special law governing excise duties, is considered an excise duty obliged entity. The mandatory share of obliged entities in meeting the national target is expressed as a percentage for each planning year of implementation of the Plan. The national target and the mandatory share of obliged entities in meeting the target are shown in the figure below for each planning year in the period from 2023 to 2030.

In addition to the obligation to place biofuels on the market, users of fuels in public transport and the public sector also contribute to the fulfilment of the national target by purchasing, renting, or leasing a certain number of vehicles using biofuels, electric propulsion, or hydrogen from renewable energy sources. Also, users of electricity in railway and public road transport are obliged to procure for transport purposes only the electricity produced from plants using a renewable energy source, which is listed in the origin guarantee system.



	2021	2022	2023	2024	2025	2026	2027	2028
Share of the obligee	7,1%	7,7%	8,4%	9,2%	15,0%	16,1%	17,3%	18,6%
Public sector share	1,8%	1,9%	2,1%	2,2%	2,4%	2,6%	2,8%	3,0%
National target	8,9%	9,6%	10,5%	11,5%	17,4%	18,7%	20,1%	21,6%

Figure 2-5 National target for renewable energy in transport and share of obligees from 2023 to 2030

iii. Estimated trajectories of renewable energy technologies planned to be used by Member States to achieve total and sectoral trajectories of renewable energy from 2021 to 2030, including expected final gross energy consumption by technology and sector expressed in Mtoe and total planned installed capacity

Estimated contributions of renewable energy technologies are shown in Figure 2-6. and Tables 2-2 to 2-5.

Table 2-2. Estimated contribution of RES technologies to gross final consumption

ktoe	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gross final RES consumption	2304,5	2373,5	2442,6	2511,6	2580,7	2654,0	2727,4	2800,8	2874,2	2965,0
Solar energy	17,1	19,4	21,8	24,1	26,5	28,8	31,2	33,6	35,9	38,3
Solid biomass	1154,4	1127,9	1101,4	1074,9	1048,4	1021,9	995,4	968,9	942,4	915,8
Gaseous biofuels	0,5	2,3	4,1	5,9	7,7	9,5	11,3	13,1	15,0	16,8
Liquid biofuels	91,2	102,1	113,0	123,9	134,8	145,7	156,6	167,5	178,4	189,3
Geothermal energy	5,0	7,0	9,1	11,1	13,2	15,2	17,3	19,3	21,4	23,5
Thermal energy from RES	108,7	136,1	163,6	191,1	218,6	246,1	273,5	301,0	328,5	356,0
Electricity from RES	927,8	978,7	1029,6	1080,6	1131,5	1182,5	1233,4	1284,4	1335,3	1386,3
Hydrogen RES	0	0	0	0	0	4,4	8,7	13,1	17,4	39,2

Table 2-3. Estimated contribution of RES technologies in electricity

ktoe	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gross final RES electricity	927,7	978,7	1.029,6	1.080,6	1.131,5	1.182,5	1.233,4	1.284,4	1.335,3	1.386,3
Hydro	571,4	570,2	569,0	567,8	566,6	565,4	564,2	563,0	561,8	560,6
Wind	177,3	216,4	255,5	294,6	333,7	372,8	411,9	451,0	490,1	529,2
Solar PV	12,8	21,0	29,2	37,5	45,7	53,9	62,1	70,4	78,6	86,8
Geothermal energy	45,0	46,3	47,6	48,9	50,2	51,5	52,8	54,1	55,4	56,7
Thermal - solid and gaseous biofuels	121,2	124,7	128,2	131,8	135,3	138,8	142,3	145,8	149,3	152,9

Table 2-4. Estimated contribution of RES technologies in heating and cooling

ktoe	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gross final RES for heating and cooling	1.285,1	1.292,9	1.300,7	1.308,5	1.316,3	1.324,1	1.337,8	1.351,5	1.365,2	1.408,3
Solar energy	17,1	19,4	21,8	24,1	26,5	28,8	31,2	33,6	35,9	38,3
Solid biomass	1.154,4	1.127,9	1.101,4	1.074,9	1.048,4	1.021,9	995,4	968,9	942,4	915,8
Gaseous and Liquid biofuels	0,0	2,4	4,8	7,2	9,7	12,1	14,5	16,9	19,3	21,7
Geothermal energy	5,0	7,0	9,1	11,1	13,2	15,2	17,3	19,3	21,4	23,5
RES Heat	108,7	136,1	163,6	191,1	218,6	246,1	273,5	301,0	328,5	356,0
Hydrogen	0	0	0	0	0	0	5,9	11,8	17,7	53,1

Table 2-5. Estimated contribution of RES technologies in transport

ktoe	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gross final RES in transport	103,4	111,1	112,7	114,6	116,6	118,9	121,2	123,8	126,5	129,3
Biofuels, 1st generation	55,7	51,9	52,2	52,6	52,8	53,1	53,3	53,4	53,5	53,6
Biofuels from UCO	35,5	36,1	36,1	36,0	36,0	35,8	35,7	35,6	35,4	35,2
Advanced biofuels	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Electricity from RES	12,2	23,0	24,4	25,9	27,7	29,8	32,2	34,7	37,5	40,4

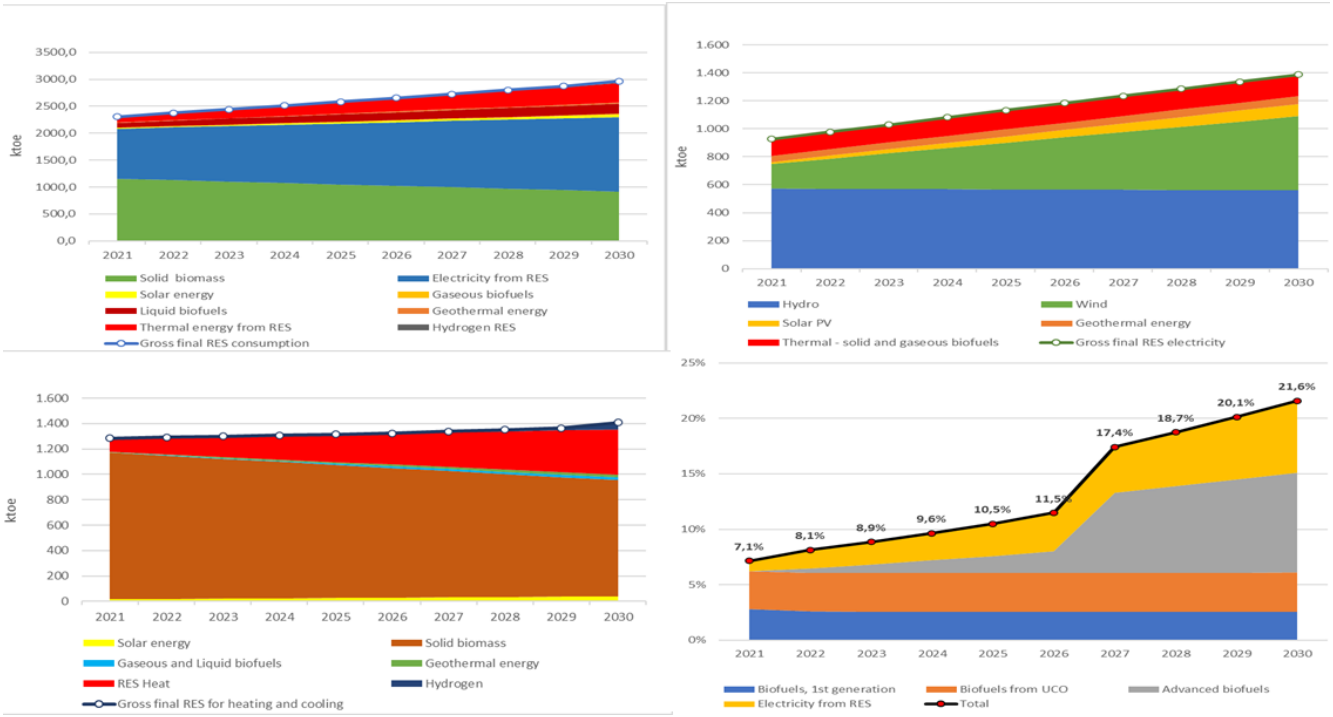


Figure 2-6. Estimated contribution of RES technologies by sector

The expected capacity structure for electricity production is shown in Table 2-6. and is also shown in Figure 2-7 (capacities are indicative - deviations between individual RES technologies are expected).

Table 2-6. Estimated powerplant capacities in the scenario with additional (WAM) measures (MW)

Year	Nuclear	Hydro	Gas	Fuel Oil	Coal	Biomass	Biogas	Geothermal	Wind	Integrated solar	Non-integrated solar	Total
2021	348	2.201	840	344	210	95	59	10	987	83	55	**5.232**
2030	348	2.393	1.079	0	210	145	59	68	2.562	576	384	**7.824**
2040	348	3.814	1.212	0	0	245	59	168	4.384	960	640	**11.830**
2050	0	3.882	2.231	0	0	245	59	238	8.519	1.913	1.275	**18.362**

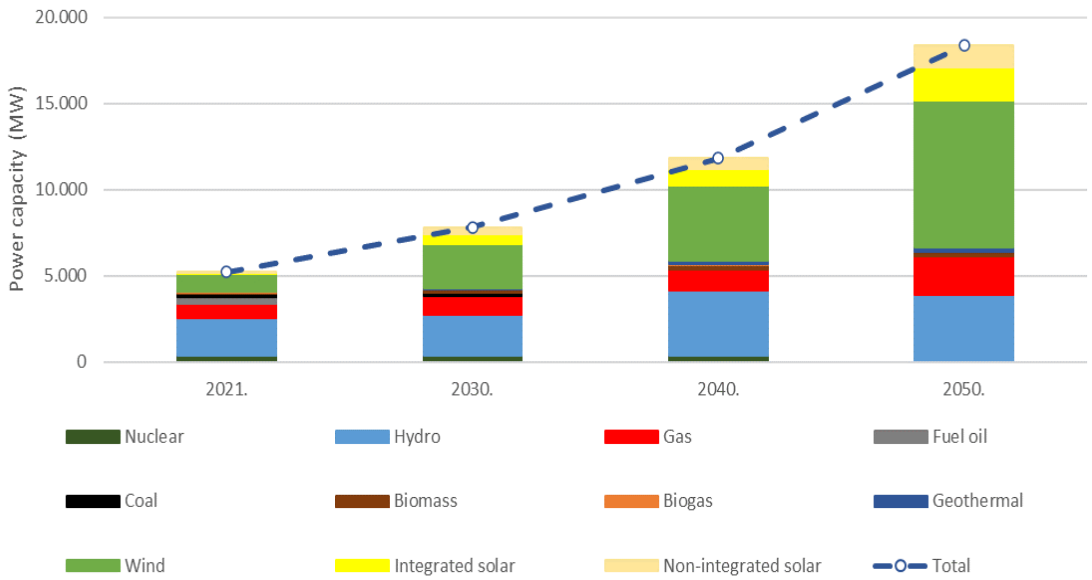


Figure 2-7. Estimated power plant capacities in the scenario with the additional (WAM) measures

In Croatia, about 1% of electricity consumption is currently covered by solar power plants, which is about 200 MW of installed power. Of the total installed and expected capacity of solar power plants for the period from 2030 to 2050, about 60% are installed solar power plants on roofs (self-supply), while about 40% are non-integrated solar power plants.

According to the Regulation on quotas for encouraging the production of electricity from renewable energy sources and high-efficiency cogeneration (Official Gazette, no. 57/2020), quotas have been established for encouraging the production of electricity from solar power plants depending on the installed power (from 50 kW to 500 kW inclusive, greater than 500 kW up to and including 10 MW and solar power plants with an installed capacity of more than 10 MW). The total quota for all three groups of solar power plants is 1,075 MW. According to the New Council Regulation (EU) 2022/2577 of December 22, 2022 on establishing a framework for accelerating the introduction of energy from renewable sources[12], ST/14787/2022/INIT, OJ L 335, 29/12/2022, it is proposed to accelerate the introduction of renewable energy sources with an emphasis on the development, installation and speeding up of the licensing procedures for small integrated solar power projects up to 50 kW for households and businesses facing high prices energy, in order to become consumers of their own energy from renewable sources. The total capacity of hydropower plants in Croatia is approximately 2,200 MW. Of these, 9 are accumulation power plants with a total capacity of 1,485 MW, 7 are run-of-the-river hydropower plants with a total capacity of 406 MW, 36 are small hydropower plants with a total capacity of 34 MW and one is a pumped-storage hydropower plant with a capacity of 276 MW in turbine operation and 240 MW in generator operation. One aggregate at HPP Dubrovnik (126 MW) is directly connected to the transmission grid of the BiH electricity system.

[12] Council Regulation (EU) 2022/2577 of 22 December 2022 establishing a framework for accelerating the introduction of energy from renewable sources, https://eur-lex.europa.eu/legal-content/HR/TXT/?uri=CELEX:32022R2577

By 2030, the construction of two to three large hydropower plants, several small hydropower plants (on watercourses and water supply systems) and one pumped-storage hydropower plant is expected. Revitalization of existing plants is expected to extend their life cycle with a slight increase in the power of hydropower plants.

The agreement between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on the regulation of status and other legal relations related to the investment, exploitation and decommissioning of the Krško Nuclear Power Plant and the Social Contract, which entered into force in 2003, regulate mutual relations, rights and obligations on the basis of equal ownership shares of company members: GEN energija, and Hrvatska elektroprivreda. According to the aforementioned contracts, the Krško Nuclear Power Plant, which is located on the territory of the Republic of Slovenia, supplies 50% of the produced electricity to Hrvatska elektroprivreda.

It should be noted that the estimated installed power capacities are the result of a simulation model and that deviations from the calculated values may be expected in the implementation. The efforts of the Republic of Croatia will be directed towards achieving the target regarding the share of RES in gross final consumption, and the installed capacity in some technologies can be expected to be higher or lower than estimated. The dynamics of the development of individual projects will affect this, and especially in the development of geothermal projects, where the minimum contribution to the goal is considered, more new capacities are expected from the stable production of renewable electricity and thermal energy, for which new legal prerequisites have been made and more projects are in the mature phase of potential testing.

iv. Estimated trajectories of demand for energy of biomass, broken down into heat and electricity and transport, and trajectories of biomass supply by feedstock and origin (differentiation between domestic production and import). For forest biomass, evaluation of its source and impact on the sink in the LULUCF sector

The estimated trajectory of demand for biomass energy broken down into crude biomass, heat and electricity produced from biomass and biofuels in transport is shown in Figure 2-8.

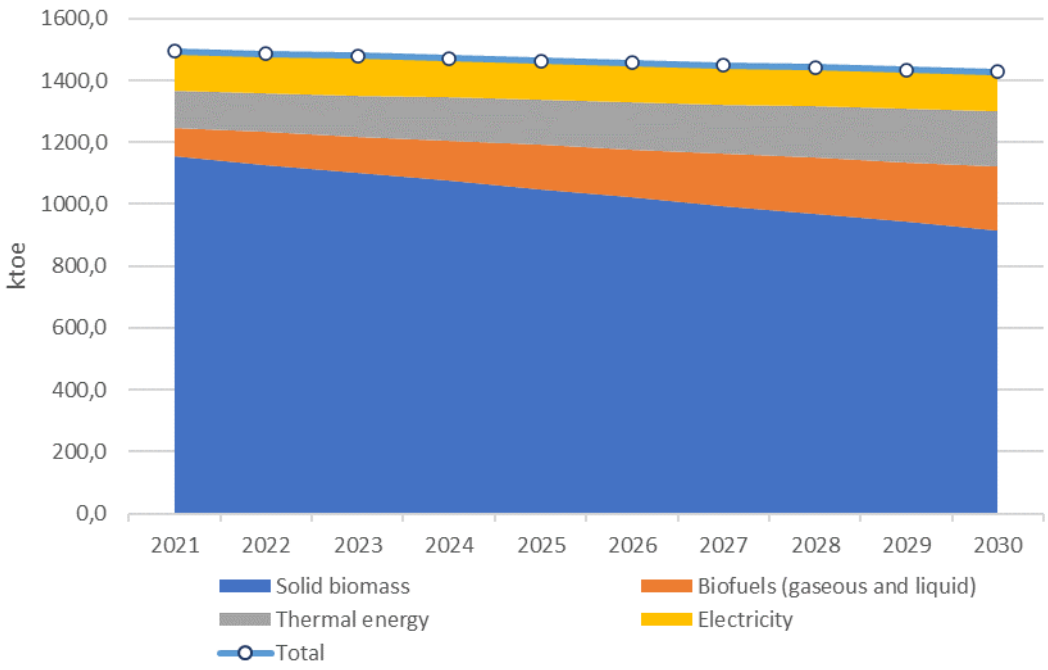


Figure 2-8. Estimated trajectory of demand for biomass energy

The study "Analysis of all data and the existing biomass balance and opinions for their improvement", within the framework of which a detailed analysis of biomass consumption and origin had been carried out, was finalized at the end of 2019. The focus of the analysis is the production and use of biomass for energy generation.

v. If applicable, other national trajectories and targets, including long-term and sectoral ones (e.g. share of renewable energy in district heating, use of renewable energy in buildings, renewable energy produced by cities, renewable energy communities and consumers of own renewable energy, energy produced from sewage sludge from wastewater treatment)

Under the new Directive on the promotion of the use of energy from renewable sources 2018/2001 of 11th December 2018, all Member States committed to increase the share of RES for heating and cooling by 1.3 percentage points per year, or 1.1 percentage points per year if waste heat is not used, as the annual average for the period 2021-2025 and the period 2026-

2030, compared to this share in 2020, expressed as a share of final consumption and according to the methodology laid down in the said document. Focusing on the sector of district heating and cooling, an increase in RES share is required at the level of 1.3 percentage points per year in the period 2021-2025 and in the period 2026-2030, compared to this share in 2020, expressed as a share of final consumption and according to the methodology laid down in the said document. This increase is limited to an indicative 1.1 percentage points if waste heat or cold is not used. However, this requirement shall also be deemed fulfilled if the share of renewable energy and waste heat and cold in centralized heating and cooling is more than 60%. However, in accordance with the Comprehensive assessment of the potential for efficiency in heating and cooling in Croatia according to Annex VIII of Directive 2012/27/EU, the heat produced from cogeneration plants cannot be considered as waste in the sense that it meets the conditions laid down in Article 24 (4) of Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources. In accordance with the current situation and estimated increases in the share of RES in gross final consumption for heating and cooling, the Republic of Croatia fails to meet the condition referred to in Article 24 of the Directive on the promotion of the use of energy from renewable sources.

According to the Energy Efficiency Directive 2012/27/EU of 25th October 2012, a district heating or cooling system can be considered efficient if it uses at least 50 % renewable energy, 50 % waste heat, 75 % cogeneration heat or 50 % of the combination of such energy and heat. As the estimated share of cogeneration heat and heat from RES in Croatian district heating and cooling systems meets the above criteria, a centralized heating system can be considered efficient.

On 14th July 2021, the European Commission adopted the 'Fit for 55' package, which adapts existing climate and energy legislation to meet the EU's new greenhouse gas emission reduction target of at least 55% by 2030. A key element in the 'Fit for 55' package is the revision of Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources, where the same Directive revised and strengthened the provisions and set a new EU target of at least 40% of the share of RES in final energy consumption by 2030, accompanied by new sectoral targets.

The current Russian-Ukrainian crisis has caused a significant increase in the prices of energy and energy-generating products and has led to increased energy security concerns. Based on all short-term developments at the European level, but also globally, a proposal for a new set of measures was adopted through the REPowerEU plan for energy savings, diversification of deliveries, abandonment of dependence on Russian fossil fuels, increasing investments in renewable, clean energy and combining investments and reforms.

In addition, a revision of the targets referred to in the Directive on the promotion of the use of energy from renewable sources from recent 40% to 45% by 2030 is also being ambitiously considered (the so-called RED III Directive). According to the RED III directive (still in the process of adoption), the share of renewable energy, including heat from electricity from renewable sources, and waste heat in district heating and cooling, aims to increase from 1.3 to 2.3 percentage points as an annual average calculated for the period from 2021 to 2025 and for the period from 2026 to 2030 compared to the share from 2020. This increase would be 2.8 percentage points for Member States using waste heat and cold. In this case, Member States may account for waste heat and cold up to 40 % of the average annual increase.

Also, the increase in energy efficiency in district heating and cooling systems is already being implemented in the period until 2020 as part of the State Aid Programme for increasing the efficiency of district heating systems, and under the Operational Programme "Competitiveness and Cohesion 2014-2020", Priority Axis 4 "Promoting energy efficiency and renewable energy sources", specific objective 4c3 "Increasing the efficiency of the heating system" through the mechanism of Integrated Territorial Investment. The expected effects are a reduction in losses in distribution systems by relative 4% points on the national level by the end of 2023, and primary energy savings of 1 PJ over the same period. As planned beyond 2020, these savings will be relevant given the requirements of the Directive on the promotion of the use of energy from renewable sources, and it is expected that the reduction in losses in district heating and cooling systems, with the assistance of ESI funds, will continue in the period until 2030. In terms of electricity generation for own needs, the largest contribution is expected from photovoltaic systems integrated in buildings with connected energy storage systems at the same location. The EU Solar Strategy 13 sets out a comprehensive vision for rapidly reaping the benefits of solar energy and presents four initiatives to address the remaining challenges in the short term: i) promoting fast and massive use of photovoltaic technology within the framework of the European Solar Rooftops Initiative; ii) simplifying and shortening permit granting procedures iii) ensuring the availability of a large number of skilled labour to meet the challenges of solar power generation and deployment across the EU; and iv) establishing an EU Alliance for the Solar Photovoltaic Industry to facilitate the spread of a resilient industrial value chain in the field of solar energy in the EU, in particular in the sector of photovoltaic systems production.

The new Council Regulation (EU) 2022/2577 of 22 December 2022 laying down a framework to accelerate the deployment of renewable energy, ST/14787/2022/INIT(OJ L 335, 29th Dec 2022) laying down a framework to14 accelerate the deployment of renewable energy of 22nd December 2022 is binding and should apply to all EU Member States for the next 18 months. It was adopted as a response to the deteriorating market situation due to the Russian-Ukrainian crisis, the sharp rise and instability of natural gas and electricity prices and the threat to the Union economy itself, i.e., security of supply. To mitigate any adverse effects, this Regulation proposes to accelerate the deployment of renewable energy sources with a focus on the development, installation, and acceleration of permit granting procedures for small-scale integrated solar energy installation projects to become self-consumers of own renewable energy. The focus is on the local community, households, renewal of the capacity of existing plants, installation of solar energy equipment and related energy storage capacities at the same location, as well as the means necessary for their connection to the grid, including permits for connection to the grid and environmental impact assessments if necessary. The Regulation establishes a framework for reducing the time limits for the permit granting

[13]COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EU Solar Energy Strategy COM/2022/221 final, 18th May 2022;

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC022

[14]Council Regulation (EU) 2022/2577 of 22nd December 2022 laying down a framework for the acceleration of the deployment of energy from renewable sources

https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32022R2577

procedure, for those licenses that have a start date within the period of its application, relating to the installation of solar energy equipment up to 50 kW and the renewal of the capacities of renewable energy generating plants.

In the context of the low carbon transition, it will be particularly important to consider a fair energy transition as well as the need for regional added value within that transition, especially in specific areas such as islands. On islands, generating electricity from RES at the place of consumption means less investment in infrastructure and greater security of the system, while helping to achieve national targets for the share of renewable energy in total production. In mid-2020, Croatia signed a Memorandum of Understanding for the implementation of the Clean Energy for EU Islands Declaration (Memorandum of Split) as a follow-up to the Valletta Declaration, which aims to improve the energy transition on islands while respecting the specificities of each island and to expand and strengthen cooperation between Member States. The Memorandum ensures detailed support to islands in preparing their strategies for the clean energy transition process and for the cooperation of energy communities on islands. It recognizes the importance of implementing projects aimed at increasing the use of renewable energy sources using innovative technologies, the development of clean and sustainable transport and the integration of the electricity system with other sectors. The Memorandum considers the objectives of the Paris Agreement and the European Green Deal, the objectives of achieving a climate-neutral EU by 2050, the Clean Energy for All Europeans legislative package and national energy and climate plans.

Croatia, as a signatory to this document, focused on the process of decarbonisation on islands. The main objective will be precisely defining the needs related to the energy transition and the transition to clean energy, taking into account that self-supply is promoted on the islands (both for individuals and larger projects) as well as solutions which will not further burden the transmission system, and which will ensure the supply of electricity in any situation. In addition, clean transport should be additionally promoted on islands, including shipping lines which will enable better connectivity between islands and land while reducing CO_2 emissions related to ship transport.

Therefore, it is important that the measures proposed in the plan specifically address the islands and the needs that the islands have in terms of electricity generation, energy efficiency and decarbonisation. This is extremely important because it encourages self-supply and the creation of renewable energy and energy communities in areas that are geographically separated from the rest of the country, while also solving the problem of increased electricity consumption during the summer months. However, the most important thing is that the promotion of measures on the islands reduces the pressure on the energy transmission system, and at the same time creates pilot projects that can then be applied to other parts of the Republic of Croatia. In addition to these measures, which will place special emphasis on the islands, additional sources of financing need to be found for the purposes of generation of clean energy on the islands and their decarbonisation, which will facilitate the transition of the islands to clean energy and accelerate their decarbonisation, considering the people living there.

In addition to the above, the Smart Islands Declaration emphasizes the need to encourage island communities to switch to clean energy, and it is especially important to strengthen the synergy between energy, transport and information and communication technology, along

with including topics related to water and waste. This approach is based on ensuring optimal use and management of island resources and the contribution of sustainable and equitable development that will maximize island potentials. One of the main determinants of smart islands is reducing the use of fossil fuels, increasing the use of significant resources of renewable energy sources and energy efficiency. The aim of exploiting the significant potential of renewable energy sources, sun, wind, sea currents and waves is decarbonization, which will also contribute to increasing the energy efficiency of buildings (lighting, heating and cooling in buildings) and infrastructure (e.g., street lighting, pumping stations). It emphasizes the potential of islands as pilot locations for the development of integrated solutions such as the production of energy from waste, the use of energy produced from RES in transport and electric vehicles, or for desalination purposes by exploiting the synergy between sustainable energy, waste, water, and mobility.

2.2 Dimension: energy efficiency

i. Elements referred to in Article 4, item (b)

Indicative national target of increase in energy efficiency **by 2030**

The national targets for increasing energy efficiency by 2030 are shown in Table 2-7.

Table 2-7. Indicative national goals for energy efficiency in 2030

2030 targets	PJ	Mtoe
Primary energy consumption[15]	340,9	8,14
Final energy consumption	274,2	6,55

Figure 2-9 shows energy consumption trends by years in the period from 2021 to 2030.

[15] total energy consumption without non-energy consumption

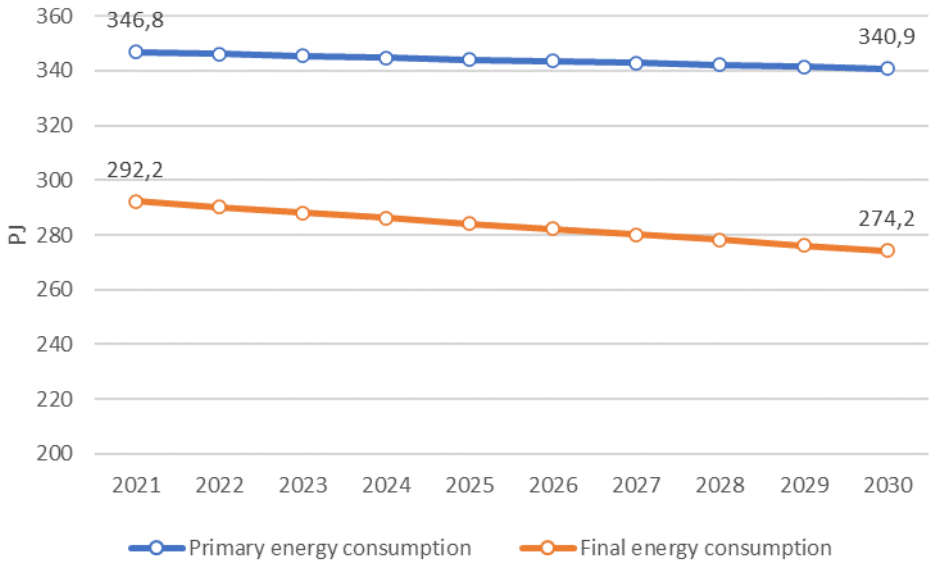


Figure 2-9. Trends in energy consumption from 2020 to 2030

Cumulative energy savings in the period 2021-2030 in accordance with Article 7 (1) (b) on the energy efficiency obligation scheme of Directive 2018/2002 amending Directive 2012/27/EU on energy efficiency

The specified target of cumulative savings in the amount of **2,993.7 ktoe (125.3 PJ)** is calculated in accordance with Article 7 (1), item (b) of Directive 2018/2002, as shown in **Pogreška! Nevaljana samo-referenca knjižne oznake.**. A detailed calculation is given in Annex II.

In view of the agreed proposal for amendments to the March 2023 Directive, a new increased target has been calculated and presented in the table below.

Table 2-8. The cumulative energy savings goal from 2021 to 2030 in line with Article 7 of the Energy Efficiency Directive

Targets 2030	Annual savings		Cumulative savings	
	PJ	ktoe	PJ	ktoe
According to Article 7(1)(b)	2,3	54,4	125,3	2.993,7
According to the agreed proposal to amend the Directive	3,9	93,1	180,6	4.313,6

Indicative targets of the long-term strategy of renovation of the national residential and non-residential building stock

After 2020, in accordance with the Technical Regulation on Rational Use of Energy and Thermal Insulation in Buildings, all newly constructed buildings will be nearly-zero energy (nZEB). It is expected that the total residential stock will grow at an average rate of approximately 6,600 residential units from 2021 to 2030, 6,300 from 2031 to 2040 and 6,050 units from 2041 to 2050. The useful area of permanently occupied residential buildings in 2020 reduced by the area of newly built and renovated buildings since 2011 is 110,143,965 m², and the total useful area of non-residential buildings in 2020 is 58,722,937 m². Out of 110,143,965

m² of residential buildings, 38.5% (42,395,923 m²) are multi-apartment buildings and 61.5% (67,748,042 m²) are single-family homes. The total useful area in non-residential buildings is 58,722,937 m², of which 42,623,410 m² is for commercial buildings and 16,099,527 m² for public buildings. The average building renovation rate from 2021 to 2030 is 2.0% (growth from 1.0% in 2021 to 3% in 2030, from 2031 to 2040 3.5% and from 2041 to 2050 4%).

The average final energy consumption in the residential sector will be 30 kWh/m² for newly built and renovated buildings, and it is expected that there will be no significant variations for the non-residential sector.

Pursuant to Article 2a of Directive 2018/844 amending Directive 2010/31/EU on the energy performance of buildings, the Republic of Croatia has adopted a new Long-term strategy for renovation of the national building stock until 2050 (29th session of the Government of the Republic of Croatia, 14th December 020), with a plan of measures and indicators for 2030, 2040 and 2050.

The total area of public administration buildings that are being renovated or equivalent savings in the period 2021-2030 pursuant to Article 5 on the leading role of the public sector of Directive 2012/27/EU

A total of 13.8 million m^2 of useful heated area of public sector buildings was recorded in the Republic of Croatia in 2010, according to the data from the National Information System for Energy Management. In order to meet the obligation to renovate 3% of the total floor area of heated and/or cooled buildings owned and managed by the central government, in the period until 2020 the Republic of Croatia has chosen an alternative approach, i.e., it has set the target of 0.00489 PJ per year in equivalent savings. This approach will also be applied in the period until 2030.

ii. Indicative milestones for 2030, 2040 and 2050, measurable indicators of progress defined at the domestic level, estimated expected savings and benefits based on evidence, and their contribution to the Union's energy efficiency targets as incorporated in the plans established in the strategies for the long-term renovation of the national residential and non-residential building stock (public and private), in accordance with Article 2a of Directive 2010/31/EU

Pursuant to Article 2a of Directive 2018/844 amending Directive 2010/31/EU on the energy performance of buildings, the Republic of Croatia has adopted a new Long-term strategy for renovation of the national building stock until 2050 (29th session of the Government of the Republic of Croatia, 14th December 020), with a plan of measures and indicators for 2030, 2040 and 2050. The building renovation rate according to the text of the Long-Term Strategy in the period from 2021 to 2030 is growing from the current 1.0% per year to 3% per year in 2030, rising to 3.5% in the period until 2040 and 4% by 2050. The increased renovation rate expressed in the Long-Term Strategy is the result of a significantly lower building demolition rate that describes the quantity of buildings that are abandoned or removed (in terms of energy consumption, buildings that are not used do not represent a burden on the energy system, but the obligation to decarbonise the total building stock by 2050 produces the need for renovation of buildings that are not used as well, i.e. the need to increase the intensity of renovation in relation to the intensity of new construction).

Table 2-9. Indicative goals of the energy renovation of buildings according to the Long-term strategy of renovation of the national building fund until 2050

	2030	2040	2050
Total renovated buildings	30.838.830	41.063.535	32.099.102
Renovated residential buildings	20.171.751	26.966.267	21.117.537
Target annual energy renewal rate	2 %	3,5 %	4 %
Renovated non-residential buildings	10.667.079	14.097.268	10.981.565
Target annual energy renewal rate	2 %	3,5 %	4 %

iii. If applicable, other national targets, including long-term targets or strategies and sectoral targets, and national targets in areas such as energy efficiency in the transport sector and energy efficiency in relation to heating and cooling

Not applicable.

2.3 Dimension: energy security

i. Elements referred to in Article 4, item (c)

ii. National targets for strengthening the diversification of energy sources and supply from third countries for the purposes of increasing the resilience of regional and national energy systems;

The most important objective within the dimension of energy security is to ensure a lasting, secure, and quality supply of all energy-generating products. To achieve this objective, it is necessary to introduce integral and systematic planning of supply of all energy-generating products and forms of energy.

Other national energy security objectives are:

- diversification of supply routes of energy and energy-generating products,
- increasing gas and energy storage capacity in the electricity system,
- increasing the flexibility (and thus resilience) of energy systems,
- protection of critical infrastructure and mitigating risks related to cyber security and climate change.

In terms of gas supply security, it is necessary to ensure domestic operational security of gas supply as well as the security of gas delivery. Croatia is currently supplied with gas from domestic production and from imports through the Slovenian and Hungarian delivery routes, and through the LNG terminal on the island of Krk, and peak demand is met through supply from the underground gas storage facility Okoli. One of the objectives in the context of energy security is to increase the capacity of gas storage facilities, diversify supply routes and fulfil obligations of security of supply according to the infrastructure standard (N-1 criterion)

pursuant to Regulation (EU) 2017/1938 concerning measures to safeguard the security of gas supply.

In order to preserve the security of natural gas supply, the LNG terminal on the island of Krk was put into operation on 1st January 2021, which provided a new natural gas delivery route and diversified the routes and sources of natural gas supply on the market of the Republic of Croatia and the European Union. This significantly increased the security of natural gas supply.

For the purposes of diversification of gas supply routes, in addition to increasing the capacity of the LNG terminal, it is planned to connect to the Ionian Adriatic gas pipeline.

To increase gas storage capacity, it is planned to further develop the gas storage system and build a new underground gas storage at the location of the hydrocarbon exploitation field Grubišno Polje. Energy storage within the ES will be enabled by the construction of pumped-storage power plants, which will also provide greater system flexibility and greater integration of variable renewable energy sources, primarily the sun and wind. In addition to energy storage, the possibility of participation of consumption response in the operation of the ES will also contribute to system flexibility.

iii. If applicable, national targets for reducing dependence on energy imported from third countries, for the purposes of increasing the resilience of national and regional energy systems

Increasing the share of RES in the structure of used energy-generating products will contribute to reducing dependence on imports, including imports from third countries. Also, to reduce imports of energy-generating products from third countries, potential hydrocarbon deposits in Slavonia, the Dinarides and the Adriatic should be explored.

iv. National targets for increasing the flexibility of the national energy system, particularly the use of domestic energy sources, demand management and energy storage

Electricity sector

National goals regarding the security of electricity supply are as follows:

- creating a favourable investment climate for investments in new electricity generation facilities and revitalization of existing facilities to reduce the dependence on electricity imports, increasing the competitiveness of power plants located in the territory of the country and further increase of possibilities for electricity generation in the territory of the country and relieving the grids.
- construction of different types of power plants with respect to the characteristics of the system (basic, regulation-peak, other), for the purposes of proper technical functioning of the electricity system as a whole and always ensuring sufficient reserves for balancing production and consumption of electricity (short period),
- diversification of power plants according to the types of primary energy-generating product used, to avoid major disruptions in electricity generation during periods of unavailability of primary energy-generating products,

- timely implementation of investment plans of the transmission and distribution system operators with regulatory supervision, to increase the availability of the grid capacity for market participants and avoid disruptions in customer supply during grid failures,
- implementation of energy efficiency measures to reduce electricity consumption, to reduce electricity demand, and
- construction of distributed power sources with a medium-voltage and low-voltage grid connection near the point of consumption to further increase the power generation capacity in the territory of the country and relieve the grids.

Gas sector

The basic framework for regulating the security of natural gas supply in the Republic of Croatia is laid down in Regulation (EU) 2017/1938 of the European Parliament and of the Council concerning measures to safeguard the security of gas supply and repealing Regulation (EU) 994/2010 (Text with EEA relevance.) (OJ L 280, 28th Oct 2017). This Regulation aims to ensure that all necessary measures are undertaken to safeguard an uninterrupted gas supply, in particular supply to protected customers in the event of difficult climatic conditions or disruptions in gas supply.

Regulation 2017/1938 entered into force on 1st November 2017, and the purpose of the Regulation is to increase solidarity and trust among Member States and to establish measures needed to achieve those objectives by cost-effective measures and in a way that will not destabilize gas markets. The main improvements in relation to the previous Regulation (EU) 994/2010 of the European Parliament and of the Council of 20 October 2010 concerning measures to safeguard security of gas supply and repealing Council Directive 2004/67/EC Text with EEA relevance (OJ L 295, 12th Nov 2010) are:

- introduction of the solidarity mechanism, according to which, in the event of a crisis, neighbouring member states will assist in ensuring supply to households and key public services,
- strengthening regional cooperation through regional risk groups, and joint assessment of security risks and agreed joint preventive and crisis measures, and
- greater transparency through the introduction of an obligation of disclosure to the competent body of the contract between the supplier and customer covering 28% or more of annual gas consumption on the national market.

In accordance with the provisions of the Gas Market Act, gas market participants are responsible for the security of gas supply within the scope of their activity. The competent body responsible for the implementation of measures listed in Regulation 2017/1938 is the ministry responsible for energy, which has the following tasks:

- monitoring the ratio of supply and demand on the gas market,
- preparing estimates of future consumption and available supply,
- planning the construction and development of additional capacity of the gas system and

- proposing and undertaking measures in the event of a crisis.

Regional self-government units are responsible for:

- monitoring the ratio of gas supply and demand in their area,
- preparing estimates of future consumption and available supply,
- planning the construction of additional capacity and development of the distribution system in their area and
- proposing and undertaking measures within their competence as established by law.

Furthermore, Regulation (EU) 2017/1938 establishes the obligation of competent institutions to prepare:

- preventive action plans with measures to eliminate and mitigate the identified risks,
- emergency plans with measures to remove or mitigate the effects of gas supply disruptions.

Pursuant to Article 8 (2) (b) of Regulation (EU) 2017/1938 of the European Parliament and of the Council of 25 October 2017 concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010, the Government of the Republic of Croatia has adopted *an Intervention Plan on measures to safeguard the security of gas supply of the Republic of Croatia* (OG No. 127/22). The intervention plan regulates the procedures, roles and responsibilities of competent bodies and all participants in the gas market in case of gas supply disturbances, and measures to eliminate or mitigate the effects of gas supply disturbances, which include ensuring reliable and efficient natural gas supply, criteria and the method of determining sufficient quantities of natural gas to ensure reliable supply of natural gas to protected customers, and the schedule of reduction in or suspension of natural gas supply to individual categories of customers in the event of a crisis situation.

Furthermore, the Intervention Plan regulates compliance with Regulation (EU) 2022/1032 of the European Parliament and of the Council of 29 June 2022 amending Regulations (EU) 2017/1938 and (EC) No 715/2009 with regard to gas storage (Text with EEA relevance) (OJ L 173, 30th Jun 2022) which ensures that the underground gas storage systems on 1st November, starting from 2023, are filled to at least 90 % of their capacity, considering the transitional targets set for February, May, July, and September for each subsequent year. The charging curve and transitional targets are based on the average charging rate over the previous five years. The Republic of Croatia can partially achieve the set goal of filling the warehouse by counting the stocks of liquefied natural gas (LNG) stored in the liquefied natural gas terminal. In the event that the storage system operator cannot reach the filling target in a timely manner due to technical problems, such as problems related to gas pipelines supplying underground gas storage systems or problems with injection facilities, the filling target may also be achieved at a later stage, but no later than 1st December of the current year in order to safeguard the security of gas supply during the winter period.

To identify the criteria for acquiring the protected customer status and protection measures with the aim of reliable supply of protected customers, the Government of the Republic of Croatia adopted the Regulation on criteria for acquiring the status of protected customer in conditions of crisis situations in gas supply (OG No. 65/15).

Heating sector

The development of infrastructure for district heating and cooling networks should be stepped up and directed towards efficient and flexible exploitation of a wider range of renewable heat and cold sources to increase the use of energy from renewable sources and deepen the integration of the energy system as referred to in Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources[16]. It is therefore necessary to update the list of renewable energy sources that district heating and cooling networks should increasingly accept and require the integration of thermal energy storage as a source of flexibility, greater energy efficiency and more cost-effective operation.

To ensure the full integration of district heating and cooling into the energy sector, it is necessary to extend cooperation from electricity distribution system operators to transmission system operators and to extend the scope of cooperation to network and market investment planning to better exploit the potential of district heating and cooling for the provision of flexibility services in electricity markets.

Coordination between district heating and cooling system operators and distribution and transmission system operators for electricity should be facilitated to ensure that balancing, storage as well as other flexibility services such as demand management, provided by district heating and cooling system operators, can be present in their electricity markets.

The distribution system operator shall, in cooperation with the thermal system distributors, make an analysis of the possibilities of thermal systems with the aim of providing balancing and other services with the electricity system, including the management of consumption and storage of excess electricity from renewable sources. The distribution system operator shall prepare an analysis of the possibilities of thermal systems with the aim of providing balancing and other services with the electricity system every four years and submit it to the Ministry. The same is stipulated in Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources and the Act on Renewable Energy Sources and High-Efficiency Cogeneration (OG No. 138/21).

In addition, further cooperation with gas network operators, including hydrogen and other energy networks, is necessary to ensure wider integration among energy carriers and their most cost-effective use.

Oil sector

The establishment and implementation of measures for secure and reliable supply of oil and petroleum products is regulated by the Oil and Petroleum Products Market Act (OG Nos. 19/14, 73/17 and 96/2019).

In the event of an extraordinary disruption of the supply of the oil and petroleum products market that may be caused by a disruption of the supply of the regional market for oil and

[16] DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11th December 2018 on the promotion of the use of energy from renewable sources (recast)

https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=LV

petroleum products, the Intervention Plan in the event of an extraordinary disruption of the supply of the oil and petroleum products market (OG No. 111/12) is applied. The Emergency Intervention Plan defines:

- procedures and criteria for identifying an extraordinary disruption of the oil and petroleum products market supply,
- competences and responsibilities in case of supply disruption,
- procedures for normalization of the oil and petroleum products market supply and
- procedures in the event of an international decision on the release of compulsory stocks of oil and petroleum products on the market.

In cases of imminent threat to the independence and integrity of the Republic of Croatia, as well as major natural disasters on the territory of the Republic of Croatia, the procedures regulated by the Act on Strategic Commodity Reserves shall apply.

Apart from creating and holding compulsory stocks to increase the security of supply, the objective is a continuous analysis of the oil sector, both in terms of market supply and existing and future consumption, for the purposes of timely assessment of possible risks related to supply security. Furthermore, item 1 of Article 1 of the Oil and Petroleum Products Market Act, which regulates the rules and measures for the secure and reliable production of petroleum products, transportation of oil and petroleum products, wholesale and retail trade in petroleum products, storage of oil and petroleum products, wholesale and retail trade in liquified natural gas, the third party right of access, open access to the market, an intervention plan in the event of an extraordinary disruption in the supply of the oil and petroleum market and operational and mandatory reserves of oil and petroleum products imposes the obligation of continuous maintenance and investment in the security of transport and storage of oil and petroleum products.

v. If applicable, national targets for the development of domestic energy sources

According to the goal of implementing the energy transition, total energy consumption by 2050 is reduced by about 18% compared to 2021. Own supply capacity increases to 55.8% in 2030 and amounts to 67.2% in 2050.

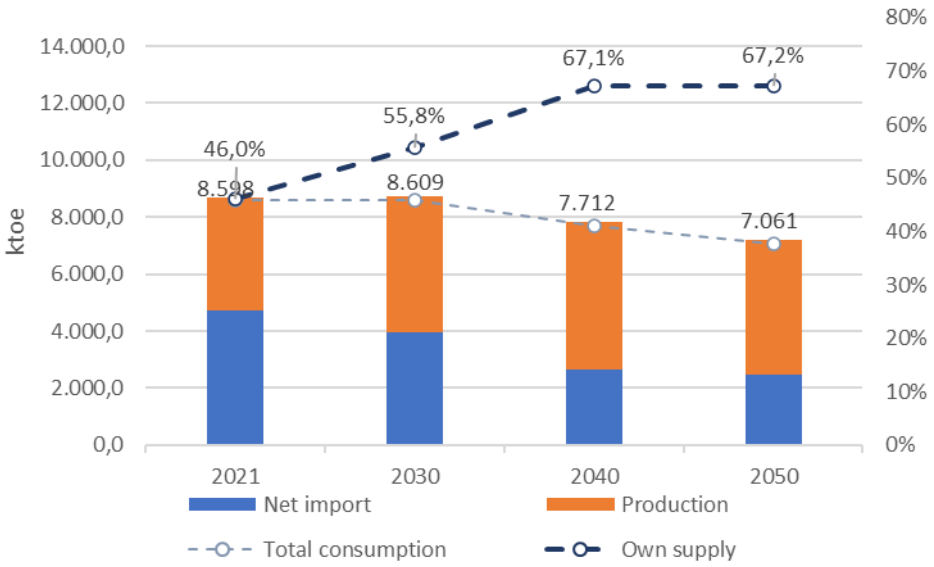


Figure 2-10. Total energy consumption and own supply

The estimates show a strong increase in the share of variable RES (wind farms and solar plants), and in the period until 2030, anticipate activities aimed at increasing the flexibility of the system that will be ensured from existing and planned impoundment hydroelectric power plants, existing and planned reversible hydroelectric power plants, battery systems at the system and consumption level, gas plants, organizing a balancing market (for the supply of services from domestic sources and other systems; introducing balancing responsibilities for market participants, etc.), improving forecasts of production from variable RES, enhancing transmission grid elements and developing advanced grid systems and system management.

The installed power of RES (primarily wind power plants) in Dalmatia is at the level of about 1,000 MW and for additional significant integration of RES in this area, it is necessary to strengthen the internal transmission network, including the 400 kV network on the route Konjsko substation (Split) - Melina substation (Rijeka). There is also a significant increase in requirements for the balancing mechanism and providing ancillary services of secondary and/or fast tertiary regulating reserve (power and frequency regulation).

Oil sector

Exploration of new deposits and hence increasing hydrocarbon production from domestic sources is one of the key factors for increasing domestic oil and gas supply capacity. The figures below show the existing production of oil and natural gas, and provide production estimates from existing fields and new production as a result of additional investments in the exploration of new hydrocarbon deposits.

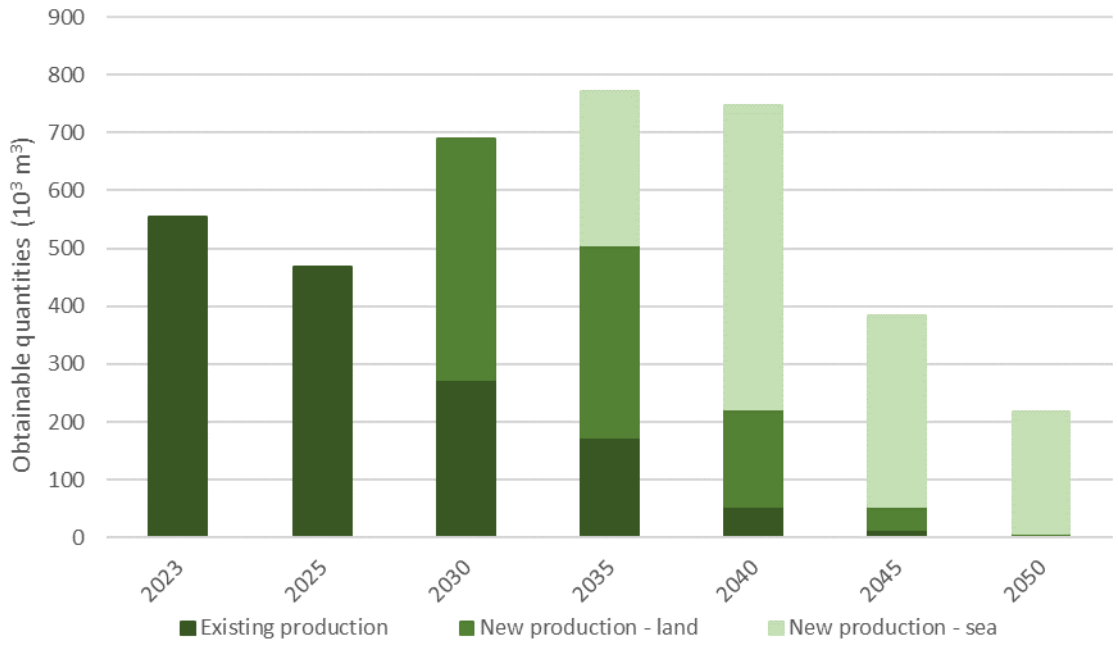


Figure 2-11. Oil and condensate production estimate by 2050

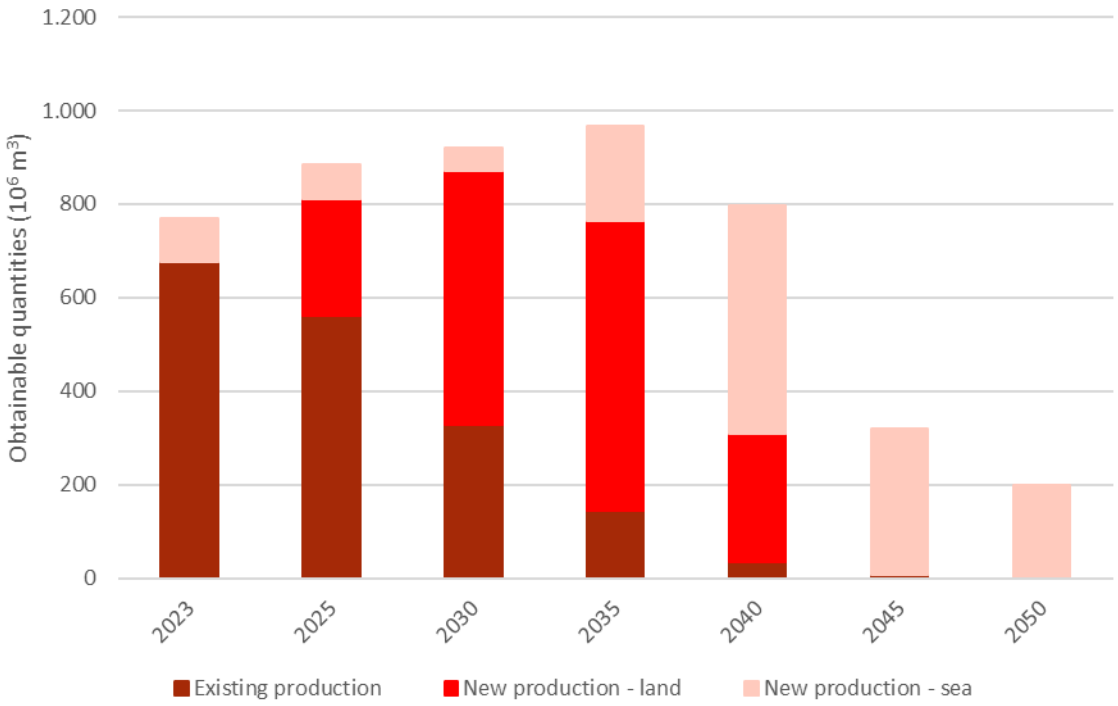


Figure 2-12. Natural gas production estimate by 2050

2.4 Dimension: the internal energy market

2.4.1 Electricity interconnection

i. Level of electricity interconnection

Regarding the EU targets related to the desired level of electricity interconnection of at least 15% compared to installed power of power plants in the observed member state by 2030, the transmission system in the territory of the Republic of Croatia already meets and exceeds that target many times over. The same applies if the existing electricity interconnection capacity is compared with the peak load of the system or the installed power of RES in the territory of the Republic of Croatia.

Namely, the sum of installed transmission capacities of interconnectors/interstate powerlines in the existing state is about 13,303.5 MVA, which is almost two and a half times more than the total installed power of power plants of 5,444 MW, or over four times the peak load of the system of about 3100 MW. The total theoretical available cross-border capacity for import is estimated at over 4,000 MW, while the total cross-border capacity for export is estimated at over 3,800 MW, and in relation to the sum of transmission capacity of interconnectors, it is limited by potential congestion in the internal grid in terms of meeting the operational safety criteria. The total cross-border exchange amounted to 11,504 GWh at the entry to the Republic of Croatia and 7,159 GWh at the exit from the Republic of Croatia. The difference in prices on the wholesale market exceeded the indicative threshold of EUR 2/MWh between Member States, regions, or trading zones, however, the average hourly price differences for the day-ahead markets in 2021 were significantly lower at the border between Croatia and Slovenia - EUR 0.35/MWh, which was contributed by the integration of the Slovenian and Croatian electricity markets in 2018. The same progress is expected at the border between Croatia and Hungary, since as part of the CORE project (Core Flow-Based Market Coupling project) in June 2022, there was a connection between CROPEX and HUPX day-ahead markets where daily cross-border capacities at the Croatian-Hungarian border are no longer allocated directly through the JAO platform, but indirectly through the mechanism of connecting electricity exchanges. Regarding further increase of cross-border capacity by 2030, no specific requirements are set. Neighbouring transmission system operators (BiH, Serbia) are interested in the construction of new 400 kV interconnectors to BiH (Lika - Banja Luka) and Serbia (Ernestinovo - Sombor), which are being analysed through the development of a 10-year transmission grid development plan (TYNDP) within the ENTSO-E.

The development of new interconnection projects will be based on technological and economic considerations and on cost-benefit analysis in accordance with the ENTSO-E methodology. Regarding further enhancement of possibilities of existing cross-border capacity exchanges, the aim is to continuously enhance the use of cross-border lines, primarily by eliminating congestion/limitations in the internal grid. It is expected that the following will have the greatest impact on the transmission network development plan: the start of the application of regional day-ahead capacity calculation based on power flows, the conclusion of CORE region agreements with third countries to consider the flows of third countries in the processes of regional capacity calculation, the adoption of regional rules for activation of coordinated re-dispatching and trading in the opposite direction.

2.4.2 Infrastructure for energy transmission

i. Key projects for electricity transmission and gas transport and, where appropriate, modernization projects needed to achieve the targets within the framework of the five dimensions of the Energy Union Strategy

Key targets for the power transmission infrastructure:

- maintaining a high reliability of the transmission system and the security of electricity supply of stipulated quality to customers,
- accelerated integration of variable RES into the electricity system, and increased availability of regulatory reserves to balance their production,
- timely realization of investment plans, in particular capital investments that enable the integration of RES into the ES,
- strengthening the electricity market by increasing the availability of transmission capacities for market participants within the trading zone and the region for coordinated capacity calculation by removing the constraints of the transmission network when bidding,
- revitalization and replacement of old/deteriorated grid units,
- increasing the transmission capacity of individual lines planned for revitalization by using high-temperature low-sag conductors (HTLS), and reducing losses in the transmission of electricity,
- application of new technologies in transmission if they are technically and economically justified.

The existing transmission grid and interconnection capacity to neighbouring countries enable the integration of significant installed power of RES. Given the climate characteristics, the region of Dalmatia is particularly suitable for the development of wind and solar power plants, and there is a strong investor interest in the construction of new facilities in the region. Now, the installed power of RES (primarily wind farms) in Dalmatia is at the level of about 1,000 MW. For additional significant integration of RES in this area, it will be necessary to upgrade the internal transmission grid, including the 400 kV grid on the route Konjsko substation (Split) - Melina substation (Rijeka) so that the energy generated from RES could be transmitted to remote consumption areas.

ii. Key goals for the gas transmission infrastructure

By upgrading and reconstructing the existing gas storage facility, the preconditions for increasing its output capacity by up to 20% have been met, the safety and reliability of the storage facility operation have been increased, and the costs of fuel and maintenance costs have been reduced. The gas storage system development plan includes further development and modernization of existing storage facilities, as well as the construction of new storage capacities, which primarily includes the construction of an underground gas storage facility at the location of the Grubišno Polje hydrocarbon exploitation field, but also the potential construction of a new seasonal gas storage facility in accordance with possibilities and needs.

The underground gas storage facility Grubišno Polje is planned as a storage facility of a relatively small working volume (about 60 million m^3), but relatively large injection capacities (about 70,000 m^3) and withdrawals (about 100,000 m^3). The primary purpose of this storage facility will be to cover the peak gas needs in the Croatian gas system, which will enable an optimal utilization of the existing gas storage facility and increase the flexibility of the entire gas system, as well as the security of gas supply in the Republic of Croatia.

Energy storage facilities and facilities for receipt, storage and gasification or decompression of liquefied natural gas (LNG) and compressed natural gas (CNG) have an increasingly important role in the European energy infrastructure. Expansion of such infrastructure facilities is an integral part of the functional network infrastructure.

The energy infrastructure for gas that needs to be built to implement priorities in the area of energy infrastructure of common interest is defined in the 10-year plan for the development of the gas transport system. In accordance with Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on guidelines for trans-European energy infrastructure, amending Regulations (EC) No 715/2009, (EU) 2019/942 and (EU) 2019/943 and Directives 2009/73/EC and (EU) 2019/944, and repealing Regulation (EU) No 347/2013 (OJ L 152, 3rd Jun 2022), a list of projects of common interest of the EU is defined every two years.

iii. If applicable, major infrastructure projects envisaged, other than projects of common interest

Major infrastructure projects are:

- gas pipelines for the transport of natural gas and biomethane which are part of the network mainly consisting of high-pressure gas pipelines, excluding high pressure gas pipelines used for the production or local distribution of natural gas;
- underground gas storage facilities;
- facilities for receipt, storage and gasification or decompression of LNG and CNG;
- all equipment important for protected, secure and efficient operation of the system or enabling a two-way interconnection, including compressor stations,

provided that the construction is technically and economically justifiable or enables the fulfilment of supply security obligations and according to the infrastructure standard (N-1 criterion) in accordance with Regulation (EU) 2017/1938 concerning measures to safeguard the security of gas supply.

2.4.3 Market integration

i. National goals related to other aspects of the internal energy market, such as increasing system flexibility, in particular with regard to promoting market prices of electricity in accordance with the relevant sectoral law, market integration and coupling with the aim of increasing the marketable capacity of existing interconnectors, smart grids, aggregation, demand management, storage, distributed energy production, mechanisms for dispatch, re-dispatch and limitation of service and price signals in real time, including the timeframe for achieving the goals.

Connecting the day-ahead markets at the border between the Republic of Croatia and the Republic of Slovenia had significant effects on increasing the liquidity of the Croatian Power Exchange (CROPEX), increasing the possibilities of energy placement and price harmonization. The existing market integration activities should continue with the aim of achieving full integration into the EU internal market, and in accordance with that, in June 2022, within the CORE project, the integration of the Croatian and Hungarian day-ahead markets took place.

By connecting the CROPEX and HUPX day-ahead markets, the daily cross-border capacity at the Croatian-Hungarian border will no longer be allocated directly through the JAO platform, but indirectly through the mechanism of connecting electricity exchanges. Within the implementation of the CORE project, there is also a change in the methodology of calculating the available capacities at the Croatian-Slovenian border, switching to the calculation of capacities by the power flow method.

The markets of South-Eastern Europe are very significant for Croatia given its good cross-border connectivity and energy availability, but market integration is limited by the level of development of national electricity markets in these countries. Bosnia and Herzegovina do not yet have a power exchange in place, while connecting the day-ahead market with Serbia can be achieved in a relatively short time. The project of connecting day-ahead markets in the WB6 countries is expected to result in full integration of markets in the region by 2025.

The second phase of the expansion of the intraday market through the XBID project is expected, which includes the following countries: Bulgaria, Croatia, Czech Republic, Poland, Romania, and Slovenia, along with the already operational countries with which they border.

Although the wholesale electricity market in Croatia is fully open, it is characterized by the existence of a dominant electricity producer. It is necessary to increase the number of participants in the wholesale market, especially in electricity generation, in order to increase competitiveness on the supply side.

It is necessary to increase the participation of end customers with their own generation in the electricity market, to ensure flexibility and sufficiency and to consider the possibility of forming capacity markets.

It is necessary to enable aggregation of end customers as well as participation of consumption response in the electricity market.

Objectives:

- Further integration of the electricity market with neighbouring markets and the EU market
- Strengthening the competitiveness and liquidity of the wholesale market by increasing the number of market participants and the share of stock trading

The current IDA (Intraday Auctions Implementation) project is in the testing phase, and the test phase is planned to be completed by the end of 2023. Implementation is expected in the second quarter of 2024. The IDA will be implemented across Europe to enable cross-border capacity pricing on an intraday time frame, as well as to accommodate a new market link that allows renewable energy producers to bid their energy based on reliable production forecasts, thereby reducing imbalances caused by variable RES.

In accordance with the EU clean energy package, the move of the market one day in advance from a resolution of 60 minutes to 15 minutes is being prepared, which implies a product offer of 15 minutes. The 15-minute products will enable better market integration of renewable energy sources. The mentioned project is in its implementation phase. Operators and exchanges are being adjusted, and implementation is expected in the second quarter of 2025.

The introduction of lower resolution cross-border products for continuous trading in Croatia will enable participants to access existing 15-minute products and better adjust their position on the market. Thus, it will be possible to conclude a transaction of a 15-minute product in Croatia with another 15-minute product within the connected intraday market, which have already implemented products of the same name in their markets such as Austria, Germany, the Netherlands, Belgium, Bulgaria, Hungary, Romania, Slovakia and Slovenia. The mentioned project is in the implementation phase and adaptation of operators and exchanges is in progress. The implementation itself is expected in the second quarter of 2025.

In general, the goals of further integration of the electricity market with neighbouring markets and EU markets and the strengthening of the competitiveness and liquidity of the wholesale market are expected in 2025 and 2026 at the latest after successfully implemented test phases and successful adaptations of system operators and exchanges to new trading conditions.

ii. If applicable, national goals related to the non-discriminatory participation of renewable energy sources, management of consumption and storage, inter alia through aggregation, in all energy markets, including the timeframe for achieving the goals

In the segment of ancillary services and system balancing, it is necessary to establish market mechanisms that will enable more market participants, as well as end consumers, to provide such services.

Objectives:

- Development of the national balancing and ancillary services market
- Development of the national electricity market

During 2023, it is expected that all by-laws will be adjusted and adopted and applied in accordance with the requirements of the Electricity Market Act (Official Gazette, 111/2021).

The goal has been partially met, and all transmission and distribution network users, aggregators and all other electricity market participants who are capable of doing so can participate in the balancing market. Additional liberalization and upgrading of the market and integration into EU markets is expected in 2023 and 2024.

iii. If applicable, national goals with regard to ensuring that consumers participate in the energy system and benefit from their own production and new technologies, including smart meters

Analytical backgrounds developed for the purposes of adopting the Energy Development Strategy ([2], [4]) define the introduction of advanced metering systems by 2025 as priorities for investment in the distribution system. Also, pilot projects for advanced grids are envisaged, based on which additional insights will be gained into the characteristics of grid users and possibilities of their active participation in the ES will be explored. The share of advanced meters increased from about 7% in 2019 to about 13% in 2021.

iv. National goals with regard to ensuring the adequacy of the electricity system as well as the flexibility of the electricity system with regard to production of renewable energy, including the time frame for achieving the goals

Regarding the future adequacy of the ES, it is necessary to consider the expected changes in the ES. According to the estimates of the share of RES in Chapter 2.1.2, it is necessary to secure appropriate investments in the transmission network and the management system, and sufficient (available) possibilities of system balancing, to ensure the satisfactory adequacy of the ES and to support the expected flexibility of its operation. Active participation of users in providing services to system operators will also contribute to the flexibility of the ES.

It is necessary to prepare the analysis of the impact of climate change on the adequacy of the ES, which may be reduced due to the failure of key production and transmission facilities caused by extreme weather, as a result of a decrease in electricity production from hydroelectric power plants due to a reduction in the amount of water available and as a result of limited operation of thermal power plants due to a decreased availability of the cooling medium of a reduced flow.

Given the existing capacities of cross-border lines, it is expected that cross-border exchange of electricity will contribute significantly to the adequacy of the ES in the context of growing intermittent production from RES. It will be necessary to further strengthen the cross-border and regional cooperation between power transmission system operators to ensure the quality and security of the system's operation.

Strengthening of cross-border cooperation in order to ensure satisfactory adequacy of EES in conditions of growing intermittent production from RES is expected during 2023, but also in the following years when the construction of new transmission lines, increase of transmission capacity of existing transmission lines 220 kV and 110 kV, and construction of transformer capacities for connecting the 400 kV and 110 kV networks are expected.

v. If applicable, national goals for the protection of energy consumers and improvement of competitiveness on the retail market of the power sector

The rate of supplier switch by end customers is one of the key indicators of the development of the retail electricity market. The rate of supplier switch by end customers from the category of entrepreneurship is significantly affected by the legislative framework regulating public procurement, whereby particular end customers are required to regularly issue tenders for the selection of the most favourable electricity supplier.

The Croatian goal in terms of improving competitiveness in the retail electricity market is to expand the choice of suppliers (reduction of the HHI index for metering points from the household and entrepreneurship categories) and the number of products, which should be implemented in accordance with the current legal and expected by-laws. Further improvement of competitiveness on the electricity retail market is expected even after 2023, and everything in accordance with the amendments and additions to legal and by-laws.

2.4.4 Energy poverty

i. If applicable, national energy poverty goals, including the time frame for achieving the goals

The first problem that arises when setting goals and measures to combat energy poverty is the definition of energy poverty, i.e., which households should be considered energy poor. In most countries, including the Republic of Croatia, energy poverty is defined exclusively by the income census: households with income levels below a certain level are considered energy poor (in principle, socially disadvantaged households). While it is inevitable that socially disadvantaged households are also energy poor, low income is not the only cause of energy poverty. Analyses conducted in other countries show that energy poverty is caused by several factors, from the already mentioned low income, to low energy efficiency of households, which entails high consumption and energy costs, to higher energy needs (such as in households with more members, pensioners who spend most of their time in their homes, families with children). Therefore, socially vulnerable households represent only a subset of energy vulnerable households and most often represent households with the most acute problem of energy poverty. By focusing on socially disadvantaged households as the only category of energy poor customers, other categories of households that also suffer from the problem of energy poverty are neglected.

Therefore, it is necessary to develop the Program for elimination of energy poverty. Within the Program, the following will be achieved:

- Establish the definition of energy poverty
- Evaluate the scope and socio-economic characteristics of energy poor households,
- Establish the objectives of measures to combat energy poverty,
- Establish indicators for monitoring the success of the implementation of the energy poverty elimination program,
- Provide energy consulting for all energy-poor citizens of the Republic of Croatia,

- Establish a system of measuring and monitoring energy poverty indicators at the national level and
- Establish a system of increasing energy efficiency at the level of energy-poor households and households at risk of energy poverty.

The list of priorities for the implementation of technical measures, the degree of co-financing and sources of funding will be elaborated in the Program for Elimination of Energy Poverty, which will be adopted by the end of 2024. The plan for the use of funds obtained from the sale of emission allowances through auctions in the Republic of Croatia for the period until 2020 (OG No. 19/18, OG No. 84/2019) includes co-financing of measures to eliminate energy poverty.

2.5 Dimension: research, innovation and competitiveness

i. National goals and objectives for financing public and private research and innovation related to the Energy Union

The Republic of Croatia has set a goal to reach investments in research, development and innovation in the amount of 1.4% of GDP by 2020, and the share of the total allocation for research and development in Croatia in 2021 was 1.24% of GDP[17]. Croatia's goal is to reach a level of 2.5% by 2025 and 3% by 2030[18]. The share of research and innovation related to the Energy Union has not been determined. Total budget investments for research and development amounted to 0.71% of GDP in 2021 (i.e., 102 euros per capita, of which 0.7 euros per capita for energy and 1.1 euros per capita for the environment).[19] Regarding private financing, according to the draft of the Smart Specialization Strategy until 2029, it is envisaged to increase operating expenditure for research and development (BERD) from 0.6% of GDP to 1% of GDP%. Amendments to the Act on State Aid for Research and Development Projects and defining the conditions of tax relief for conducting basic research, applied research or experimental development are envisaged. State aid programs have been adopted to establish new businesses and demonstrate an innovative concept. [20]

The draft of the Smart Specialization Strategy until 2029 aims to achieve progress on the *European Innovation Scoreboard* from 25th to at least 18th place.

[17] Eurostat, 2023

[18] The target by 2025 is defined by the Government Programme of the Republic of Croatia 2020-2024, and by 2030 by the National Development Strategy of the Republic of Croatia until 2030

[19] Eurostat, GBARD by socioeconomic objectives, 2023

[20] State aid scheme for projects establishing start-up spin offs of young researchers' enterprises, adopted in February 2023, State aid scheme for projects proving an innovative concept, adopted in July 2022.

ii. If applicable, national targets by 2050 relating to the promotion of clean energy technologies and, if needed, national targets that include long-term goals (2050) for the use of low carbon technologies, including targets for the decarbonization of energy intensive industrial sectors and industrial sectors with a high carbon share and, if applicable, targets for carbon storage and transport infrastructure

The Republic of Croatia has increased investment in research, development and innovation, and investment in the transfer of knowledge and technologies and the development of knowledge and innovation-based technologies through various programs - from grants and loans to state aid programs. In the draft of the Smart Specialization Strategy until 2029 (hereinafter: S3), 4 of the 7 identified thematic priority areas (TPAs) are linked to low-carbon targets, energy efficiency and adaptation to climate change:

- Smart and clean energy
- Smart and green transport
- Sustainable and circular food
- Customized and integrated wood products

Also, within S3, indicative lists of interventions have been made according to individual TPAs, which include projects in the field of Smart and Clean Energy and Smart and Green Transport: microgrid pilot projects, development of a technological centre for smart and green mobility.

TPA ***Smart and Clean Energy*** includes plans for applied research (research projects) in areas such as smart grid technology, waste-to-energy conversion, energy storage, carbon capture (a key link in greening the energy sector) - solutions for capturing and storing CO_2, and to produce green energy using CO_2. This is complementary to the implementation of the 2026 carbon capture pilot project planned under the NPOO (C1.2.R1-I3), green thermal energy, geothermal energy, hydrogen (research of hydrogen-based decarbonisation solutions, applied research and development related to low-carbon production, distribution, storage and use of hydrogen in industrial processes and transport). In addition to the aforementioned microgrid pilot project, the public procurement of innovative solutions and the assessment of the existing data regulation framework are planned, with the aim of possible liberalisation of access to certain energy-related data, revision of microgrid regulations and construction of a biorefinery for the production of advanced biofuels (NPOO investment (C1.2.R1-I4).

The ***Smart and Green Transport*** TPA includes plans to turn towards environmentally friendly and digitalized transport solutions and technologies by encouraging research and innovation activities related to sustainability, technological optimization and relevant application of ICT solutions related to transport and mobility. Such activities could be supported by decarbonization and development of integrated systems, the use of the Internet of Things (IoT) and data-driven innovation. More specifically, investments in **applied research projects** will be made, e.g. in the following areas:

• development of software for engine testing,

• advanced production methods (e.g. 3D printing, precision and/or robotic production),

• artificial intelligence and machine learning in the transport system (e.g. logistics optimization, vessel autonomy, railway safety, infrastructure monitoring),

• functional security (e.g. software maturity, resilience, security, safety assessment models for new technologies, advanced crash and passenger safety systems),

• fuel storage and low greenhouse gas emissions operation for marine vessels, road vehicles, mobile machinery and locomotives,

• new and advanced materials (e.g. high-strength steel, non-ferrous metal alloys and carbon fibre composites); and

• electronic devices, sensors and components,

then in the establishment of the Technology Centre for Smart and Green Mobility (for smart and environmentally friendly transport solutions), in the public procurement of innovative solutions, in the projects under the European Battery Innovation (EuBatIn), in the infrastructure for vehicles and vessels using alternative fuels (e.g. charging stations for electricity, hydrogen and natural gas), in the regulatory review and reform activities to stimulate the green transition, in vocational skills, in the establishment of a centre for intelligent transport systems, etc.

For specific technologies, the Hydrogen Strategy (OG No. 40/2022) sets the following goals related to encouraging the development of science, research, and development of hydrogen technologies.

Strategic goal	Performance indicator	Initial value 2021/2022	Target 2030	Target 2050
Encouraging the development of science, research, and development of hydrogen technologies	Number of patents related to the hydrogen-based economy Unit of measure: number Code: II.02.6.51	0	5	50

iii. If applicable, national goals regarding competitiveness

Competitiveness is a broad issue that goes beyond the scope of the National Energy and Climate Plan. According to data for 2019, Croatia was ranked 63rd in the global competitiveness index, and the National Development Strategy for 2030 sets the goal of Croatia being among the 45 most competitive economies in the world. In the S3 draft, a goal has been set related to the regional scale of success in innovation, that by 2030 Croatia ranks at least 38th according to the European Regional Competitiveness Index.

The Republic of Croatia currently has no defined national goals for competitiveness related to the Energy Union. The national goals, indicators needed to monitor the achievement of goals and data sources will be defined by the Committee for Intersectoral Coordination for Policies and Measures for Climate Change Mitigation and Adaptation (envisaged by measure MS-1). The MESD will establish a system for monitoring the achievement of goals.

3 POLICIES AND MEASURES

3.1 Dimension: decarbonization

3.1.1 Emissions and elimination of greenhouse gases

i. Policies and measures to achieve the target defined in Regulation (EU) 2023/857 as specified in section 2.1.1. and policies and measures for compliance with Regulation (EU) 2023/839, covering all key sectors generating high emissions and sectors for strengthening elimination of emissions, within the framework of a long-term vision and a long-term target to become a low-emission economy and to achieve a balance between emissions and their elimination in accordance with the Paris Agreement

Measures are specified for the following sectors significant for greenhouse gas emissions: cross-sectoral measures, industrial processes, waste management, agriculture and LULUCF.

Cross-sectoral measures are specified below.

MS-1 Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change

Regulatory measure; implementation 2021-2030

Objective and description of the measure: Pursuant to the Air Protection Act (OG Nos. 130/11, 47/14, 61/17, 118/18), the Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change was established by the Decision of the Government of the Republic of Croatia in 2014 (OG Nos. 114/14, 9/18). The Committee gives recommendations to the Government of the Republic of Croatia on the overall policy and measures for mitigation of and adaptation to climate change and ensures political support to the implementation of the policy and measures for mitigation of and adaptation to climate change. The Committee also proposes to the Government of the Republic of Croatia the adoption of strategic planning documents and regulations pertaining to policies and measures for climate change mitigation and adaptation, proposes public policy objectives, measures and activities and monitors their effects and outcomes in implementation, and proposes and supports the promotion of interdisciplinary and synergistic public policy objectives, measures, and activities. The composition, tasks, and the manner of work of the Committee shall be determined by the Government of the Republic of Croatia at the suggestion of the ministry responsible for the environment. The task of the Committee is to monitor the implementation of the Integrated Energy and Climate Plan and the achievement of set targets, both in terms of reducing greenhouse gas emissions and other targets by dimensions.

In 2019, the Act on Climate Change and Protection of the Ozone Layer (OG No. 127/19) was adopted, which defines the competence and responsibility for climate change mitigation, climate change adaptation and protection of the ozone layer, as well as the work of the Commission for Cross-Sectoral Coordination for Policy and Measures for Climate Change Mitigation and Adaptation (Article 26). A decision is under way to establish a new Commission

for Cross-Sectoral Coordination for Policies and Measures for Climate Change Mitigation and Adaptation with two technical working groups on 1) climate change mitigation and 2) climate change adaptation.

Funds needed for implementation: regular work of state bodies

Executive Body: MESD

Monitoring (supervisory) bodies: MESD

Impact: Indirect contribution to reduction in greenhouse gas emissions.

Monitoring method: Number of meetings and number and structure of participants.

Connection to other dimensions: The measure is related to all five dimensions.

Connection to climate change adaptation: The Committee is also responsible for climate change adaptation.

Research and development: Have impact, in the context of monitoring the implementation and achieving goals.

MS-2 Encouraging the establishment of regional energy and climate agencies and capacity building

Organizational and financial measure; implementation 2021-2030

Objective and description of the measure: Regional energy agencies do not currently operate on the entire territory of the Republic of Croatia, and capacity building of existing regional energy agencies in the field of climate change mitigation and resilience and adaptation to climate change and their transformation into energy and climate agencies is needed. The aim of this measure is to encourage the establishment of regional energy and climate agencies for the areas of the Republic of Croatia where they do not operate, and capacity building aimed at transforming existing energy agencies into energy and climate agencies.

Funds needed for implementation: approximately EUR 200,000 annually for a period of 3 years for the establishment of one regional energy and climate agency.

Sources of financing: EU funds, funds of regional/local self-government units

Executive Body: MESD

Monitoring (supervisory) bodies: MESD

Impact: Establishment of a regional energy and climate agency and transformation of existing regional energy agencies into regional energy and climate agencies.

Monitoring method: Number of newly established energy and climate agencies, number of agencies transformed.

Connection to other dimensions: The measure is related to all five dimensions

Connection to climate change adaptation: Regional energy and climate agencies will implement energy projects and projects for climate change adaptation and increasing the resilience of cities and regions.

MS-3 The EU emissions trading system

Regulatory measure; implementation 2021-2030

Objective and description of the measure: The EU emissions trading system (EU ETS) includes all the activities listed in Annex I to the Regulation on the method of greenhouse gas emission allowances trading (OG No. 89/20), adopted based on the Act on Climate Change and Protection of the Ozone Layer (OG No. 127/19) and operators of facilities and operators of airplanes included in the system are responsible for reducing greenhouse gas emissions. Through an even allocation of emission allowances, participants in the system from all Member States took on an obligation of reducing emissions for the purposes of contributing to a reduction in emissions by at least 21 % by 2020 and by at least 62% by 2030 compared to 2005 levels. This leads to the conclusion that the reduction of emissions from activities within the EU ETS is regulated at the EU level (2030 Climate and Energy Policy Framework). Since 1st January 2013, the Republic of Croatia is integrated into the EU ETS. Operators of facilities and operators of airplanes, in accordance with the EU ETS rules, obtained greenhouse gas emissions permits and established a regime for monitoring emissions and delivering verified reports to the competent authority. Greenhouse gases covered by the EU ETS are: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). All operators except for electricity producers have submitted their requests for issuing free emission allowances. Free emission allowances are allocated to facilities, based on benchmarks defined in accordance with the reference value for 10% of the most efficient facilities in the same sector. Operators who will not have enough free allowances to cover their greenhouse gas emissions have the option of purchasing emission allowances through auctions or on the secondary ETS market (Ordinance on the method of free allocation of emission allowances to facilities and on the monitoring, reporting and verification of reports on greenhouse gas emissions from facilities and aircrafts, OG No. 89/20).

The Act on Climate Change and the Protection of the Ozone Layer (OG No. 127/19), which transposes into the Croatian legal system the relevant EU regulations for the establishment and functioning of the EU ETS, regulates the monitoring of and reporting on greenhouse gas emissions, the greenhouse gas emissions trading system, aviation activities and sectors outside the greenhouse gas emissions trading system. On the basis of this law, by-laws were also adopted (Regulation on the method of greenhouse gas emission allowance trading and Ordinance on the method of free allocation of emission allowances to facilities and on the monitoring, reporting and verification of reports on greenhouse gas emissions from facilities and aircrafts, OG No. 89/20) and two sectoral strategies were adopted: the Strategy for Climate Change Adaptation in the Republic of Croatia for the period up to 2040 with an outlook to 2070 (OG No. 46/20) and the Low Carbon Development Strategy of the Republic of Croatia by 2030 with an outlook to 2050 (OG No. 63/21), the next revision of which will determine the manner of achieving net zero greenhouse gas emissions by 2050, and in this regard the increase in ambition by 2030. The revision will follow the amendment and adoption of the EU climate and energy legislation, which also includes the reform of the existing ETS system and the establishment of a separate ETS system for transport and buildings.

Activities: The following will be implemented within the framework of the measure:

- continuation of activities of EU ETS participants (facility operators and aircraft operators): updating of greenhouse gas emission monitoring plans, preparation of greenhouse gas emission reports, preparation of the verification report, preparation of the improvement report (if necessary), emissions trading at the primary and secondary market, submission of emission allowances, etc.;
- activities of other EU ETS participants (MESD, verifiers, brokers…)
- activities of new EU ETS participants (ship operators): updating of greenhouse gas emission monitoring plans, preparation of greenhouse gas emission reports, preparation of the verification report, preparation of the improvement report (if necessary), emissions trading at the primary and secondary market, submission of emission allowances, etc.
- activities of participants of a special EU ETS system (regulated entities): preparation of greenhouse gas emission monitoring plans, preparation of greenhouse gas emission reports, preparation of the verification report, preparation of the improvement report (if necessary), emissions trading at the primary and secondary market, submission of emission allowances, etc.

Funds needed for implementation: €350 million per year (assuming a cost of emission allowances of €100)

Sources of funding: funds of EU ETS obliged entities

Executive Body: MESD

Monitoring (supervisory) bodies: MESD

Impact: The targeted reduction in greenhouse gas emissions is at least 2.2% per year (the new targeted reduction by 4.3 % by 2024 and 4.4% by 2028), by increasing energy efficiency, using renewable energy sources and other measures to reduce emissions (undesirable: reducing production in facilities or reducing the number and length of flights of airlines).

Monitoring method: Preparation and verification of GHG emission reports.

Connection to other dimensions: The use of renewable energy sources (decarbonisation) and increase in energy efficiency is encouraged, with the aim of reducing greenhouse gas emissions of EU ETS obliged entities.

Connection to climate change adaptation: When deciding on measures to reduce greenhouse gas emissions, it is necessary to consider the impact and adaptation to climate change (it is possible that climate change will make it difficult to implement certain measures to reduce greenhouse gas emissions).

Research and development: Innovation Fund and Modernization Fund, within the EU ETS, co-finance research and development of emission-free or low-greenhouse gas emission technologies.

MS-4 Strategic planning at the regional and local level

Organizational measure; implementation 2024-2030

Objective and description of the measure: Regional and local self-government units play an important role in achieving climate goals, which define measures for climate change mitigation and adaptation for their territory through strategic planning.

Counties, the City of Zagreb, and large cities are obliged to adopt programs for climate change mitigation, adaptation to climate change and protection of the ozone layer, which is an integral part of the umbrella program of environmental protection (Act on Climate Change and the Protection of the Ozone Layer, OG No. 127/2019). Environmental protection programmes are adopted by the representative body of a county, the City of Zagreb, and a large city for a four-year period, after which reports on the implementation of the Programme are prepared (Environmental Protection Act OG Nos. 80/13, 153/13, 78/15, 12/18 and 118/18). Of the 37 obliged entities, 8 have adopted Environmental Protection Programmes with programs of climate change mitigation, adaptation to climate change and protection of the ozone layer (http://dokumenti.azo.hr/).

In 2008, the European Commission launched an initiative called the European Covenant of Mayors for Climate and Energy to encourage and assist local authorities in implementing climate and energy objectives. Cities and municipalities are voluntarily involved, individually or jointly, and by signing the Covenant, commit to act and develop a Sustainable Energy Development and Climate Adaptation Action Plan (SECAP), and report on its implementation every two years.

This initiative was endorsed by more than 100 cities and municipalities in the Republic of Croatia, so that the Covenant of Mayors covers over 2 million inhabitants in the Republic of Croatia, but only a part of them has adopted documents and prepared reports.

Therefore, the aim of this measure is to improve strategic planning at the regional and local level.

Activities: The following will be implemented within the framework of the measure:

- Development of Sustainable Energy and Climate Action Plans (SECAP) for cities and municipalities signatories to the Covenant of Mayors and adopting a common approach to addressing climate change mitigation and adaptation within two years of accession to the Covenant.
- Monitoring progress towards the SECAP target (reporting on progress of plan implementation every two years);
- Coordination of monitoring and implementation of activities envisaged in individual SECAPs and within the Integrated Energy and Climate Plan;
- Development of a national programme for monitoring the implementation of adaptation measures defined in the adopted SECAPs for cities and municipalities
- Development of guidelines for validation and verification of adaptation measures
- Use of data on activities and projects carried out within each SECAP during each subsequent revision of the Integrated Energy and Climate Plan.

Sources of funding: EPEEF, budget of cities and municipalities, EU projects

Executive body: EPEEF

Monitoring (supervisory) bodies: MESD

Impact: Reducing energy consumption and greenhouse gas emissions.

Monitoring method: Number of municipalities and cities signatories to the Covenant, number of SECAPs produced, reports on the progress of implementation of the plan at the municipality or city level.

Connection to other dimensions: The Covenant of Mayors encourages the use of renewable energy sources (decarbonisation) and increases energy efficiency, with the aim of reducing greenhouse gas emissions.

Connection to climate change adaptation: Climate change adaptation and climate change risk and vulnerability assessment of cities and municipalities are part of SECAP.

Research and development: The measure is indirectly connected to research and development and innovative measures to reduce greenhouse gas emissions.

MS-5 Establishing a platform for the collection, use and storage of CO_2

Research and analytical measure; Financial measure; implementation 2021-2030

Objective and description of the measure: According to Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 (Text with EEA relevance) (OJ L 140, 5th Jun 2009), that is, Article 36 of the Industrial Emissions Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) (recast) (Text with EEA relevance) (OJ L 334, 17th Dec 2010), for power plants of more than 300 MW which have been granted a construction permit after the entry into force of Directive 2009/31/EC on geological storage of carbon dioxide, it is necessary to evaluate whether the following conditions are met: a) availability of a suitable location for storage, b) transport facilities are technically and economically feasible and c) upgrade of facilities for CO_2 capture is technically and economically feasible. If these conditions are met, the competent authority shall ensure at the site of the facility the appropriate space for equipment for CO_2 capture and compression. This is regulated by the Hydrocarbon Exploration and Exploitation Act (OG Nos. 52/18, 52/19, 30/21), which enables CO_2 storage on the territory of the Republic of Croatia. This method should be further developed and the potentials and possibilities for this technology should be considered at the national level. In view of this, there are plans for the development of a storage capacity evaluation study, as well as the National Feasibility Study with the action plan for preparatory activities for carbon capture and storage projects. This study will cover the capture stages on emission sources, transport, injection and storage of CO_2, and the interconnection of the CO_2 transport system with other EU countries. By the end of 2026, a pilot project will be implemented that will enable the development and commercialization of the CO_2 capture and storage process, for which an investment of about EUR 14 million is planned through the NPOO.

Activities: The following will be implemented within the framework of the measure:

- Conducting research into the potential for geological storage of CO_2 in the Republic of Croatia;
- Developing/amending the evaluation study of storage capacities available in the territory of the Republic of Croatia
- Implementation of CO_2 geological storage projects in the Republic of Croatia in accordance with expressed potentials;
- Preparation of a strategic study of the impact of the permanent carbon dioxide disposal on the environment;
- Informing the interested public about CO_2 capture and storage technology;
- Implementation of a pilot project for the capture and geological storage of CO_2.

Funds needed for implementation: EUR 300,000 for the study and action plan, and for the implementation of projects the amount will be determined after the analysis of potentials

Sources of funding: EU funds, state budget

Executive body: CHA

Monitoring (supervisory) bodies: MESD

Impact: Reduction in greenhouse gas emissions.

Monitoring method: The executive body shall submit to the monitoring body a Study with an Action Plan. Geological CO_2 storage projects will be monitored by annual reports submitted by the executive body (CHA) to the monitoring body (MESD).

Measure implementation indicator (indicator): Annual amount of CO_2 permanently stored in geological structures.

Connection to other dimensions: The implementation of the measure has a direct impact on research, innovation, and competitiveness.

Connection to climate change adaptation: The measure directly affects the reduction of CO_2 emissions.

Research and development: The measure is directly connected to research and development and innovative measures to reduce greenhouse gas emissions.

MS-6 Improving sustainability of urban areas

Financial measure; implementation 2023 --2030

Objective and description of the measure: The aim of this measure is to encourage cities and municipalities to build projects for revitalization and development of new urban environments on sustainability principles. The first step in achieving this goal was the development of the Programme for the Development of Green Infrastructure in Urban Areas for the period 2021-2030 and the Circular Spatial and Building Management Development Programme for the period 2021-2030, which were adopted by the Government of the Republic of Croatia in December 2021, and represent the national framework for the development of sustainability

in urban areas. The programmes aim to improve the environmental, economic and social benefits of sustainable development, through increasing the energy efficiency of buildings, developing green infrastructure in urban areas, reducing the temperature in the areas of heat islands, and encouraging circularity measures when planning new buildings, reusing abandoned and/or neglected existing spaces and buildings, reducing the amount of construction waste in urban areas. The next step is the implementation of the adopted Programmes, which envisages the development of studies, strategies and/or urban development plans, in which, based on the analysis of the current situation, and the development of studies and strategies, development projects will be defined that will improve the development of cities and municipalities. The projects are co-financed by the EU's Recovery and Resilience Mechanism, as part of the Reconstruction of Buildings initiative, reform C6.1.R5 "Introduction of a new model of green urban renewal strategies and implementation of a pilot project for the development of green infrastructure and circular management of space and buildings" and from the ESI Funds within the Competitiveness and Cohesion Programme 2021-2027, in line with the target for the period 2021--2027 PO2 "Greener, resilient Europe with low carbon emissions transitioning to zero net carbon emissions rate by promoting the transition to clean and equitable energy, green and blue investments, a circular economy, climate change mitigation and adaptation, risk management and prevention and sustainable urban mobility".

Activities: The following activities will be implemented within the measure:

- Implementation of measures and activities set out in the Programme for the Development of Green Infrastructure in Urban Areas for the period 2021-2030 (OG No. 147/21).
- Implementation of measures and activities set out in the Circular Spatial and Building Management Development Programme for the period 2021-2030 (OG No. 143/21).

Funds needed for implementation: Estimated cost for the implementation of programme activities in the period 2021-2030 is EUR 1,142,528,933.57 (HRK 8,608,384,250.00).

Sources of funding: MPPCSA, EU funds

Executive body: MPPCSA, RLSUs and City of Zagreb

Monitoring (supervisory) bodies: MPPCSA

Impact: Reduction of heat demand and energy consumption in public and residential buildings and increase in RES usage and consequently reduction in CO_2 emissions;

Monitoring method: Number of LSGUs with developed strategies, number of implemented (pilot) projects, area of new and improved green infrastructure, area of circularly renovated buildings, reduction of projected energy consumption in circularly renovated buildings.

Connection to other dimensions: The measure is innovative and enables the development of urban environments that will contribute to decarbonization and energy efficiency, but will also have numerous other social, economic, and environmental benefits.

Connection to climate change adaptation: With the development of green infrastructure in urban areas, buildings and construction areas become more resilient to some of the effects of climate change (e.g. extreme temperature conditions, urban heat islands, etc.).

Research and development: The measure is directly linked to research and development and innovative measures to improve the sustainability of urban areas.

MS-7 Establishing the Programme to Calculate and Reduce the Carbon Footprint of Economic Operators and Public Sector Entities

Regulatory measure; implementation 2021-2030

Objective and description of the measure: The objective of the measure is to establish a Programme for the calculation and reduction of carbon footprint of non-ETS entities (economic operators and public sector), to reduce the total greenhouse gas emissions for all activities which the entity is responsible for or dependent upon. It is necessary to calculate direct greenhouse gas emissions and their removal at the location of the entity, whether due to combustion of fuel in the thermal power plant, from the production process and/or from the company vehicles, and fugitive emissions, then indirect emissions that occur outside the entity's location, related to the procurement and consumption of electricity, heat and cooling energy, but also other indirect emissions/removals related to human and material flows. The carbon footprint calculation will enable entities to familiarize themselves with the structure of greenhouse gas emissions, and to identify activities that most significantly contribute to the reduction in emissions, which is a good basis for the development and implementation of the Action Plan for the carbon footprint reduction. The implementation of the Action Plan would lead to a reduction in greenhouse gas emissions and mitigation of climate change, which would mean easier fulfilment of commitments under the Paris Agreement.

Activities: The following activities will be implemented within the measure:

- development of a national base of greenhouse gas emission factors (implemented activity)
- implementation of a pilot project for the calculation of the carbon footprint in selected public administration bodies (implemented activity)
- establishing and implementing a voluntary programme for the calculation and reduction of the carbon footprint;
- monitoring and analysis of the achieved reduction in the carbon footprint of entities;
- the adoption of a by-law that will establish the obligation to calculate carbon footprints and develop an action plan to reduce the carbon footprint of economic operators and public sector entities will be considered.

Sources of funding: EPEEF (co-financing of carbon footprint calculations and development of action plans for non-ETS economic operators), Operational Programme Competitiveness and Cohesion 2021-2027; regular work of state bodies

Executive body: MESD, EPEEF

Monitoring (supervisory) bodies: MESD

Impact: Increasing energy efficiency, increasing RES usage, promoting sustainable use of resources and the circular economy, and mitigating climate change by reducing the greenhouse gas emissions of businesses.

Monitoring method: The number of economic operators calculating the carbon footprint, developing an action plan, implementing measures and monitoring the impact of measures by reducing greenhouse gas emissions; analysis of non-financial reports in the Register of annual financial reports kept by the Financial Agency; calculating the annual reduction in greenhouse gas emissions for all economic operators participating in the voluntary/ mandatory programme of carbon footprint calculation and reduction.

Connection to other dimensions: The calculation and reduction of carbon footprint of economic operators contributes to other dimensions, to increasing energy efficiency and greater use of RES (decarbonisation). The implementation of the measure also has an indirect impact on increasing energy security and on research, innovation, and competitiveness.

Connection to climate change adaptation: The implementation of measures to reduce the carbon footprint of economic operators is planned along with the integration of climate change adaptation measures and strengthening of resilience, i.e., reduction of vulnerability of RES technologies to climate change.

Research and development: The implementation of innovative measures to reduce carbon footprints because of research and development is encouraged.

MS-8 Establishing a digital circular economy platform

Informative, educational, regulatory measure; implementation: 2021 - 2030

Objective and description of the measure: The new Circular Economy Action Plan, COM (2020) 98 final, presents a set of interconnected initiatives to establish a robust and coherent policy framework in which sustainable products, services and business models become the standard and consumption patterns are transformed so that waste is not produced. This product policy framework is gradually introduced, with value chains of key products as a priority.

The circularity rate of the Croatian economy is very low, which means that most of the materials we consume do not return to the economy as raw materials. It is necessary to elaborate a systematic approach in all value chains relevant to the Croatian economy, which include measures listed in the New Circular Economy Action Plan, based on which the EC integrates the principles of the circular economy into the production and consumption of plastic, water management, food systems, management of special waste flow, etc.

A successful transition of Croatia to a circular economy requires a political and economic response that entails close cooperation of all stakeholders: government, businesses, civil society, academia, media, and citizens. To this end, the World Bank has supported the establishment of the Circular Economy Committee, an interdisciplinary advisory body of the Ministry of Economy and Sustainable Development (MESD). Board members come from 14 organisations and professional associations representing all key sectors - public, private, scientific-research and civil. The Committee's task is to exchange knowledge and provide expert support to strengthen cooperation between all sectors and to guide the way of thinking to improve the longevity of products and their recycling. One of the initiatives of the Committee is the establishment of a digital platform for the circular economy - a space for sharing knowledge, innovation, and best practices among all stakeholders. In the future, such a platform could be a physical place where circular technologies could be demonstrated,

adapted, and recreated at the level of a small household or production line. According to circular economy stakeholders, it is necessary to draw up a National Action Plan for the transition to a circular economy through the adjustment of the legislative framework. The inclusion of representatives of the Republic of Croatia in the European Circular Economy Stakeholder Platform enables direct access to and cooperation in innovation and best practices. The measure is linked to MS-12 and all measures in the Waste and Circular Economy sector.

Activities:

- Establishment of the Circular Economy Committee;
- Establishment of a digital circular economy platform;
- Developing a National Action Plan for the transition to a circular economy;
- Inclusion of representatives of the Republic of Croatia in the European Platform of Circular Economy Stakeholders.

Sources of funding: Use of EU funds, the Environmental Protection and Energy Efficiency Fund, development bank loans (World Bank, European Bank for Reconstruction and Development, European Investment Bank).

Executive Body: Ministry of Economy and Sustainable Development (MESD)

Monitoring (supervisory) bodies: Ministry of Agriculture (MA), Ministry of Physical Planning, Construction and State Property (MPPCSA), Ministry of Science and Education (MSE), Croatian Chamber of Economy (CCE).

Impact:

- Encouraging sustainable use of resources and circular economy;
- Mitigating climate change through reducing greenhouse gas emissions;
- Direct access to innovation and best practices through the European Platform of Circular Economy Stakeholders;
- National action plan for the transition to a circular economy through the adaptation of the legislative framework.

Monitoring method:

- Report on the implementation of policies and measures to reduce greenhouse gas emissions;
- Inclusion of representatives of the Republic of Croatia in the European Platform of Circular Economy Stakeholders.

Measure implementation indicator: Direct access to innovation and best practices through the European Platform of Circular Economy Stakeholders.

Connection to other dimensions: Research, innovation, and competitiveness

Connection to climate change adaptation: Increasing resistance to the consequences of climate change.

Research and development: Direct access to innovation and best practices through the European Platform of Circular Economy Stakeholders.

MS-9 Transformation of the bioeconomy sector

Informational, educational, regulatory measure; implementation: 2024 -2030

Objective and description of the measure:

In the Bioeconomy Strategy 2018[21], the European Commission additionally emphasized the importance of the bioeconomy as a sector that, in addition to increasing the competitiveness of production and creating new jobs in the EU, will greatly contribute to mitigating climate change. The European Commission added reducing dependence on non-renewable sources, strengthening European competitiveness and creating jobs to the goals of the 2012 Bioeconomy Strategy (achieving food security, sustainable management of natural resources and mitigating and adapting to climate change).

In order to encourage the development of the bioeconomy in Croatia, it is necessary to connect three key aspects: the development of new technologies and processes; market development and competitiveness of bio-based sectors and political will for policy and stakeholder cooperation. This will ensure the transformation of the existing "traditional" stakeholders of the bioeconomy from the agriculture, forestry, fishing and aquaculture sectors as well as the food, wood, pharmaceutical and chemical industries into new, modern stakeholders of the low-carbon bioeconomy. For the transition to a low-carbon bioeconomy, it is necessary to connect stakeholders (producers, industry, researchers with policy makers) in the exchange of information and the establishment of value chains in accordance with market requirements.

Activities: Within the framework of this measure, it is necessary to carry out various activities that will contribute to the strengthening of the Croatian bioeconomy, which includes the removal of administrative and other obstacles, the promotion of research, the improvement of the biomass market and the support of production in the bioeconomy: the exchange of information through the Central Portal for Bioeconomy in Croatia, the planning of centres for collection and processing of biomass, co-financing of investments in the construction and modernization of capacities in the bioeconomy sectors, and encouragement of innovative solutions in bio-based industrial production.

- Mapping of stakeholders in the bioeconomy;
- Raising the level of knowledge about bioeconomy;
- Transformation of existing “traditional” bioeconomy stakeholders into new, modern low-carbon bioeconomy and sustainable development stakeholders;

[21] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Sustainable bioeconomy for Europe: Strengthening the link between economy, society and environment

- Adjustment of the system for the use of EU funds intended for bioeconomy transition;
- Linking national stakeholders with stakeholders at the EU and international level.

Sources of funding: State budget, Competitiveness and Cohesion Program 2021-2027, Integrated Territorial Program, Strategic Plan of the Common Agricultural Policy of the Republic of Croatia for the period 2023-2027, Modernization Fund, Fund for Environmental Protection and Energy Efficiency, Innovation Fund, Horizon Europe Program.

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: Ministry of the Economy and Sustainable Development (MESD), Ministry of Regional Development and EU Funds.

Impact:

- Development of new technologies and processes;
- Market development and competitiveness of sectors based on the principles of the circular bioeconomy;
- Achieving the objectives of development based on low levels of carbon dioxide and other greenhouse gas emissions;
- Sustainable use of resources;
- Development of rural areas;
- Encouraging investment in technology and innovation.

Monitoring method:

- Report on the implementation of the Bioeconomy Strategy until 2035.

Measure implementation indicator: Direct access to innovation and best practices through connecting with EU bioeconomy initiatives.

Connection to other dimensions: Research, innovation, and competitiveness

Connection to climate change adaptation: Increasing resilience to the effects of climate change.

Research and development: Direct access to innovation and best practices through connecting manufacturers, industry and research.

MS-10 Legal adjustments and technical backgrounds for the introduction of hydrogen into the energy system

Regulatory and financial measure; implementation 2024-2030

The role of hydrogen in energy and transport systems of the future is expected to be more significant, especially as the goals for reducing greenhouse gas emissions are more ambitious. It is therefore necessary to identify, in a timely manner, the opportunities associated with the use of hydrogen, to consider its use in the coming decade, and to explore the possibilities of financially stimulating hydrogen production and consumption. To this end, a hydrogen

technology platform will be established, bringing together national stakeholders relevant to the research and application of hydrogen technology, monitoring the development of hydrogen technologies at the EU and international level, and serving as a link between national, EU and international levels. The aim of the measure is to present possible areas of development, financing, and support in the implementation of the strategy and specific projects for the development of hydrogen technology to achieve the objectives defined in the Strategy. In addition, it is necessary to adopt a relevant legislative framework that will enable the implementation of hydrogen in the energy system.

Activities:

- Technical background for the adoption of the Action Plan for the implementation of the Croatian Hydrogen Strategy from 2021 to 2050 (by the end of 2024).
- Adjustment of the legislative framework for the introduction of hydrogen into the energy system (by the end of 2025).

Funds needed for implementation: EUR 500,000 for the development of technical backgrounds.

Sources of funding: State budget

Executive body: CHA in the field of developing technical backgrounds, MESD in the field of adjustment of the legislative framework.

Monitoring (supervisory) bodies: MESD

Impact: The executive body shall provide the monitoring body with the developed Technical Background for the adoption of the action plan.

Monitoring method: Reports

Measure implementation indicator: National, regional, and international cooperation in the field of hydrogen technologies is indispensable for the development of a hydrogen-based economy. The measure will ensure and create conditions for the advancement and competitiveness of the use of hydrogen technologies.

Connection to other dimensions: The measure is linked to the dimension of decarbonisation and energy efficiency and Research, Innovation and Competitiveness.

Connection to climate change adaptation: The measure directly affects the reduction of CO_2 emissions.

Research and development: The measure is related to the research and development of RES technologies and the integration of hydrogen energy systems.

MS-11 Reducing an individual's carbon footprint by changing living habits

Information measure; implementation 2024-2030

Objective and description of the measure:

By changing the lifestyles and styles of individuals and society, a significant reduction in resource consumption and greenhouse gas emissions can be achieved. Therefore, the goal of this measure is to encourage changes in consumer habits, eating habits, habits related to

transportation and travel, ways of using and owning various devices in households, etc., which can be expressed through the reduction of an individual's carbon footprint. However, in order to change our habits, we need to be aware of the impact of our own carbon footprint and know how to reduce it. Therefore, it is proposed to carry out activities that will educate and encourage citizens to change their lifestyle and adopt energy-efficient practices.

Activities:

- Maintenance and regular updating of the national database of greenhouse gas emission factors (MESD)
- Creation and implementation of the Information and Education Program on the topic of changing lifestyles to reduce the carbon footprint (MESD, EPEEF)

Funds needed for implementation: 500,000 EUR per year

Sources of funding: funds obtained from the sale of emission units through auction, EU funds, other available sources

Executive Body: EPEEF

Monitoring (supervisory) bodies: MESD

Impact: Changing habits in the direction of increasing (energy) efficiency, sustainable/circular use of resources, materials and products, avoiding the generation of waste, especially from food, by gradually changing eating habits and movement habits, positive effects on people's health; awareness of the personal role in change and spillover into other aspects of professional life and decision-making, and ultimately mitigating climate change through the reduction of greenhouse gas emissions and the personal carbon footprint.

Monitoring method: Monitoring the implementation of the Information and Education Program (number of published tenders, funds spent on the implementation of the Program)

Connection to other dimensions: Energy efficiency, Energy security

MS-12 Collecting and processing of biomass from agriculture, forestry, fishing and aquaculture

Informational, financial measure; implementation 2024-2030

Objective and description of the measure:

According to the estimate of the European Commission[22], the annual production of biomass in Croatia is 9.3 million tons, of which 70% comes from agriculture and 30% from forestry, which is a relatively large amount of biomass that, in addition to producing bioenergy, could be used for the production of biobased products (food, wood products and furniture, chemical and pharmaceutical products, plastics, rubber, textiles, paper, etc.).

Biomass production from agriculture, according to data from 2019, amounted to 6.7 million tons, with an additional net import of 3.1 million tons. Of the total available agricultural

[22] https://knowledge4policy.ec.europa.eu/visualisation/biomass-flows_en

biomass, 49% was intended for domestic food consumption, 10% was exported, and 41% was leftovers or by-products. The amount of food waste amounted to 298 thousand tons of dry matter. The consumption of agricultural biomass for the production of bioenergy was estimated at 1,000 tons of dry matter.

The production of forest biomass amounted to 2,785 thousand tons of dry matter according to data from 2019, and it is estimated that another 819 thousand tons of forest biomass were available that were not reported. Of the total available forest biomass, 478 thousand tons were exported in the form of logs, 1,594 thousand tons ended up in processing, and the rest was used to obtain energy. 704 thousand tons of sawn timber, 325 thousand tons of pellets and 353 thousand tons of wood processing by-products were exported from Croatia. The specified quantities can be further increased by improving the waste treatment system.

An obstacle in the use of biomass from agriculture is the dispersion in production, which increases the costs of collection. Croatia does not have adequate capacities for the collection and processing of biomass, and by organizing centers for the collection and processing of biomass, opportunities will be created to increase the competitiveness of producers through the valorization of biomass in innovative value chains in the bioeconomy. In addition, the return of biomass to the production cycle contributes to the reduction of the CO_2 footprint of the economy and the efficient use of existing natural resources.

Centers for the collection and processing of biomass represent places where biomass generated in the process of production and processing in agriculture, forestry, fishing and aquaculture is collected, sorted and prepared for the market. Since biomass is a source of renewable carbon, its use in new value chains will contribute many times to the reduction of CO_2.

Activities: The following will be implemented within the framework of the measure:

1. Biomass collection
2. Organizing centers for the collection and preparation of biomass for the market
3. Starting the biomass market
4. Creation of new value chains

Funds needed for implementation: State Budget of the Republic of Croatia, Competitiveness and Cohesion Program 2021-2027, Integrated Territorial Program, Strategic Plan of the Common Agricultural Policy of the Republic of Croatia for the Period 2023-2027, Modernization Fund, Fund for Environmental Protection and Energy Efficiency, Innovation Fund.

Executive body: Ministry of Agriculture

Monitoring (supervisory) bodies: Ministry of Regional Development and EU Funds

Impact:

- Biomass market development and creation of new value chains through organized biomass collection
- Transition to a low-carbon bioeconomy
- Encouraging the development of a circular bioeconomy

- Investments in new technologies and innovative solutions

Monitoring method: Report on the implementation of the Bioeconomy Strategy until 2035.

Measure implementation indicator: Established centers for biomass collection and processing

Connection to other dimensions: Research, innovation, competitiveness

Connection to climate change adaptation: Adaptation to climate change

Research and development: Direct access to best practices in biomass management through linking producers and research.

MS-13 Elimination of fossil fuel subsidies

Financial measure; implementation 2021 - 2030

Objective and description of the measure: To determine the dynamics of the cancellation of subsidies, primarily the exemptions from excise duties in transport, agriculture and fisheries on fossil fuels, it is necessary to carry out an analysis of the current system of subsidies, establish accompanying social programs that will reduce the impact on the poorest citizens and define a plan for their cancellation.

Activities: Analysis of the current system of subsidies, identify accompanying social programs that will reduce the impact on the poorest citizens and define a plan for their cancellation. It is also necessary to analyse the economic impact of the elimination of fossil fuel subsidies and to define the performance indicators of the implementation of the measure.

Funds needed for implementation: Regular work of ministries

Sources of funding: State budget

Monitoring (supervisory) bodies: Ministry of the Economy and Sustainable Development and Ministry of Finance of the Republic of Croatia**.**

Measure implementation indicator: The analysis of the current system of measures would have to be carried out by the end of the second quarter of 2026.

MS-14 Carbon Removal Certification

Financial, environmental and regulatory measure; implementation: 2021-2030

Objective and description of the measure: Carbon certification should increase carbon removal activities in natural reservoirs, geological formations, and products. The achieved carbon removal, after certification and verification of credibility, can be sold on an optional market, thus generating financial revenue for the operator implementing the carbon removal measure.

The European Commission (EC) is preparing a Regulation establishing a Union framework for carbon removal certification. To this end, the EC proposes an EU-wide quality standard for carbon removal certification based on four quality criteria (covered by the abbreviation QU.A.L.ITY): quantification, additionality and baselines, long-term storage, and sustainability.

The problem is that stakeholders do not have trust in carbon removal certificates because these certificates can be generated through non-transparent and unreliable certification procedures for activities that do not bring real climate or sustainability benefits. Also, the problem is that carbon removal service providers face barriers to accessing finance. To address these problems, certification schemes should comply with harmonised certification requirements to ensure transparency and build trust.

The main objectives of the EC initiative are as follows: 1) to ensure a high quality of carbon removal in the EU and 2) to establish an EU management certification system to avoid manipulative green marketing, through correct, reliable, and harmonised application and implementation of the EU's quality framework criteria across the Union.

The EU framework for the certification of carbon removal will be based on or play an important role in facilitating the following Union policies: nature restoration law, the Common Agricultural Policy (CAP), the Renewable Energy Directive and the EU Forest Strategy.

The carbon removal activity must be optional. To this end, the carbon removal activity must meet both of the following criteria: (a) it must go beyond the Union's legal requirements and national legal requirements; (b) it is carried out due to the stimulating effect of certification.

The operator or group of operators must demonstrate that the objective of the carbon removal activity is to ensure long-term carbon storage.

Carbon removal activities must have a neutral impact or bring indirect benefits to all the following sustainability objectives: mitigation of climate change that goes beyond the benefits of net carbon removal; (b) adaptation to climate change; (c) sustainable use and protection of water and marine resources; (d) transition to a circular economy; (e) prevention and control of pollution; (f) protection and restoration of biodiversity and ecosystems.

It is intended that the trading framework be on a voluntary basis, the beneficiaries of certificates are greenhouse gas emitters who can no longer reduce their emissions and can purchase certified carbon removal units (emission offset) for their path towards carbon neutrality.

The Republic of Croatia will develop this measure in line with the progress of the framework prepared by the European Commission.

Carbon certification will refer to the following:

1. Durable solutions for storing atmospheric or biogenic carbon over several centuries, either in geological reservoirs or in other media. Particularly promising solutions are: the use of biofuels with carbon capture and storage (BECCS), Direct air carbon capture and storage (DACCS).
2. Carbon farming and forestry solutions for enhanced carbon capture in soil or living biomass in synergy with other sustainability objectives such as biodiversity: Examples of measures are: afforestation and reforestation, agroforestry, wetland protection, improved forest management, increase of organic carbon in mineral soil, sequestration of blue carbon in marine biomass.

3. Carbon storage in products stores atmospheric or biogenic carbon in materials used to make long-lasting circular cycle products. Examples: biomass in buildings, utilization, and use of captured carbon (CCU).

Activities: A working group was formed to draft the position of the Republic of Croatia on the regulation for the certification of carbon separation. The working group is in session until the adoption of the Regulation, and includes representatives of public institutions, academia, business entities and NGOs. The working group pointed to the problems of reliable monitoring of the effects of the measures, given the high uncertainties of determining carbon content, base solutions and proving additionality. The EU regulation is expected to elaborate a methodology that sufficiently considers the diversity of soil, vegetation and climate in the Republic of Croatia. The fragmentation of land in agriculture is a serious obstacle as administrative costs could be too high.

The following activities are needed to develop a certification system: To categorize the use of land and land cover by harmonizing the existing bases and using remote imaging techniques (LIFE CROLIS project), to define the baselines in relation to which it will be possible to measure progress. Establish a national certification and verification framework. Improving the inventory of greenhouse gas emissions in accordance with the provisions of Regulation 2018/839.

Implementation is expected after 2027.

Funds needed for implementation: Funds will be needed for research to determine the baselines, as national reference control levels. This is mainly ensured in the context of inventory upgrades according to Tier 2 and Tier 3 levels of complexity, for which the necessary funds need to be determined.

Sources of funding: Funds raised by auctions from the EU ETS system, and after the introduction of the system, funds for administrative costs will be collected as compensation for trading transactions.

Executive Body: MESD

Monitoring (supervisory) bodies: MESD, Croatian Accreditation Agency

Impact: Impact cannot be estimated at this time. During the discussion on the implementation of this measure, it was pointed out that Croatia has relatively little potential in forestry because forest management is carried out in a sustainable way, so it will be difficult to apply measures that are additional. In agriculture, the problem is proof of removal, as these are slow changes, and the costs of reliable monitoring, reporting and verification could be higher than the revenue from carbon sales. There are no mapped carbon maps in the soil that could represent reference values.

Monitoring method: The methodology will be determined by the EC Carbon Removal Regulation

Connection to other dimensions: The measure is interdisciplinary.

Connection to climate change adaptation: Implementation of measures to increase carbon in storage facilities increases resilience to climate change.

Research and development: Research is needed on techniques for monitoring changes in carbon stock, in particular possible application of modern technological solutions such as satellite imagery, drone application techniques, and more. It is necessary to support carbon mapping projects in soil, for forest land and for agricultural land. Research related to carbon capture, transport, storage, and utilization techniques should be supported. Research is needed to improve emission inventories, in terms of geo-explicit representations and the application of national data.

The measures related to **industrial processes and use of products** are presented below.

IP-1 Reduction in clinker percentage in cement production

Economic and environmental measure; implementation: 2025 - 2030 (2050)

Objective and description of the measure: Of the total direct carbon dioxide (CO_2) emission from cement production, about 60 percent is related to the clinker production process, and the other 40 percent is due to fuel combustion in a rotary kiln and for other needs in the cement production process. By reducing the clinker content, i.e., by increasing the proportion of mineral additives in cement production, the required amount of clinker produced is reduced, which contributes to the reduction of total CO_2 emissions in cement production. The clinker content in cement is defined by the standard HRN EN 197-1. The increase in the proportion of mineral additives in cement depends on the composition of the raw material, the availability of additives of the appropriate composition on the market and on the market requirements for certain types of cement with a higher proportion of additives and a smaller proportion of clinker.

Activities: The following will be implemented within the framework of the measure:

- defining the availability of raw materials and the necessary mineral additives;
- defining the composition of basic minerals;
- defining the quality of the clinker produced;
- defining the price of mineral additives;
- defining market requirements;
- determining the reduction of CO_2 emissions, the reduction of energy consumption and the reduction of financial expenditure on raw material.

Funds needed for implementation: EUR 1,000,000.00

Sources of funding: Income from the sale of emission allowances, use of funds of the Environmental Protection and Energy Efficiency Fund, the Modernization Fund and the EU structural funds.

Executive body: Cement production operators, Croatia Cement (Association of Croatian Cement Factories), Croatian Chamber of Economy.

Monitoring (supervisory) bodies: MESD

Impact: Reduction of CO_2 emissions, increase in energy efficiency (reduction of specific heat consumption) due to reduced clinker production, reduced financial expenditures on raw material due to lower price of mineral additives.

Monitoring **method: Monitoring of** greenhouse gas emissions and monitoring of the fulfilment of the national annual quota is achieved through the following components:

- National system for calculating and reporting anthropogenic emissions from sources and removals by greenhouse gas sinks,
- National system for monitoring emission reduction policies and measures and estimates,
- Union Register.

Connection to other dimensions: Increase in energy efficiency is encouraged, for the purpose of reducing greenhouse gas emissions from facilities included in the EU ETS.

Connection to climate change adaptation: When deciding on measures to reduce greenhouse gas emissions, it is necessary to consider the impact and adaptation to climate change (it is possible that climate change will make it difficult to implement certain measures to reduce greenhouse gas emissions).

Research and development: Innovation Fund and Modernization Fund, within the EU ETS, co-finance research and development of emission-free or low-greenhouse gas emission technologies.

IP-2 Limiting fluorinated greenhouse gas emissions

Regulatory, economic, educational measure; implementation: 2021 - 2030 (2050)

Objective and description of the measure: Regulation (EU) 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006 Text with EEA relevance (OJ L 150, 20th May 2014) stipulates gradual reduction of emissions of fluorinated gases. The measure defines activities and procedures for the prevention of fluorinated greenhouse gas emissions, conducting equipment leakage checks, use of equipment with leakage detection systems, keeping records of equipment on which leakage checks should be carried out, collection of fluorinated greenhouse gases to ensure their recovery, recovery or destruction, the development of a producer responsibility system for the collection of fluorinated greenhouse gases and their renewal, recovery or destruction, and the implementation of training and certification programmes.

Activities: The following will be implemented within the framework of the measure:

- proper handling of equipment and devices using fluorinated greenhouse gases;
- preventing or eliminating the release of fluorinated greenhouse gases into the atmosphere;
- collection, recovery, and reuse of fluorinated greenhouse gases.

Funds needed for implementation: EUR 1,000,000.00

Sources of funding: Use of funds of the Environmental Protection and Energy Efficiency Fund, the Modernization Fund and the EU structural funds.

Executive Body: MESD

Monitoring (supervisory) bodies: MESD

Impact: Reduction of greenhouse gas emissions, proper collection and handling of fluorinated greenhouse gases during servicing of devices and equipment, prevention or elimination of release into the atmosphere, development of a system of producer liability for the collection of fluorinated greenhouse gases and their recovery, reuse or destruction, and application of training and certification programmes for individuals performing the activities of collection, verification, installation and servicing of equipment and devices containing fluorinated greenhouse gases.

Monitoring method: National system for calculating and reporting anthropogenic emissions from sources and removals by greenhouse gas sinks and national system for monitoring emission reduction policies and measures and estimates.

Connection to climate change adaptation: The measure has a direct impact on reducing greenhouse gas emissions.

Research and development: The measure is indirectly connected to research and development and innovative measures to reduce greenhouse gas emissions.

IP-3 Gradual decrease in the amount of hydrofluorocarbons that can be placed on the market

Regulatory, economic, educational measure; implementation: 2021 -2030 (2050)

Objective and description of the measure: Regulation (EU) 517/2014 introduces a system of quotas for the placing of hydrofluorocarbons on the market. The calculation of the benchmarks and the allocation of quotas should be based on reported quantities of hydrofluorocarbons placed on the market during the reference period 2009-2012. The quotas for the placing hydrofluorocarbons on the market shall be allocated to each producer and importer for each year, beginning in 2015, on the basis of benchmarks, applying defined percentages to calculate the maximum amount of hydrofluorocarbons to be placed on the market and the allocation mechanism.

Activities: The following will be implemented within the framework of the measure:

- limiting the amount of hydrofluorocarbons available on the market.

Funds needed for implementation: No additional funds are required.

Executive body: MESD, Customs Administration.

Monitoring (supervisory) bodies: MESD

Impact: Reducing greenhouse gas emissions, limiting the amount of hydrofluorocarbons available on the market.

Monitoring method: National system for calculating and reporting anthropogenic emissions from sources and removals by greenhouse gas sinks and national system for monitoring emission reduction policies and measures and estimates.

Connection to climate change adaptation: The measure has a direct impact on reducing greenhouse gas emissions.

Research and development: The measure is indirectly connected to research and development and innovative measures to reduce greenhouse gas emissions.

IP-4 Restrictions and prohibitions on launching certain products and equipment on the market

Regulatory, economic, educational measure; implementation: 2021-2030 (2050)

Objective and description of the measure: Fluorinated greenhouse gases with high greenhouse potential are restricted for use in new refrigeration and air-conditioning equipment, fire extinguishing systems, foam suppressants and aerosols.

Activities: The following will be implemented within the framework of the measure:

- limiting the use of fluorinated greenhouse gases with high greenhouse potential in new refrigeration and air conditioning equipment, fire extinguishing systems, foam suppressants and aerosols.

Funds needed for implementation: No additional funds are required.

Executive body: MESD, Customs Administration.

Monitoring (supervisory) bodies: MESD

Impact: Reducing greenhouse gas emissions, limiting the use of fluorinated greenhouse gases with high greenhouse potential.

Monitoring method: National system for calculating and reporting anthropogenic emissions from sources and removals by greenhouse gas sinks and national system for monitoring emission reduction policies and measures and estimates.

Connection to climate change adaptation: The measure has a direct impact on reducing greenhouse gas emissions.

Research and development: The measure is indirectly connected to research and development and innovative measures to reduce greenhouse gas emissions.

The following are measures related to **waste and the circular economy**.

It is necessary to observe the joint effect of the measures since the measures complement each other. The measures include the objectives from the Waste Management Plan of the Republic of Croatia for the period 2017 - 2022 (OG No. 3/17, 1/22):

- Objective 1.1 Reduce the total amount of municipal waste produced by 5%;
- Objective 1.2 Separately collect 60% of the mass of municipal waste produced (primarily paper, glass, plastic, metal, bio-waste);

- Objective 1.3 Separately collect 40% of the mass of bio-waste produced, which is an integral part of municipal waste;
- Objective 1.4 Dispose of in landfills less than 25% of the mass of municipal waste produced;
- Objective 2.2 Establish a system of waste sludge management from wastewater treatment plants;
- Objective 4 Rehabilitate waste contaminated sites;
- Objective 5 Continuously carry out educational and information activities;
- Objective 7 Improve the supervision of waste management.

and obligations of the Republic of Croatia arising from EU legislation and regulations:

- reducing waste disposal and increasing waste recycling.

GO-1 Prevention and reduction of waste generation

Regulatory, environmental, economic, educational measure; implementation: 2021 - 2030

Objective and description of the measure: Waste prevention is a priority in waste management. The prevention and reduction of waste generation is achieved through reuse procedures, by establishing centres for reuse, the use of by-products instruments and the elimination of waste status, and by restricting the placing of certain products on the market. The measure should be achieved through cleaner production, education, information and awareness-raising projects on sustainable waste management, economic instruments, the application of regulations governing waste management and investments in modern technologies that prevent and/or reduce the generation of waste.

Prevention and reduction of waste generation is defined in the Waste Management Act (OG No. 84/21) and the Waste Prevention Plan in the Waste Management Plan of the Republic of Croatia for the period 2017 - 2022 (OG No. 3/17, 1/22).

The Waste Management Act defines goals and deadlines for reducing the total mass of disposed waste, according to which by 2035 the mass of municipal waste can be no more than 10% of the mass of total municipal waste produced.

The Republic of Croatia submitted a request to postpone the fulfillment of the goals and deadlines, because it is among the member states that disposed of more than 60% of municipal waste in landfills in 2013. The European Commission has not yet approved the postponement of the goals and deadlines.

GO-2 Increasing the amount of separately collected and recycled waste

Regulatory, environmental, economic, educational measure; implementation: 2021 - 2030

Objective and description of the measure: The measure includes quantitative goals and deadlines for increasing the amount of separately collected and recycled waste defined by the Waste Management Act (OG No. 84/21) and the Waste Management Plan of the Republic of Croatia for the period 2017 - 2022 (OG No. 3/17, 1/22).

According to the Waste Management Act, in order to contribute to the circular economy, the Republic of Croatia should achieve the following goals:

1. at least 50% of the total mass of waste produced in households and waste from other sources whose waste streams are similar to the stream of household waste, including at least paper, metal, plastic and glass, must be recovered by recycling and preparation for reuse;
2. at least 55% of the mass of municipal waste must be recovered by recycling and preparation for reuse by 2025;
3. at least 60% of the mass of municipal waste must be recovered by recycling and preparation for reuse by 2030,
4. at least 65% of the mass of municipal waste must be recovered by recycling and preparation for reuse by 2035;
5. at least 70% of the mass of non-hazardous construction waste, except for materials from nature determined by the key waste number 17 05 04 - soil and stones that are not listed under 17 05 03, must be recovered by recycling, preparation for reuse and other material recovery procedures, including filling, where waste is used as a substitute for other materials.

The Republic of Croatia submitted a request to postpone the fulfillment of the goals and deadlines because it is among the member states that recycled less than 20% of municipal waste in 2013. The European Commission has not yet approved the postponement of the goals and deadlines.

GO-3 Reducing the amount of disposed biodegradable waste

Regulatory, environmental, economic, educational measure; implementation: 2021 - 2030

Objective and description of the measure: The aim of the measure is to reduce the mass of the biodegradable fraction of waste disposed of in landfills, thereby reducing methane emissions from anaerobic waste decomposition processes. The Waste Management Act (OG No. 84/21) stipulates that the maximum permissible mass of biodegradable municipal waste whose disposal in a calendar year can be allowed by all permits for waste management in the Republic of Croatia is 264,661 tons, which is 35% of the mass of biodegradable municipal waste produced in 1997. The application of binding targets for the reduction of disposal and recycling of waste, described in the measures Preventing generation and reducing the amount of waste and increasing the amount of separately collected and recycled waste, positively affects the reduction of the mass of disposed biodegradable waste.

GO-4 Ensuring a system for the treatment and use of landfill gas

Regulatory, environmental, economic, educational measure; implementation: 2021 - 2030

Objective and description of the measure: The Ordinance on Landfills (OG No. 4/23) stipulates the operating conditions for landfills, which reduce possible adverse effects of landfills on the environment. Landfill gas is collected from all landfills receiving biodegradable waste. The collected landfill gas should be treated and used. If the collected gas cannot be

used to generate energy, it should be incinerated and methane emissions into the atmosphere should be prevented.

The application of binding targets for the reduction of disposal and recycling of waste, described in the measures Preventing generation and reducing the amount of waste and increasing the amount of separately collected and recycled waste, positively affects the reduction of the amount of landfill gas generated.

Activities of measures GO-1, GO-2, GO-3, GO-4:

- Application of the order of priority of waste management;
- Reducing the mass of waste for disposal;
- Increasing the amount of separately collected and recycled waste;
- Reducing the amount of disposed biodegradable waste;
- Incineration of landfill gas on a flare if the landfill does not have an electricity generation facility installed and if the landfill gas is not of the appropriate composition and quantity for electricity production.

Funds needed for implementation: Estimated financial resources in the period 2021 - 2030 amount to EUR 49,000,000 (considering the estimated cost of implementing measure C1.3. R2 Implementation of sustainable waste management projects from the National Recovery and Resilience Plan 2021 - 2026).

Sources of financing: Use of EU funds, local and regional government units, utility companies, Environmental Protection and Energy Efficiency Fund, development bank loans (World Bank, European Bank for Reconstruction and Development, European Investment Bank).

Executive Body: Ministry of Economy and Sustainable Development (MESD)

Monitoring bodies: Local and regional self-government units

Impact:

- Reduction of greenhouse gas emissions (kt CO_2-eq);
- Reducing the mass of disposed waste;
- Reducing the amount of disposed biodegradable waste;
- Establishment of an integrated waste management system according to the order of priority implemented in accordance with the objectives of national and EU legislation;
- Efficient waste recovery - waste management must be directed towards the effective application of the principles of the circular economy;

  - the backbone of the waste management system of the Republic of Croatia consists of waste management centers;

  - the establishment of recycling yards ensures the availability of separate municipal waste collection services;
- Transfer of knowledge and experience of EU countries in the application of best available techniques for waste treatment and recovery;

- Provision of support for investment projects.

Monitoring method:

- Report on the implementation of policies and measures to reduce greenhouse gas emissions;
- Five-year report on monitoring the implementation of the Low Carbon Development Strategy;
- Reports on municipal waste.

Measure implementation indicator: Reduction of the mass of disposed waste (t), greenhouse gas emission reduction potential (kt CO_2).

Connection to other dimensions: Research, innovation, and competitiveness

Connection to climate change adaptation: Increasing resilience to the effects of climate change.

Research and development: Application of best available techniques for the treatment and recovery of waste.

GO-5 Reduction of food waste in accordance with the guidelines for the development of a bioeconomy

Regulatory, environmental, economic, educational measure; implementation: 2021 - 2030

Objective and description of the measure: The prevention and reduction of food waste has been singled out as a priority theme of European policies, strategies and initiatives, including the European Green Plan (COM(2019) 640 final), the Farm-to-fork Strategy (COM(2020) 381 final) and the New Circular Economy Action Plan (COM(2020) 98 final). The measure applies the main principle of waste treatment defined in the order of priority and refers to the prevention of waste generation. The prevention and reduction of food waste is defined by the Food Waste Prevention and Reduction Plan of the Republic of Croatia for the period from 2023 to 2028 (OG No. 156/22).

Food losses and waste occur at all stages of the food production and supply chain, starting from primary production through processing, distribution, storage, sale, catering industry, institutional kitchens to households. The measure includes encouraging and promoting sustainable food consumption models and habits, donating food, etc. In line with the UN 2030 Agenda for Sustainable Development, measures need to be taken to promote the prevention and reduction of food waste, to achieve the goal of reducing per capita food waste at retail and consumer levels and food losses in production and supply chains, including post-harvest losses, by 50% by 2030. This trend will continue to grow by 2050, according to future assumptions. This will prevent and reduce food waste in primary production, processing, and production, in retail and other food distribution channels, in restaurants and places where food is served, and in households, i.e., along the entire food chain.

During 2018 and 2019, a new legal framework was adopted at the European Union level regulating the monitoring and measurement of food waste, to obtain relevant and comparable data on quantities and contribute to the achievement of the global goal of reducing food waste. Food waste has been identified as one of the key problems that need to

be addressed to achieve sustainability of food production and consumption. The legislative framework for food donation in Croatia was improved in 2019 with the adoption of the new Ordinance on food and feed donation (OG No. 119/19).

With the aim of exchanging knowledge, information, and experiences on the topic of food waste prevention, in 2021 an expert panel was held entitled "Food is not waste, together to reach the goal", which gathered representatives of public authorities, local and regional government, food business entities, intermediaries in the food donation system, academia and scientific community, representatives of civil society and international representatives. The introduction of special food waste prevention measures also includes awareness-raising campaigns on possible ways to reduce food waste in waste prevention programmes. Most of the awareness-raising and consumer information activities on the prevention and reduction of food waste are carried out under measure C1.5. R4 Improvement of the food donation system from the National Recovery and Resilience Plan 2021 - 2026.

The National Development Strategy of the Republic of Croatia until 2030 defines food self-sufficiency and the development of a bioeconomy as one of its strategic goals. Within this strategic objective, priorities are defined: (i) increasing agricultural and aquaculture productivity and their resilience to climate change in an environmentally friendly and sustainable manner; (ii) contributing to climate neutrality, reducing pesticide use and increasing organic production in line with the new EU guidelines under the Green Deal, the Farm to Fork Strategy and the EU Biodiversity Strategy; (iii) strengthening competitiveness and innovation in agriculture and aquaculture; (iv) revitalising rural areas and improving the quality of life in rural and coastal areas.

The Croatian Bioeconomy Strategy until 2035 (under development) will define the priorities and goals of the development of a bioeconomy in accordance with the national development directions, potentials and needs of the domestic bioeconomy. A bioeconomy is defined as one of the solutions for further economic development, so the intention is to ensure a coordinated implementation of public policies relevant to the field of bioeconomy, which are based on the sustainable, circular use of natural resources. Through the development of a bioeconomy, as a renewable segment of the circular economy, new and innovative solutions for providing food, production and energy are realized without exhausting limited biological resources. This requires modernisation of production models, and research and innovation play a key role in accelerating the green transition of the economy and achieving the UN sustainable development goals. There is great potential for new green jobs in this area, especially in rural and coastal areas.

Activities of the measure:

- Application of the order of priority of waste management;
- Encouraging the reduction of food waste at all stages of the food chain, in line with the guidelines for the development of the bio-economy;
- Encouraging and further improving the food donation system;
- Promoting social responsibility of the food sector;
- To raise awareness and inform consumers about the prevention and reduction of food waste;

- Conducting educational workshops and promotional activities for food donation chain stakeholders;
- Monitoring the mass of food waste;
- Investing in research and innovative solutions that contribute to the prevention and reduction of food waste.

Funds needed for implementation: Estimated financial resources in the period 2021 - 2030 amounts to EUR 6,000,000 (considering the financial resources for the implementation of the Food Waste Prevention and Reduction Plan of the Republic of Croatia for the period from 2023 to 2028 and the estimated cost of implementing measure C1.5. R4 Improvement of the food donation system from the National Recovery and Resilience Plan 2021 - 2026)

Sources of financing: Use of EU funds, local and regional government units, utility companies, Environmental Protection and Energy Efficiency Fund, development bank loans (World Bank, European Bank for Reconstruction and Development, European Investment Bank).

Executive Body: Ministry of Economy and Sustainable Development (MESD)

Monitoring bodies: Ministry of Agriculture, Ministry of Labour, Pension System, Families and Social Policy, Croatian Agency for Agriculture and Food, Croatian Chamber of Economy, Croatian Employers' Association, Croatian Chamber of Trades and Crafts, Croatian Chamber of Agriculture, local and regional government units, food donation intermediaries, non-profit humanitarian organizations, civil society organizations

Effect:

- Reduction of greenhouse gas emissions (kt CO_2-eq);
- Reducing food waste;
- Implementation of good food waste prevention practices;
- Contribute to the implementation of the measures of transition to a smart, circular and low-carbon society, the reduction of poverty and social exclusion, food self-sufficiency and the development of the bioeconomy;
- Infrastructure equipping the food bank and strengthening the infrastructure capacities of intermediaries in the food donation chain;
- Launch of an online platform to prevent food waste and upgrade of the technical solution of the IT system for food donation;
- Conclusion of voluntary agreements for the prevention of food waste;
- Strengthening competitiveness and fostering a sustainable and innovative economy, promoting innovation and patents that contribute to reducing food waste.

Tracking method:

- Report on the implementation of policies and measures to reduce greenhouse gas emissions;
- Five-year report on monitoring the implementation of the Low Carbon Development Strategy;

- IT solution of the IT system for food donation for the purpose of functional use of the platform.

Measure implementation indicator: Reduction of food waste mass (t), greenhouse gas emission reduction potential (kt CO_2 -eq).

Connection to other dimensions: Research, innovation, and competitiveness

Connection to climate change adaptation: Increasing resilience to the effects of climate change.

Research and development: Sharing experiences and best practices, advice and recommendations for food business operators, the scientific community, and consumers.

GO-6 Circular economy measures to increase resource efficiency and apply business models based on repair, recycling and recovery

Regulatory, environmental, economic, educational measure; implementation: 2024 - 2030

Objective and description of the measures: The new Circular Economy Action Plan (COM(2020) 98 final) introduces measures to ensure the reduction of waste production and the good functioning of the EU internal market for high-quality secondary raw materials. The EU Circular Economy Action Plan focuses on changing the way we produce and empowering consumers to make sustainable decisions in business and everyday choices and to apply a production and consumption model that includes sharing, reusing, repairing, and recycling existing products and materials for as long as possible. This extends the lifespan of products and raw materials at the same time and reduces the mass of waste. Therefore, the introduction of the circular economy principle reduces environmental pressure, increases the security of raw material procurement, competitiveness, and innovation, creates new jobs, and consumers have longer, more resilient, and more valuable products.

The aim of the circular economy concept is to separate economic growth from the use of natural resources, which can be achieved by eliminating waste and pollution already at the stage of designing products and materials, by keeping them in use for as long as possible. For real circularity, products that can be reused, repaired, refurbished, reprocessed, and repurposed are needed, which prevents the value of the product from falling, and they can even gain quality by circulating the system for as long as possible.

Waste management, including waste collection and treatment, is crucial for increasing the circularity of the Croatian economy and reducing the negative impacts of landfills on the environment, human health, and greenhouse gas emissions. The largest share of total waste in Croatia is municipal waste; the recycling rate of municipal waste in 2020 was only 34%, compared to the EU average of 48% in 2020.

The World Bank supports the Government of the Republic of Croatia in improving the waste management process. The Government of the Republic of Croatia has selected the construction and demolition waste sector as a priority waste category for the application of circular principles in waste management, regardless of good results in recycling this type of waste (in 2020, the rate of recovery of construction waste in Croatia was 60%, while the EU target for 2020 was 70%). This decision was triggered by the devastating earthquakes that occurred in 2020 and the large amounts of construction waste generated. The World Bank

supports the development of a five-year Circular Economy Action Plan for the construction sector for 2022 - 2026 The aim of the Plan is to encourage other sectors in Croatia to effectively apply the principles of the circular economy, aimed at reducing the generation of waste and, where waste cannot be avoided, exploiting its economic value, while avoiding negative impacts on the environment and climate change.

Closing the cycle of material management requires rethinking how we design products, how we produce, consume them, and how we reuse materials at the end of product life. The Croatian economy opens opportunities that require a strategic approach focused on the measures listed in the New Circular Economy Action Plan, based on which the EC integrates the principles of the circular economy into the production and consumption of plastics, water management, food systems, management of special waste streams, etc. In Croatia, four priority sectors are defined: food, construction, plastics, and textile production, given their significant environmental and socio-economic aspects. The World Bank supported the establishment of the Circular Economy Committee with the task of sharing knowledge and providing expert support to strengthen cooperation between all sectors, and one of the initiatives of the Committee is the establishment of a digital platform for the circular economy. With these efforts and measures, a higher rate of circularity of the Croatian economy can be achieved, and according to the stakeholders of the circular economy, a National Action Plan for the transition to a circular economy can be made through the adjustment of the legislative framework.

Activities of the measure:

- Implementation of the establishment of a sustainable and efficient waste management system - introduction of the circular economy principle;
- Application of production and consumption models involving the sharing, reuse, repair and recycling of existing products and materials;
- Extending the life of products and raw materials;
- Development of a systematic approach in all value chains related to the Croatian economy, which include measures listed in the New Circular Economy Action Plan - integrating the principles of the circular economy into the production and consumption of plastic, water management, food systems, management of special waste streams, etc.
- The construction and demolition waste sector are a priority waste category for the application of circular principles in waste management in the Republic of Croatia (triggered by the devastating earthquakes that occurred in 2020 and large quantities of construction waste generated);
- Development of a five-year Circular Economy Action Plan for the construction sector for the period 2022 - 2026;
- Encouraging other sectors in Croatia to effectively apply the principles of the circular economy, aimed at reducing waste generation and exploiting its economic value, while avoiding negative impacts on the environment and climate change - a strategic approach focused on four priority sectors: food, construction, plastics and textile production, given their significant environmental and socio-economic aspects;

- Establishment of the Circular Economy Committee, an interdisciplinary advisory body of the Ministry of Economy and Sustainable Development (MESD);
- Sharing knowledge and providing expert support to strengthen cooperation between all sectors and channelling thinking to improve product longevity and recycling;
- Establishing a circular economy platform;
- Developing a National Action Plan for the transition to a circular economy through the adaptation of the legislative framework.

Funds needed for implementation: Estimated financial resources in the period 2024 - 2030 amounts to EUR 110,000,000 (considering the estimated cost of implementing measure C1.3 R2 Implementation of sustainable waste management from the National Recovery and Resilience Plan 2021 - 2026)

Sources of financing: Use of EU funds, local and regional government units, utility companies, Environmental Protection and Energy Efficiency Fund, development bank loans (World Bank, European Bank for Reconstruction and Development, European Investment Bank).

Executive Body: Ministry of Economy and Sustainable Development (MESD)

Monitoring bodies: Local and regional government units, utility companies.

Effect:

- Separation of economic growth from the use of natural resources;
- Strengthening the policy framework to accelerate the transition to a circular economy by all economic sectors;
- Reducing environmental pressures, increasing the security of raw material procurement, competitiveness and innovation, creating new jobs;
- Reduction of greenhouse gas emissions (kt CO_2-eq);
- Developing awareness of the need for waste management - circular economy, encouraging cross-sectoral cooperation;
- Provision of support for investment projects.

Tracking method:

- Report on the implementation of policies and measures to reduce greenhouse gas emissions;
- Five-year report on monitoring the implementation of the Low Carbon Development Strategy;
- The inclusion of representatives of the Republic of Croatia in the European Circular Economy Stakeholder Platform enables direct access to and cooperation in innovation and best practices.

Measure implementation indicator: Reducing environmental pressures, increasing the security of raw material procurement, creating new jobs.

Connection to other dimensions: Research, innovation, and competitiveness

Connection to climate change adaptation: Increasing resilience to the effects of climate change.

Research and development: Application of best available techniques for recycling and recovery of waste.

The measures related to the **agricultural sector** are presented below.

According to the IPCC methodology, in the agriculture sector, CH4 and N_2O emissions are observed due to livestock farming, the use of fertilizers and soil degradation processes, while in the LULUCF sector, outflows/carbon emissions are observed in six storage facilities and are closely related to the management methods of each soil category (e.g., soil cultivation). The future EU policy envisages linking emission reduction targets from the LULUCF sector and the agriculture sector to targets for one sector. In the Republic of Croatia, the Ministry of Agriculture is responsible for animal husbandry and plant production, i.e., the agricultural sector and LULUCF according to the IPCC definition, which is an advantage for the planning and implementation of measures.

POLJ-1 Improving storage capacity and practices when handling manure

Informational, educational, economic measures; implementation 2021-2030

Objective and description of the measure: The aim of the measure is to reduce emissions of methane, nitrogen, and ammonia through the system of manure collection and storage. The manure management category is the source of emissions of nitrogen compounds, ammonia, and particulates. Emissions come from the excreta of animal manure deposited in and around the dwellings and collected as liquid manure, solid manure, or manure in a pit in the yard, with the latter two being viewed together as solid manures. Emissions come from animal housing and the yard, from storage areas and from the application of manure on the soil and during grazing. In practice, several measures are most applied at the same time, with different measures that can have a significant impact on emission reductions such as:

- Manipulation of nutrient content and their mutual relationship in the meal,
- Changes in the fertilisation system (type of manure) and improvement of manure collection facilities,
- Measures during manure storage,
- General improvement measures.

This measure is linked to the Common Agricultural Policy (CAP) under intervention 73.10 – Aid for investment in primary agricultural production.

Activities: Development of development programmes to increase the share of implementation of measures:

1) Manipulation of nutrient content and their mutual relationship in the feed:
    - reducing the protein content of the feed,
    - feed rich in fibre,
    - reduction in the intensity of grazing.

2) Changes in the fertilisation system (type of manure) and improvement of manure collection facilities:
    - The application of the fertilisation system in the breeding of pigs characterized by a short time from the moment of defecation or urination until the moment of removal of faeces and urine from the premises.
3) Measures during manure storage:
    - Reducing the storage/disposal time on manure farms.

Improvements to manure management facilities:

- Manure tanks shall be watertight and shall satisfy the manure collection for a six-month period,
- Increasing the energy efficiency of dwellings.

Projects for the improvement of the system for the calculation of greenhouse gas emissions (development of nationally specific emission factors and parameters).

Funds needed for implementation: EUR 4,000,000.00

The CAP foresees the allocation of investment funds in the amount of EUR 223,663,407.50 for the necessary investments through measure 73.10. – Support for investments in primary agricultural production.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Effect: Emission reduction ($ktCO_2$), Improving competitiveness and efficiency of livestock production

Monitoring method: Feed analysis, Organic fertilizer analysis, Inspection supervision of manure management facilities, Results of completed research and projects.

Connection to climate change adaptation: Intervention 73.10 – Support for investment in primary agricultural production.

POLJ-2 Anaerobic decomposition of manure and biogas production

Information, economic, regulatory measure; implementation 2021-2030

Objective and description of the measure: The objective of the measure is to reduce methane emissions from the manure management system for cattle and pigs by increasing the share of biogas plants.

The introduction of biogas plants reduces the emission of greenhouse gases due to the disposal of used litter and produces electricity from a renewable source. Additionally, apart from the fact that anaerobic decomposition in biogas plants reduces the source of easily degradable carbon in manure applied to agricultural land, the nitrification process (N2O emission) is also potentially reduced.

The digester or fermenter is the central part of the biogas plant, and bears the highest investment costs of the biogas plant. It also has the highest operating costs resulting from energy consumption for heating.

The main mechanism for encouraging the use of biogas for electricity production and encouraging the construction of cogeneration biogas plants are incentive prices (tariffs) that depend on the installed electrical power of the plant. A common classification of biogas plants is large biogas plants, co-digestion plants and farm plants. For small farms, this is a significant and potentially excessive investment, so the basic mechanism of implementing this measure could be the association of farmers in order to reduce the costs of installing the plant.

It is also planned to use biogas in transport sector and inject biomethane into the gas network.

This measure is linked to the Common Agricultural Policy (CAP) under intervention 73.03. – Use of renewable energy sources and 73.10. – Support for investments in primary agricultural production.

Activities: Farmers' associations to reduce the costs of installing biogas plants.

Funds needed for implementation: the CAP provides for the allocation of funds for investments in the amount of EUR 30,000,000.00 through measure 73.03. – Use of renewable energy sources and EUR 223,663,407.50 for necessary investments through measure 73.10. – Support for investments in primary agricultural production.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia

Executive Body: Ministry of Agriculture

Effect: Emission reduction ($ktCO_2$), electricity production, thermal energy production, use of digestate as fertilizer or energy source

Monitoring method: Agricultural inventory

POLJ-3 Improving and changing the soil tillage system (reduced tillage)

Informational, educational measure; implementation in 2021-2030

Objective and description of the measure: Increasing soil carbon sequestration through improvements and modifications to soil treatment systems.

Soil treatment systems are crucial for the parameters that are important for the storage of soil water, in general water-air relationships, water losses by evapotranspiration, soil thermal state, and thus microbial activity and soil respiration. The issue of reducing CO_2 emissions from agricultural soils in Croatia has not been sufficiently investigated in local conditions.

Reduced tillage is the application of the results of scientific research and practical checks that result in a change to the conventional tillage system by reducing the depth of basic and supplementary tillage, omitting one or more working operations, reducing the frequency of tillage, or completely omitting tillage.

Thus, reduced tillage can be divided into basic concepts:

- Reducing classic tillage systems,
- Minimum tillage,
- No-till,
- Conservation tillage,
- Rational tillage.

Detailed pedological surveys conducted in Croatia are only one of the input parameters for the general assessment of the suitability of land for the application of no-tillage systems, but a project is needed that would provide detailed answers to the question of the suitability of soils for no-tillage in Croatia.

In conditions of global climate change and more frequent and intensive droughts (according to the IPCC, in the regions of southern, south-eastern, and eastern Europe, and thus in the Republic of Croatia, a reduction in soil humidity of 15-25% can be expected in the warm half of the year), perhaps the most important the task of reduced tillage becomes the accumulation and storage of water in the soil. At the same time, in years of abundant rainfall, which have also been occurring lately, there is often excessive saturation of the soil with water, which makes the problem of tillage even more difficult to solve. Other reasons for applying these tillage systems are related to improvements in the biological, chemical, and physical properties of the soil and to the prevention and mitigation of erosion. Management systems that include conservation tillage, organic fertilization, keeping part of the area under lawns, appropriate crop rotation, etc. have a positive impact on the uplift of organic matter in the soil, which plays a key role in maintaining all soil roles. The direct impact on greenhouse gas emissions from a reduced tillage system is primarily related to a significant impact on organic carbon content (increase in soil organic matter accumulation, especially in combinations of minimum tillage systems and intermediate crops in cereal cultivation) and from the point of view of reduced energy consumption (fossil fuels) due to fewer machine hours. Reduced tillage is also advantageous from the standpoint of weed control, establishing optimal soil functioning and optimal crop height per unit of production area - i.e., a total reduction in production costs.

Agrotechnical interventions, as well as processes by which the content of organic matter in the soil can be maintained or even increased in Croatia are not satisfactorily implemented. Problems in the reduction of soil fertility are caused by the apparent decrease in the yield of cultivated crops, as well as difficult cultivation of the soil, the reduced utilization of applied fertilizers, and the overall efficiency of production.

The use of different tillage systems also alters current established understandings about the relationship between tillage and fertilization, which requires additional analysis to avoid acidification and excessive fertilization with nitrogen fertilizers, especially in the initial establishment of conservation treatments.

This measure is linked to the Common Agricultural Policy (CAP) as part of interventions 31.06. - Conservation agriculture.

Activities:

- The project is aimed at determining the question of the suitability of soil for no-tillage in Croatia.
- National surveys aiming to define the real potential for increasing carbon sinks in agricultural soils and the relationship of the reduced soil treatment system with fertilising recommendations.
- National studies of the impact of reduced treatment on the upliftment of organic matter in soil.
- Programmes for education of users of agricultural areas in Croatia on the topic of preservation of organic matter in soil

Funds needed for implementation: the CAP provides for the allocation of 7,500,000.00 EUR in the form of compensation of additional costs and loss of revenue resulting from commitments made to users who undertake an annual commitment within the measure 31.06. - Conservation agriculture.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Effect: Emission reduction ($ktCO_2$), increased production intensity

Monitoring method: Results of completed projects and research

Research and development: To assess potential emission reductions, systematic research in the land use sector, increased production intensity is needed.

POLJ-4 Extension of crop rotation with a higher share of legumes

Informational, educational measure; implementation in 2021-2030

Objective and description of the measure: Defining the potential for organic matter content change / increasing soil carbon sequestration through crop rotation.

Fertilization is a system of plant production practiced on arable land, which represents the regular, spatial and temporal crop rotation (swapping crop). When determining crop rotation, care must be taken of soil type and fertility, pH value, climatic conditions, and the impact of culture on soil fertility, structure, and nutrient supply. Fertilization is planned individually for each economy according to production requirements, where adherence to the recommended sequence of cultures is essential. Crop rotation must include three basic groups of plants - arable crops, cereals, and legumes.

Practiced crop rotation, today, together with soil treatment systems, strongly influence changes in the content of organic matter in the soil. Narrow crop rotation in which corn and winter wheat are almost necessarily included, without intensifying crop rotation, with the illicit burning of harvest residues, is a practice that cannot have a favourable effect on increasing the content of organic matter in the soil. The crop rotation intended to have a long-term effect on maintaining the same humus level should include leguminous crops, clovers, clover grass mixtures, and should, where possible, include the sowing of second crops for green harvests. According to the results of Butorac et al. (1995), average humus content of soil for different crops, from tobacco monoculture, over two two-field, three-field, two four-field, and one five and six-field crop rotation, varied from 1.3 to 1.6%, but in the 10-year period there was a significant differentiation in terms of differences in humus content according to crop rotation types. From this the studies which study the effect of practiced crop rotation on the changes in the chemical, as well as the physical and biological characteristics of the soil, must last for a long time, since even a 10-year period is not considered long enough to study such changes.

Sowing leguminous crops has many beneficial effects for agricultural soils. This binds atmospheric nitrogen, which is used immediately for protein synthesis and prevents the risk of groundwater contamination by nitrates that otherwise occur with the intensive application of mineral nitrogen fertilizers. The soil is enriched with organic matter, which has multiple positive effects on improving and maintaining the favourable physical, chemical, and biological properties of the soil. Soil fertility is maintained and cultures that follow in the crop rotation are allowed to use biologically bound atmospheric nitrogen. Individual crops (clover) can be effective in soil carbon sequestration. Furthermore, growing leguminous crops reduces the amount of nitrogen-rich organic fertilizers to be applied. As a rule, they do not need to be fertilized except only in small amounts at the beginning of their vegetation for initial growth and development until they form root knots and until the process of nitrogen fixation begins.

This measure is linked to the Common Agricultural Policy (CAP) as part of interventions 31.05. - Minimum leguminous content of 20% within agricultural areas.

Activities:

- Start of multi-year impact studies of practiced crop rotation on soil characteristics changes (expected duration >10 years),

- Encouraging producers to increase the share of leguminous crops when creating crop rotation.

Funds needed for implementation: the CAP provides for the allocation of 13.482.350,00 EUR in the form of compensation of additional costs and loss of revenue resulting from commitments made to users who undertake an annual commitment within the measure 31.05. - Minimum leguminous content of 20% within agricultural areas.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia.

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Effect: Emission reduction ($ktCO_2$)

Monitoring method: Results of completed projects.

Connection to other dimensions: Research, innovation, and competitiveness

Research and development: To assess potential emission reductions, systematic research in the land use sector, increased production intensity is needed.

POLJ-5 Intensification of crop rotation by using intercrops

Informational, educational measure; implementation in 2021-2030

Objective and description of the measure: Changes in organic matter content / increase of carbon sequestration in soil and reduction of nitrate leaching by sowing of intercrops.

The principles of good agricultural practice in soil and water protection against nitrates recommend the introduction of intercrops (second crops) between the harvest of the main crops. Sowing intermediate crops that can be used to feed livestock or plow for green fertilization will utilize residual nutrients, prevent further evaporation of soil water, reduce carbon loss from soil (eliminating the negative effect of "bare soil"), prevent nitrogen leaching into groundwater (especially in lighter soils) and increase organic mass on farms that have a narrow crop rotation on their arable land. Leguminous crops bind nitrogen from the air to enrich the soil, preserve and stimulate microbial activity in the soil and prevent soil erosion. The increased cost of agricultural production per hectare is usually offset by savings in animal feed preparation or reduced need for mineral fertilizers. The problems that arise in this process concern the time and organization of work on the farm, but they are solvable, which can only be conditionally said for the drought that can occur at the time after the harvest of the cereals, whereby the sowing of second crops is questionable.

This measure is linked to the Common Agricultural Policy (CAP) as part of interventions 31.01. - Intensified diversity of agricultural areas and 31.05. - Minimum leguminous content of 20% within agricultural areas.

Activities:

- Research on the impact of the application of intermediate crops on changes in soil characteristics.

- Encouraging the use of typical common wheat or spelt crops for fodder use as intermediate crops

Funds needed for implementation: EUR 4,000,000.00

The cap provides for the allocation of EUR 41,158,709.25 in the form of an additional payment on basic income support for sustainability under measure 31.01. - Intensified diversity of agricultural and EUR 13,482,350.00 funds in the form of reimbursement of additional costs and loss of revenues resulting from commitments made to beneficiaries who undertake an annual commitment within the measure 31.05. - Minimum leguminous content of 20% within agricultural areas.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia.

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Effect: Emission reduction ($ktCO_2$)

Monitoring method: Results of completed projects**.**

Connection to other dimensions: Research, innovation, and competitiveness

Research and development: To assess potential emission reductions, systematic research in the land use sector, increased production intensity is needed.

POLJ-6 Improvement of mineral fertilizer application methods

Informational, educational, economic measures; implementation 2021-2030

Objective and description of the measure: Reduction of nitrous oxide emissions from agricultural soils due to optimization of mineral fertilizer application.

Mineral fertilization has a very complex effect on soil organic matter. As a rule, intensive fertilization can affect the higher production of biomass of crops, weeds, but also microorganisms of the soil, which is especially true for soils that have no other fertility restrictions other than a lack of nutrients. The modern development of agriculture in Croatia implies the introduction of new technologies, of which for agricultural production the so-called "Variable liming" and "variable fertilization rate" or "site-specific management" are very interesting. The basis for fertilization is soil fertility maps that are made using the kriging method. This creates the preconditions for much better sustainable soil management. Modern machines for the precise distribution of materials are already sold in Croatia today, but they cannot be used without knowing the differences in soil fertility. The introduction of information technology, remote sensing with applications in agriculture, and the production of yield maps are nowadays commonplace. In this way, the income of users of new technologies is generated, as well as the savings of farmers in the application of fertilizers, and thus a favourable environmental impact. The basis for fertilization is the results of soil analysis, which should be provided on each farm over a 4–5-year period.

Subjective, "experiential" or visual assessments most often result in minimal increase or even decrease in crop yields and quality, as well as increased consumption of mineral fertilizers -

which in addition to increased production costs also entails an increased loss of unused nitrogen from the soil as well as unnecessary acidification of the soil.

In addition to optimizing the application of conventional mineral fertilizers to reduce nitrogen loss from the soil, the application of slow-acting fertilizers has a positive effect. Controlled or slow-acting nitrogen fertilizers find their use today primarily in high-income production (horticulture, etc.). The older generation of such fertilizers is not economically viable in the production of cereals because of the high cost of fertilizers and the low income per crop. The emergence of new crop fertilizers suitable for growing crops (especially polymer-coated fertilizers) has, through research, shown the possibility of reducing the need for fertilizers per hectare by up to 35%, with unchanged or increased revenues, making them economically viable and cost-effective.

The application of limestone materials, together with fertilization and soil treatment, is crucial in the overall solution of the problem of agricultural soils management because of the need to correct the excess acidity of soils in many agricultural holdings. It is commonly believed that the use of lime materials leads to improved conditions for more intensive work of microorganisms, which can lead to accelerated decomposition of humus.

This measure is linked to the Common Agricultural Policy (CAP) under intervention 73.10. – Support for investments in primary agricultural production and 73.12. – Support for small farmers.

Activities:

- Introduction of information technologies, remote research with application in agriculture, and making soil fertility maps
- Works on the establishment of real monitoring systems for the consumption of mineral fertilisers on farms and realized yields
- Improvement of the greenhouse gas emission calculation system

Funds needed for implementation: EUR 7,000,000.00

The CAP foresees the allocation of investment funds in the amount of EUR 223,663,407.50 for the necessary investments through measure 73.10. – Support for investments in primary agricultural production and EUR 30,000,000.00 through measure 73.12. – Support for small farmers.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Impact: Emission reduction ($ktCO_2$), Increased revenue of users of new technologies, Saving farmers in the application of fertilizers

Monitoring method: Results of completed projects.

Connection to other dimensions: Research, innovation and competitiveness

Research and development: Systematic research is needed to assess potential emission reductions.

POLJ-7 Improvement of organic fertilizer application methods

Informational, educational measure; implementation in 2021-2030

Objective and description of the measure: Research on increasing carbon sequestration in soil by improving the methodology of application of organic fertilizers

The use of organic fertilizers is important for the circulation of soil organic matter, of which there is a relatively large database on the global scale. Unfortunately, there are no stationary studies of such lengths on agricultural land in Croatia. Bertić et al. (1998) found in some soils in Baranja certain changes in the humus content during the 24-year period of intensive plant production from 1967 to 1990. In almost all soils the humus content increased (0.1-1.64%), depending on the amount of solid manure used.

Organic fertilizers stimulate the activity of soil microbes much more strongly than mineral fertilizers and bring much less salt and acid into the soil. Efficiency depends on the microbial activity in the soil, i.e. at what rate they are degraded and transformed into nutrients suitable for adoption. Organic fertilizers have a much longer degradation time, so their effect extends over many years. Regular application of organic fertilizers increases the amount of humus in the soil, improves soil properties, in particular the structure resulting in a better water-air ratio, higher water retention, greater availability of all nutrients and greater erosion resistance on sloping surfaces.

Underground application - direct injection into the soil using an injector prevents the loss of ammonia and reduces or completely eliminates the spread of unpleasant odours. The method is applicable to the application of liquid form of bovine and porcine manure, with NH3 emissions lower by up to 30%.

When using the injector, even though the loss due to volatilization or the amount of nitrogen available to plants increases, it is also possible to increase the loss of nitrous oxide from the soil. Therefore, the importance of proper dosing and application of fertilizers (organic and mineral) is further increased.

The limiting factor for increasing the use of specialized equipment for the injection of organic fertilizer is the relatively high cost of the equipment itself, and therefore such investment is indicated for larger (or enlarged) farms with the need for large fertilization capacities.

This measure is linked to the Common Agricultural Policy (CAP) under intervention 73.10. – Support for investments in primary agricultural production and 73.12. – Support for small farmers.

Activities:

- Introduction of information technologies, remote research with application in agriculture, and making soil fertility maps.
- Monitoring soil changes in different ways of using and applying organic fertilizers.
- Encouraging investment in direct injection systems into the soil.
- Clustering of agricultural land.

Funds needed for implementation: EUR 20,000,000.00

The CAP foresees the allocation of investment funds in the amount of EUR 223,663,407.50 for the necessary investments through measure 73.10. – Support for investments in primary agricultural production and EUR 30,000,000.00 through measure 73.12. – Support for small farmers.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Impact: Emission reduction ($ktCO_{2)}$), Increased revenue of users of new technologies.

Monitoring method: Results of research, projects, and monitoring.

Connection to other dimensions: Research, innovation, and competitiveness

Research and development: Systematic research is needed to assess potential emission reductions.

POLJ-8 Agroforestry

Informational, educational measure; implementation in 2021-2030

Objective and description of the measure: Defining the potential and benefits of various agroforestry technologies to increase soil carbon sequestration

Agroforestry encompasses technologies used in forestry and agriculture to create greater productivity, economic viability, environmental friendliness, and sustainable land use. Agroforestry is a common name for land management systems whereby permanent woody species are integrated with the cultivation of crops and / or animals on the same area unit. The integration can be of a spatial character or in a time sequence. Ecological-economic interaction between forestry and agricultural components is common. The goal is to create diverse, productive, profitable, healthy, and sustainable land management systems. The production capacity of the land is used to a greater extent, but at the same time a balance is reached between economic viability and habitat protection based on sustainability or sustainable development. Research shows that, with all the other benefits, some agroforestry systems (e.g., agro-silviculture) are significant carbon sinks.

Agroforestry is applied worldwide to agricultural and forest land; including areas with degraded habitats (erodible areas, economically poorly valued devastated and degraded areas. Through experiments, agroforestry should show its applicability in our conditions with respect to different forms and divisions, but also to different needs. It is important to point out that some elements of agroforestry have been recorded throughout history in the coastal and littoral areas of our country. First, the cultivation of land on terraces that were used to raise perennial plantations; olive groves, vineyards, various fruit trees and could only be used for animal husbandry in a limited manner.

This measure is linked to the Common Agricultural Policy (CAP) as part of intervention 70.08 – Preservation of extensive orchards and olive groves.

Activities:

- Research possibilities of application of agroforestry with identification of suitable areas.

Funds needed for implementation: EUR 1,000,000.00

The cap provides for an intensity of 100% support for compliant operations through measure 70.08 – Preservation of extensive orchards and olive groves, for a mandatory implementation period of 5 years.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Effect: Emission reduction ($ktCO_2$), higher productivity, environmental friendliness and sustainable land use.

Monitoring method: Results of research projects.

Connection to other dimensions: Research, innovation and competitiveness

Research and development: To assess potential emission reductions, systematic research in the land use sector, increased production intensity is needed.

POLJ-9 Hydro-amelioration interventions and systems of protection against natural disasters

Informational, educational, economic measures; implementation 2021-2030

Objective and description of the measure: Increasing the share of agricultural soils under irrigation and the consequent reduction of nitrate leaching from agricultural soils.

Agriculture, more than any other activity, pollutes the water with nitrogen (nitrates), phosphates and plant protection products (pesticides). The intensification of agriculture has led to the intensification of agrochemical pollution. Environmentally friendly agriculture means controlled application of mineral fertilizers, controlled drainage, re-use of drained water and use of water of appropriate quality.

Irrigation with larger rations than necessary can result in increased nutrient leaching from the arable horizon, especially nitrogen into deeper horizons, resulting in the need for additional fertilization and thus increased emissions and increased costs. Drainage has the function of draining excess amounts of water from a green surface, which most often occurs after heavy rain. Also, changes in soil air-water relationships also affect the activity of beneficial microorganisms.

Microorganisms, with proper irrigation and drainage of excess water, have enhanced activity that reduces soil degradation and thus CO_2 losses. The activity of earthworms is also increased, who transfer carbon into deeper layers where it is longer lasting.

In Croatia, surface drainage systems are built on an area of about 1050000 ha, and underground drainage systems are built on an area of about 149000 ha. The age of most of the system is over 25 years.

Hydro-amelioration systems play a major role in sustainable development. Significantly improve the properties of existing hydro-amelioration systems. Human interventions in water control include the application of technologies and new management to ensure adequate quantities of water for plants; preventing excessive soil moisture and salinization; protecting the soil from flooding and maximizing profits by using water. These interventions take place within economic, social, and environmental constraints.

Croatia is in a good position because it has sufficient water supply, but successful technological innovations in drainage and irrigation systems depend to a large extent on research programmes and personnel education in the sector. The main goals are therefore the growth of agricultural production and the sustainability of the system.

This measure is linked to the Common Agricultural Policy (CAP) under intervention 74.01 – Support for public irrigation systems.

Activities:

- Research programmes to improve the properties of existing hydro-amelioration systems.
- Construction of a system for irrigation and personnel education.

Funds needed for implementation: EUR 15,000,000.00

The cap foresees an aid intensity of 100% for compliant operations through measure 74.01 – Support for public irrigation systems, for a mandatory implementation period of 5 years. Amounts to 80 to 100% of the total eligible project costs, depending on the development of the area where the investment is carried out. The maximum value of support per project is up to EUR 15,000,000.

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia.

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Impact: Reduction of emissions ($ktCO_2$), reduction of losses and optimisation of production, increased competitiveness, environmental friendliness while reducing agrochemical pollution, and sustainable land use, adaptation to climate change.

Monitoring method: Results of research programmes, results of educational programmes, statistics on agricultural areas under irrigation.

Connection to climate change adaptation: Increasing resilience to the effects of climate change.

POLJ-10 Introduction of new cultivars, varieties and crops

Informational, educational measure; implementation 2021-2030

Objective and description of the measure: Determining the potential of new cultivars, varieties, and crops to increase soil carbon sequestration

The introduction of new cultivars, varieties and crops is, in principle, subject to emergency adaptation measures (per the UNDP) - i.e., time-critical measures that also include the implementation of the system as a defence measure against climate change impacts on food production or achieving lower emissions.

In this context, it is important to encourage the development, education, and implementation of technologies at the national and regional levels, including encouraging the transition and adaptation of producers (as well as consumers, and therefore of the entire production chain) to the production of new agricultural crops, or by enabling and encouraging the use of cultivars and varieties who are more resistant to drought or disease, have a smaller carbon footprint, or have other benefits.

An example of a possible strategy is the more rational production and use of new leguminous crops in response to lack of protein in animal feed, the need to reduce the use of mineral fertilizers and to reduce soil fertility.

Due to their considerable amounts of protein, naturally occurring legumes require a large amount of N, they can provide a large part (or complete need) of this nutrient from the atmosphere through biological fixation, provided they live in symbiosis with the effective strains of root nodule bacteria. It is for these reasons that little-known plant species that have a symbiotic relationship with root nodule bacteria have been recently investigated, such as Galega orientalis Lam., a new perennial forage legume living in effective symbiosis with Rhizobium galegae.

The main advantage of growing Galega orientalis Lam. is almost exclusively the use of symbiotically bound elemental nitrogen and not N from mineral fertilizers or small doses of "initial" mineral N up to 40 kg / ha. Galega as a new legume is interesting because of its longevity (7-15 years), resistance (soil type, drought, temperature); it is one of the earliest legumes, contains high-value proteins (1.5-2 t/ha); represents an excellent choice of animal feed (in green form, pelleted, as hay or in silos), with grain yield 3-6 times higher than in alfalfa; fertilizing and seed prices are low.

Activities:

- Research programs for the application of new cultures of legumes.

Funds needed for implementation: EUR 500,000,000.00

Sources of financing: European Agricultural Fund for Rural Development (EAFRD), State Budget of the Republic of Croatia.

Executive Body: Ministry of Agriculture

Monitoring (supervisory) bodies: MESD

Effect: Emission reduction ($ktCO_2$), higher productivity, environmental friendliness and sustainable land use.

Monitoring method: Results of completed research

Connection to other dimensions: Research, innovation, and competitiveness

Connection to climate change adaptation: Increasing resilience to the effects of climate change.

Research and development: Systematic research is needed to assess potential emission reductions.

The measures related to the land use, land-use change, and forestry sector (LULUCF) are presented below.

The LULUCF sector achieves removals by sinks, mostly in the wood mass of forests. Changes are monitored in six categories according to the methodology of the International Climate Change Authority (IPCC): forest land, crop/plantation land, grassland, wetland, populated areas and other land. Carbon storage facilities are observed: above-ground biomass, underground biomass, deciduous (O soil horizon), dead wood, soil, and wood products. Although soil carbon stocks are at the level of those in living biomass, it is not possible to monitor changes in soil carbon stocks in land categories without conversion (the largest area of a particular land category) because there is insufficient data. In the crop/plantation and grassland land categories (so-called agricultural land categories), the greatest contribution to the removal of carbon from the atmosphere can be made by implementing management practices that increase the carbon stock primarily in soil storage (carbon farming measures).Only through the establishment of a comprehensive monitoring and reporting system will it be possible to monitor the actual contributions of individual measures in soil storage on agricultural land categories at the national level.

The LULUCF sector is becoming crucial for the transition towards a climate-neutral economy, as greenhouse gas emissions from other IPCC sectors cannot be reduced to zero by implementing defined measures. The residue that can no longer be reduced will be covered by removals by sinks (carbon sequestration). Measures in the LULUCF sector should be carefully selected as influential factors are numerous. Sustainable forest management, agricultural land management in such a way that it contributes to the accumulation of carbon (carbon farming), sustainable pasture management have multiple benefits. It contributes to biodiversity, increases soil resilience and productivity, resilience to climate change, prevents soil drainage and erosion, ensures conditions for sustained productivity in food production and the use of biomass.

At the EU level, many regulations are relevant for achieving the emission reduction targets in the LULUCF sector (LULUCF Regulation, ETS Regulation, ESR Regulation, Energy Union Governance Regulation, Climate Change Adaptation Strategy, Soil Deal for Europe, EU Forest Strategy 2030, Farm to Table Strategy, Biodiversity Strategy, Circular Economy Action Plan, Nature Recovery Act).

The LULUCF Regulation, which entered into force in 2018, aimed to increase removals by sinks and reduce greenhouse gas emissions in the LULUCF sector. When adopted, it did not set quantitative targets, it set a 'net-emission' rule, which means that emissions and sinks in LULUCF land accounting categories should be in balance. The revision of the 2018 Regulation

enters into force on 5th May 2023, setting a new target of -310 million t CO_2-eq in 2030 at the EU level and setting removal targets for Member States from 2026 to 2030. Overall, for the EU, the reduction is 15%, and for the Republic of Croatia the individual target is a 12% reduction compared to the average 2016-2018. There is also a binding reduction trajectory from 2026 to 2030.

Considering the share of a certain category of land in the total land area of the Republic of Croatia, the backbone for the implementation of measures in the LULUCF sector are for Forest Land the Forest Economic Basis of the Area (FLFEBA), which are prepared for ten-year periods with views on the next ten years, and the implementation of measures from the Strategic Plan of the Common Agricultural Policy (CAP) of the Republic of Croatia for the period 2023-2027. The SP CAP is allocated support from the European Agricultural Funds for each measure, and it is aligned with the Agriculture Strategy until 2030, i.e., the National Development Strategy of the Republic of Croatia until 2030. The implementation of the SP CAP will ensure the contribution to the objectives of the European Green Plan including the Biodiversity Strategy and the Forest Strategy and contribute to the objectives of the Low Carbon Strategy of the Republic of Croatia, the Integrated National Energy Climate Plan, and the new regulatory framework from the 'fit to 55%' package.

The SP CAP contributes to the sustainable management of forests and forest land with a rich biodiversity of flora and fauna. Interventions for the reconstruction (conversion) of forests, as well as interventions related to pastures, grasslands as well as arable crops, contribute to this. For numerous climate and environmental interventions, reimbursement is ensured for farmers and forest owners who change their usual production processes to preserve biodiversity and the environment in accordance with sustainable use of resources, which implies environmentally responsible, economically viable and socially responsible management.

In the SP CAP, related to LULUCF activities are mainly defined in Requirement 7 “Improve practices that contribute to adaptation and mitigation of climate change” includes the following interventions:

-31.02. - Extensive pasture management,

-31.04. - Use of manure on arable land,

-31.05. - Minimum leguminous content of 20% within agricultural areas,

-31.06. - Conservation agriculture,

-31.07 - Preservation of high nature value grassland (TVPV),

-70.02. - Conservation of biodiversity and the environment on permanent grasslands,

-70.04. - Organic farming,

-70.08. - Preservation of extensive orchards and olive groves,

-73.05. - Reconstruction (conversion) of degraded forests,

-78.01. - Support to knowledge transfer.

In addition to the statutory management requirements, farmers receiving CAP support are required to comply with cross-compliance (OG 113/2019) and EU Good Agricultural and Environmental Conditions (GAEC) standards. Objectives of the GAEC standard: to prevent soil erosion by defining minimum soil cover and minimum soil management practices, to maintain

soil organic matter and soil structure, to maintain permanent grasslands, to protect biodiversity and preserve landscape features, to protect waters and manage them by establishing boundary zones along watercourses, to authorise the use of water for irrigation and to protect groundwater from pollution

Measures in the LULUCF sector and in the agriculture sector are strongly contributing to decarbonisation. The scope of some measures so far is not entirely measurable because the monitoring system is not in place and needs to be worked on (e.g., soil carbon, timber products, deadwood, deciduous wood), which is also an obligation under the UNFCCC Convention and the LULUCF Regulation.

The following describes the measures that are part of the Scenario for Existing Measures (WEM). As explained below, the Republic of Croatia cannot achieve the objectives of the LULUCF Regulation with the WEM scenario for the period 2026- 2030. Research, analysis, and intensive public consultations are needed to define additional measures (Scenario with additional measures (WAM)). There are uncertainties, due to natural disasters such as fires, pests and diseases, the effects of climate change and organic soil on emissions.

Measures in the LULUCF sector are relatively cost-effective, mobilising funds for implementation will be key (CAP, LIFE, private funds). The LULUCF sector needs stronger policy support and a far stronger education of all segments of society, as this is a new and interdisciplinary area that has not been sufficiently perceived in decarbonisation so far. This includes the introduction of new mechanisms and business models and EU initiatives such as **carbon farming and the products of a particular carbon** storage facility. This should be assisted by the establishment of carbon storage certification schemes and by a regulation prepared by the European Commission.

LUF-1 Development of the Maintenance plan of the National Information System for land in the Republic of Croatia

Regulatory, economic, information measure; implementation: 2021-2030

Objective and description of the measure: By 2025, it is necessary to develop the Maintenance plan of the National Information System for land in the Republic of Croatia For its development, it is necessary to implement projects that:

1. establishes a unique land information system in the Republic of Croatia or determine the areas of each LULUCF land category by using spatially correctly determined data, for each land category and for each land conversion type from one land category to another.

Activity: MESD has launched the LIFE CROLIS project (LIFE19 GIC/HR/001270) with the aim of establishing a single information land monitoring system for data on the land cover (LC) and land use (LU) in the Republic of Croatia. The task of the project is to create a new data model using spatial data collected at the national level as well as those available at the European level (e.g., within the COPERNICUS programme). For the selected years from the 1970-2020 series, LC and LU layers will be made, which, with the application of the EAGLE concept, will serve as the basis for creating layers for different purposes, for example, the LULUCF sector for which the total area of the Republic of Croatia should be shown in six categories of land. The project is funded by the LIFE Programme, Environmental Protection and Energy Efficiency

Fund (EPEEF), project partners. The project also upgrades the ARKOD system, which will cover all areas of agricultural land (ARKOD+), not only those that are in the process of promotion.

2. conducts analysis of all LULUCF land categories depending on land cover, land use and management practices used on each land and associated emissions / outflows to consider the potential of each of the storage sites within each LULUCF land category to reduce emissions and increase greenhouse gas outflows.

The project Defining activities to increase absorption in carbon storage in accordance with the provisions of Regulation 2018/841/EU regarding the trading of sinks occurring in land accounting categories is in progress. The project should propose measures for the WAM scenario. (Funded by: EPEEF) and provide guidelines for the implementation of measures.

3. Make detailed projections for the development of future emissions / outflows in the LULUCF sector after carrying out the above analysis.

The project is planned to strengthen the capacity for LULUCF projections (funded by the EPEEF). The CROWOODS project – Project for the establishment of a reporting system for timber products is in preparation.

The calculation of emissions / outflows in the LULUCF sector and these projects should form the basis for planning the cover, use, and management of LULUCF land categories for each of the storage sites to develop a Land Management Strategy and to properly define the measures to be implemented in each land category, which will reduce emissions and increase greenhouse gas outflows in the Republic of Croatia. Improving and defining forest fire protection measures should be an integral part of this strategy.

Executive Body: MESD

Monitoring body (supervision): MESD, MPO

Impact: Provided conditions for long-term sustainable land management.

Monitoring method: Execution of projects necessary for the development of the Plan.

Connection to other dimensions: Renewable sources, energy security, energy market.

Connection to climate change adaptation: good land management is fundamental to increase resilience to climate change.

LUF-2 Carbon sequestration on areas of existing forests

Economic measure; implementation: 2021-2030

Objective and description of the measure: Implementation of activities that contribute to increasing the carbon content of forests, in the storage of biomass, and implementation of which ensures removal in a given period. According to the amendment to Regulation 2023/839, which enters into force on 5th May 2023, targets have been set for 2030 for two periods: from 2021 to 2025 and the period from 2026 to 2030. For the period 2021-2025, the rules for the calculation of sinks are methodologically based on a comparison with the Reference Level for Forests, and the reference levels for cropland, managed grassland, and managed wetland (average years 2005 -2009).

For the period 2021- 2025, the Republic of Croatia sets a removal target higher than defined by the reference level for forests, thus fulfilling the condition of the so-called 'no debit rule' in the LULUCF sector, which is set by Regulation 2018/841 for the period 2021-2025.

Maintaining sinks higher than those defined by the FRL also ensures an increase in outflow units that can be transferred to sectors outside the ETS, as well as the use of flexible mechanisms, i.e., sales to Member States.

In the period 2021-2025, activities will be carried out that are outlined on the Forest Economic Basis of the Republic of Croatia for the period 2016-2025. (FLFEBA). FLFEBA includes state-owned forests and private forests. FLFEBA established economic practices, logging plans and restrictions in forest management about other regulations in force.

The management of forests in Croatia is largely influenced by the consequences of the Homeland War. In Croatia, in the period from 1991- 1995, no regular forest management activities were carried out in areas inaccessible due to the occupation of the territory. After the end of the war, parts of the area were gradually included in regular management activities, and part of the area cannot be managed today due to land mines. In the next few years, until the complete completion of the demining process, the Republic of Croatia will not be able to carry out regular activities of management of a part of its forests on the mine contaminated areas. Pursuant to the explanation, Article 8, paragraph 4 of Regulation (EU) 841/2018 had the opportunity to participate in the FRL for 2021-2025, in addition to the criteria set out in Section A of Annex IV, may also take into account the occupation of the territory, the circumstances of the war and post-war that had an impact on forest management during the reference period. This possibility was implemented by the Republic of Croatia by proposing the FRL for the period 2021-2025, which was adopted by a Delegated Act. In accordance with Annex IV of Regulation 2018/841, the EU FRL for Croatia was set at -3,906 G g CO_2eq per year for the period 2021-2025. In this calculation, a method was used that assumes instantaneous oxidation when estimating emissions/sinks in the storage of wood products with the addition of fire emissions. The FRL is -4,368 gGCO_2-eq per year using a first-order decomposition formula to estimate carbon in a deadwood store.

In the negotiations on 2023/839, the Republic of Croatia repeatedly pointed out the fact that the specificity of the Republic of Croatia was not recognized in the new Regulation, and that the goal for the period 2026-2030 is not continuous with the objective from the previous period. The set target for the LULUCF sector in the Regulation 2023/839 for the period 2026-2030 is based on the 2016-2018 sink averages, which limits the increase in stats as envisaged by the existing plans.

Regarding the increase in states, i.e. logging, it should be emphasized here that logging forest-cultivation interventions are a function of the care of a particular stand, and its restoration. In diverse stands, these interventions occur at the same time on the same surface (stand), and in one-year stands they are spatially and temporally separated. In simple terms, foresters, by carrying out logging operations, do nothing but imitate nature by enabling the production process so that the selected trees reach the target dimension in an optimal period. Trees from landscaped, well-groomed stands achieve their target dimensions in optimal time and ensure a higher share of higher quality raw materials, much higher economic value.

Regarding the existing method of forest management, it should be mentioned that the Republic of Croatia celebrated the 250th anniversary of organized forestry in 2015. The term sustainable development in the Republic of Croatia has its roots **in the forestry term permanent management**, which was first mentioned in 1713, and was introduced in Croatia in 1769. The basic idea is to not cut more than is produced.

The LULUCF sector of the Republic of Croatia achieved 1.8% of the total removal of the EU LULUCF sector for the period 2016.-2018. The proposed amendments to the Regulation envisage a share of the removal of the LULUCF sector of the Republic of Croatia in the EULULUCF sector of 1.35 t CO_2eq per capita, which is twice the EU average of 0.69t CO_2 eq per capita.

In contrast to the projections made for the purpose of calculating the reference level for forests (FRL), when parameters obtained on the basis of economic practices during the reference period 2000-2009 were used, for the last available WEM (new WEM) projections, the regulations of the stats in the current forest management plans were used, as they were found in 2020 (based on FLFEBA). The new WEM scenarios developed for the needs of this NECP were taken from the project Capacity Building for LULUCF Projections, a project that is still ongoing and has not finalized the calculations. Projections show that the Republic of Croatia could have an excess of sinks in the period 2021- 2026. This surplus may be used under the rules of Regulation (EU) 2023/857 in relation to the emission limitation in the non-ETS sector, or it may be traded with it. The Republic of Croatia cannot transfer the surplus from the first to the second commitment period. Deviations from this projection can be most affected by natural disasters if they are significantly intensified in the future period.

In the period 2026-2030 according to the new WEM scenario, the accumulation of carbon will continue but with reduced intensity. To ensure long-term sustainable use, it is necessary to increase the statute to balance the age structure of forests and thus ensure an optimal balance of economic productivity of forests with all existing and new goals of biodiversity protection. However, according to this scenario for the period 2026-2030, the LULUCF sinks targets set out in the Regulation 2023/839 are not achieved. Additional measures in forestry and all other categories of LULUCF need to be established, which includes possible changes in **logging plans, leaving the challenge of how and in what period the age structure of forests will be improved.** The shortage of sinks can be compensated by the flexibility mechanisms of Regulation 2023/839: by transferring allowances from non-ETS systems, purchasing allowances from other countries and/or compensating under Article 13b of the Regulation 2023/839 (if conditions at EU level are met).

The Republic of Croatia should establish measures to achieve the targets by 2030. The analysis of the WAM scenario should consider the issue of the impact of climate change, for which reliable data are not currently available. Additional objectives stemming from the EU Biodiversity Strategy, nature restoration measures and the European Forest Strategy, circular economy measures and bioeconomy should also be considered. The energy development strategy of the NECP envisages an increase in the use of heating biomass in view of the planned increase in production. To increase the outflow in *the category of managed forest land*, it is necessary to determine the areas of coppice forests and macchia forests and thicket that are justified to be transported to forests of a higher cultivation form, and to intensify activities to protect forests from fire.

Funds needed for implementation: the company Hrvatske šume d.o.o., which manages state-owned forests, operates based on turnover on the market with controlled price control. For state-owned forests that are not in the management system of the Croatian Forests, the institutions are the owners (e.g., nature protection institutions, the Ministry of Defence, the Faculty of Forestry, etc.). Significant long-term income is generated through the Fund for Financing the Generally Useful Functions of Forests (OKFŠ), through compensation paid by all economic operators in the Republic of Croatia above a certain income threshold. This is an instrument that has been in operation for dozens of years, and its value lies in the fact that the funds are used for non-economic purposes only. Sources of financing are also private funds of forest owners, rural development program, the CAP and other regular work of state bodies. For illustration, funds needed to implement the existing policies at the level of 270 million EUR per year, for state forests (budget of Hrvatske šume d.o.o., average five years). Reducing the volume of logging reduces revenue and puts at risk the sustainability of the long-term existing forest management system, the impact of climate change will require increasing care and preventive action. This does not include the long-term adverse effects of forest ageing and the multiplier effects on the forest-based economy, as well as the negative social impacts. Of course, any additional protection of biodiversity also has its positive effects, which are undeniable and significant, but they are difficult to quantify. These elements need to be carefully considered in creating a future WAM scenario.

Listed are the CAP measures contributing to the LUF2 measure for 2023-2029: Modernization of forestry technologies in wood extraction, forest breeding and production of forest reproductive material) – EUR 40,000,000, Construction of forest infrastructure – EUR 12,383,901, Reconstruction (conversion) of degraded forests - EUR 11,764,706 (1176 ha). Total from the CAP for the period 2023-2029: EUR 64,148,606.

The measures and the envisaged resources are insufficient for the WAM scenario, which should ensure that the LULUCF target is met by 2030.

Executive Body: Ministry of Agriculture

Monitoring body: MESD, Ministry of Agriculture

Impact: Provided conditions for long-term sustainable land management.

Monitoring method: Areas of coppice and macchia forests and thicket that have been translated into a higher cultivation form (FLFEBA, NIR).

Connection to other dimensions: Renewable sources, energy security, energy market.

Connection to adaptation to climate change: good land management is fundamental to increasing climate resilience; secured fire protection contributes to lower greenhouse gas emissions and has several positive effects in the part of the overall beneficial functions of forests.

LUF-3 Implementation of afforestation works

Economic measure; implementation: 2021-2030

Objective and description of the measure: Afforestation on non-forest areas (in terms of IPCC methodology), is an activity that generates sinks. Due to the regulations in the field of nature protection governing the establishment of Natura 2000 sites, the Republic of Croatia is not able to dispose of all lawn areas (according to the national regulation: non-overgrown production forest land) for afforestation purposes. Considering that there are non-cultivated agricultural areas in the Republic of Croatia that have been neglected for many years, the problem of these areas must be adequately addressed when developing the Land Management Strategy. The justification of converting these areas to forested areas by afforestation needs to be assessed. It should be borne in mind that there is no restriction on the application of the amount of outflows in the calculation of outflows due to afforestation, and that these outflows are fully taken into account in the calculation. An assessment of the effects of afforestation of additional non-overgrown, productive forest land on the fulfilment of Croatia's obligations related to the use of renewable energy sources is also needed. Guidelines for further development need to be drawn up based on the knowledge and experience gained from the implementation of afforestation activities. In case of introduction of afforestation measures on neglected agricultural land, the measure will require strengthening of seed production and nursery services in the forestry sector and cultivation of planting material necessary for the implementation of these works.

Considering that it has not yet been established on which areas an additional increase in the areas for the strata of deciduous and coniferous plants could be implemented, an increase of at least 20000 ha by 2050 (about 1% of the existing forest area) is assumed by natural forest expansion in sparsely populated areas, partly by afforestation where this will be possible or by conversion of a part of the stands from the strata of macchia and thickets. In addition, a certain potential of the sinkhole will be realized by the initiative of one million planted trees per year (forest areas, urban planting, agroforestry, waterways), however, this will have noticeable effects in twenty to thirty years.

In addition, the conversion of shrubs and gargoyles formed on uncultivated agricultural soil into higher cultivation forms, which would then be introduced into FLFEBA, could yield significant quantities of new sinks. Areas where such interventions are possible should be determined, if it is land that is agricultural, the conversion should be into forest land and inclusion in the FLFEBA. It is estimated that such an area could be 33,000 to 35,000 ha.

The latter can help increase the sinks, but it does not even remotely solve the problem of achieving the goal by 2030.

Funds needed for implementation: The CAP provides for the financing of these interventions: Reconstruction (conversion) of degraded forests - EUR 11,764,706 (1176 ha), which is far less than the potential that is almost thirty times greater.

Monitoring bodies: Ministry of Agriculture

Impact: The impact will be determined when areas and locations are determined. The effect cannot be significant until 2030, as these are seedlings whose growth will become significant after twenty years.

Monitoring method: FLFEBA, NIR,

Executive body: Hrvatske šume d.o.o.

Connection to other dimensions: Connection to renewable energy sources, depending on the type of forest stands, at their mature age when the patrol begins, part (remains) will be used for firewood.

Connection to climate change adaptation: Increasing forest area contributes to increasing the resilience of the overall forest ecosystem, and in general the flora and fauna in it

Research and development: It is necessary to determine the areas on which afforestation will be carried out and it is necessary to provide the necessary nursery capacities in time.

LUF-4 Manufacture and use of wood and wood products

Regulatory, economic, educational, information measure; implementation: 2021-2030

Objective and description of the measure: Harmonize the available data and statistical reports and use new research to harmonize the information available for the purposes of different reporting to international organizations to provide accurate, transparent, and high-quality reporting, as well as to create harmonized bases for the adoption of medium and long-term strategies in the forestry and wood processing sector. It implies mapping of forestry and timber industrial production. Encourage the use of wood products in traditional and new products to increase outflows and reduce greenhouse gas emissions in the wood storage facility. This also requires the regulation of exports of untreated and semi-treated timber, which encourages the development of the domestic timber industry, and the regulation of energy timber exports increases the share of energy production from renewable sources, thus fulfilling international commitments. Outflow-generating activities must be promoted to ensure that wood products and wood are used for energy purposes in ways that contribute to meeting both EU targets by 2030 (reducing emissions and increasing the share of renewables in total energy consumption) and are beneficial to climate and environment. Guidelines for further development need to be drawn up based on the knowledge and experience gained from the implementation of this measure.

Carbon bound in wood products will be emitted into the atmosphere gradually, over several years to several decades (depending on the type of product), while the use of biomass for firewood represents the current emission. The substitution of other materials that have a large carbon footprint such as metal, plastic, concrete products with wood, reduces emissions. The Republic of Croatia has a significant sink in the wood products sector at the removal level of-700 $ktCO_2$-eq/year in recent years, which makes 12% of the removal through sinks. It is necessary to increase the proportion of wood products, reduce the proportion of wood mass used as fuel. To increase the category of products of a higher degree of finalization and products of higher added value, the main factors identified for the Republic of Croatia are listed here: Human resources/'know-how', demand for wood products, availability of raw materials, technological investments in the wood processing and wood production sector, raising the technological level, increasing productivity and profitability.

The CAP establishes that the marketing of forest wood and non-wood products needs to be increased, which will also create and preconditions for new jobs in rural areas. Two measures

are foreseen by the CAP: Modernisation of technologies in pre-industrial wood processing (EUR 53,776,066) and Promotion of forest products and services (EUR 1,238,390).

Sources of funding: CAP, EU funds for regional development, EPEEF through funds raised from auctions

Monitoring body: MESD, Ministry of Agriculture

Effect: The amount of wood products depends, among other things, on the intensity of logging; the goal is to increase the proportion of wood volume that is embedded in wood products, to reduce the use of biomass for energy needs. The implementation of energy efficiency measures will reduce the need for heating biomass in households. The outflow of wood products has historically varied from 250 to 850 $ktCO_2$-eq in the last ten years.

Monitoring method: "Hrvatske Šume" data on logging and sorting volume, statistics on wood products monitoring.

Connection to other dimensions: Connection to renewable energy sources and security of energy supply. If there is a supply in disruption, an increase in the consumption of biomass for energy needs can be expected.

Climate change adaptation: energy renovation makes buildings more resilient to some of the effects of climate change, such as extreme temperature conditions

Research and development: It is necessary to determine mass flows in the cascading approach to the use of wood from production to final products, to improve monitoring statistics. The CROWOODS project is an initial project to improve monitoring, define directions of action and possible measures.

LUF-5 Land under managed crops

Economic measure; implementation: 2021-2030

Objective and description of the measure: By implementing activities in the management of agricultural production areas in a way that contributes to the reduction of the emission factor, it is of interest to family farms. Land management practices that can affect emissions and outflows, for example in soil storage, are soil treatment methods, plantation/crop life (rotation period) and crop / plantation type, fertilizer application, residue management, erosion control, application of irrigation systems etc.). Manner of area management in a climate and environmentally beneficial manner should be promoted, and guidelines for further development should be drawn up based on the knowledge and experience gained from the implementation of this measure.

The method of managing agricultural categories of land that applies emission reduction measures, which conserves and increases the carbon content of the soil, is called 'carbon agriculture'. Carbon farming is the premise of agricultural development on the road to a climate-neutral economy. Currently, the obstacle is that there is not enough data on the carbon content of the soil, no carbon maps have been made in agricultural soil. The EU is introducing the certification of outflows, which is intended to provide additional funding for carbon farming.

The following is a description of the carbon farming measures financed through the CAP SP:

31.03. Intensified maintenance of ecologically significant areas: The intervention represents a modification of the green practice of ecologically significant area, according to which it is carried out on all types of use of agricultural land, and on farms, regardless of the size of their agricultural area. Intervention shall be carried out to a minimum.

31.01 Conservation agriculture: The goal of conservation agriculture is to achieve a high and sustainable level of production while preserving natural resources and achieving acceptable profit and is based on three interdependent principles: a minimum set of soil treatment interventions, permanent coverage of the production area with plants or plant residues and proper crop rotation. The target in 2023-2029 is the application to 150,000 ha, indicative financial allocation in the form of a planned Union contribution is EUR 37,500,000.

70.01. Reduction of land use in perennial plantations The intervention aims to reduce the pressure of intensive agriculture on the environment through the reduction of soil, water and air pollution through the reduced and timely application of protective agents. Targeted application at 120,745 ha. Annual indicative financial allocation, total public expenditure is EUR 41,834,630.

70.04. Organic farming The plan of the Republic of Croatia is to reach the goal of 14% of agricultural area in organic farming by 2030. To encourage new farmers to participate in the organic production system and to keep those already in the system, the financing of support for organic farming continues. In the same way, continuous education of farmers and raising awareness of the benefits of production according to the principles of organic farming, which further contributes to the achievement of this goal, continue. It is planned to be implemented in 2023-2029 to 841,359 ha, with an annual indicative financial allocation of EUR 237,784,815, of which financing from EU funds EUR 190,227,852.

According to GAEC 3 standards, which prohibit the burning of harvest residues except for the purpose of preventing the spread or suppression of organisms harmful to plants, the maintenance of organic matter in the soil is ensured, which ensures adaptation to climate change.

Sources of funding: CAP, EU funds for regional development, EPEEF through funds raised from auctions Part of the funding could be realised through a system of sink certification, in a market that will be voluntary.

Monitoring body: MESD, Ministry of Agriculture

Impact: The impact of this measure could be decisive for the implementation of the objectives of Regulation 2023/839. Given the possible limitation in the increase in logging, outflows can be maximized through this measure, increasing the carbon content of the soil.

Monitoring method: It is necessary to urgently establish a soil carbon content monitoring system, according to the IPCC methodology, for the category 'land with crops that remain land with crops' Today, Tier 1 approach is used for this category, it is necessary to move to Tier 2 by 2028 and then to Tier 3 reporting level after 2030. Partly at project level, changes in soil carbon stocks will be registered through the sink verification system, the integration of these data into the national system needs to be elaborated, especially as they are likely to be voluntary verification schemes. It will also be monitored through a register of biofuel sustainability certificates, which should be established. The final, aggregated data will be in NIR. The areas of land under crops and conversions will be monitored by the CROLIS system.

Connection to other dimensions: This is related to the dimension of RES about the use of biomass from agriculture. For the time being, the RED II Directive has established the obligation to determine from plants greater than 20 MW of input power, and for biogas plants, for those greater than 2 MW of input power.

LUF-6 Managed grassland

Economic measure; implementation: 2021-2030

Objective and description of the measure: By implementing activities in the management of pasture in a way that contributes to the reduction of the emission factor, it is of interest to family farms. Manner of area management in a climate and environmentally beneficial manner should be promoted, and guidelines for further development should be drawn up based on the knowledge and experience gained from the implementation of this measure.

Good agricultural and environmental conditions of the land relating to GAEC 1, according to which the maintenance of areas under permanent grassland is prescribed based on the allowed maximum reduction of 5% of the area of permanent grassland at the national level compared to the reference year 2018, form the starting point for interventions (eco schemes) Extensive pasture management.

Under the SP CAP, the following measures contribute to the LUF-6 measure:

31.02. Extensive pasture management: The maintenance of pasture grazing will contribute to the survival of characteristic landscapes, the preservation of pasture vegetation, characteristic plant and animal species and valuable habitats. The grazing of animals on pastures for a long period of time contributes to the welfare of animals. It is planned to apply to 122,500 ha in the period 2023-2029. The Union's annual indicative financial allocation is EUR 29,807,500.

31.07 - Preservation of high nature value grassland, the intervention includes obligations that are so far within the Rural Development Programme of the Republic of Croatia for the period 2014-2020 implemented by users of type operation 10.1.3. Preservation of high natural value grassland, and it differs in that for the eco scheme Preservation of high natural value grassland users undertake a one-year commitment. In total, the period 2023-2029 plans for 22,500 ha, with an annual indicative financial allocation, the Union contribution in EUR 29,807,500.

70.02. - Conservation of biodiversity and the environment on permanent grasslands and arable land Intervention is carried out on grasslands of great natural value and arable land where grasslands and flower strips are established. These grasslands play a significant role in the storage of carbon in soil and biomass. Implementation is planned for the period 2023-2029 on 3,548 ha, and the annual indicative allocation of financial resources, total public expenditure amounts to EUR 2,700,958, of which two thirds will be financed from EU funds.

Sources of funding: CAP, EU funds for regional development, EPEEF through funds raised from auctions, private investments

Monitoring body: MESD, Ministry of Agriculture

Impact: Grasslands have a higher carbon content in the soil than land under crops, while the carbon stock in the biomass storage is higher in the crop category than in the grassland category, therefore the conversion of grassland to another soil category should be specifically

analysed, since the result (when all storage sites are considered) may be either emissions or outflows.

Monitoring method: The impact of the measure will be monitored under the CAP and in the NIR.

Connection to other dimensions: Connection to RES, relatively lower intensity.

Connection to adaptation to climate change: The measure contributes to increasing resilience to climate change.

Research and development: In the management of this accounting category of land, the key issue is the protection of nature and biodiversity. Any repurposing should be carefully analysed and justified. It is necessary to identify potential areas that would be suitable for conversion under afforestation and forestation measures.

LUF-7 Implementation of technical projects and scientific research in the LULUCF sector

Research measure; implementation: 2021-2030

Objective and description of the measure: In the period until 2030, it is necessary to provide financial resources for the implementation of technical and scientific projects in the LULUCF sector. Given the cost-effectiveness of measures in the LULUCF and agriculture sectors and the multiple positive indirect effects of these measures, and given the state of available data and uncertainty, research in LULUCF projects should be prioritised. Scientific projects should enable the development of different models for the purposes of moving to a higher level of IPCC methodology (Tier 3) with the aim of determining as accurately as possible the GHG emissions / outflows and, consequently, the planning of measures to reduce emissions and increase outflows.

Some of the priority projects are:

- Analyses of measures to achieve the objectives in the LULUCF sector by 2030.
- Mapping of land suitable for conversion from lower cultivation forms to more
- Complete the LIFE CROLIS project and ensure its full implementation and upgrade
- Launch the CROWOODS project to build a reporting system for timber products
- Scientific projects to analyse the impact of climate change on carbon storage and the LULUCF sector
- Improvement of forest inventory methodology and international harmonization, measurement system, monitoring of growth and logging, content and change of carbon in deadwood and charter Completion of the CRONFI II project – inventory of forests of the Republic of Croatia
- Carry out the mapping of environmentally sensitive areas of the Republic of Croatia about the new goals of 10% strict protection from the EU Biodiversity Strategy. Mapping of forests by age groups as defined by the Forest Strategy
- Creating a register to monitor the impact of the million trees annually initiative
- Create a map of carbon in the soil of the Republic of Croatia, for forest soils and agricultural soils. Use international databases

- Develop a system for monitoring the contribution of CAP measures to the reduction of greenhouse gas emissions
- Improve the system of monitoring the use of wood products and connect with the benefits of substitution of other materials.

In the construction of the planning, management, and reporting system, it is essential to establish an information system with georeferenced and harmonised data on land use and land cover, naturally sensitive areas, soil vulnerable to desiccation and soil rich in carbon as soon as possible. It is necessary to develop a plan for the transition to higher reporting levels from the LULUCF sector in accordance with Regulation 2023/839.

The following are measures related to **reducing fugitive emissions**.

FUG-1 Modernization and transformation of refineries

Economic measure; implementation: 2026-2027

Objective and description of the measure: Implementation of investments in the modernization and improvement of production to maintain the competitiveness of refineries and reduce fugitive emissions from refineries.

The measure includes the implementation of biofuel and sustainable fuel production projects of non-biological origin.

The measure reduces the use of fossil fuels and contributes to increasing the share of RES in the transport sector. It is expected to replace about 415,000 GJ per year of energy in transport, which traditionally comes from fossil sources.

Activities: Production of liquid and gaseous biofuels as well as renewable liquid and gaseous fuels of non-biological origin (RFNBO) intended for use in transport.

Funds needed for implementation: EUR 133,000,000.00

Monitoring (supervisory) bodies: MESD

Impact: The demand for energy at the site is not reduced but increased due to the installation of new plants. Reduction of CO_2 emissions: 50,000 t/year.

Monitoring method: The monitoring of the effects of this measure is carried out based on INA d.d. data before and after the application of the measures.

Executive body: INA d.d.

Connection to other dimensions: Investing in the modernization and improvement of production achieves the goals of decarbonisation.

FUG-2 Measures to increase energy efficiency by improving processes and process units

Economic measure; implementation: 2024- 2026

Objective and description of the measure: Increasing energy efficiency is achieved by implementing measures that contribute to reducing energy intensity through more rational

use of energy and raw materials and by modifying production processes and equipment at pumping stations and refineries, which contributes to reducing fugitive emissions.

Activities: Projects to increase energy efficiency in the Rijeka Oil Refinery include the replacement of existing equipment in the Rijeka Oil Refinery to significantly improve energy performance.

Funds needed for implementation: EUR 46,000,000.00

Monitoring (supervisory) bodies: MESD

Impact: Total reduction in energy consumption: 550,000 MWh/year, reduction in natural gas consumption: 653,000 MWh/year, increase in electricity consumption: 103,000 MWh/year, reduction in CO_2 emissions: 115,000 t/year.

Monitoring method: The monitoring of the effects of this measure is carried out based on INA d.d. data before and after the application of the measures.

Executive body: INA d.d.

Connection to other dimensions: Investing in increasing energy efficiency achieves the goals of decarbonisation.

ii. If relevant, regional cooperation in this area

At a regional workshop held in Ljubljana in July 2019, the proposed topics for regional cooperation within the framework of the dimension of decarbonisation / emission and greenhouse gas removal were

- joint development of parts of national climate change adaptation strategies (e.g. for the Adriatic region),
- joint management of waterways,
- joint development of a soil map (relevant for the cultivation of biomass for non-food purposes and for monitoring the carbon content of soil),
- scientific cooperation in the study of hydrogen, the removal and storage of greenhouse gases
- exchange of experiences related to greenhouse gas emissions and removals and adaptation to climate change.

In addition, the dissemination of information and networking is foreseen by the LIFE-CROLIS project on the use of geo-information system and modern satellite imaging technologies in land data harmonisation for LULUCF, which envisages workshops with a call to neighbouring countries.

A good opportunity is Interreg programmes with neighbouring countries with which the climate and environmental space is shared and joint projects can provide synergies.

According to Article 9.1 of the Paris Agreement, developed country Parties to the Agreement should provide financial resources to assist developing country Parties in mitigation and adaptation, in addition to their existing obligations under the Convention. Reporting on implementation shall be submitted every two years. In the framework of the activities of the

Environmental Protection and Energy Efficiency Fund, support schemes should be developed, and provision should be made for the proceeds of auctions from the ETS and the future trading system in the transport and building sector.

iii. Without prejudice to the applicability of the rules on state aid, financial measures in this area at the national level, including Union support and use of Union funds, if applicable

Part of the costs of implementing the measures envisaged within the dimension of decarbonisation - greenhouse gas emissions and removals will be financed from the state budget, auction funds, the Modernization Fund and extra-budgetary funds, and the use of EU funds is expected, namely cohesion policy funds through technical assistance to national bodies administration and direct support from future operational programmes. The bulk of support for agriculture and the LULUCF sector is currently delivered through SP CAP measures.

Financing of the envisaged measures is also expected through the programmes of the European Investment Bank, the European Bank for Reconstruction and Development and other financial institutions and the Modernization Fund. The development of innovative projects for funding from the Innovation Fund will be encouraged. The use of financial resources from the sale of a part of the national quota in sectors outside the ETS was not considered, as there is no information on how transfers between Member States will be carried out, and so far there is limited experience in this area and no information on the cost of these units of emission.

In line with the Regulation 2023/839, the EU will consider the possibilities of financing the emission reductions achieved in the LULUCF sector from the ETS auction funds, in addition to the SP CAP, also considering the future carbon storage certification system. In the forestry sector, changes will be needed in view of existing plans that could have economic and sociological consequences. The LULUCF sector is linked to rural development and these incentives have strong horizontal action.

3.1.2 Renewable energy

i. Policies and measures for achieving a national contribution to the binding target at the EU level by 2030 for renewable energy and trajectories referred to in Article 4, item (a), subitem 2 and, if applicable and available, elements from item 2.1.2, including sector-specific measures and technology-specific measures

OIE-1 Information, education, and capacity building for using RES

Information measure; implementation 2021-2030

Objective and description of the measure: Informing all relevant stakeholders will be conducted through the organization of targeted informational campaigns related to investments in systems using renewable energy sources, especially in systems for own needs. Information, education, and capacity building for use of RES will be implemented at the national level and the target sectors are the energy sector (NACE code D), primary sector

(NACE code A), manufacturing (NACE code C), construction industry (NACE code F) and the population of the Republic of Croatia (general population).

Activities: The following activities will be implemented within the measure:

- information campaigns (raising awareness of the benefits of RES technologies through education and promotion of good practices with an emphasis on small projects up to 500 kW);
- implementation of educational programmes on the use of RES in kindergartens and schools;
- promotion of accredited university study programmes in the field of renewable energy sources (in addition to general energy/RES studies, the emphasis is also on specific fields such as geo energy, geoengineering, bioeconomy, etc.);
- training programs that promote the design, implementation and use of RES systems in buildings (photovoltaic systems, solar thermal systems, heat pumps, furnaces and biomass boilers);
- education and promotion of the use of geothermal energy for thermal purposes;
- setting up and organizing an advisory service with experienced practitioners involved, especially for small projects (up to 500 kW);
- development of online tools, publications and other modern communication tools to make available all relevant information on administrative procedures, accredited equipment and certified installers;
- capacity building and enhancement for all market players (active customers, energy communities, renewable energy communities, energy suppliers, aggregators, system operators, installers);
- promotion of new financial mechanisms that increase RES capacities
- promotion of corporate power purchase agreements for larger price-related projects;
- consulting with the financial sector, promoting good practice and education, for larger projects.

Funds needed for implementation: around EUR 1 million per year

Funding sources: Emission allowance auction assets (EPEEF) and EU funds.

Executive body: MESD – implementation and sponsorship of education and promotion programs, organization of an advisory service, design of new business models for the implementation of biogas plants and biomass cogeneration; EPEEF– provision of part of the funds, participation in promotion and education activities; MPPCSA – promotion of the use of RES systems in buildings; CHA: promotion of the use of geothermal energy; Croatian Chamber of Commerce – promotion of the use of RES systems to entrepreneurs; Hep DSO – promotion of small RES capacities built so far, with an emphasis on the positive impact on the network (reduction of peak loads, etc.); Ministry of Agriculture in cooperation with LGUs - promotion and supply of biomass for the needs of the bioeconomy, decarbonisation of livestock, development of the bioeconomy; Suppliers - promotion of corporate contracts; Ministry of

Science and Education in collaboration with LGUs - with programmes to promote RES in kindergartens and schools

Monitoring (supervisory) bodies: MESD

Effect: Increase in energy production and the share of RES in total energy consumption and reduction of greenhouse gas emissions from the energy sector and the above target sectors. Increasing the number of citizens interested in using RES.

Monitoring method: Number of events, number of users

Connection to other dimensions: The measure is related to the dimension of increasing energy security and developing the internal energy market. The measure can also be linked to the energy efficiency dimension by promoting the use of RES in buildings, with energy efficiency measures.

Connection to climate change adaptation: The use of RES is planned with the integration of climate change adaptation measures and strengthening of resilience, i.e., reduction of vulnerability of RES technologies to climate change.

Research and development: Information, education and capacity building for RES use is not directly related to research and development.

OIE-2 Spatial planning requirements for using RES

Regulatory measure; implementation: 2021- 2026

Objective and description of the measure: Analysis of the existing state of spatial capacities, defining guidelines and criteria for specific spatial planning elements for RES planning at the state, county and local level.

Activities: The following activities will be implemented within the measure:

- analysis of spatial plans with review of planned locations, mapping of resource potential for individual renewable sources (wind, solar, hydropower, geothermal water for energy purposes) with respect to existing and advanced energy conversion technologies and adaptations to climate change based on ecosystem characteristics within specific space for utilization of RES (planned and potential space), possibilities of energy storage from RES and integration into the existing distribution system;
- identification and mapping of spatial, environmental (bio-ecological, landscape, geological) and social (use of space) and infrastructural constraints, and the sensitivity of space for plant construction and operation, given the characteristics of existing and advanced RES utilization technologies;
- development of sensitivity maps for RES accommodation, with a focus on wind and solar power plants, for the entire Republic of Croatia, i.e. defining the so-called *Go-to*

areas according to the Communication from the European Commission "REPowerEU*: Joint European Action for more affordable, secure and sustainable energy*"

- defining guidelines and criteria for the selection of spaces suitable for RES exploitation, spatial-planning conditions and protection measures in procedures under special laws;
- adopting guidelines and criteria for the regulation of specific spatial planning elements in the state-level RES utilization space and their implementation into state-level spatial planning documents at the national, regional and local levels, with the application of protection measures in procedures under special laws;
- professional education and encouragement of cross-sectoral cooperation of experts in the field of spatial planning, nature and environment protection, energy and other experts relevant to the spatial planning and development of RES projects;
- upgrading existing information systems with the data necessary to identify the potential constraints and sensitivity of space to the construction of RES facilities (generating plants using RES with associated infrastructure).

Funds needed for implementation: initial funds HRK 300 000, funds earmarked for implementation of the strategy and action plan for the application of protection measures in procedures under special laws, regular work of state bodies

Funding Sources: EU funds, World Bank (for mapping and analysis); budget of the state, counties, cities and municipalities (for the application of protection measures in procedures under special laws and the new generation of spatial plans)

Executive body: Ministry of Physical Planning, Construction and State Assets (MPUGDI) and Ministry of Economy and Sustainable Development (MESD), in cooperation with the Ministry of Agriculture; counties, cities and municipalities.

Monitoring (supervisory) bodies: MPUGDI and MESD

Impact: Increasing the number of sites and areas for RES in new generation spatial plans (PP), with sustainable use of space and natural resources (acceptable environmental and nature impacts) and reducing greenhouse gas emissions, accelerating the duration of RES projects development.

Tracking method: Number of counties that have defined the conditions for the location and construction of RES plants, based on prescribed guidelines, with due regard for the sensitivity of the area in their area, with the application of protection measures in procedures under special laws; duration of administrative procedures in the framework of development of RES projects; number of locations and areas for RES (production facilities using RES with associated infrastructure).

Connection to other dimensions: The measure is related to the dimension of increasing energy security (conditions for increasing energy production) and developing the internal

energy market. Within this measure, some research needs to be carried out, so the measure is related to the research and development dimension.

Connection to climate change adaptation: The use of RES is planned with the integration of climate change adaptation measures and strengthening of resilience, i.e. reduction of vulnerability of RES technologies to climate change.

Research and development: Link through exploration of resource potential and mapping of spatial, environmental, and infrastructural constraints and sensitivity of space for plant construction and operation.

OIE-3 Developing a regulatory framework for using RES

Regulatory measure; implementation: 2023- 2026

Objective and description of the measure: It is necessary to rework (complete and refine) the existing legal framework and improve procedures and practice. The goal is to establish a rounded and functional regulatory framework and establish established procedures for planning and implementation of RES projects at the state and local level.

The regulatory framework for the use of renewable energy sources is made up from more laws and by-laws whose provisions complement each other and intertwine. These are essentially the Energy Act (OG 120/12, 14/14, 95/15, 102/15 and 68/18), the Electricity Market Act (OG 121/21), the Thermal Energy Market Act (OG 80/13 and 14/14) and the Renewable Energy Sources and High-Efficiency Cogeneration Act (OG 138/2021) as a separate law for the field of renewable sources, with accompanying by-laws. Exploration and exploitation of geothermal energy are regulated by the Hydrocarbon Exploration and Exploitation Act (OG 52/18, 52/19 and 30/21). The Biofuels for Transport Act (OG 145/10, 26/11, 144/12, 14/14, 94/18 and 52/21) regulates the use of renewable energy sources in transport. In addition to energy laws, regulations and documents relevant for spatial planning and construction (Spatial Planning Act (OG 153/13, 65/17, 114/18, 39/1 and 98/19), the Construction Act (OG 153/13, 20/17, 39/19 and 125/19) as well as spatial plans at the state and lower level) and regulations in the field of environmental protection (Environmental Protection Act (OG 80/13, 153/13, 78/15, 12/18 and 118/18) and the Nature Protection Act (OG 80/13, 15/18, 14/19 and 127/19) with regulations on the needs and assessment of the impact of projects on the environment are of crucial impact on the administrative procedures necessary for obtaining the necessary permits.

The Energy Act, as the basic act governing the energy sector, defines the basic strategic documents of the energy sector and declares the use of renewable energy sources of interest to the Republic of Croatia. Pursuant to the Energy Act, the Ordinance on permits for performing energy activities and keeping a register of issued and revoked permits for performing energy activities (OG 44/22) was adopted, which recognizes new activities in the energy sector (aggregation, energy storage and organization of the energy community of citizens). Based on the Act, a system of guarantees of energy origin was established, elaborated in more detail by the new Regulation on the system of guarantees of energy origin

(OG 28/23), which, among other things, extends the forms of energy for which CEMO issues guarantees of energy origin.

The Electricity Market Act has transposed into Croatian legislation Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast) (Text with EEA relevance.) (OJ L 158, 14th Jun 2019) and thus the newspapers and institutes which that Directive brings into the framework for the electricity market. Pursuant to the Act, methodologies have been adopted for determining the amount of tariff items for electricity transmission and distribution and guaranteed supply, Ordinance on general conditions for the use of the network and electricity supply (OG 100/22), Methodology for determining the fee for connection to the electricity network (OG 84/22), Rules on the change of suppliers and aggregators (OG 84/22) and Ordinance on the quality of electricity supply (OG 84/22). However, the rules governing the procedure for connection to the electricity network have not yet been adopted (the rules are adopted by the transmission or distribution system operator with the prior opinion of MESD and the consent of CERA), the decision on the amount of the unit fee for connection to the electricity network (CERA) and the regulation which should regulate the conditions of the public tender for energy approval, issued by MESD (Government of the Republic of Croatia at the proposal of MESD). The public consultation includes the Rules on wholesale market organisation adopted by CEMO.

The Renewable Energy and High-Efficiency Cogeneration Act entered into force in December 2021 and takes over the provisions of the amended Directive 2018/2001 on the promotion of the use of energy from renewable sources and ensures the implementation of Directive (EU) 2018/1999 on the and Regulation on the Governance of the Energy Union and Climate Action (EC) No 1083/2009 and Regulation 1099/2008 of the European Parliament and of the Council of 22 October 2008 on energy statistics (Text with EEA relevance) (OJ L 304, 14th Nov 2008). The law regulates the development of the NECP, measures to encourage renewable energy sources and high-efficiency cogeneration, the system of incentives, the takeover of electricity from end customers with their own production or users of self-supply plants, the inclusion of renewable energy for heating and cooling and centralised heating and cooling, and other issues important for the functioning of all segments of the RES sector. Pursuant to the Act, the Energy Efficiency Programme for the Decarbonisation of the Energy Sector was adopted (OG 143/21), the Regulation on the Share in Net Supplied Electricity of Privileged Producers, which electricity suppliers are obliged to take over from the electricity market operator for 2023 (OG 156/22), the Regulation on the Use of Renewable Energy Sources and High-Efficiency Cogeneration (OG 28/33), the Decision on the Fee for Renewable Energy Sources and High-Efficiency Cogeneration (OG 31/23) and the Regulation on the Criteria for Payment of Reduced Fee for Renewable Energy Sources and High-Efficiency Cogeneration (OG 31/23). It is precisely the Regulation on the use of renewable energy sources and high-efficiency cogeneration that establishes the methodology for determining the share of energy from RES in gross final energy consumption, sustainability and greenhouse gas emission saving criteria for biofuels, bioliquids and biomass fuels and their verification. Together with the Regulation on the system of guarantee of energy origin, it presents the acts necessary for the full transposition of the Directive 2018/2001 on the promotion of the use of energy from renewable sources into Croatian legislation. Regarding floating solar power plants and their installation on water

surfaces that are a public property by amending the law in the field of water management (Water Act (OG 66/19 and 84/21) and the Ordinance on the issuance of water rights acts (OG 9/20)) Z), it is possible to obtain a water rights permit for the use of water surfaces for the installation of floating facilities.

Accordingly, the competence to create and improve the regulatory framework for the RES sector is divided between MESD (energy, environmental and nature protection), MPUGDI (spatial planning, construction), CHA (geothermal energy), CERA, CEMO, CTSO and DSO, as well as other competent public bodies for individual administrative areas (agricultural land, forests, water management).

Further refinements of the RES framework, the next revision of the EU climate and energy legislation and the proposed reform of the EU electricity market model are also to be expected, which, among other things, aims to increase the use of RES.

Activities: The following activities will be implemented within the measure:

All participants: i) continuous removal of obstacles and relief of administrative procedures that limit the greater use of energy from RES, ii) elimination of cross-sectoral non-compliance of regulations that prevent the implementation of RES projects.

MESD (climate and energy): i) prepare for the Government of the Republic of Croatia a proposal for a regulation on the conditions of tenders for energy approval ii) ensure the adoption of the missing by-laws and proactively cooperate with the competent entities in the process of their preparation and harmonization ii) strengthen the capacity to provide guidance to investors during the entire licensing procedure, iii) prepare an analysis of the drivers, obstacles and alternatives and the possibilities of support for the conclusion and implementation of corporate contracts for the purchase of renewable energy, in order to determine their potential in achieving national goals and create a favourable and stable regulatory environment iv) monitor the adoption of EU legislative acts and harmonise regulations within their competence in accordance with the adopted directives and regulations.

CTSO, DSO, MESD, CERA: adopt the rules of connection to the power grid

CERA: determine the unit amount of the fee for connection to the electricity network

MESD (environmental protection): i) consider the need to raise the limit for the purpose of carrying out the environmental and nature impact assessment procedure ii) legally define cases in which it is not necessary to carry out new procedures related to environmental impact assessment when applying newer technology.

MESD and MPUGDI: i) ensure compliance of energy regulations with regulations for spatial planning and construction, ii) ensure uniform application by competent authorities through education, information, supervision, etc.

MPUGDI**:** i) Regulation on simple buildings regulate the status of solar power plants used for self-supply in order to exempt them from the obligation to obtain an energy permit ii) regulate the status of agrosolar power plants and geothermal wells for agricultural purposes in the Spatial Planning Act iii) ensure the continuation of the functioning of the system of certified installers for small RES systems iv) ensure the implementation of the obligation to use the RES system on new buildings (regulations related to construction);

CEMO, MESD, MPUGDI, CERA, CTSO, DSO: develop and publish a manual - a guide that provides complete information on the procedures for obtaining permits for the construction of a renewable energy production plant, considering in particular small projects and projects of consumers of their own energy from renewable sources (obligation under the Renewable Energy Sources and High-Efficiency Cogeneration Act)

MA: i) refining regulations for agriculture and land use in such a way as to enable wider construction of solar power plants on agricultural land, as a secondary activity with primary agricultural production or on derelict agricultural areas ii) follow the criteria of sustainability and use of digestate

MPUGDI: regulates and introduces obligations for the use of RES in new buildings (construction-related regulations);

MPUGDI: ensure the continuation of the functioning of the system of certified installers for small RES systems;

Funding sources: Budgetary funds

Executive body: MESD – general regulation of the legislative framework (adoption of missing regulations, refinement of existing regulations, monitoring of the revision of EU legislation and harmonization); MPUGDI – refinement of regulations for spatial planning and construction with regard to RES projects, continuation of the functioning of the system of certified installers; CERA – methodology and connection fee, energy activity permit; CEMO – rules for organizing the energy market, drafting a comprehensive manual in cooperation with other stakeholders; CTSO and DSO - rules for connection to the electricity network, planning the development of the transmission and distribution system; MA – construction of PV systems on agricultural land; CHA - continuation of the implementation of geothermal projects.

Monitoring (supervisory) bodies: MESD

Effect: The result of the implementation of the measure is a functional RES market and an increase in energy production and a share of RES in total energy consumption.

Monitoring method: Energy balance, plan, and implementation of legislative acts

Connection to other dimensions: The measure is related to the dimension of increasing energy security and developing the internal energy market (legislative sector development).

Connection to climate change adaptation: The use of RES is planned with the integration of climate change adaptation measures and strengthening of resilience, i.e. reduction of vulnerability of RES technologies to climate change.

OIE-4 Use of RES for electricity production

Financial measure; implementation 2021 - 2030

Objective and description of the measure: Provide financial incentives for the development of RES projects for electricity and heat production. Encouraging the use of RES for electricity production will be implemented at the national level.

Activities: The following activities will be implemented within the measure:

- CEMO continues to pay incentives for the production of electricity to power plants using RES for the duration of the purchase contract (incentive system, premium system);
- CEMO prepares three-year RES plans and announces tenders for assigning market premiums;
- The promotion of electricity production through the premium system under the Renewable Energy Sources and High-Efficiency Cogeneration Act will continue with system modifications made possible by changing the market status of individual RES technologies and by developing a day-ahead and intraday electricity market, exclusively to mitigate the market risks of new RES projects; the premium system is implemented to a minimum extent, including the implementation of a hybrid model of stimulating premiums/market, as a transition measure to full market integration of RES;
- Revision of quotas for all types of renewable energy sources
- Developing a new model of incentives for biomass fuel plants while ensuring maximum fulfilment of sustainability objectives and greenhouse gas saving criteria
- The activities of reviewing and analysing potential geothermal potentials and initiating the launch of bidding procedures to select the most suitable bidder for the exploration of geothermal waters for energy purposes will continue in order to increase the share of RES in electricity production;
- Continued application of the surplus energy absorbing model from self-supply plants and self-producing end-customers with possible investment support and the supplier's obligation to absorb surplus energy;
- Development of models for encouraging the participation of citizen energy communities and renewable energy communities as applicants for tenders in which renewable energy technologies are co-financed;
- The EPEEF allocates part of the proceeds from the sale of emission units through EU ETS auctions for measures to stimulate RES on the investment side and to relieve end customers from increasing the RES incentive fee;

- Certification of origin of renewable energy sources, green hydrogen, biomethane and other biofuels
- The Ministry of Agriculture, through the Agriculture Strategy, provides financing of investment aid for biomass and other RES projects.
- Development of models for encouraging the participation of citizen energy communities and renewable energy communities as applicants for tenders in which renewable energy technologies are co-financed

Funds needed for implementation: around EUR 1 billion for the entire period under review.

Levelled costs of electricity production from solar and wind power have reached market price levels, especially after a significant increase in electricity prices in the previous period and are market competitive. The reaction to the rise in electricity prices is also evident in the incentive system itself, where a part of the incentive system projects terminated long-term contracts and turned to the market. Taking all the above into account, it is not necessary to plan significant financial incentives for larger solar and wind power projects, but to enable them to appear on the market (measure). However, it is expected to continue encouraging the use of biomass, biogas, hydropower and geothermal energy, both through the system of stimulating electricity production and through other sectoral measures. Furthermore, it is necessary to encourage the exploitation of geothermal energy through the reduction of investigative risk, which can be realized with EU funds, and through other financial mechanisms as well as through geological risk reduction programs by conducting preliminary exploratory activities by the CHA, to equalize the price of energy obtained from geothermal water with other RES.

Funding Sources: RES fee (CEMO); proceeds from the sale of renewable energy in the market; proceeds from trade in guarantees of origin; the proceeds from the auctioning of emission allowances (the EPEEF) for RES investment grants and as additional revenue to the EPEEF for the operational promotion of RES managed by CEMO; EU funds; special funds (European Agricultural Fund for Rural Development, etc.) to support biomass projects.

Executive body: CEMO - payment of incentives, establishment of a premium model with a protective price and a shortened duration of premium agreements, invitation to tender; MEPE - making plans; EPEEF - participation in RES investment grants and as support of operational incentive systems; MA - implements the Rural Development Programme and participates in RES investment grants; CHA (Hydrocarbon Agency) - defining exploratory actions, determining rules and conditions when exploring and exploiting geothermal waters for energy purposes, as well as providing expert support in conducting public tenders.

Monitoring (supervisory) bodies: MESD

Effect: The measure will ensure an increase in energy production and a share of RES in total energy consumption and, consequently, a reduction in greenhouse gas emissions. It also creates preconditions for the establishment of a monitoring system to meet the sustainability criteria and the expected reductions in greenhouse gas emissions from biomass plants.

Monitoring method: Energy balance, according to the amount of electricity produced from RES, according to reports by CEMO and system operators.

Connection to other dimensions: The measure is related to the dimension of increasing energy security since the expected result of the measure is an increase in energy production from locally available sources and the development of the internal energy market.

Relationship to climate change adaptation: The use of RES is planned with the integration of climate change adaptation measures and strengthening of resilience, i.e., reduction of vulnerability of RES technologies to climate change.

Research and development: The measure is related to the research and development of RES technologies and the integration of RES into energy systems.

OIE-5 Use of RES for thermal purposes

Financial measure; implementation 2021 -- 2026

Objective and description of the measure: Providing financial incentives for the development of RES projects for thermal needs.

Activities: The following activities will be implemented within the measure:

- EPEEF participates with financial incentives on the investment side for projects using RES for thermal needs
- CHA will continue with the activities of review and analysis of geothermal potential in Pannonian part of Croatia, initiate the initiation of tender procedures in order to select the most favourable bidder for the exploration of geothermal waters for energy purposes and ensure their inclusion in spatial plans (related to the RES measure – 2)
- CHA and EPEEF will support the development of geothermal energy use projects
- The Ministry of Agriculture, through the Agriculture Strategy, provides financing of investment aid for biomass and other RES projects.

Funds needed for implementation: EUR 1 billion for the entire observed period

Continued encouragement of the use of biomass, biogas, geothermal energy, and heat pumps is expected. The exploitation of geothermal energy will be encouraged through co-financing of geothermal potential research.

Sources of funding: funds obtained from the auctioning of emission allowances (EPEEF) for RES investment grants; funds from EU funds, the EEA Financial Mechanism, and the Norwegian Financial Mechanism.

Executive body: MESD; EPEEF – participation in RES investment grants; MAF– implements the Agriculture Strategy and participates in RES investment grants; CHA – defining investigative actions, determining the rules and conditions for the exploration and exploitation of geothermal waters for energy purposes, as well as providing expert support during public tenders; conducting exploratory activities to reduce the geological risk of exploration and

exploitation of geothermal waters; MRDEF – implements financing programmes from European and other funds

Monitoring body: MESD

Effect: The measure will ensure an increase in the share of RES in the production of thermal energy and consequently a reduction in greenhouse gas emissions. It also creates preconditions for the establishment of a monitoring system to meet the sustainability criteria and the expected reductions in greenhouse gas emissions from biomass plants.

Monitoring method: Number of co-financed RES projects for thermal needs; amount of heating and cooling energy resulting from these projects; number of geothermal water reservoirs investigated

Connection to other dimensions: The measure is related to the dimension of increasing energy security since the expected result of the measure is an increase in energy production from locally available sources and energy efficiency in the building sector.

Relationship to climate change adaptation: The use of RES is planned with the integration of climate change adaptation measures and strengthening of resilience, i.e., reduction of vulnerability of RES technologies to climate change.

Research and development: The measure is related to the research and development of RES technologies and the integration of RES into energy systems.

OIE-6 Use of RES in centralized and closed thermal systems

Financial measure, regulatory measure; implementation 2023-2030

Objective and description of the measure: enable an increase in the share of RES in DHS by using available sources such as shallow and deep geothermal, solar energy, water energy and enable the achievement of the status of efficient centralised heating and cooling for all heating systems in the Republic of Croatia.

Activities: The following activities will be implemented within the measure:

- Amendments to the Thermal Energy Market Act that would identify key technologies for the decarbonisation of thermal energy heating and storage systems and identify steps for their planning, construction, connection and use
- Amendment to the Decree on Environmental Impact Assessment - daily and seasonal thermal energy tanks are not directly recognized as a type of intervention according to the current Decree on Environmental Impact Assessment
- The upgrading of the Construction Act and the Physical Planning Act – in the current Construction Act and the Physical Planning Act, the types of buildings are recognized, but integrated building systems such as, for example, the construction of a geothermal well, a seasonal tank and a heat pump are vaguely defined as one integrated system. Currently, the Physical Planning Act recognizes the concept of stage construction and phase construction in a complex building, with one location permit for which one or more building permits are issued. It is necessary to define how to approach the stages of construction in such a case around the impact on the environment, obtaining spatial planning documentation and obtaining the necessary permits

- Defining the conditions for the construction of seasonal heat tanks - For the storage of thermal energy, no geological or pedological conditions have been defined that need to be met during, for example, the construction of seasonal heat tanks (depths for excavation, soil composition, etc.).
- Determination of urban zones of potential heating – analysis of spatial plans, mapping of thermal energy consumption and determination of zones in urban areas where users can potentially connect to the thermal network.
- Co-financing the development of plans for increasing RES in centralised or closed thermal systems
- Co-financing investments in technologies for the use of RES, identified in the plan for increasing the share of RES in DHS/SHS.

Funds needed for implementation: 750 mil. EUR for the entire observed period

Sources of financing: Environmental Protection and Energy Efficiency Fund through public calls and tenders, EU funds

Executive body: EPEEF

Monitoring (supervisory) bodies: MESD

Impact: Increasing the share of renewable energy sources, reducing CO_2 emissions and increasing energy efficiency in heating systems.

Monitoring method: Produced energy from renewable energy sources in heating systems and energy delivered to the thermal network. Measurement of electrical energy to drive the heat pump compressor to gain insight into the energy taken from the environment.

Connection to other dimensions: The measure is related to all dimensions

Connection to climate change adaptation: The use of RES in heating has a direct impact on reducing CO_2 emissions.

Research and development: The measure is related to the research and development of RES technologies and the integration of RES into energy systems. The greatest emphasis should be placed on research into the use of waste heat in heating systems. It is necessary to map waste heat sources in cities with existing centralized heat systems and make preliminary studies of technical feasibility. Centralized heat systems can also be used for cooling via absorption heat pumps. For this purpose, it is necessary to conduct a preliminary feasibility study in a city with an existing heating system.

OIE-7 Sharing Energy and Energy Communities

Regulatory and financial measure; implementation 2021 -2030

Objective of the measure: to encourage energy sharing and the establishment of energy communities; to increase the share of RES in final consumption; to improve access to and sharing of data

Description of the measure: It is necessary to supplement the existing rules of access to the electricity network, elaborate procedures and practice of information exchange between

system operators and users, and improve the possibilities of calculating energy exchange. Support will be given to the creation of energy communities.

The current regulatory framework for the use of renewable energy sources is covered by several laws, and key laws in this regard are the Renewable Energy Sources and High-Efficiency Cogeneration Act and the Electricity Market Act with a number of bylaws. In order to encourage the wider use of renewable energy sources in final consumption and in order to meet the set climate objectives and to align the national regulatory framework with EU directives, it is necessary to complement the aforementioned laws, relevant by-laws and rules of the distribution system operator by extending the possibilities of using energy from renewable sources. It is necessary to supplement by-laws with the aim of enabling energy sharing, enable self-supply from a source that is not behind the same meter as the customer's meter, enable equal (peer-to-peer) energy sharing of users, improve incentive tariffs for more efficient use of the distribution network, improve the rules of data access by data users in order to provide services and share energy.

The establishment and operation of energy communities will be encouraged by capacity building (instructions for the establishment and operation of energy communities will be developed – related to the RES-1 measure), technical documentation and investment in RES technologies will be co-financed (related to the RES-4 measure). The number of established energy communities and installed RES capacities owned by established energy communities will be monitored.

Activities: The following activities will be implemented within the measure:

MESD regulates the regulatory framework for enabling the wider use of civic energy by defining the terms in the appropriate place in the Act;

The DSO applies non-discriminatory grid access rules for all participants, enables access and easier exchange of information on metering and billing data

All participants have the task of ensuring the general simplification, regulation and establishment of administrative procedures and the removal of barriers to the implementation of the necessary activities;

Sources of funding: Budgetary resources, compensation for the use of the grid, Cohesion Fund, Modernization Fund, Recovery and Resilience Plan, EEA Financial Mechanism, Norwegian Financial Mechanism, other sources of financing

Executive body: MESD – general regulation of the legislative framework, supplementing the existing with new solutions , **CERA –** improve network usage rules, DSO– improve data access rules.

Monitoring (supervisory) bodies: MESD, CERA

Effect: The result of the implementation of the measure is a functional RES market and an increase in energy production and a share of RES in total energy consumption.

Monitoring method: Energy balance, plan and implementation of legislative acts

Measure implementation indicator: Number of established energy communities; installed RES capacities owned by energy communities

Connection to other dimensions: The measure is related to the dimension of increasing energy security and developing the internal energy market (legislative sector development).

Connection to climate change adaptation: The use of RES is planned with the integration of climate change adaptation measures and strengthening of resilience, i.e. reduction of vulnerability of RES technologies to climate change.

ii. If relevant, specific measures for regional cooperation as well as, optionally, an estimated renewable energy production surplus that could be transferred to other Member States in order to achieve the national contribution and trajectories from item 2.1.2.

At a regional workshop held in Ljubljana in July 2019, the proposed topics for regional cooperation within the decarbonisation/renewable energy sources dimension were

- joint development of RES projects, analysis of statistical transfer opportunities,
- cooperation in the context of the "Clean Energy Initiative for EU Islands",
- exchange of experiences related to energy communities and energy production from RES for own needs,
- exchange of experiences related to energy-positive neighbourhoods and joint development of project proposals for the Joint Program Initiative Urban Europe,
- exchange of experiences related to the integration of RES into space and social acceptance of RES.

Countries participating in informal regional coordination are considering the proposals made and will agree on next steps.

iii. Specific measures for financial support, if applicable, including EU support and use of EU funds, to promote the production and use of renewable energy in electricity generation, heating, cooling and transport

The required amount of RES support for electricity is estimated in the next section.

iv. If applicable, an assessment of the support for electricity from renewable sources to be implemented by Member States in accordance with Article 6 (4) of Directive (EU) 2018/2001

It is estimated that support of EUR 0.8 to 1.1 billion is needed over the period under review.

The aforementioned amount of aid was calculated on the basis of the investment subsidy required to make the levelling cost of electricity 55 EUR / MWh. This calculates the amount of subsidy required for all the technologies envisaged per MW of installed capacity. That amount was multiplied by the projected power installed in power plants, by technology.

The final amount of support required will depend primarily on the development of technology.

v. Specific measures to introduce one or more contact points, streamline administrative procedures, provide information and training and facilitate acceptance of energy purchase contracts

As referred to in Directive (EU) 2018/2001 of the European Parliament and of the Council of 11th December 2018 on the promotion of the use of energy from renewable sources and relating to authorisation, certification and licensing procedures applicable to electricity-generating installations and associated transmission and distribution networks for the production of electricity, heating or cooling from renewable sources, to the process of converting biomass into biofuels, bioliquids, biomass fuels or other energy products, as well as to renewable liquid and gaseous transport fuels of non-biological origin, proportionate and necessary, and contributing to the implementation of the energy efficiency principle in the first place, it is necessary to take the necessary measures to ensure that:

(a) simplified and accelerated administrative procedures at the appropriate administrative level and the establishment of predictable timeframes;

(b) the objectivity, transparency and proportionality of the rules governing authorisation, certification and licensing, and that they do not discriminate against applicants and take full account of the specificities of individual renewable energy technologies;

(c) transparency and dependence on the costs of administrative fees paid by consumers, planners, architects, builders and installers and suppliers of equipment and systems;

and (d) establishing simplified and less burdensome authorisation procedures, including through a simple notification procedure, for decentralised installations, and for the production and storage of energy from renewable sources.

vi. The assessment of the need for the construction of new infrastructure for centralized heating and cooling produced from renewable energy sources

In terms of greater integration of RES into district heating systems and the eventual development of district cooling systems, it is necessary to create the conditions for connection and operation of production plants for the production of heating and cooling energy from RES. Aspects of the procedure and cost of connection of such facilities need to be further considered in such a way as to maximize the technology of high-capacity electric boilers and heat pumps as production plants for district heating and cooling systems. It is also estimated that greater integration of RES into district heating systems and the construction of district cooling systems in the market will offer highly competitively priced thermal energy, which will consequently create the need to build new and expand existing distribution infrastructure. Of particular interest are geothermal power plants, which are mainly of the baseload type, which means that they are in operation throughout the year with very short shutdown periods. In the projects of geothermal power plants, in addition to electricity production, there is also the possibility of cascading use of the remaining thermal energy of geothermal water for various purposes (heating, space heating, dryers, aquaculture, etc.). Such systems increase the efficiency of geothermal plants and thus the cost-effectiveness of the entire geothermal project. The use of geothermal energy reduces the consumption of conventional energy sources (e.g. fossil fuels), resulting in a positive environmental impact. The use of RES in

district heating systems will be supported by the implementation of the ENU-15 measure Increasing the efficiency of the heating system.

vii. If applicable, specific measures to encourage the use of energy from biomass, in particular for the production of new biomass, taking into account the availability of biomass: domestic potential and imports from third countries and other uses of biomass in other sectors (agriculture and forestry sectors); as well as measures for the sustainability of biomass production and use

The most important measures to stimulate the use of energy from biomass are the measures POLJ-4 Anaerobic degradation of manure and biogas production and TR-7 Development of the low-carbon fuel market. Sustainability of biomass production and use will be encouraged under measure MS-9 Strengthening activities for the development of the bioeconomy.

3.1.3 Other elements

i. National policies and measures affecting the EU emission trading system (EU ETS) sector and assessment of its complementarity with and impact on the EU Emissions Trading System (EU ETS), if applicable

Pursuant to the Decree on the criteria for payment of the reduced fee for renewable energy sources and high-efficiency cogeneration (OG 31/23) and the Decision on the fee for renewable energy sources and high-efficiency cogeneration (OG 31/23), EU ETS entities pay a lower fee for renewable energy sources and high-efficiency cogeneration compared to the fee for other final customers of electricity.

Croatia introduced CO_2 emission allowances in 2007 based on the Regulation on unit charges, corrective coefficients and detailed criteria and benchmarks for determining the charge for emissions of carbon dioxide into the environment (OG 73/07, 48/09, 2/18). The payers are individual stationary sources, which emit CO_2 in excess of 450 tonnes per year and the unit charge is HRK 11,20/ tCO_2. ETS participants are exempted from the obligation to pay CO_2 emission allowances, to avoid the double financial burden due to greenhouse gas emissions.

Reducing the amount of the fee for renewable energy sources and high-efficiency cogeneration and releasing the obligation to pay the CO_2 fee makes it easier for ETS participants from the Republic of Croatia to do business, while on the other hand, the relatively high price of emission allowances on the ETS market stimulates the implementation of measures to reduce greenhouse gas emissions.

ii. Policies and measures for achieving other national goals, if applicable

Not applicable.

iii. Policies and measures for achieving low-emission mobility (including transport electrification)

The expected effects of a group of low-emission mobility incentives are:

- cumulative reduction of final energy consumption in traffic in projections for the scenario with additional measures compared to the scenario with existing measures, which amounts to 2.86 PJ in 2030;
- share of RES in turnover of 21.6%.

TR-1 Regulatory instruments to promote a cleaner transport system

Regulatory measure, parafiscal measure; implementation 2021 - 2030

Objective and description of the measure: The aim of the measure is to encourage changes in the transport system that will reduce environmental pollution and achieve a more sustainable transport system. This measure includes the application of regulatory instruments such as regulations, standards and taxes that will encourage the use of low-emission vehicles and increase the use of public transport, pedestrian and bicycle paths.

Activities: The measure covers the following activities:

- Informing consumers about fuel economy and CO_2 emissions of new passenger cars, in accordance with the Ordinance on the availability of data to consumers on official fuel consumption and official specific CO_2 emissions of new passenger cars (OG 113/2021). The purpose of this Regulation is to provide consumers with information on official fuel consumption and official specific emissions of carbon dioxide of new passenger cars intended for sale or leasing, in order to enable them to make informed choices.
- Collection of a special environmental fee for motor-powered vehicles, in accordance with the Regulation amending the Regulation on unit fees, correction coefficients and more detailed criteria and benchmarks for determining the special environmental fee for motor-powered vehicles (OG 2/2021). This Regulation lays down the unit fees and correction coefficients on the basis of which the calculation of the specific environmental charge for power-driven vehicles is carried out, as well as the detailed criteria and criteria for determining the specific charge. The special fee is charged taking into consideration the type of engine and fuel, engine operating volume, type of vehicle, CO_2 emissions and vehicle's age.
- Collection of special tax on motor vehicles intended for use on roads in accordance with the Act on special tax on motor vehicles (OG 15/13, 108/13, 115/16, 127/17, 121/19). Objective and description of the measure: Based on the "polluter pays" principle, the calculation model is based on CO_2 emissions into the air from motor vehicles. The special tax is determined on the basis of the sales or market price of the motor vehicle, CO_2, emissions expressed in grams per kilometer, engine volume in cubic centimeters and the level of greenhouse gas emissions. This special tax encourages the purchase of energy efficient vehicles and vehicles with lower greenhouse gas emissions.
- Monitoring, reporting and verification of greenhouse gas emissions in the lifetime of fuels and energy, in accordance with the Ordinance on the manner of monitoring and reporting and the methodology of calculating greenhouse gas emissions in the lifetime of fuels and energy delivered and the manner of implementing projects for reducing

emissions resulting from oil and gas exploration and production (OG 131/2021). Greenhouse gas emission monitoring shall apply to fuels used for the propulsion of road vehicles, non-road mobile machinery (including inland waterway vessels when not at sea), agricultural and forestry tractors, recreational craft when not at sea and electricity for use in road vehicles.

- Encouragement of integrated freight traffic in accordance with the Ordinance on Incentives in Combined Freight Transport (OG 5/18). The Ordinance provides for incentives for combined transport of goods by rail, inland waters or sea, and incentives for combined transport of goods on road sections.
- Legislative adaptations for cleaner transport that will ensure the development of alternative fuels infrastructure, increase the share of renewable sources in final energy consumption in transport and promote clean and energy-efficient vehicles in road transport through amendments to laws and bylaws.

In this regard, Croatia will fully transpose the obligations under the Renewable Energy Directive adopted in December 2018, as well as the obligations that will arise from the adoption of the Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources. It will be necessary to achieve an ambitious target in the context of renewable energy in the transport sector in 2030, and in particular to stimulate the use of renewable electricity in transport. In this regard, the Biofuels for Transport Act will be amended (OG 65/09, 145/10, 26/11, 144/12, 14/14, 94/18, 52/21).

The activity also foresees the implementation of obligations defined by the Construction Act (OG 153/13, 20/17, 39/19, 125/19), with regard to the promotion of electromobility and the establishment of charging infrastructure in buildings, and the Act on the Establishment of Alternative Fuels Infrastructure (OG 120/16, 63/22), which establishes a common framework of measures for the establishment of alternative fuels infrastructure, in order to minimize oil dependence and mitigate the negative impact of transport on the environment, and which establishes minimum requirements for the construction of alternative fuels infrastructure, including charging points.

- Promotion of public procurement of clean vehicles in road transport in accordance with the Act on the Promotion of Clean Vehicles in Road Transport (OG 52/21). This Act lays down obligations for contracting authorities and contracting entities to take into account the energy and environmental effects of certain road transport vehicles in the context of public procurement in order to promote and stimulate the market for clean and energy-efficient vehicles and to increase the contribution of the transport sector to Union policies relating to environmental, climate and energy protection for the entire life of the vehicle, including energy consumption, CO_2 emissions and emissions of certain pollutants. Pursuant to the said law, the Ordinance on the obligation to report to the European Commission and minimum objectives in public procurement procedures for road transport vehicles (OG 86/2021) was adopted, which defines minimum procurement objectives for the share of clean light and heavy vehicles.

Funds needed for implementation: The competent ministries plan to finance the implementation of these activities within its annual budgets as an integral part of its regular activities.

Funding Sources: State Budget

Executive bodies: MESD, MMPI, MOI, MPGI, EPEEF

Monitoring (supervisory) bodies: MESD, MMPI, Central State Administration Body in charge of public procurement policy, MPGI

Impact: Energy savings, reduction of CO_2 emissions, reduction of pollutant emissions, acceleration of the development of the market for alternative energy products, increase of the share of RES in final energy consumption in transport and increase of the share of vehicles powered by alternative energy sources in road transport.

Monitoring method: Vehicle register, reports on passenger and tonne-kilometres achieved final energy consumption balance, verified reports on greenhouse gas emissions over the life of the fuel, documentation on public procurement procedures carried out.

Measure implementation indicator: Share of registered vehicles powered by alternative energy sources, shares of passenger and tonne-kilometres achieved in a particular type of transport, shares of renewable energy sources in final energy consumption, reduction of greenhouse gas emissions, share of clean light and heavy vehicles and in the total number of vehicles covered by public procurement contracts.

Connection to other dimensions: Direct connection to the energy efficiency dimension (activities act on the market by directing it towards more energy-efficient vehicles).

Research and development: Sustainable mobility and alternative fuels in transport require the development of new technologies in the field of vehicles, infrastructure and advanced management systems based on information and communication technologies.

TR-2 Programme for co-financing the purchase of new alternative fuel vehicles and the development of alternative fuel infrastructure in road transport

Financial measure; implementation 2021 - 2030

Objective and description of the measure: In the context of co-financing of cleaner transport projects, special lines of co-financing for specific purposes will be defined for the purchase of vehicles of all categories with alternative energy sources. Incentives for co-financing the purchase of vehicles will be conducted consistently, transparently and continuously, and will be primarily geared towards alternative fuels for which the assessment of the existing situation has shown a minor representation in the total number of vehicles and will be time-limited until the minimum representation of vehicles is achieved. The minimum degree of market uptake will be defined by the revision of the National Policy Framework for the Establishment of Infrastructure and the Development of Alternative Fuel Markets in Transport by 1st January 2024.

In order to achieve the appropriate modal integration of Croatian transport flows with the European Union transport network, the Republic of Croatia is obliged to carry out activities that will result in the construction of alternative fuels infrastructure on the trans-European transport network located geographically in the territory of the Republic of Croatia. In this regard, the Republic of Croatia is obliged to implement the initiative of transition towards the use of alternative energy sources in the transport sector, in a way that encourages the construction of publicly available infrastructure for alternative fuels. By adopting and implementing *the Programme to encourage the construction of alternative fuels infrastructure in the Republic of Croatia*, the Republic of Croatia will endeavour to provide sufficient infrastructure for the supply of alternative fuels to light and heavy road transport vehicles.

Activities: The measure covers the following activities:

- Conducting activities to co-finance energy-efficient vehicles with low greenhouse gas emissions through public calls.
- Implementation of co-financing activities for alternative fuels infrastructure through public calls.
- Establishment of a central register of alternative fuels infrastructure that will facilitate the user experience for drivers and ultimately provide real insight into energy consumption for analytical purposes.

Funds needed for implementation:

- EUR 172.5 million for the construction of alternative fuels infrastructure
- EUR 319.5 million for energy-efficient vehicles with low greenhouse gas emissions

Sources of financing: EPEEF from funds obtained from the sale of emission allowances through auction, from funds collected from the special vehicle fee and from the special environmental fee for non-marketing biofuels, Recovery and Resilience Mechanism, National Recovery and Resilience Plan, Connecting Europe Facility, European Regional Development Fund, Cohesion Fund, InvestEU, Innovation Fund, Modernisation Fund.

Executive bodies: MESD, MMPI, EPEEF

Monitoring body: MESD

Effect:

- increasing the number of places for supplying light vehicles with electricity in residential areas,
- increasing the installed power for supplying light-duty vehicles with electricity along the core and comprehensive TEN-T network,
- increasing the installed power for the supply of heavy-duty vehicles with electricity along the basic and comprehensive TEN-T network,
- increasing the installed power for electricity supply in safe and secure parking lots,
- increase in installed power for the supply of heavy-duty vehicles with electricity in urban hubs,
- increase in the number of stations for the supply of hydrogen,

- increasing the share of vehicles powered by alternative energy sources in the total number of registered vehicles,
- Save energy, reduce CO_{2e} emissions and reducing pollutant emissions,
- estimated savings in 2030. 0.74 PJ; estimated CO_2 emission reductions in 2030.361,7 $ktCO_{2e}$; cumulative energy savings in 2021-2030 2.76 PJ; cumulative reduction of CO_{2e} emissions in the period 2021- 2030 of 1532.9 $ktCO_{2e}$.

Note: the estimated savings are a cumulative of the implementation of TR-2, TR-3 and TR-7 measures.

Tracking method: This measure will be monitored by the Energy Saving Monitoring, Measurement and Verification System (SMIV) estimation method. The cumulative capacity of alternative fuels infrastructure will be monitored through the central register of alternative fuels infrastructure.

Measure implementation indicator: number of registered vehicles powered by alternative energy sources, installed capacities and geographical distribution of alternative energy supply infrastructure

Connection to other dimensions: direct connection to the energy efficiency dimension

Research and development: Sustainable mobility and alternative fuels in transport require the development of new technologies in the field of vehicles, infrastructure and advanced management systems based on information and communication technologies.

TR-3 Improving the public transport system and promoting sustainable integrated transport

Financial measure, information and organizational measure; implementation 2021 - 2030

Objective and description of the measure: The aim of the measure is to promote the sustainable development of urban transport systems through the optimization of freight transport logistics and intelligent management of public parking areas, the introduction of platforms for integrated passenger transport, the introduction of car-sharing systems in cities, the introduction of low-emission zones in cities, the introduction of public urban bicycle systems and the construction of associated cycling infrastructure, intelligent traffic management (upgrading, adaptation and replacement of obsolete signalling devices and equipment, the installation of advanced traffic equipment and intelligent traffic lights equipped with an autonomous system of power from renewable sources, the construction and equipping of central operational centres for supervision and management of intersections with set traffic lights). At the local level, it is necessary to continuously prepare and implement Sustainable Mobility Plans in cities, as well as strategic plans that build on the existing planning practices, and take into account integration, participation and evaluation principles to meet the citizens' mobility needs now and in the future, and ensure better quality of life in cities and their surroundings. The activities will be accompanied by appropriate outreach campaigns. The objective of these measures is to cover all counties, large cities (with more than 35,000 inhabitants) and municipalities and cities that together form a geographical entity with more than 35,000 inhabitants.

In addition, the measure aims to modernise public urban and suburban regular bus traffic of passengers through the procurement of new vehicles with electric or hydrogen propulsion, and to build the necessary infrastructure to promote the use of vehicles with reduced CO_2 emissions. The aim is also to modernize the tram fleet in Osijek and Zagreb in order to provide a better and faster public transport service and increase the number of passengers using public transport, which will ultimately result in a reduction of CO_2 emissions in transport.

The measure will also encourage projects for the development and implementation of urban mobility ecosystems (i.e. the so-called *MaaS* – mobility as a service), closely integrated with public urban transport, which will consist of three key components necessary for fully autonomous vehicles to function and participate in traffic. These are: (i) fully autonomous electric vehicles of the fifth level of autonomy, (ii) development and construction of specialized infrastructure for autonomous and electric vehicles integrated with public urban transport, (iii) development of a software platform for managing the complete system.

Activities:

- Activities: Within the measure, co-financing activities will be implemented through public calls from the EPEEF as well as activities undertaken independently by the LGUs in accordance with their plans for the sustainable development of transport systems.
- Procurement of alternatively powered buses and construction of associated infrastructure.
- Modernization of tram traffic through the procurement of modern low-floor / semi-floor trams.
- Implementation of a digitized system of self-driving vehicles.

Funds needed for implementation: EUR 320 million

Sources of financing: National Recovery and Resilience Plan, EPEEF from the auctioning of emission allowances, from the funds collected from the special vehicle fee and from the special environmental fee for non-marketing of biofuels, Modernisation Fund.

Executive body: MMPI, EPEEF

Monitoring (supervisory) bodies: MMPI, MESD

Effect:

- a fully functional commercial service of the autonomous driving system,
- a minimum of 70 buses powered by alternative fuels,
- at least 30 modern trams,
- Save energy, reduce CO_{2e} emissions and reducing pollutant emissions,
- estimated savings in 2030. 0.74 PJ; estimated CO_2 emission reductions in 2030.361,7 $ktCO_{2e}$; cumulative energy savings in 2021-2030 2.76 PJ; cumulative reduction of CO_{2e} emissions in the period 2021- 2030 of 1532.9 $ktCO_{2e}$.

Note: the estimated savings are a cumulative of the implementation of TR-2, TR-3 and TR-7 measures.

Monitoring method: The effects of this measure will be recorded separately by projects, prescribed by the TD methodology, with the possible addition / development of a new BU methodology.

Measure implementation indicator: Number of fully implemented projects.

Connection to other dimensions: direct connection to the energy efficiency dimension

Research and development: Sustainable mobility and alternative fuels in transport require the development of new technologies in the field of vehicles, infrastructure and advanced management systems based on information and communication technologies.

TR-4 Encouraging the development of energy-efficient maritime transport and inland navigation

Financial measure; implementation 2021 - - 2030

Objective and description of the measure: the measure involves encouraging the construction of an onshore electricity supply system for seagoing ships and inland waterway vessels. Supply of electricity from the mainland for ships and vessels *On-Shore Power Supply (OPS)* is a form of distributed energy system that reduces the need for ships and vessels to use built-in generators and helps reduce air pollution and noise in ports. In addition, the measure also envisages encouraging the construction of publicly available stations for the supply of hydrogen, ammonia and / or liquefied natural gas to seagoing ships and / or inland waterway vessels powered by hydrogen, ammonia or liquefied natural gas. Likewise, the measure involves co-financing the procurement of alternative fuel vessels.

Activities:

- Encouraging the construction of infrastructure for the supply of maritime transport (system of electricity supply from land to container and passenger ships for navigation by sea, and infrastructure for the supply of hydrogen, liquefied natural gas and ammonia in seaports),
- Encouraging the procurement of ships / vessels powered by alternative fuels.

Funds needed for implementation: EUR 51.5 million

Sources of financing: EPEEF from funds obtained from the sale of emission allowances through auction, from funds collected from the special vehicle fee and from the special environmental fee for non-marketing biofuels, Recovery and Resilience Mechanism, National Recovery and Resilience Plan, Connecting Europe Facility, European Regional Development Fund, Cohesion Fund, InvestEU, Innovation Fund, Modernisation Fund.

Executive body: MESD, MMPI, EPEEF

Monitoring (supervisory) bodies: MESD, MMPI

Impact: The indicative target for the period to 2030 is 80 MVA of installed OPS power, and the installed infrastructure in 7 seaports and 4 inland waterway ports

Monitoring method: Central Register of Infrastructure for Alternative Fuels.

Measure implementation indicator (indicator): Installed capacity of OPS systems, number of ports in which alternative fuel supply infrastructure is installed, capacity of installed infrastructure, number of ships / vessels powered by alternative fuels.

Connection to climate change adaptation: a direct link to the energy efficiency dimension.

Research and development: Sustainable mobility and alternative fuels in water transport require the development of new technologies in the field of vessels/vehicles, infrastructure and advanced management systems based on information and communication technologies.

TR-5 Encouraging the development of energy-efficient rail transport

Financial measure; implementation 2021 - - 2030

Objective and description of the measure: This measure establishes the objective of constructing an appropriate number of stations for the supply of electricity or hydrogen from electric trains with a battery storage system and from hydrogen-powered trains on sections of the basic and comprehensive TEN-T network whose electrification is not possible for technical or cost reasons.

Activities: Introduction of new battery-powered trains for passenger transport by rail on non-electrified railways and construction of stable energy connections for battery charging in accordance with the *Program for encouraging the construction of infrastructure for alternative fuels in the Republic of Croatia* (which is expected to be adopted during 2023/2024).

Funds needed for implementation: EUR 320 million

Sources of funding: National Recovery and Resilience Plan

Executive Body: MESD, MMPI

Monitoring (supervisory) bodies: MESD, MMPI

Effect: The indicative target for 2030 is 6 operational sites with a high-power battery charging port

Monitoring method: Central Register of Infrastructure for Alternative Fuels.

Measure implementation indicator: Number of locations with a high-power battery charging port, number of trains powered by electricity or hydrogen.

Connection to other dimensions: direct connection to the energy efficiency dimension

Research and development: Sustainable mobility and alternative fuels in transport require the development of new technologies in the field of vehicles, infrastructure and advanced management systems based on information and communication technologies.

TR-6 Encouraging the development of energy-efficient air transport

Financial measure; implementation 2021 - - 2030

Objective and description of the measure: In order to reduce greenhouse gas and pollutant emissions, the electricity supply should replace the consumption of liquid fuel in airports. All aircraft in the commercial transport function should be able to use the external electricity supply while parked at exits or at positions away from terminals at TEN-T airports. In this respect, it is necessary to build infrastructure for the electricity supply of stationary aircraft and infrastructure for the supply of preconditioned air (fixed or mobile systems that enable the external supply of conditioned air for cooling, ventilation or heating of stationary aircraft cabins).

Activities:

The adoption of the Programme to encourage the construction of alternative fuels infrastructure in the Republic of Croatia will define the objectives for the construction of infrastructure intended for air transport supply. In principle, the airports of the TEN-T core and comprehensive network set the objective of ensuring the supply of electricity (aeronautical fixed or mobile power units*) at all terminals used for commercial air transport by 1st January 2025. Ground Power Unit (GPU*) and Preconditioned Aircraft at Standstill (Fixed or Mobile Air Supply Units*) Pre-Conditioned Air Unit (PCA)*).

In the period up to 1st January 2030, the objective in question shall also be set for all positions away from the terminal used for commercial air transport.

The objective shall be that the electricity supplied comes from the electricity grid or is produced on the site as energy from renewable sources, by 1st January 2030 at the latest.

The objectives set do not apply to short-term parking spaces, to the defrosting of aircraft, to parking spaces in military zones and to parking spaces for general air traffic (maximum take-off masses of less than 5,7 t).

The adoption of a new national policy framework for the development of the market for alternative fuels in the transport sector and for the deployment of appropriate infrastructure (by 1st January 2024) will define a roadmap for the deployment of alternative fuels infrastructure in non-electric airports, in particular for hydrogen refuelling and refuelling.

Funds needed for implementation: EUR 52 million

Sources of funding: National Recovery and Resilience Plan

Executive Body: MESD

Monitoring (supervisory) bodies: MESD

Impact: Indicative target for 2030 - infrastructure available at 7 airports (total of 40 GPU systems and total of 50 PCA systems)

Monitoring method: Report on the installed infrastructure by airports

Measure implementation indicator (indicator): Number of airports where infrastructure is available, number of GPUs and PCAs intended for air traffic supply.

Connection to other dimensions: direct connection to the energy efficiency dimension

TR-7 Developing a low-carbon fuel market

Financial measure, regulatory measure; implementation 2023 - 2030

Objective and description of the measure: increasing the share of RES in transport by 2030 through the development of the market for low-carbon fuels and achieving the planned share of fuels produced from renewable energy sources in final energy consumption in transport. The implementation of the measure is based on amendments to the relevant laws and by-laws based on the Renewable Energy Directive. The measure also implies the creation of a long-term sustainable supply chain of biomass and the construction of a bio-industrial complex designed to produce advanced biofuels with negative net greenhouse gas emissions. Likewise, the measure implies the creation of preconditions for investment to enable sustainable business models for investment in the construction of synthetic fuel plants.

Activities:

- construction of an energy self-sustaining bio-industrial complex intended for the production of advanced biofuels
- Development, adoption and implementation of the Plan and Programme for the production and use of biofuels in transport
- development, adoption and implementation of the Plan and Program for the Production and Use of Synthetic Fuels

Funds needed for implementation: EUR 332 million

Sources of funding: National Recovery and Resilience Plan, State Budget

Executive Body: MESD, INA

Monitoring (supervisory) bodies: MESD

Impact: Meeting the preconditions for supplying the market with low-carbon fuels, meeting the set targets for the share of renewable energy sources in the transport sector.

Monitoring method: Reports on RES quantity placed on the market in the transport sector

Measure implementation indicator: Share of RES in final energy consumption in the transport sector.

Connection to other dimensions: Connection to the dimensions of energy efficiency, security, and research, innovation and competitiveness.

Research and development: Improving existing and developing new technologies for low-carbon fuel production, as well as new business models to increase the use of advanced biofuels and synthetic fuels are necessary to achieve the goal.

iv. Where applicable, national policies, deadlines and measures planned with a view to phasing out energy subsidies, in particular for fossil fuels

Climate change mitigation and adaptation are considered pillars of climate policy implementation. In terms of climate change adaptation, a Climate Change Adaptation Strategy has been developed *in the Republic of Croatia for the period until 2040 with a view to 2070.* (Official Gazette 46/20). The development of a Climate Change Adaptation Strategy is a fundamental prerequisite and appropriate instrument for the successful implementation of the vulnerability assessment process, the implementation of adaptation measures, and in this regard, for increasing the resilience of certain sectors and the entire economy and society to climate change.

According to the Draft Adaptation Strategy, the vulnerability of the Republic of Croatia to the effects of climate change is high, especially for the sector of agriculture, forestry, fisheries, energy and tourism, because the success of all these sectors depends largely on climatic factors.

Five national priorities have been identified under which climate change adaptation measures need to be implemented. These are:

1. ensuring sustainable regional and urban development
2. ensuring preconditions for the economic development of rural areas, coastal areas and islands
3. ensuring sustainable energy development
4. strengthening management capacity through a networked monitoring and early warning system
5. ensuring continuity of research activities.

Based on the general principles for defining measures, analysing the current situation by sector and assessing the degree of vulnerability and possible responses to the challenges of climate change adaptation, the Adaptation Strategy identifies a set of measures for each sector as well as cross-sectoral measures. By their nature, the measures are regulatory and administrative, implementing, public education and awareness measures, and research and development measures. In addition to character, measures are also prioritized (measures of very high importance, high importance and medium importance).

The adaptation strategy will be implemented through implementation action plans, which will include the elaboration of concrete measures and activities for a specific five-year period.

3.2 Dimension: energy efficiency

The expected impact of a group of measures to promote energy efficiency and transport is equivalent to a reduction in immediate energy consumption in projections for the scenario with additional measures compared to the scenario with existing measures, which amounts to 17.61 PJ in 2030.

Planned policies, measures and programmes for the achievement of the national target of increase in energy efficiency by 2030, as well as the other targets set out in Section 2.2,

including planned measures and instruments (as well as that of financial nature) for the promotion of energy performance of buildings, are listed below, according to specific areas.

i. Energy efficiency obligation schemes and alternative policy measures referred to in Articles 7a and 7b and Article 20 (6) of Directive 2012/27/EU

ENU-1 Energy Efficiency Obligation System for Suppliers

Regulatory measure; implementation: 2019 – 2030

Objective and description of the measure: The Energy Efficiency Obligation System was established by the Energy Efficiency Act (OG 127/14, 116/18, 25/20), and its functioning is further defined by the Ordinance on the Energy Efficiency Obligation System (OG 41/19). With the entry into force of the Energy Efficiency Act (OG 41/21), the Ordinance on the system of energy efficiency obligations (OG 41/19) ceases to be valid and the elements of the system of energy savings obligations and the manner of its implementation are transferred to the Ordinance on the system for monitoring, measuring and verifying energy savings (OG 98/21, 30/22). Obligated entities of the energy efficiency obligation system are supplied by energy suppliers. The system has been operational since 2019, when it was entered by suppliers that have delivered more than 300 GWh of energy to the market during 2017. In 2020, the suppliers who delivered more than 100 GWh of energy to the market in 2018 enter the system of obligations, and from 2021 onwards all those suppliers who supplied more than 50 GWh of energy to the market during the previous year. From 2021 to 2030, the goal is to achieve cumulative energy savings in final consumption by achieving new annual savings every year. According to Directive 2018/2002 amending Directive 2012/27/EU on energy efficiency, the system is set up in such a way that savings of 0.8% of annual final consumption are to be achieved each year. According to the agreed amendments to the 2023 Energy Efficiency Directive, these targets change and are as follows: in the period from 2021 to 2023, the goal is to achieve savings of 0.8%, from 2024 to 2025 1.3%, from 2026 to 2027 1.5% and from 2027 to 2030 1.9% of annual final energy consumption. This raises the national target of the Republic of Croatia from the previous 125.3 PJ (2,993.7 kten) to 180.6 PJ (4,313.6 kten).

According to the Energy Efficiency Act, the objective is to achieve 70% of the savings referred to in Article 8 (7.) of the Energy Efficiency Directive through the energy efficiency obligation scheme. In view of the new objective, it is necessary to carry out detailed analyses and, if necessary, determine a new distribution of the objective between alternative policy measures and the obligation system and prescribe it through amendments to the Act.

Activities: The following activities will be implemented within the measure:

- Detailed analysis of the ability of suppliers to achieve increased savings as set out in the amendments to the Directive
- on the Amendments to the Energy Efficiency Act in order to transpose the amended Energy Efficiency Directive

- It is necessary to amend and regularly improve the Ordinance on the system for monitoring, measuring and verifying energy savings, in order to fully comply with the requirements of the amended Energy Efficiency Directive;
- In the light of past experience and the provisions of Directive 2018/2002 on energy efficiency, legislative changes should also be considered in order to improve the functioning of the system, especially in the area of savings trading;
- Revenues from fees collected on the basis of the obligation system shall be used by the Fund purposefully. That is why it is necessary to create a Schedule for the use of funds collected from the obligation system fees, the application of which must start from 2021. Creating such a Schedule is absolutely necessary to ensure the optimal allocation of funds from all available sources and to ensure that the Fund has clear guidelines on how to invest these resources. In view of the alternative measures provided in this Plan, it is necessary to direct these funds to the building sector, in particular to public buildings of the central government and the family home.

Funding Sources: Energy Efficiency Obligation Scheme payer funds

Executive body: Obligated entities of the Energy Efficiency Obligation System (suppliers)

Monitoring (supervisory) bodies: MESD-NKT

Effect: Reduction of final energy consumption and consequent reduction of CO_2 emissions: estimated savings in 2030 27.3 PJ (652.5 ktoe); estimated reduction in CO_2 emissions in 2030 1,532.9 $ktCO_{2e}$; cumulative energy savings in the period 2021-2030 126.4 PJ (3,019.5 ktoe); cumulative reduction in CO_2 emissions in 2021-2030 7,093.9$ktCO_{2e}$

Monitoring method: The realized savings are monitored and proven by using bottom-up methods according to the Ordinance on the system for monitoring, measurement and verification of energy savings

Connection to other dimensions: given that the obligation is placed on the market energy activity of energy supply, there is a direct link to the dimension of the internal energy market

The Republic of Croatia also envisages the implementation of alternative measures, including measures described as follows: ENU-3, ENU-4, ENU-5, ENU-7, ENU-8, EUNU-17 and ENU-18. In addition, alternative measures include transport measures TR-2 and TR-3 and measures to combat energy poverty UET-9.

ii. Long-term strategies for the renovation of the national stock of residential and non-residential buildings, public and private, including policies, measures and actions to encourage cost-effective major renovations, policies and actions targeting the worst performing segments of the national stock of buildings, in accordance with Article 2a of Directive 2010/31/EU

Key to this area is the Long-Term Strategy for Mobilising Investment in the Renovation of the National Building Stock of the Republic of Croatia by 2050. To achieve the strategic goals of reducing energy consumption in construction of buildings, three key energy renovation programmes for the period between 2021 and 2030 are expected to be conducted for

apartment buildings, family houses and public buildings. A new programme for commercial buildings that would be based on co-financing will not be adopted, but it is expected that this segment of the building stock will be covered by the activities of the supplier within the energy efficiency obligation system as well as the energy services market. In addition to these programmes based on financial incentives, it is planned to implement a comprehensive information measure, the ultimate goal of which is to encourage the decarbonisation of buildings and a generally green and digital transition in the building sector based primarily on the principle of "*energy efficiency first*".

ENU-2 Promoting the decarbonisation and application of the "*energy efficiency first*" principle in buildings

Information measure; implementation 2019 -2030

Objective and description of the measure: The Charter of Cooperation for the Decarbonisation of Buildings by 2050, initiated by the Ministry of Physical Planning, Construction and State Property, which supports the EU's vision of decarbonisation of buildings by 2050, was initiated to improve cross-sectoral communication and cooperation between state administration bodies and the private sector. The aim is to create, through workshops and the Open Partner Dialogue, a broad network of connected professionals who are ready to engage in dialogue and contribute to the decarbonisation of the building stock by 2050. Open Partner Dialogues bring together representatives of state and local government, the academic community and the professional public, the construction and energy sectors, and related industries at thematic workshops organized by the Ministry. The contents of the Charter include the achievement of energy and climate targets at the national and EU level through the decarbonisation of the building stock, renovation of buildings and construction of nearly zero energy buildings, aware of the importance of further reduction in greenhouse gas emissions, increasing the share of renewable energy sources, improving energy security and introducing innovation and smart technologies that allow buildings to support the overall decarbonisation of the economy. The signing of the Charter encourages continuous cooperation on the development of the Long-Term Strategy for the Renovation of the National Building Stock and the transition to a nearly zero energy building standard (nZEB). The signatories to the Charter support and promote the decarbonisation of buildings in their future activities, wherever possible. Current activities should be expanded in line with EU guidelines, and the principle of "*energy efficiency first*" should be encouraged in particular.

In addition to networking of experts through the dialogue of the partners, informing the general public and target groups will be carried out by organizing targeted *"Energy efficiency first"* information campaigns related mainly to energy renovation and decarbonization of buildings. The application of the principles of green building (building on the principles of sustainability) as an essential segment of sustainable development and circular economy will be promoted. It is necessary to strengthen and support the hitherto adopted policies of the Republic of Croatia in the field of sustainable development, energy efficiency and national guidelines for building quality and culture (ApolitikA), to apply the best global standards of green building (e.g. international green building certificates), to develop the national green building system, and to raise awareness of the untapped opportunities and risks (if not implemented) and of the various opportunities (if implemented) that arise from applying the

principles of green building to the individual and the community as a whole, to the private and social sectors of the economy and investment.

Activities: The following activities will be implemented within the measure:

- Information and promotion is envisaged through open partner dialogues, workshops and implementation of educational activities focused on the principles of energy efficiency, systematic energy management, smart technologies, green building, nZEB standards.
- Timely information and assessment of the readiness of buildings for smart technologies in accordance with the *"Smart Readiness Indicator"* protocol and a broad dialogue related to the application of SRI in the Republic of Croatia are envisaged.
- Preparation of the Guide and guidelines on green and sustainable construction and nZEB standards for investors and designers
- Media campaigns for energy certification and promotion of nZEB standards - campaigns will provide information to the general public to raise awareness of the significance of energy certificates and their relevance for energy renovation and demonstration of nZEB standards, availability of information in the Information system of energy certificates (IEC), and also a targeted campaign for informing and raising awareness will be carried out.
- Organisation of open partner dialogues on energy poverty, raising awareness of energy poverty, establishing criteria for energy poor households and low-income households with a view to preventing and alleviating energy poverty through the implementation of energy efficiency and RES measures.
- Organization of open dialogues related to energy renovation of multi-residential buildings (cooperation with managers), promotion of energy communities, etc.

Funds needed for implementation: The MPGI plans to finance the implementation of these activities within its annual budgets as an integral part of its regular activities.

Funding Sources: State Budget (MPGI)

Executive Body: MPGI

Monitoring (supervisory) bodies: MPGI, MESD-NKT

Impact: Increasing the level of awareness of the benefits of energy efficiency with the consequent change in behaviour and reduction in energy consumption by applying concrete measures Support for a regulatory measure for the construction and renovation of buildings as well as a promotional measure that will result in measurable reduction of energy consumption, greater use of RES and avoided CO_2 emissions. Increase of professional capacities for the implementation of energy efficiency measures.

Monitoring method: Using top-down methods at a sectoral level. Reports on information and education activities carried out.

Connection to other dimensions: Direct connection to decarbonisation (nZEB standard implies a tendency towards zero emissions of embodied and operational carbon (green

building, reduced energy consumption and increased use of RES), internal market (energy poverty).

Connection to climate change adaptation: through education on green building, which includes the promotion of green infrastructure on buildings (green roofs, green facades, etc.), capacity to implement these measures is strengthened, which represent significant measures for adaptation to climate change (e.g. reduction of urban heat islands, etc.) Information and education should also cover the link between energy consumption and climate change, as well as the benefits of energy efficiency in terms of adaptation to climate change (increased resilience to e.g. extreme temperature conditions, etc.).

Research and development: educational activities in the field of green building stimulate research and development in this segment (technologies and methods for 'greening' of buildings). NZEB standard creates the need to develop new building materials, improve technical systems in buildings, and control and automation systems based on information and communication technologies. Digitalization of the system encourages innovation in the information segment (use of information and communication technologies).

ENU-3 Energy renovation programme for apartment buildings

Financial measure; implementation 2021 - 2030

Objective and description of the measure: The programme should be conceptualized as a continuation of the implementation of the Energy renovation programme for apartment buildings for the period from 2014 to 2020. For this purpose, funds from ESI funds should be planned for the next programming period 2021-2027 (with implementation until 2030), and implementing procedures need to be significantly facilitated, especially in the area of implementation of public procurement. Several categories of renovation are envisaged (integrated energy renovation, deep renovation, comprehensive renovation) and three implementation models (renovation of multi-apartment buildings undamaged by the earthquake, renovation of multi-apartment buildings damaged by the earthquake, financial support to citizens at risk of energy poverty). The renovation up to the nZEB standard should be further encouraged. In addition, it is necessary to consider the establishment of a special fund from which the costs will be reimbursed to energy poor households or households at risk of energy poverty, in order to remove the obstacle to securing a sufficient number of co-owners' consents for energy renovation. The implementation of the Programme must be accompanied by strong promotional activities, provided technical assistance to applicants and it is necessary to ensure the monitoring of energy consumption before and after energy renovation, for which it is necessary to create preconditions within the ISGE. A total of 6.27 million m^2 of multi-apartment buildings should be renovated in the period up to 2030, in line with the Long-Term Strategy for the Renovation of the National Building Stock. It is planned to renovate an average of about 700,000 m^2 of multi-apartment buildings per year. Savings were calculated assuming the energy renovation of buildings to the level of meeting the requirements of the Technical regulation on rational use of energy and thermal protection in buildings, according to the periods of construction of buildings.

Note: the objectives, conditions and activities and the stated numerical values are indicative, and are set out in detail in the Energy Renovation Programme for Multi-residential Buildings for the period up to 2030, which is updated every three years

Activities: The following activities will be implemented within the measure:

- The implementation is carried out in the manner set out in the Energy Renovation Programme for Multi-residential Buildings for the period up to 2030 (adopted on 23rd December 2021).

Funds needed for implementation: The estimated investment cost in the period 2021-2030 is EUR 3.81 billion (HRK 28.7 billion).

Sources of financing: Grants from NPOO, ESI Funds and EPEEF in the amount of EUR 2.28 billion (HRK 17.2 billion) should be provided, with maximum co-financing of energy audits, energy certificates, project documentation and technical assistance in the preparation and implementation of the project. Consideration should be given to using national funds and other sources of funding.

Executive body: MPGI; other bodies in the system of use of the European Funds;

Monitoring (supervisory) bodies: MESD-NKT

Impact: Reduction of thermal needs and energy consumption in multi-apartment buildings and increase in the use of RES and consequent reduction of CO_2 emissions; estimated savings in final consumption in 2030 amount to 1.87 PJ (44.55 ktoe; 518.16 GWh); estimated reduction in CO_2 emissions in 2030 124.88kt CO_2); cumulative energy savings in the period 2021-2030 8.45 PJ (201.82 ktoe; 2,348.0 GWh); cumulative reduction in CO_2 emissions in 2021- 2030. 565.87 ktCO_2.

Monitoring method: Energy Saving Monitoring, Measurement and Verification System using the bottom-up method for integral building renovation

Connection to other dimensions: direct connection to the decarbonisation dimension, as energy renovation use encourages the use of RES in buildings

Climate change adaptation: energy renovation makes buildings more resilient to some of the effects of climate change, such as extreme temperature conditions

Research and development: energy renovation, especially its focus on the nZEB standard, is an incentive for research and development in the field of new building materials, advanced technical systems in buildings, and information and communication based management and automation systems

ENU-4 Energy renovation programme for family houses

Financial measure; implementation 2021 - 2030

Objective and description of the measure: The programme needs to be conceptualized as a continuation of the implementation of the Energy Efficiency Programme for single-family homes from 2014 to 2020, with co-financing from the Environmental Protection and Energy Efficiency Fund. It is necessary to ensure the continued implementation of the renovation of

family homes by renewing public calls for grants every year for the period 2021-2030 The primary sources of co-financing should be revenues from the auctioning of greenhouse gas emission units and revenues from the fees paid by suppliers in the energy efficiency obligation system in the event of default of obligations. Several categories of renovation are envisaged (implementation of individual energy renovation measures, integrated energy renovation, deep renovation, comprehensive renovation) and three implementation models (renovation of family houses undamaged by the earthquake, renovation of family houses damaged by the earthquake and renovation of family houses of citizens at risk of energy poverty). The Programme will allow for the possibility of implementing individual measures, but taking into account the order of measures (e.g. replacing the heating system by a more efficient systems that uses RES should only be possible for those houses that have good thermal characteristics and do not require any interventions on the building envelope). The renovation up to the nZEB standard should be further encouraged. The implementation of the Programme must be accompanied by strong promotional activities. In total, over 11.5 million m^2 should be renovated by 2030. This would mean the annual renovation of an average of 13,500 houses or 1.35 million m^2 per year. Savings were calculated assuming the energy renovation of buildings to the level of meeting the requirements of the Technical regulation on rational use of energy and thermal protection in buildings, according to the periods of construction of buildings. Annual savings amount to 0.447 PJ.

Note: the objectives, conditions and activities and the stated numerical values are indicative and will be specified in detail in the Energy Renovation programme for family homes for the period 2021 to 2030.

Activities: The following activities will be implemented within the measure:

- In 2023, the MGPI will develop an Energy renovation programme for family homes for the period 2021 to 2030, approved by the Government;
- The EPEEF is responsible for the full implementation of this measure by announcing annual public calls, the criteria of which it develops in cooperation with the MCPP.

Funds needed for implementation: The estimated investment cost in the period 2021-2030 is EUR 3.44 billion (HRK 25.90 billion).

Funding sources: Grants from the EPEEF should be provided up to the eligible costs of equipment and energy renovation works. EPEEF provides funds from the proceeds from the sale of emission units through auctions and revenues from the energy efficiency obligation system as well as from other sources of income from the EPEEF.

Executive body: MPPCSA - development of the Programme, defining criteria, operational monitoring of the implementation of the Programme; EPEEF - overall implementation of the Programme through annual public calls

Monitoring (supervisory) bodies: MESD-NKT

Impact: Reduction of thermal needs and energy consumption in family houses and increase of RES use and consequent reduction of CO_2 emissions; estimated savings in final consumption in 2030 amount to 4.47 PJ (106.76 ktoe; 1.241,80 GWh); estimated reduction in CO_2 emissions

in 2030 299.27kt CO_2; cumulative energy savings in the period 2021-2030 20.26 PJ (483.90 ktoe; 5,627.2 GWh); cumulative reduction in CO_2 emissions in 2021-2030 1,356.16 ktCO_2.

Tracking method: Energy Saving Monitoring, Measurement and Verification (SMiV) system using the bottom-up method for integral building renovation or other appropriate method, if individual measures are implemented

Connection to other dimensions: direct connection to the decarbonisation dimension, as energy renovation use encourages the use of RES in buildings

Climate change adaptation: energy renovation makes buildings more resilient to some of the effects of climate change, such as extreme temperature conditions

Research and development: energy renovation, especially its focus on the nZEB standard, is an incentive for research and development in the field of new building materials, advanced technical systems in buildings, and information and communication based management and automation systems

ENU-5 Energy renovation programme for public sector buildings

Financial measure; implementation 2021 - 2030

Objective and description of the measure: The measure is a continuation of the implementation of the Public Sector Buildings Renovation Programme 2016-2020. For this purpose, funds from ESI funds should be planned for the next programming period 2021- 2027 (with implementation until 2030). Funding needs to be planned to ensure the activation of private capital and ESCO markets, especially for buildings that are suitable for such financing models (continuous operation buildings such as hospitals, penitentiary homes, senior citizens' homes, etc.) and belong to the category of central government buildings, for which the Energy Efficiency Directive 2012/27/EU stipulates the renovation obligation. Market models need to be combined with grants with the aim of meeting the nZEB standard. In addition to ESI funds, the EPEEF is also required to plan funds for this Programme in the part related to the co-financing of energy renovation of central government buildings under the ESCO model. For buildings that are not suitable for market models, it is necessary to provide grants under the same conditions as in the current programme. The renovation of the public sector building must be directed to the nZEB standard wherever technically feasible. Approximately 350,000^{m2} of public buildings are planned to be renovated annually. Savings were calculated assuming the energy renovation of buildings to the level of meeting the requirements of the Technical regulation on rational use of energy and thermal protection in buildings, according to the periods of construction of buildings. Annual savings amount to 0.169 PJ.

Note: the objectives, conditions and activities and the stated numerical values are indicative and will be specified in detail in the Energy Renovation programme for public sector buildings for the period to 2030.

Activities: The following activities will be implemented within the measure:

- Implementation in the manner established by the Programme

- For energy renovation of central government buildings and other public sector buildings, the Energy Service Model (ESCO), implemented by ATMIP, will be applied where feasible, with co-financing provided by EPEEF and other sources including ESI funds - this segment of the Programme is necessary in order to mobilize private capital, develop the energy services market and achieve the objectives without additional public sector borrowing.

Funds needed for implementation: The estimated investment cost in the period 2021-2030 is EUR 1.2 billion.

Funding sources: Grants are provided from NPOO and ESI funds with maximum co-financing of energy audits, energy certificates, project documentation and technical assistance in the preparation and implementation of the project. EPEEF provides funds for the ESCO model from the proceeds from the sale of emission units through auctions and revenues from the energy efficiency obligation system as well as from other sources of income from the EPEEF.

Executive body: MPGI; other bodies in the system of use of the European Funds;

Monitoring (supervisory) bodies: MESD-NKT

Impact: Reducing heat demand and energy consumption in public sector buildings and increasing RES usage and consequently reducing CO_2 emissions; estimated savings in 2030 1.69 PJ (40.40 ktoe); estimated CO_2 emission reductions in 2030 46.52 $_{kt}CO_{2e}$; cumulative energy savings in 2021-2030 9.30 PJ (222.20 ktoe); cumulative CO_2 emission reductions in the period 2021-2030 264.93 $ktCO_2e$

Monitoring method: Energy Saving Monitoring, Measurement and Verification System using the bottom-up method for integral building renovation

Connection to other dimensions: direct connection to the decarbonisation dimension, as energy renovation use encourages the use of RES in buildings

Climate change adaptation: energy renovation makes buildings more resilient to some of the effects of climate change, such as extreme temperature conditions

Research and development: energy renovation, especially its focus on the nZEB standard, is an incentive for research and development in the field of new building materials, advanced technical systems in buildings, and information and communication based management and automation systems

ENU-6 Energy renovation programme for buildings that have the status of a cultural property

Financial measure; implementation 2021 - 2030

Objective and description of the measure: Protected buildings within the meaning of this Programme are those which can be classified into two categories: Individually protected cultural property (individual buildings and building complexes) and Buildings within a protected cultural and historical unit. The programme does not cover buildings protected as a preventively-protected cultural property, nor buildings protected as a registered cultural property. The Programme has developed two basic approaches to the energy renovation of

buildings that are the subject of this Programme: a holistic (integral) approach and an approach with the application of individual energy renovation measures.

Note: the objectives, conditions and activities and the stated numerical values are indicative, and are set out in detail in the Programme for Energy Renovation of Buildings with Cultural Property Status by 2030.

Activities: The following activities will be implemented within the measure:

- Implementation in the manner established by the Programme.

The total needs for the implementation of energy renovation programmes for buildings that have cultural property status and for the purpose of achieving national goals amount to HRK 18.74 billion in the period from 2021 to 2030. This amount includes required investments of HRK 13.67 billion and maintenance costs of HRK 5.07 billion.

Funding sources: Given the very high investment return periods, it will be necessary to make the most of the programme's co-financing with grants to reduce simple investment return periods and to encourage the energy renovation of such buildings. EU Funds and funds raised through monument annuities are recognized as sources of funding for grants. The funds provided in the NPOO are also used. Considering the total investment needs, the total required investments amount to approximately HRK 1.37 billion annually over the period 2021 to 2030, of which the required co-financing would amount to HRK 1.02 billion. Given that around HRK 100 million is collected annually from the monumental annuity, the remaining amount of about HRK 920 million annually needs to be secured from EU Funds. In order to encourage the energy renovation of buildings that have the status of cultural property, it is necessary to co-finance the same with grants, with a considerable share of the same in the total investment.

Executive body: MPGI; other bodies in the system of use of the European Funds;

Monitoring (supervisory) bodies: MESD-NKT

Impact: Reduction of thermal needs and energy consumption in buildings with the status of cultural property and increase in the use of RES and consequently reduction of CO_2 emissions; estimated cumulative savings in the period up to 2030. 6.32 PJ (150.95 ktoe); estimated reduction in CO_2 emissions in 2030 245.48ktCO2e;

Monitoring method: Energy Saving Monitoring, Measurement and Verification System (SMiV) using the bottom-up method for integral building renovation

Connection to other dimensions: direct connection to the decarbonisation dimension, as energy renovation use encourages the use of RES in buildings

Climate change adaptation: energy renovation makes buildings more resilient to some of the effects of climate change, such as extreme temperature conditions

Research and development: energy renovation, especially its focus on the nZEB standard, is an incentive for research and development in the field of new building materials, advanced

technical systems in buildings, and information and communication based management and automation systems

iii. Description of policies and measures to encourage energy services in the public sector and measures to remove regulatory and non-regulatory barriers that prevent the acceptance of energy efficiency contracts and other models of energy efficiency services

According to Article 25 of the *Energy Efficiency Act* (OG 127/14) defines the energy service as a framework for the implementation of energy efficiency projects and other related activities, based on an energy performance contract with a guarantee that under benchmark conditions it leads to a verifiable and measurable or assessable improvement of energy efficiency and/or energy and/or water savings. According to the *Act on Amendments to the Energy Efficiency Act* (OG 116/18) the definition is being extended to include cases where an energy service provider provides energy management expertise without direct investment and the possibility of reducing energy-related costs without reducing energy consumption is included.

The content of the energy performance contract is, according to the *Act on Amendments to the Energy Efficiency Act*, defined only for public buildings, and in the private sector access to this issue is being liberalized, so a positive impact on the market can be expected.

The Act on Amendments to the Energy Efficiency Act corrects most of the observed shortcomings, such as value added tax, inclusion of professional services without investment or reducing only energy-related costs.

Legislation and the implementation policy so far provide incentives for implementing energy efficiency measures through financial instruments, especially through energy services. It is also necessary to secure the inclusion of financial resources from the European structural and investment funds with a combination of energy service or public-private partnership. It is also necessary to further align secondary legislation (ordinances) and prepare publicly available documentation that will explain in more detail the complex issue of energy performance contracts such as the energy service contracting model, details of contracting and securing supply of energy products and energy performance, budget and legal issues, workflows of projects, identification of projects and various technical specifications related to the intensity of consumption of specific public buildings, examples from practice and a sample contract with all elements.

iv. Other planned policies, measures and programmes for achieving the indicative national target of increase in energy efficiency for 2030, as well as other objectives under section 2.2. (for example, measures aimed at promoting public buildings and energy-efficient public procurement as desirable models, measures to promote energy audits and energy management systems, providing information to consumers and training measures, and other measures to promote energy efficiency)

Measures in the public sector

The public sector is expected to continue implementing the existing measures and expanding their scope.

ENU-7 Systematic energy management in the public sector

Informational measure; implementation 2014 -2030

Objective and description of the measure: The public sector in Croatia is obliged to systematically manage energy, which is specifically stipulated by the Energy Efficiency Act, and the Ordinance on Systematic Energy Management (Official Gazette 18/15, 06/16). The measure is based on the information system for energy management (ISEM). The goal is to cover and regularly monitor all public sector buildings and public lighting systems by the end of 2030 using the ISEM. Savings based on systematic energy management activities and the introduction of telemetry in the previous period have been set at around 335 TJ per year (according to 4th NEEAP. Given that this measure has been systematically worked upon since 2014, the assumed potential for savings has been reduced to 100 TJ per year due to conservative estimates.

Activities: The following activities will be implemented within the measure:

- Automation of energy generating product and water consumption data collection (remote reading), integration of ISEM with energy generating products and water supplier systems, education of energy experts and advisers responsible for energy management in their buildings, and further development and improvement of ISEM will be implemented by 2021. Emphasis will be placed on developing modules for monitoring and verifying the energy savings achieved as a result of renovation, as well as fulfilling the default regime of use of the building for the purpose of achieving and maintaining the level of comfort. The goals are: to remotely read all locations in the public sector whose energy and water consumption exceeds HRK 400,000.00/year by 2020, to connect supplier databases with the ISEM database for automatic data collection and to connect ISEM with all relevant energy databases. In addition, by 2021, plans are being implemented for measures that include: potential analysis and optimization of peak electricity contracting, reduction of excess reactive energy, and potential analysis and optimization of thermal power contracting.
- In the period from 2021 to 2030, it is planned to introduce the energy management system and apply ISEM in all public sector buildings, and to improve and expand the whole system through the following activities:
    1. Bring together all installed remote reading systems in the ISEM;
    2. Integrate ISEM with other bases: DGU (Geoportal of the State Geodetic Administration), Cadastre, Register of protected facilities, IEC, SMIV, etc.);
    3. Prescribe ISEM as a system for verifying actual savings after building renovation (define what data the sensors on the premises send to the system, ISEM is already ready to receive data) and develop a methodology for calculating and verifying actual savings after building renovation, taking into account the default building usage regime;

4. Extend the use of ISEM to all sectors (private, industrial...) on a voluntary basis and/or as an obligation related to receiving financial assistance for renovation or implementation of energy efficiency measures;
    - The pilot project for the establishment and implementation of systematic energy management and the development of a new financing model for multi-apartment buildings will be implemented using exclusively the funds from the Resilience and Recovery Mechanism (NPOO)
5. Upgrading the ISEM so that it can carry out a financial analysis of cost-effectiveness of renovation on the basis of actual data;
6. The development of ISEM in the direction of so-called artificial intelligence, whereby the system would propose measures to increase energy efficiency according to input parameters.
7. Introduction of measuring devices / sensors to measure indoor temperature and air quality in public buildings and connect to ISEM.

- Apart from upgrading the ISEM, this measure envisages continuing and broadening the scope of education for institutions of the public and other sectors, creating a base of users familiar with energy efficiency and competent to act within their institutions and elaborating the proposal that the position of energy manager is introduced in public institutions.

Funds needed for implementation: The funds needed for the implementation of all planned activities are planned by APN as part of its regular activities and budget, while for the pilot project, funds from NPOO are provided exclusively (EUR 1.6 million (HRK 12 million)).

Sources of funding: State Budget (APN) + NPOO for the Pilot Project.

Executive body: APN

Monitoring (supervisory) bodies: MESD-NKT

Effect: Reducing energy consumption in public buildings; changes in the habits and behaviour of users of public sector buildings, estimated savings in 2030 0.20 PJ (4.78 ktoe); estimated CO_2 emission reductions in 2030 5.50 $_{kt}CO_{2e}$; cumulative energy savings in 2021-2030 1.90 PJ (45.41 ktoe); cumulative CO_2 emission reductions in the period 2021-2030 54.13 $_{kt}CO_{2e}$

Tracking method: Up to now, monitoring of energy savings has been made possible through the ISEM system with basic and advanced database analyses. The savings achieved are based on measured data on the consumption of all forms of energy. Database synchronization provides verified data and, by connecting to metering systems, provides real-time data that enables strategic planning and implementation of measures. Based on direct hourly monitoring of energy and water consumption through the ISEM system, quality indicators of energy needs are obtained and they can be better planned and managed.

Connection to other dimensions: through systematic monitoring and understanding of energy consumption, the public sector will be able to become an informed player in the energy market

Research and development: the obligation of systematic energy management in the public sector is stimulating for research and development in the field of monitoring and managing energy consumption in buildings based on information and communication technologies

ENU-8 Energy renovation programme of public lighting

Financial measure, energy services; implementation 2021 -2030

Objective and description of the measure: Energy renovation of public lighting in the Republic of Croatia is currently being implemented with ESI funds from the European Regional Development Fund, using the financial instrument of loan at favourable interest rates offered by the CBRD to units of local and regional government. To this end, HRK 152 million are available and the loan covers up to 100% of eligible project costs. This financial allocation is expected to be used by 2023. The estimated savings in this first phase of the Programme are around 15 GWh in 2023 The current potential by the end of 2030 is estimated at about 225-280 GWh. At the same time, renovation of public lighting would meet the technical standards for road lighting, which would mean improving traffic safety and reducing light pollution. The financing models to be used in the next period should also enable the mobilization of private capital through energy services or public-private partnerships in order to achieve the best multiplier effect. Models to be considered include subsidies for interest rates on commercial loans/required returns to the service and guarantee provider, and for projects requiring investment in new public lighting infrastructure (columns, additional lamps and the like), in order to meet the standardized technical requirements, it is necessary to secure grants. It has been assumed that by the end of 2030, all the estimated potential for improving the energy efficiency of the public lighting system would be achieved, and an annual electricity saving of 25 GWh (0.90 PJ; 2.15 ktoe) has been estimated. (Note**:** The objectives, conditions and activities set out in this document are indicative and will be specified in detail in the Energy Renovation Programme of Public Sector Buildings for the period up to 2030).

Activities: The following activities will be implemented within the measure:

- MESD will develop an Energy Renovation Programme for the Public Lighting System for the period up to 2030, which is adopted by the Government, based on market models of project implementation;
- The implementation of the Programme itself should start in 2024, implemented by local government units.

Funds needed for implementation: The estimated investment cost in the period until 2030 is around EUR 400 million (HRK 2.88 billion).

Sources of financing: Private equity (ESCO companies), local self-government units.

Executive body: MESD – establishes the implementation model by developing the Program, promotes and informs local self-government units; L(R)GUs – initiation of projects, contracting energy service/PPP

Monitoring (supervisory) bodies: MESD - National Coordination Body for Energy Efficiency

Impact: Reduction of electricity consumption in public lighting systems, reduction of light pollution; estimated savings in 2030 0.90 PJ (21.50 ktoe); estimated CO_2 emission reduction in 2030 - 19.60 $ktCO_{2e}$; cumulative energy savings in 2021-2030 4.95 PJ (118.25 ktoe); cumulative CO_2 emission reduction in 2021-2030 - 157.95 $ktCO_{2e}$

Monitoring method: Energy Saving Monitoring, Measurement and Verification System, using the bottom-up method for replacement of public and outdoor lighting**.**

Connection to other dimensions: With the potential integration of photovoltaic power generation systems for public lighting, there is a direct link with the decarbonisation dimension.

Research and development: Energy renovation of public lighting is an incentive for the further development of lighting technology and lighting management systems based on information and communication technologies, but also for the integration of other services into the public lighting system (e.g., broadband Internet, etc.)

ENU-9 Green Public Procurement

Information measure; implementation 2014 -2030

Objective and description of the measure: The Government of the Republic of Croatia adopted in 2015 the first National Action Plan for Green Public Procurement for the period from 2015 to 2017 with an outlook to 2020, and green public procurement was also accepted as a measure in the 4th NEEAP, which sets the target that by 2020 green public procurement criteria are applied in 50% of implemented public procurement procedures. A national Green Public Procurement Committee was set up to monitor the implementation of Green Public Procurement through a survey questionnaire and an electronic public procurement bulletin. This measure is a continuation of the initiated measures and further greening of public procurement procedures. Green Public Procurement will favour innovative low-carbon products and services, further boosting their entry into the market, with the public sector serving as a good example. A national website for Green Public Procurement (www.zelenanabava.hr) was established, which serves as a communication channel for benchmarks of green public procurement, examples of good practice, education and other information related to green public procurement. In addition, the Government of the Republic of Croatia adopted in 2021 the Decision on Green Public Procurement in Central Public Procurement Procedures (OG 49/2021) which set the obligation for the Central Office for Central Public Procurement to use the benchmarks of Green Public Procurement for the purchase of green products and services. The objective is to have 75% of implemented public procurement procedures that apply Green Public Procurement criteria in 2030.

Activities: The following activities will be implemented within the measure:

- Training of participants in public procurement and promotion of Green Public Procurement criteria;
- Improving the monitoring of the implementation of Green Public Procurement for the purposes of quantifying the effects – public procurement clients are obliged to publish their public procurement plans on websites at the beginning of the year, however the

statistical public procurement report generated from the EPPC also contains information on whether Green Public Procurement criteria have been used and will be drafted for year 2017 as late as the beginning of 2018, however without specifying details – therefore, it is not possible to calculate energy savings without elaborating how Green Public Procurement is monitored in the EPPC and it is mandatory to improve the monitoring system;

- Ongoing development of new criteria and benchmarks for Green Public Procurement, including energy efficiency.

Funds needed for implementation: The funds needed to carry out all the activities envisaged are planned by the MESD as part of its regular activities and budget**.**

Sources of funding: State budget (MESD)

Executive body: MESD in cooperation with the members of the Green Public Procurement Committee; State Office for Central Public Procurement; State administration bodies, L(R)GUs and other public procurement clients.

Monitoring (supervisory) bodies: MESD

Impact: Reducing energy consumption in public buildings; changes in the habits and behaviour of users of public sector buildings.

Monitoring method: Monitoring the achieved energy savings in the future will be carried out by applying BU methods for each group of devices that have been procured, respecting the energy efficiency criteria. It is expected that the largest number of purchases will be related to computer and office equipment and motor vehicles. The State Central Public Procurement Office monitors the data on the quantities and types of equipment purchased and submits the data to the NCB, which enters them into System for Measuring, Monitoring and Verification of Energy Savings. The quantities of all procurement procedures applying the 'green' criteria should be monitored.

Connection to other dimensions: Direct connection to the decarbonisation dimension (green electricity supply, electric vehicle procurement, etc.)

Research and development: Public procurement can be a major driver of development activities by continuously increasing 'green' requirements for devices, equipment and buildings.

Measures to promote energy audits and the energy management system

The implementation of energy audits and the promotion of systematic energy management in the period from 2021 to 2030, apart from the leading role of the public sector, will be ensured by the continuation of the application of legally binding provisions. Namely, based on the Energy Efficiency Act and the Building Act, the following obligated parties in Croatia have the legal obligation to perform energy audits:

- Large enterprises (assets > 130 mil HRK, revenue > 260 mil HRK, > 250 employees) every 4 years (except where energy and environment management system (ISO 50001) has been set up with an energy audit obligation);

- Public lighting;
- Public buildings whose usable (net) area exceeds 250 m² every 10 years;
- Existing buildings or parts of buildings constituting autonomous units and subject to the obligation of energy certification of buildings when they are sold, rented or leased;
- Heating systems in buildings with boilers using liquid (> 100 kW every 2 years) or gaseous fuel with a total nominal power of 20 kW (every 10 years) and larger (every 4 years);
- Cooling and air conditioning systems in buildings with one or more thermal/cooling energy generating units with a total nominal power of 12 kW and larger (every 10 years).

These statutory obligations shall be adjusted continuously, in particular in the light of the amended Energy Performance of Buildings Directive and the Energy Efficiency Directive, which imposes an obligation to introduce an energy management system in companies that are large consumers. The new requirements for energy audits and energy management systems will be transposed into the legislative framework by amending the Energy Efficiency Act and the relevant regulations that follow from it.

In addition, the introduction of a new fiscal measure for the promotion of systematic energy management in the business sector is expected.

ENU-10 Systematic energy management in the business (service & production) sector

Fiscal measure; implementation 2023-2030

Objective and description of the measure: Although large companies are obliged to regularly carry out energy audits, this obligation does not ensure continuous consideration of energy consumption in the company, nor does it include small and medium-sized enterprises. In order to encourage companies to introduce certified energy management systems (ISO 50001), a comprehensive analysis will be performed regarding the possibilities of using the tax system (including taxes and parafiscal charges) to stimulate companies to introduce such a system and thus ensure continuous consideration of energy consumption.

Activities: The following activities will be implemented within the measure:

- In cooperation with the Ministry of Finance, the MESD shall in 2023 prepare a comprehensive analysis of the possibilities of using the tax system to encourage systematic energy management in the business sector - for each proposed solution, the effects must be evaluated and the method for monitoring them should be defined;
- The recommendations of the analysis are incorporated into the laws and regulations related to the tax solutions that are proposed to be used during 2024 and their implementation begins 2025.

Funds needed for implementation: The funds needed to develop a comprehensive analysis of the use of the tax system to stimulate systematic energy management in the business sector

are planned by the MESD as part of its regular activities and budget; the implementation of the tax policy itself does not require additional funds

Sources of funding: State budget (MESD)

Executive body: MESD – preparation of analysis and proposal of solution; MFIN - integration of proposed solutions into the tax system.

Monitoring (supervisory) bodies: MESD - National Coordination Body for Energy Efficiency

Impact: Reducing the energy consumption of businesses in the service and industrial sectors.

Monitoring method: The monitoring method for the selected tax solution will be determined.

Connection to other dimensions: Through systematic monitoring and understanding of energy consumption, the business sector will be able to become an informed participant in the energy market and to choose solutions that will contribute to decarbonisation.

Research and development: encouraging systematic energy management opens up the need for research and development of energy monitoring and management systems based on information and communication technologies.

Providing information to consumers and training measures

Providing information to consumers will continue through the improvement of the implementation of existing regulatory and informational measures.

ENU-11 Information on energy efficiency

Informational measure; implementation 2014 -2030

Objective and description of the measure: Providing information to the general public and target groups shall be conducted through the organization of targeted information campaigns related to specific programmes of encouraging energy efficiency, particularly energy renovation of buildings.

The NCB will maintain the national energy efficiency portal and provide up-to-date information to ensure continued promotion of energy efficiency and energy services. Particular attention should be given in the following period to informing consumers of the obligations of the supplier within the obligation system.

Activities: The following activities will be implemented within the measure:

- Ensuring continuous information through the National Energy Efficiency Portal – portal www.enu.hr is the central point for current information in the field of energy savings in the Republic of Croatia. The content of the portal is grouped around three fundamental drivers of change: citizens, the public sector, the commercial sector along the EE heading in Croatia, which contains all important documents, strategic orientations and information on institutions operating within the field of energy efficiency. The portal publishes all information on activities, advice, events, projects, tenders, news and obligations related to energy efficiency in the Republic of Croatia.

MESD - NCBEE is committed to maintaining and ensuring the full functionality of the portal;

- Targeted information campaigns need to be implemented as part of other measures, in particular energy renovation measures for buildings, and the bodies responsible for implementing these measures are also in charge of implementing information activities.
- Targeted information campaigns should also be directed to the professional public, which in cooperation with other stakeholders (professional associations, academic community, non-governmental organizations, etc.) should be regularly informed about the current issues and trends in the field of energy efficiency, including green building, circular economy and sustainable mobility.

Funds needed for implementation: The funds needed to carry out all the activities envisaged are planned by the MESD as part of its regular activities and budget.

Sources of funding: State budget (MESD)

Executive body: MESD - NCBEE; Bodies responsible for the implementation of other measures (MCPP, EPEEF, L(R)GUs, etc.)

Monitoring (supervisory) bodies: MESD - National Coordination Body for Energy Efficiency

Impact: Increasing the level of awareness of the benefits of energy efficiency with the consequent change in behaviour and reduction in energy consumption by applying concrete measures.

Monitoring method: Monitoring the impact of this measure is possible by applying top-down methods on the sectoral level. Before conducting each info campaign, a market research should be done and the effects proven by repeating the same survey after the campaign.

Connection to climate change adaptation: Information should be provided about the link between energy consumption and climate change as well as the benefits of energy efficiency in terms of adaptation to climate change (increased resilience to, for example, extreme temperature conditions, etc.).

Research and development: the measure encourages innovation in the information segment (use of information and communication technologies).

ENU-12 Development of a framework to ensure adequate skills in the context of green jobs required for building renovation

Educational measure; implementation 2017-2030

Objective and description of the measure: Training will be achieved by continuing the implementation of the existing measure and adapting the activities to the needs and the actual situation. It is especially important to systematically work on attracting young people to construction and other technical occupations, which will contribute to the availability of professional staff for the implementation of energy renovation of buildings in the long run, which is the basis for achieving the set energy and climate targets. Through education in the field of energy efficiency, the principles of green building will be set and applied: it is necessary to encourage the promotion and implementation of green building (building on the principles

of sustainability) as an essential segment of sustainable development and the circular economy. The aim is to develop a framework for ensuring adequate skills necessary for a long-term, complex and systematic process of reconstruction after the earthquakes through the improvement of educational and training programs.

Activities: The following activities will be implemented within the measure:

- It is envisaged to further implement the system of continuous training and certification of construction workers - through authorized CROSKILLS training centres, according to the Ordinance on the system of training and certification of construction workers who install parts of the building that affect energy efficiency in building construction. This should lead to increased use of energy efficiency and renewable energy sources in everyday construction practice and increased demand for educated workforce, by increasing the practical knowledge of on-site workers who specialize in all phases of construction and maintenance procedures
- A National Skills Development Plan will be developed in the context of green jobs related to energy renovation and post-earthquake reconstruction
- National guidelines for continuous training of construction workers in energy efficiency will be improved and implemented
- Development of educational programs that will encourage greater use of BIM in the construction and spatial planning system in order to develop relevant skills, with integrated knowledge of energy renovation and post-earthquake reconstruction
- Promotion of the use of BIM technology in the construction and spatial planning sector
- Implementation of a campaign for retraining and training of workers for the purpose post-earthquake reconstruction and promotion of educational programs that are the subject of this reform, with the aim of attracting interested participants of the program.

Funds needed for implementation: The funds needed to carry out all the activities envisaged should be determined on the basis of the results and recommendations of CROSKILLS training centres.

Sources of financing: NRRP – EUR 5.3 million (HRK 40 million); ESI funds for strengthening human resources, with the aim of integrating the principles of green and sustainable construction and circular economy into the existing systems of vocational education, adult education and lifelong learning.

Executive body: AVETAE – co-financing training centres for the implementation of worker training; CES – co-financing of training/retraining of the unemployed; Faculty of Civil Engineering in Zagreb, within the CROSKILLS project; MCPP - setting up and applying the principles of green building in cooperation with the Croatian Green Building Council and the Faculty of Architecture (AF).

Monitoring (supervisory) bodies: MPPCSA and MESD-NCBEE

Impact: Available expert capacities for implementation of energy efficiency measures.

Monitoring method: The number of educated experts within established educational programmes/training centres is monitored.

Connection to other dimensions: Through education on green building, which includes significant use of RES, the connection with the dimension of decarbonisation is achieved.

Connection to climate change adaptation: through education on green building, which includes the promotion of green infrastructure on buildings (green roofs, green facades, etc.), capacity to implement these measures is strengthened, which represent significant measures for adaptation to climate change (e.g. reduction of urban heat islands, etc.).

Research and development: Educational activities in the field of green building stimulate research and development in this segment (technologies and methods for 'greening' of buildings).

Measurements in the process industry sector

In the period from 2021 to 2030, ETS (MS-3: European Emission Trading System) remains the main policy instrument for reducing industrial sector emissions. For non-ETS facilities (MS-5: CO_2 Emission Tax for the non-ETS Stationary Sources), the obligation to pay CO_2 emission fees shall remain, according to the Regulation on unit charges, corrective coefficients and detailed criteria and standards to determine the special environmental fee for motor vehicles (Official Gazette 73/07, 48/09, 2/18, 46/21), and the decisions on the amount of the unit fee for greenhouse gas emissions for operators of non-ETS facilities.

In addition, it is expected that the system of suppliers' obligations will also contribute to improving energy efficiency in this sector through the exploitation of cost-effective energy efficiency potentials and the use of market models, such as energy efficiency contracting.

For the period from 2021 to 2030, financially encouraging energy efficiency measures and the use of RES in manufacturing industries from public sources is also foreseen.

ENU-17 Increasing energy efficiency and use of RES in manufacturing industries

Financial measure; implementation 2021 - 2030

Objective and description of the measure: In the past period, €60 million was secured from the ESI Funds, based on the OPCC. The absorption of funds was excellent, which proves that industrial plants in the Republic of Croatia have significant potential for improving energy efficiency, reducing energy consumption and reducing the share of conventional (fossil) fuels in total energy consumption by introducing renewable energy sources. The aim of this measure is to ensure the continuation of co-financing of the implementation of such measures in manufacturing industries through grants and financial instruments.

Activities: The following activities will be implemented within the measure:

- All available funding sources that can be used to ensure co-financing of energy efficiency measures and RES in industry will be identified, taking into account both

national and EU sources of financing (ESI Funds, Modernisation Fund, Recovery Fund, etc.)
- For each identified funding source, eligible projects will be identified, and the financing mechanism and method of its implementation will be elaborated in detail (elaboration will be made by programming documents as well as in the National Energy Efficiency Action Plan, which will be developed during 2021)
- These programmes shall be provided in the manner set out in the relevant documents.

Funds needed for implementation: Not possible to determine until detailed analyses have been carried out.

Funding sources: NRRP (61 million EUR (460 million HRK) are provided) and ESI funds.

Executive body: MESD and other bodies in the system of use of EU funds.

Monitoring (supervisory) bodies: MESD - National Coordination Body for Energy Efficiency

Impact: Reducing the energy consumption of businesses in the industrial sector.

Monitoring method: Depending on the type of projects implemented, the methods defined in the Ordinance on the Energy Saving, Monitoring, Measurement and Verification System will be used.

Connection to other dimensions: Certain measures may allow energy sector business operators to become active participants in the energy market as well as to choose solutions that will contribute to decarbonisation.

Research and development: Given the diversity and continuous development of industrial production, this measure opens up the need for further research and development of more energy-efficient industrial technologies and technologies using renewable energy sources.

ENU-18 Increasing the energy efficiency of public water supply, drainage and wastewater treatment systems

Financial measure; implementation 2024 - -2030

Objective and description of the measure: Water services are activities of general interest and are performed as a public service, the infrastructure is owned by the public sector or units of local self-government and/or units of regional self-government, and legal entities for managing water services and water utility projects are local and/or regional utilities. The sector's most energy-intensive process is the supply of drinking water, which accounts for about 43.5% of the total electricity consumption of water services and 1.13% of the total electricity consumption in the EU. The water services sector is a significant consumer of electricity and has great potential for reducing energy consumption through more efficient resource management, the application of energy efficiency measures and renewable energy sources. Increasing energy efficiency and the share of renewable energy sources in the water services sector would reduce operational costs and financial losses. The water services sector could be a good example for the use of energy services by ESCO companies. The possibility of participating in savings in the water services sector in proportion to the share of co-financing/incentives in the implementation of measures could also be considered. Most

estimates of potential energy efficiency savings for water utilities in the EU indicate that savings of 10-30% are possible through a combination of operational improvements and investments, while energy savings of up to 50% can be identified in wastewater treatment plants.

Activities: The following activities will be implemented within the measure:

- Informing stakeholders about the programme and conducting educational workshops on commitments, objectives and implementation of the programme
- Evaluation of the current state of systemic energy management in the water services sector at national level (ATMIP)
- Preparation of instructions for systematic energy management, data collection and reporting (ISEM) with the purpose of determining the energy consumption of the water services sector at the national level and determining the potential for increasing energy efficiency and using the RES system of public water supply, drainage and wastewater treatment in the Republic of Croatia (MESD)
- Collection and analysis of data on energy consumption in public water supply, drainage and wastewater treatment systems, determination of priority locations for the implementation of energy efficiency and RES measures, analysis and preparation of instructions for planning and programming of financial resources for financing investment studies and project documentation (MESD)
- The EPEEF is in charge of the implementation of this measure by issuing annual public calls, the criteria of which it develops in cooperation with the MESD on basis of the conducted analyses

Funds needed for implementation: Estimates of investments will be made during and after the analyses or the first phase of the program

Funding Sources: EPEEF, L(R)GUs, Hrvatske vode, energy services of ESCO companies, obligors of the energy efficiency obligation system, state budget, ESI

Executive body: MESD, ATMIP, L(R)GUs, public local and/or regional utility companies for water service and water utility project management

Monitoring (supervisory) bodies: MESD - National Coordination Body for Energy Efficiency

Impact: Estimated savings in final consumption in 2030 amount to 0.150 PJ (3.58 ktoe; 41.67 GWh); estimated reduction in CO_2 emissions in 2030 6.63 ktCO_2; cumulative energy savings in the period 2026-2030 0.423 PJ (10.10 ktoe; 117.50 GWh); cumulative reduction in CO_2 emissions in 2026- 2030. 18.68 ktCO_2.

Monitoring method: The realized savings are monitored and proven by using bottom-up methods according to the Ordinance on the system for monitoring, measurement and verification of energy savings

Connection to other dimensions: Direct connection to the decarbonisation dimension, as the programme encourages the use of RES and emission reduction through the use of more efficient equipment, systematic monitoring of energy consumption, modernization of water infrastructure and the use of smart technologies, the sector has the potential to become an

active stakeholder in the energy market in the future (consumption response, dynamic electricity prices, electricity storage, etc.)

Research and development: Use of new technologies that contribute to decarbonisation objectives; involvement of the local professional community in the development of the project

v. If applicable, a description of policies and measures to promote the role of local RES energy communities in contributing to the implementation of the policies and measures referred to in subitems i., Ii., Iii. and iv.

Energy communities will be promoted under the RES-7 measure.

vi. A description of the measures to identify measures aimed at exploiting the potential for increasing the energy efficiency of gas and electricity infrastructure

Measures to increase the energy efficiency of the electricity infrastructure (transmission and distribution networks) are based on the Ten-Year Development Plans of the Transmission Network for the period from 2023 to 2032 and the Ten-Year Development Plan of the Distribution Network for the Period 2021to 2030 and the CERA Decision on Implementation of Energy Efficiency Measures (more details in Chapter 1.2.2). The measure to increase the energy efficiency of the gas transmission system is based on Plinacro's Ten-Year Development Plan of the Gas Transmission System for the period from 2021to 2030 For Croatia, it is essential to improve the infrastructure for production, transmission, and distribution of energy for heating and cooling.

ENU-13 Energy efficiency of the power transmission system

Financial and organizational measures; implementation 2021-2030

Objective and description of the measure: Current levels of losses in the transmission grid of the Republic of Croatia amount to about 2% of the transmitted electricity, which is the amount at the level of other operators in the ENTSO-E transmission system. An important feature of the Croatian transmission grid, both in terms of plant safety and support of market activities, as well as in terms of losses, is the extremely strong connection with neighbouring electricity systems (interconnections). While, on the one hand, this significantly increases the safety of the plant, on the other hand, the transmission increases the grid losses. CTSO (Croatian Transmission System Operator) will continue to implement measures related to the operation of the electricity system operation development and measures related to the development of the transmission grid by 2030, with the aim of further reducing technical losses in the grid. For this measure, along with provision of funds by CTSO, it is proposed to programme the use of ESI funds in the next programming period 2021 - 2027.

Activities: The following activities will be implemented within the measure:

- Measures related to the operation of the electricity system: topological changes in the grid depending on the current operating state; change of switching state of transformers 400/220 kV, 400/110 kV, 220/110 kV and 110 / x kV owned by/within the competence of CTSO and optimization of operation of transformers with oblique control (TS Žerjavinec, TS-HPP Senj); voltage management and optimization of power

flows in the grid; optimization of generator operation (operating points with power factor in the range 0.95 -1).

- Measures related to the short-term and long-term development of the transmission network include: Replacement of old power transformers with new transformers with smaller losses; revitalization of old powerlines with the replacement of conductors, using HTLS conductors with a larger cross-section of aluminium sheath or smaller losses; replacement of submarine 110 kV cables; transmission network reinforcements (construction of new lines); installation of devices for reactive energy compensation (VSR, SVC); replacement of overhead 110 kV lines with cable lines.

Replacing older equipment with new one which has a reduced amount of loss results in a reduction in overall system-level losses. Further reduction of losses in the future can be achieved by the development of new and more energy-efficient technologies, and the further revitalization and construction of the grid using the latest generation conductors with a smaller electrical resistance, i.e. smaller losses.

Funds needed for implementation: The funds needed for the implementation of all planned activities of the ten-year transmission network development plan 2022-2031 total EUR 1.246 billion, of which EUR 563 million are CTSO' own funds, and EUR 213 million from NRRP for investments without connections, EUR 125 million for investments from EU funds and EUR 345 million for connections of facilities (from the connection fee and/or EU funds).

Funding Sources: CTSO, EU funds, NRRP

Executive body: CTSO

Monitoring (supervisory) bodies: MESD - National Coordination Body for Energy Efficiency, CERA

Impact: The following table shows the reduction of losses in the transmission system:

Measure	Estimation of potential savings in losses (GWh/year)		
	2022 – 2024	**2025- 2026**	**2027 – 2031**
Replacement of conductors in the overhead lines (HTLS conductors)	0,4	0,5	0,6
Replacement of 110 kV submarine cables	0,9	1,5	1,5
Planned grid reinforcement	7,8	14,9	18,8
Installation of compensation devices (2xVSR + 1xSVC)	-3,2	-3,5	-3,5
The planned replacement of power transformers	0,2	0,2	0,3
Planned cabling of 110 kV overhead lines	0,1	0,4	0,5
Optimizing power flows	0,7	0,7	0,7
Optimizing generator performance	5,6	6,8	7,3
Optimizing the operation of power transformers	15,9	25	38

According to these estimates, in the period 2022-2024 it is possible to expect savings in electricity losses of about 15.1 GWh on average per year, in the period 2025-2026 about 25.6 GWh on average per year, and in the period 2027-2031 about 31.2 GWh on average per year.

The estimate of the savings is entirely based on the assumptions given in the Ten-Year Grid Development Plan 2022-2031 made by CTSO.

Monitoring method: The monitoring of the effects of this measure is achieved on the basis of data on realized electricity losses before and after the implementation of the measure with normalization according to the amount and duration of the load – CTSO has developed a methodology for calculating savings from energy efficiency measures in the transmission network and the savings will be determined according to this methodology.

Connection to other dimensions: Investments in the transmission grid directly affect the dimensions of energy safety and the internal energy market, while reducing losses also achieves decarbonisation goals.

Research and development: The measure entails research and development by developing new and more energy-efficient technologies related to the transmission system (electricity equipment) and its management (information and communication technologies).

ENU-14 Reduction of losses in the distribution power grid and introduction of smart grids

Financial and organizational measures; implementation 2021-2030

Objective and description of the measure: In the period of up to 2030, HEP-DSO will continue to conduct activities to reduce technical and non-technical losses in the distribution power grid. A detailed analysis will identify the causes of increased losses in some parts of the grid and the priorities for implementing activities to reduce technical and non-technical losses. Based on the experience gained from the implementation of a pilot project for the deployment of advanced grids in pilot areas using ESI funds, it is necessary to programme the continuation of the use of ESI funds in the next programming period from 2021 to 2027 for the further development of advanced grids.

Activities: The following activities will be implemented within the measure:

- Technical loss reduction activities, including:
  - increasing the cross section of the conductors in the initial parts of MV and LV bushings in which the highest amount of losses is generated
  - separation of MV and LV bushings into two or more, depending on the topology of the bushing and the acceptance options in TS HV/MV and MV /MV or TS MV /LV
  - moving part of the LV bushing to an adjacent closer and/or less loaded LV bushing or TS MV/LV
  - replacement of HV/MV and MV /MV power transformers due to overload
  - replacement of old MV/ LV energy transformers, with reduction of transformer overdimensioning

- interpolation of new TS HV/MV, MV/MV and MV/LV (primarily when overloading existing TSs, i.e. when connecting new customers and manufacturers with larger connecting power)
- transition to 20 kV and gradual introduction of 110/10 (20) kV direct transformation

- Non-technical loss reduction activities, which include:
  - further installation and introduction of as many advanced meters into the remote monitoring and readout system as possible
  - further comprehensive implementation of the connection and measuring points control (KPiMM), with the emphasis on detecting unauthorized electricity consumption
  - and continued reconstruction of existing connections and measuring points, which are located in the customers' premises.

Funds needed for implementation: HEP-DSO funds: The total investment cost of installing advanced metering devices in all of 2.4 million measuring points in the period 2021 to 2030 is approximately EUR 313 million [23].

As EU directives require the transition from conventional metering to advanced metering devices, the use of ESI funds in the area of adaptation of the existing metering system to the system for working with advanced metering devices was foreseen. First of all, it is an investment in the adaptation of the existing authorized services for the preparation of calibration meters (gauges), which are adapted to the verification of electro-mechanical meters, to the technology that enables the preparation and certification of advanced electronic meters. With the adjustments it is additionally required to make available the support to work with new technologies, above all solving of communication problems (G3 PLC) and computing process problems (upgrades of FW meters and hubs, data acquisition, transmission and processing).

The foreseen funds for the adaptation of the existing metering system to the system with advanced meters are estimated at around EUR 15 thousand.

HEP-DSO plans to invest in the ten-year period 2022-2031 EUR 1.086 billion, which consist of:

- Investments in 110kV energy facilities: 197,807,000 EUR
- Investments in 35 kV energy facilities: EUR 114,589,000
- Investments in 10kV and 20 kV energy facilities: EUR 254,365,000
- Investments in low-voltage facilities: EUR 89,379,000

[23]The stated amounts of investments and the amount of advanced meters and other systems included in the advanced measurement infrastructure are based on the results of analyses for the comprehensive introduction of advanced measurement carried out in 2017. According to Art. 31 of the Electricity Market Act, an economic assessment of all long-term costs and benefits of such a system for the market and individual end customers is underway and the assessment of the necessary funds and effects on the reduction of electricity losses will be revised.

- Investments in secondary systems, measuring devices and development: EUR 296,370,000
- Investments in business infrastructure: EUR 122,905,000
- Investments in Smart grid pilot projects (co-financing from EU funds) EUR 10,684,000

The following table provides an overview of the financial resources invested in Smart grid pilot projects:

No.	Type of Investment	Total 10Y 2022-2031 [EUR]
1	Advanced metering infrastructure	3.364.000
2	Distribution grid automation	7.320.000
	Total	10.684.000

In addition, an investment of almost EUR 600 million from the connection fee for the purpose of creating electricity conditions and connecting grid users is foreseen.

Funding Sources: HEP-DSO, EU funds

Executive body: HEP-DSO

Monitoring (supervisory) bodies: MESD, CERA

Impact: Reduction of losses in the electricity distribution grid – HEP DSO prepares a balance sheet for the previous year, which separately shows electricity losses.

Total electricity losses consist of technical and non-technical losses. Technical losses are due to the operating state of the distribution grid and the technical characteristics of the grid elements. They can be divided into:

- voltage-dependent i.e. permanent losses resulting from the maintenance of the ES in standby mode for the supply of customers with electricity,
- electricity-dependent losses i.e. variable losses resulting from the flow of electricity through the components of the ES.

Based on the assumed changes in load, consumption, investment features and start-up of individual facilities, a possible total reduction in technical losses with the implementation of the 10-Year Grid Development Plan 2019-2028 is estimated at 284 to 455 GWh (these values represent cumulative savings in a given period), of which in the first three years (period 2019-2021) from 8.5 to 13.4 GWh on average per year. Measured according to the average annual consumption in 2015-2017 of 16,310 GWh, average annual decrease in technical losses in 2019-2021 ranges from 0.05% to 0.08%. The effect of measures i.e. the reduction of technical losses, grows over the years as the scope of measures increases with time. E.g. the number of transformers with reduced losses will be significantly higher at the end of the ten-year period, therefore the annual savings at the end of the ten-year period will also be higher.

Non-technical losses i.e. commercial losses are the consequence of the taken over, i.e. consumed electricity that has, for some reason, not been accounted for. According to the estimate of the share of technical and non-technical losses in the total losses of the distribution grid, technical and non-technical losses account for about 50% of the total losses. Accordingly, for the purposes of the assessment of the effect in the period 2021-2030, a constant proportion of technical (50%) and non-technical losses (50%) in the total electricity losses was assumed.

Projection of electricity losses in TWh										
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Technical losses	0,658	0,662	0,665	0,668	0,672	0,675	0,678	0,682	0,685	0,689
Non-technical losses	0,658	0,662	0,665	0,668	0,672	0,675	0,678	0,682	0,685	0,689
Total losses	1,316	1,324	1,330	1,336	1,344	1,350	1,356	1,364	1,370	1,378

The implementation of advanced metering devices and systems for their networking has the effect of reducing non-technical losses of electricity with end customers. Advanced meters are equipped with indicators for power outages and parameter changes, which enable the detection of unauthorized power consumption by signalling unauthorized access to the device and its unauthorized use, and, ultimately, remote shutdown of power to the customer at whose point such behaviour was detected.

Summation meters installed in transformer stations based on measurements of total consumption and energy production at low-voltage outputs from the transformer station allow accurate calculation of energy losses in the medium voltage and low voltage distribution girds, comparing the amount of energy consumed in TS MV/ LV and the amount of energy consumed by end customers. By installing summation meters, more efficient and faster detection and reduction of unauthorized consumption is expected.

A number of cost-benefit analyses for the installation of advanced measuring devices, carried out in EU Member States, have identified an expected reduction in unauthorized consumption of 50% of non-technical losses (Lithuania, Slovenia), which is in line with the experience of other international pilot projects. Based on the above, the forecast for the reduction of unauthorized consumption in the case of Croatia is set at 50% of non-technical losses.

The non-technical losses incurred during the reference period by the implementation of advanced measuring devices and their networking systems are shown in the table below and calculated on the basis of an estimate of the amount of non-technical losses, an estimated maximum reduction of unauthorized consumption of 50% of the total non-technical losses after completion of the implementation of advanced metering devices and systems for their networking.

Projection of electricity losses with the implementation of advanced metering devices and systems for their networking in TWh										
	2021	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Technical losses	0,658	0,662	0,665	0,668	0,672	0,675	0,678	0,682	0,685	0,689
Non-technical losses	0,496	0,467	0,438	0,409	0,379	0,350	0,321	0,321	0,321	0,321
Total losses	1,154	1,129	1,103	1,077	1,051	1,025	0,999	1,003	1,006	1,010

Cumulative energy savings in the period 2021-2030 24.4 ktoe (284 GWh; 1.0 PJ); cumulative CO_2 emission reductions in the period 2021-2030 32.6 $ktCO_{2e}$

The estimate of the savings is entirely based on the assumptions given in the 10-Year Distribution Grid Development Plan 2019-2028 of HEP-DSO.

Monitoring method: HEP-DSO prepares a balance sheet for the previous year, specifically showing electricity losses.

Monitoring method: HEP-DSO prepares a balance sheet for the previous year, specifically showing electricity losses.

Connection to other dimensions: Investments in the distribution grid directly affect the dimensions of energy safety and the internal energy market, while reducing losses also achieves decarbonisation goals. Advanced measurements strengthen the customer's role in the energy market.

Research and development: The measure entails research and development by developing new and more energy-efficient technologies related to the distribution system (electricity equipment) and its management (information and communication technologies for advanced grids and advanced metering).

ENU-15 Increasing the efficiency of the heating system

Financial and organizational measures; implementation 2021-2030

Objective and description of the measure: In the existing large centralized heating systems, a large source of losses is the deteriorated distribution network, and this measure foresees the continuation of the replacement of deteriorated steel hot water pipes and steam lines with new pre-insulated pipes and a technological shift towards the fourth generation of district heating. In smaller systems with their own boiler room, it is necessary to allow for the reconstruction of boiler rooms, in particular by replacing them with high-efficiency cogeneration systems or systems using heat pumps. The measure also envisages the development of new heating and cooling systems, which use high efficiency cogeneration or renewable energy sources. In view of the provisions of Directive 2018/2002 on energy efficiency, and in particular with the introduction of the obligation of individual measurement at the level of the end-user, district heating systems have become systems with variable heat

demand, which requires the introduction of advanced metering systems as an additional step towards the integration of different energy systems and increasing overall energy efficiency.

Activities: The following activities will be implemented within the measure:

- Preparation of documentation for replacement of the deteriorated distribution systems.
- Replacement of distribution systems with deteriorated insulation of steel hot water pipes and steam lines with new pre-insulated pipes.
- Introducing advanced metering

Funds needed for implementation: An estimate of the funds has yet to be made according to the plans of the DHS operator

Funding Sources: DHS Operators, ESI Funds

Executive body: Manufacturers, distributors and suppliers of heat from DHS

Monitoring (supervisory) bodies: MESD - National Coordination Body for Energy Efficiency

Impact: Reducing losses in DHSs

Monitoring method: The monitoring of the effects of this measure is achieved on the basis of data from distributors of thermal energy on losses before and after application of the measures.

Connection to other dimensions: Decarbonisation, energy safety, energy markets

Connection to climate change adaptation: Taking into account the consequences of climate change in infrastructure planning

Research and development: Transition to the fourth and fifth generation of district heating and cooling; energy storage; flexibility of energy systems

ENU-16 Increasing the efficiency of the gas system

Financial and organizational measures; implementation 2021-2030

Objective and description of the measure: The potential for increasing the energy efficiency of the gas transmission system is the largest in the consumption of natural gas, which is mostly (70%) consumed for preheating of natural gas before delivery to customers, and only a smaller part (30%) for heating of business premises and various technological burdens, i.e. blowing out the system. In the coming period, Plinacro will carry out energy efficiency improvement activities in accordance with the Ten-Year Plan for the Development of the Croatian Gas Transmission System 2021-2030

Activities: The following activities will be implemented within the measure:

- Pressure reduction, from the pressure of the transmission system to the delivery pressure to the customers, causes significant subcooling of natural gas, which is unacceptable for technical and safety reasons, and consequently for commercial ones.

This preheating is carried out at reducing metering stations and reducing metering nodes through gas boilers and associated heat exchangers and heating cables. Considering that preheating systems on most of the measuring-reduction stations in the previous period have been replaced by those of newer and more efficient designs, their energy efficiency aims to be maintained by regular maintenance and, if necessary, by replacing them with new systems of maximum energy efficiency. In the next period, Plinacro will continue with the systematic replacement of boiler equipment (boilers, burners, boiler management system).

- One of the measures, which has already been implemented on several facilities, is to reduce the preheating temperature of the exhaust gas from the previous 15°C to 12°C, thus achieving additional savings. In the period from 2016 to 2019, the consumption of natural gas for preheating decreased by 16%. However, the stated temperature reduction will only be possible for those facilities where a reduced outlet gas temperature will not affect the safety of gas supply and the safety of customers.
- There is room for increased energy efficiency in the optimal management of the gas transmission system in relation to system pressures, since lower transmission system pressure means less gas reduction for the user and less preheating, and thus less energy and gas consumption. Of course, these possibilities are limited at the moment due to the current technical characteristics of the gas transportation system, the conditions for taking over domestic gas and gas from imports and its delivery to customers. However, with the further development of the gas transmission system, above all compressor stations, which are necessary, but which will be a significant customer of propulsion energy, optimal operation and management of the system will have to be given great attention. When maintaining the system, every effort should be made to minimize technological gas emissions.
- Electricity in the gas transmission system is used to drive electrical appliances, cathodic protection and, of course, lighting. Although its share in the energy consumption of the gas transmission system is significantly less than that of natural gas, its regular maintenance and (where necessary) replacement of inefficient energy using devices will effectively reduce its consumption.

Funds needed for implementation: Estimate made by Plinacro

Funding Sources: Plinacro

Executive body: Plinacro

Monitoring (supervisory) bodies: MESD - National Coordination Body for Energy Efficiency, CERA

Impact: Reducing losses in the gas transportation system

Monitoring method: The effects of this measure are monitored on the basis of Plinacro data

Connection to other dimensions: Reducing losses in the gas system contributes to the goals of safety of supply and decarbonisation

Connection to climate change adaptation: Taking into account the consequences of climate change in infrastructure planning

vii. Regional cooperation in this area, if applicable.

At a regional workshop held in Ljubljana in July 2019, the proposed topics for regional cooperation within the energy efficiency dimension were

- exchange of experience and good practice in the field of energy efficiency,
- regional freight management (encouraging the use of rail transport, energy efficient logistics),
- regional planning for the development of alternative fuel infrastructure,
- regional cooperation on the development of efficient public transport (rail, bus, green tourism).

viii. Financial measures in this area at national level, including EU support and use of EU funds.

For the period up to 2020, the following financial resources are available to stimulate energy efficiency in Croatia:

- funds that the Environmental Protection and Energy Efficiency Fund collects from the sale of greenhouse gas emission allowances in auctions and distributes in accordance with the Plan for the use of financial resources obtained from the sale of the emission allowances in auctions in Croatia by 2020 (Official Gazette no.19/18) and
- ESI Funds, in particular the European Regional Development Fund (EFRR) in accordance with the Operational Programme Competitiveness and Cohesion 2014-2020.

It should be noted that ERDF measures and related activities are implemented by the end of 2023 and the impact of activities implemented after the beginning of 2021 is monitored and counted in the period 2021 to 2030.

In the period 2021-2030, for the financial measures envisaged by this Plan, national funds from sale of emission allowances will be used, along with other revenues from the Environmental Protection and Energy Efficiency Fund, as well as ESI funds for the new programming period 2021 - 2027, with implementation until 2030. **It is necessary include in all programme and planning documents that determine the operation of the Environmental Protection and Energy Efficiency Fund and the use of ESI funds the measures proposed herein and plan for sufficient funds for their implementation**.

For the implementation of the measures defined in this NECP, funds were provided on the basis of the National Recovery and Resilience Plan (NRRP), for the use of the Recovery and Resilience Mechanism, and the Competitiveness and Cohesion Programme (PCC), for the use of ESI Funds, primarily the ERDF. In addition, the funds collected from the sale of emission allowances through auctions, which are collected by the EPEEF, as well as the funds of the Modernization Fund are also planned to be used. An overview of the available funds is given in the table below.

Table 3-1. Overview of available sources of financing for energy efficiency measures

Funds source	Investment priorities / Reform	Available allocation [mil. €]	Existing financial measure	Financing mechanism
NRRP	C6.1. R1-I1 Energy renovation of buildings	39,82	Energy renovation programme for multi-apartment buildings (ENU-3)	Grants
		73,00	Programme of energy renovation of public sector buildings (ENU-5)	Grants
		19,91	Energy Poverty Reduction Programme (UET-6)	Grants
NRRP	C6.1. R1-I3 Energy renovation of buildings with the status of cultural property	39,82	Energy renovation of buildings with the status of protected cultural heritage (ENU-6)	Grants
NRRP	C6.1. R6 Pilot project of establishment and implementation of systematic energy management and development of a new financing model	1,59	Systematic Energy Management in the Public Sector (ENU-7)	Grants
	C6.1. R2 Development of a framework to ensure adequate skills in the context of green jobs needed for post-earthquake reconstruction	5,31	Development of a framework for ensuring adequate skills in the context of green jobs required for the renovation of buildings (ENU-13)	Grants
NRRP	C1.2. R1-I2 Fostering energy efficiency, heating and renewable energy sources to decarbonise the energy sector	61,05	Increasing energy efficiency and use of RES in manufacturing industries (ENU-19)	Grants

CCP-EFRD	RSO2.1. Promoting energy efficiency and reducing greenhouse gas emissions	150,00	Increasing energy efficiency and use of RES in manufacturing industries (ENU-19)	Financial instrument: loan
		89,00	Energy renovation programme for multi-apartment buildings (ENU-3)	Financial instrument: loan
		185,00	Programme of energy renovation of public sector buildings (ENU-5) Energy Poverty Reduction Programme (UET-6)	Grants
EPEEF	Funds raised through the sale of allowances through auctions	145,00 (for the period up to the end of 2025)	Family Energy Renovation Programme (ENU-4)	Grants
Modernization Fund	Supporting investment in energy efficiency measures and high-efficiency cogeneration in the manufacturing industry	80,00	Increasing energy efficiency and use of RES in manufacturing industries (ENU-17)	Grants

3.3 Dimension: Energy security

i. Policies and measures relating to the elements referred to in Section 2.3.

Policies and measures relating to the elements referred to in Section 2.3. are classified by sectors: electricity, district heating systems, gas and oil and petroleum products and are presented below.

ES-1 Construction and use of energy storage facilities

Financial measure; implementation 2021 - 2030

Objective and description of the measure: In order to increase the possibility of energy storage in the system and increase the regulatory possibilities of the electricity system, it is

planned to build additional energy storage tanks based on battery systems, hydrogen technology, reversible hydroelectric power plants, then develop heat storage tanks with end customers, introduce charging stations for electric vehicles that enable energy storage, develop underground energy storage in the form of compressed gas and use other innovative energy storage technologies. (financed from EU funds).

Activities:

- Investment in battery energy storage tanks at the level of the transmission grid
- Investment in energy tanks at the level of the distribution grid (20 MW)
- Investment in heat tanks at the level of the distribution grid of thermal systems

Funds needed for implementation:

- EUR 19,8 million24 (transmission grid)
- EUR 13.3 million (distribution grid)

Sources of financing: Modernization Fund, NRRP

- funding from the Modernization Fund in the priority investment category for which a total of 70% of funds are allocated for the production and use of renewable electricity, improving energy efficiency, **energy storage**, modernization of the energy grid and the transition of coal-dependent regions

Executive body: HEP-Production, CTSO, DSO

Monitoring (supervisory) bodies: MESD

Impact: Approval and monitoring of the implementation of the Ten-Year Development Plan of the CTSO Transmission Grid and the Ten-Year Development Plan of the HEP-DSO Distribution Grid

Monitoring method: Ten-year Transmission and Distribution Grid Development Plan

Connection to climate change adaptation: Decarbonisation of the electricity system

Research and development: Investing in research and development of new technologies in order to modernize and increase the need for the adoption of RES in the electricity and heat grid

ES-2 Improvement of the electricity system management

Financial measure; implementation 2021 - 2030

Objective and description of the measure: The current electricity system will not be able to accept the large amount of renewable energy sources planned by 2026 and 2030, which is necessary, because the production of energy from renewable sources is one of the most important measures of decarbonization of the energy sector. So further development of

[24] https://modernisationfund.eu/investments/

techniques and procedures for managing the electricity system is expected through this measure, with the application of a number of modern tools that should enable a high level of automation of the management system, as well as the development of coordination with other transmission system operators in the region and beyond, together with the European coordination centres and communication with other participants of the electricity market. With increasing the share of renewable sources in the structure of electricity production, the need for sufficient regulatory capacity for the purposes of running the electricity system is also increased. It will be of particular relevance to maintain a high level of security of the overall management system in order to prevent cyberattacks that could endanger the electricity system and power supply. The planning will also take into account the risks of extreme weather, which are increased by climate change.

Activities:

- The measure plans to modernise and digitize, as well as expand the electricity system, which will accept an increasing amount of electricity from renewable sources in the most efficient and stable way;
- Mapping the potential of expansion and revitalization of the powerline grid and accompanying infrastructure in order to speed up the process of grid development, but also take into account the areas located within Natura 2000 and islands poorly connected to the mainland;
- Investment in electricity storage infrastructure in cases where such investments relate to projects for the implementation of which they are responsible and are implemented by transmission and distribution system operators – if the storage equipment represents a fully integrated network component;
- Adequate north-south connection with which to ensure a smooth flow of energy to continental Croatia and further to other EU members (electricity production from RES is concentrated mainly in the southern part of Croatia);
- Reducing the "bottlenecks" of the current electricity system.

Funds needed for implementation:

- About EUR 213 million for the improvement of the high-voltage grid (220 kV and 110 kV) in order to strengthen capacities in the south of Croatia, more adequate connection of the south and north of Croatia and six large islands with the mainland;
- In addition to these financial expenditures, CTSO plans to invest an additional EUR 0.667 billion by 2026;
- Around EUR 173 million for the modernisation of the distribution system (around EUR 80 million for the modernisation and development of the advanced grid including smart meters and the development of a "smart grid", almost EUR 47 million for the modernisation of the grid in Natura 2000 areas, almost EUR 13.5 million for energy storage (20 MW) and around EUR 27 million for submarine cables at the distribution level);
- in addition to the stated financial expenditures, HEP-DSO plans to invest about EUR 1.27 billion in the next ten-year period.

Funding Sources: Modernisation Fund, OPCC, potential funds from all of the above sources in terms of investment amounts

Executive body: CTSO, DSO

Monitoring (supervisory) bodies: CERA

Impact:

- By mid-2026, it is planned to revitalize about 550 km of medium and low voltage powerlines,
- By mid-2026, it is planned to connect to the network 1,500 MW of new production capacities to RES,
- Increase in the number of smart meters by 40,000,
- Renewal of submarine cables for 6 islands in order to further stabilize and modernize the system.

Monitoring method: Approval and monitoring of the implementation of the Ten-Year Development Plan of the CTSO Transmission Grid and the Ten-Year Development Plan of the HEP-DSO Distribution Grid

Connection to other dimensions: During the revitalization, construction and digitisation of the system and the accompanying infrastructure for decarbonization of the energy sector, special attention will be paid to enhanced nature protection, because during the development of the electricity infrastructure, the reduction of environmental impact will be taken into account.

Connection to climate change adaptation: The measure is directly aimed at enabling greenhouse gas emission reductions. For all components of the measure, as part of the Environmental Impact Assessment, a detailed climate risk and vulnerability assessment will be carried out, based on climate projections. The conclusions of the assessment will be incorporated into the design of the measure.

Research and development: Yes. Investing in research and development of new technologies in order to modernize and digitize due to the increasing need for the adoption of RES in the electricity grid.

District heating systems

ES-3 Development and maintenance of the district heating system

Financial measure; implementation 2021 - 2030

Objective and description of the measure: District heating systems have been defined as one of the priorities of the energy policy of the Republic of Croatia. The most significant potential for the development and improvement of existing district heating systems is primarily in increasing the energy efficiency of production units, infrastructure and equipment at end-users, measuring heat with charge according to actual consumption and increasing reliability and security of energy supply. Today's inefficient second-generation central heating systems, which have been designed for high temperatures in distribution networks, need to be

improved by third-generation systems using pre-insulated pipes, compact heat substations or fourth-generation systems based on smart energy systems and a two-way central heating system. It is extremely important to improve the DHS, primarily by reducing heat losses in the existing distribution network, as well as further development of production plants of existing central heating systems, which implies the integration of renewable energy sources, and reducing the consumption of fossil fuels (fuel oil and natural gas).Therefore, this measure envisages the maintenance and upgrading of existing DHS systems, stopping the trend of disconnecting customers from the DHS systems, introducing heat storage tanks for thermal energy, and using RES for DHS and replacing existing DHS production with renewable sources (e.g. biofuels) as well as use of heat pumps.

Activities:

- Reduction of thermal losses of the existing distribution grid of central heating systems
- Fuel oil boilers with biomass boilers replacement of fuel oil boilers with heat pumps water/water
- Replacement of natural gas boilers with compression heat pumps water/water
- Replacement of natural gas boilers – utilisation of industrial waste heat
- Replacement of natural gas boilers – waste heat utilisation
- Replacement of natural gas boilers with high-efficiency biomass cogeneration
- Replacement of natural gas boilers - utilization of geothermal energy

Funds needed for implementation: EUR 400.5 million

- 55% of the total investment amount relates to the reduction of thermal losses of the distribution network of central heating systems.
- 39.62% of the total investment amount relates to the replacement of existing natural gas cogeneration with high-efficiency natural gas cogeneration.

Two activities, i.e. investments (revitalization of the existing distribution grid and introduction of high-efficiency cogeneration) are already underway in the existing DHSs.

Sources of funding: The NRRP has secured EUR 29 million to support the development of geothermal projects. The EEA Financial Mechanism provides just over €8 million for the preparation and implementation of geothermal projects, including those related to the DHS. It is necessary to provide funds from structural and investment funds. Funding needs to be updated in line with the audit of this NECP and the Comprehensive Analysis of the Potential for Efficient Heating and Cooling. It is also necessary to consider the possibility of using the Modernisation Fund.

It is important to note that the revitalization of the existing distribution grids is carried out with co-financing from ESIF funds from the financial period 2014 to 2020. High-efficiency cogeneration projects are implemented by energy operators or owners of production plants.

Executive body: Thermal energy producers and distributors

Monitoring (supervisory) bodies: MESD

Impact: The proposed measures to increase the energy efficiency of the DHS until 2030 would ensure a reduction of primary energy in the amount of 833.18 GWh or a reduction of CO_2 emissions in the amount of 193,967.87 tons of CO_2 and in the future determine a fairer price of thermal energy for the end customer.

Monitoring method: Thermal energy suppliers are obligated parties to the energy savings obligation system under the Energy Efficiency Act and are obliged to achieve energy savings on an annual basis as well as cumulatively throughout the period from 2021 to 2030. These savings can also be achieved through measures on the DHS side (production and distribution), and a recommendation will be issued to the obligated parties to implement cost-effective measures themselves. Through the implementation of these measures, energy operators in the heating system will improve their systems, achieve financial benefits and achieve the obligation, i.e. avoid the penalization of non-compliance with this obligation, while at the same time contributing to the achievement of national energy efficiency and RES goals in heating and cooling.

Connection to other dimensions: Decarbonisation-RES**,** energy efficiency

Connection to climate change adaptation: Decarbonisation of the heating sector

Research and development: The measure is related to the research and development of RES technologies and the integration of RES into energy systems. The greatest emphasis should be placed on research into the use of waste heat in heating systems. It is necessary to map waste heat sources in cities with existing centralized heat systems and make preliminary studies of technical feasibility. Centralized heat systems can also be used for cooling via absorption heat pumps. For this purpose, it is necessary to conduct a preliminary feasibility study in a city with an existing heating system.

ES-4 LNG terminal capacity increase

Financial and technical measure; implementation 2023 - 2027

Objective and description of the measure: The liquefied natural gas terminal on the island of Krk was put into operation on 1 January 2021. The initial gasification capacity of 2.6 billion m^3/year was increased in April 2022 to 2.9 billion m^3 of natural gas per year, which is the maximum capacity of the existing gas pipeline. In August 2022, the Government of the Republic of Croatia adopted the *Decision on Increasing the Security of Gas Supply by building the Zlobin-Bosiljevo gas pipeline and increasing the capacity of the LNG terminal to 6.1 billion* m^3 *of gas per year*. The investment is estimated at EUR 180 million, of which 25 million euros are planned to increase the capacity of the terminal and 155 million euros to build the Zlobin-Bosiljevo transport pipeline. The pipeline will be able to transport hydrogen when production sources and market conditions for hydrogen consumption are developed. The construction of this section of the gas pipeline will contribute to the security of gas supply in the Republic of Croatia, but will not increase the capacity for gas transport to neighbouring countries. For greater regional impact, it is necessary to build transport pipelines to Hungary and Slovenia.

Activities: Increasing the capacity of the LNG terminal and construction of the Zlobin-Bosiljevo transport gas pipeline.

Funds needed for implementation: 180 million euros

Executive body: Plinacro

Monitoring (supervisory) bodies: MESD

Impact: Security of natural gas supply, diversification of gas supply sources

Monitoring method: Reports to CERA

ES-5 Security of natural gas supply for EU countries

Financial and technical measure; implementation 2023 - 2027

Objective and description of the measure: The evaluation of the European Network of Transmission System Operators for Gas (ENTSOG) has shown that, in the medium term, the expansion of the capacity of the LNG terminal on the island of Krk will further help to alleviate the dependence on gas supply from Russia, but in order to reap these benefits, it would be necessary to improve the Croatian transport network towards Slovenia and Hungary.

This includes the construction of gas infrastructure:

1. Towards Slovenia (Lučko-Zabok-Jezerišće-Sotla gas pipeline): 70 km, 145 million euros.

2. Towards Hungary – first phase (Bosiljevo-Sisak-Kozarac gas pipeline): 122 km, 306 million euros.

3. Towards Hungary – second phase (Kozarac-Slobodnica gas pipeline): 128 km, 272 million euros.

The construction of the pipeline is necessary to create the preconditions for transporting 6.1 billion m^3 of gas from the LNG terminal to EU countries. The planned investment amounts to 723 million euros.

Procurement for all projects can start immediately, and projects can be built within 2.5 to 3 years, or at the latest in 2026, except for the second phase of interconnection to Hungary, the completion of which can be projected for 2027. All pipelines will be able to transport hydrogen when production sources and market conditions for hydrogen consumption are developed.
Activities: Construction of transport pipelines Lučko-Zabok-Jezerišće-Sotla to Slovenia and gas pipelines Bosiljevo-Sisak-Kozarac and Kozarac-Slobodnica to Hungary.

Funds needed for implementation: 723 million euros

Funding sources: Society funds and European funds

Executive body: Plinacro

Monitoring (supervisory) bodies: MESD

Impact: Security of natural gas supply, mitigation of dependence on gas supply from Russia, diversification of supply sources, projects have a cross-border and multi-country dimension

Monitoring method: Reports to CERA

ES-6 Security of natural gas supply for the Western Balkans

Financial and technical measure; implementation 2023 - 2030

Objective and description of the measure: The evaluation of the European Network of Transmission System Operators for Gas (ENTSOG) showed that projects of common interest and additional projects identified in the REPowerEU plan, if implemented, would provide additional benefits to the Energy Community Contracting Parties, whose needs would be fully met. By completing the projects recognized by the *Flagship 5 of the Economic Investment Plan* for the Western Balkans (EIP projects), the Energy Community Contracting Parties will have access to various alternative sources and directions. Below is a quote from the Annex of the Economic Investment Plan for the Western Balkans, Flagship 5 – COAL TRANSITION:

- Gas interconnection Bosnia and Herzegovina and Croatia – brings diversification of gas supply sources, as well as increasing the potential and diversification of the existing gas distribution system in the country.

- The construction of the Fier-Vlora pipeline in Albania will be completed and priority will be given to the Ionian-Adriatic pipeline along the coast.

This measure includes the construction of:

1. Southern gas interconnections with Bosnia and Herzegovina: Gas pipeline Split-Zagvozd (DN800/75bar, 52 km) and Gas pipeline Zagvozd-border with Bosnia and Herzegovina (DN500/75bar, 22 km), with an estimated investment of 169 million euros.

2. Rest of the Ionian-Adriatic gas pipeline (IAP) Zagvozd-Ploče-Dubrovnik-Prevlaka-Dobreč (DN800/75bar, 200 km) and compressor station (KS), with an investment estimate of 580 million euros.

Procurement for the Southern Gas Interconnection can start immediately, and construction can be completed within three years. Procurement for the rest of the Ionian-Adriatic pipeline can begin in the first quarter of 2024, and construction can be completed within four years.

All pipelines will be able to transport hydrogen when production sources and market conditions for hydrogen consumption are developed.
Activities: Construction of the Southern Gas Interconnection between the Republic of Croatia and Bosnia and Herzegovina (gas pipeline Split-Zagvozd and Zagvozd-border with Bosnia and Herzegovina), construction of the Ionian-Adriatic gas pipeline (Zagvozd-Ploče-Dubrovnik-Prevlaka-Dobreč and compressor station (KS).

Funds needed for implementation: 749 million euros

Funding sources: Society funds and European funds

Executive body: Plinacro

Monitoring (supervisory) bodies: MESD

Impact: Security of natural gas supply, mitigation of dependence on gas supply from Russia, diversification of supply sources, projects have a cross-border and multi-country dimension

Monitoring method: Reports to CERA

ES-7 Construction and improvement of gas transmission system management

Financial and technical measure; implementation 2023 - 2030

This measure envisages the construction of a new gas infrastructure and the renewal and upgrade of the monitoring and management system in accordance with the Ten-Year Plan for the Development of the Gas Transmission System, in order to increase the security of natural gas supply and improve the supervision and management of the gas transmission system.

Activities: In accordance with the Ten-Year Development Plan of the Transmission System, the most significant investments in the system of monitoring and management of the transmission system are allocated to the system of remote monitoring and management of the transmission system (SCADA), associated telecommunication subsystems (optical and radio communication system), the system for managing the capacity of the transmission system (SUKAP) and investments in cybersecurity of the process communication system.

Funds needed for implementation: 26.5 million euros (10-year period)

Funding sources: Society funds and European funds

Executive body: Plinacro

Monitoring (supervisory) bodies: MESD

Impact: Safe and reliable operation of the gas transmission system

Monitoring method: Reports to CERA

Measure implementation indicator: Security and functionality of gas transmission system management and capacity leasing functionality as well as uninterrupted gas flow through the transmission system.

Connection to other dimensions: Decarbonisation - RES, energy efficiency, energy security.

Connection to climate change adaptation: The possibility of interfering, measuring and monitoring the volume of decarbonized gases in the transport system and the gas market in the Republic of Croatia.

Research and development: Not in society itself (possible innovative solutions from service providers).

ES-8 Exploration of potential hydrocarbon deposits in Slavonija, the Dinarides and the Adriatic

Financial measure; implementation 2021 - 2030

Objective and description of the measure: The aim of the measure is to mitigate the decline in oil and gas production and thus to reduce dependence on imported energy.

Activities: Activities in the preparation of tender documents for the exploration and exploitation of hydrocarbons on land and monitoring the implementation of ongoing projects. In addition to the already open tenders, the plan is to issue licenses for exploration and exploitation of hydrocarbons in the areas of previous tenders and in abandoned areas. This

activity enables continuous exploration of hydrocarbon potential, and consequently an increase in hydrocarbon exploitation in the country.

Funds needed for implementation: EUR 100 million

Funding sources: Investors' private capital

Executive body: CHA

Monitoring body: CHE

Impact: Increasing the security of hydrocarbon supply

Monitoring method: Reports to MESD

ES-9 Reducing the use of fossil fuels for thermal purposes in individual thermal systems

Regulatory measure; implementation: 2023 -2030

Objective and description of the measure: Phasing out the use of fossil fuels for individual thermal needs.

Note: It is proposed to replace thermo-technical systems using fossil fuels with heat pumps that use groundwater, soil, sea, rivers, lakes or air as well as electricity containing a significant proportion of renewable components as a source and sink; central thermal systems that carry out a clear transition towards the use of RES according to the measure of RES-4 and heating and cooling systems that directly use the energy of the Sun or another renewable energy source.

Activities: By-laws should prohibit the sale and installation of individual heating and cooling systems that use fossil fuels for all buildings that wish to maintain or achieve the status of almost zero energy buildings.

The measure contains several steps:

- -Development of an action plan with a timetable for the prohibition of individual heating and cooling systems using fossil fuels (first boilers using coal, then medium heavy fuel oil, then extra light fuel oil, etc.) and a catalogue of solutions by which technologies based on fossil fuels can be substituted by RES technologies
- -Design financial programmes that will co-finance the substitution of old heating and cooling systems according to the action plan
- -Organize information campaigns throughout the Republic of Croatia for all relevant stakeholders (citizens, equipment manufacturers, distributors, designers, installers, etc.)
- -Organize and provide technical support at all levels (building owners, entrepreneurs, etc.)
- -Define clear penalties for those who do not comply with the ban on the use of fossil fuels for the purposes of individual heating and cooling
- -Develop a system for monitoring the implementation and enforcement of this prohibition

Funding sources: EPEEF and EU funds.

Executive body: MESD and MPPCSA

Monitoring (supervisory) bodies: MPPCSA

Impact: The measure will ensure a reduction in the use of fossil fuels in total energy consumption and consequently a reduction in greenhouse gas emissions. The measure will significantly improve air quality in all urban areas where fossil fuels are used for heating and cooling purposes.

Monitoring method: Amount of energy produced for heating and cooling, according to statistical reports.

Connection to other dimensions: The measure is related to the dimension of increasing energy security and developing the internal energy market (legislative sector development).

Connection to climate change adaptation: The use of RES is planned with the integration of climate change adaptation measures and strengthening of resilience, i.e. reduction of vulnerability of RES technologies to climate change.

ES-10 Cybersecurity

Financial measure; implementation 2021 - 2030

Objective and description of the measure: Achieving resilience, reducing cybercrime, developing cyber defence policy and cyber defence capability, developing industrial and technological resources and establishing a coherent international cyber space policy with three areas highlighted: (1) resilience, technological sovereignty and leadership, (2) building operational capacity for prevention, deterrence and retaliation, (3) developing global and open cyber space.

Activities:

1. Monitoring the state of security of the national cyberspace for the purpose of detecting threats that may result in a cyber crisis.
2. Produce and submit data on trends and threats in cybersecurity on a monthly basis.
3. Preparation of reports on security incidents and threats in cyberspace.
4. Preparation of an annual activity report of the Operational and Technical Coordination for Cybersecurity.
5. Assessment of the state of cybersecurity in the Republic of Croatia based on the data obtained from the implementation of the document Methodology of assessing the state of cybersecurity in the Republic of Croatia.
6. Preparation of a report on the state of cybersecurity in the Republic of Croatia.

Funds needed for implementation: EUR 1,600,000 under the NRRP, followed by new significant investments in 2023 and beyond

Funding sources: NRRP, EU funds

Executive body: A large number of state bodies (each of these bodies should develop its own abilities to detect and deal with threats and risks that come from cyberspace on a daily basis, in order to act proactively):

- The operational and technical coordination relies in particular on the information of CARNet NCERT and ZSIS CERT, and the recommendations and instructions for the public in the event of a threat are published on the official website of the Ministry of the Interior and CARNET – NCERT
- MOI
- National CERT
- The SOA Cybersecurity Center
- Information Systems Security Bureau (ZSIS),
- HAKOM

Monitoring bodies: National Cybersecurity Council and Operational and Technical Coordination for Cybersecurity

Impact: Increasing cyber resilience and capacity building for research and prosecution of cybercrime and responses to cyber threats

Tracking methods:

- Produce and submit data on trends and threats in cybersecurity on a monthly basis.
- The members of the Operational and Technical Coordination present data on events, trends and threats in the cyber space of the Republic of Croatia at regular sessions for the sectors within their competence, and the same data are entered in the minutes of the Coordination session.
- Minutes of the Operational and Technical Coordination sessions and monthly reports on trends and threats based on the data presented during the sessions shall be regularly submitted to the National Cybersecurity Council.
- Preparation of reports on security incidents and threats in the cyber space of the Republic of Croatia on an annual basis
- Assessment of the state of cybersecurity based on the data obtained from the implementation of the document Methodology of assessing the state of cybersecurity
- Preparation of a report on the state of cybersecurity

Connection to other dimensions: Energy efficiency, development of the internal energy market

Connection to climate change adaptation: Natural disasters and climate change have increased physical risk, increasing the frequency and scale of extreme weather events and leading to long-term changes in average climatic conditions that can reduce capacity, efficiency and life expectancy of certain types of infrastructure if climate change adaptation measures are not introduced

Research and development: Yes. Strengthening research capacities to strengthen cybersecurity and investing in innovation achieves a higher level of cybersecurity in the energy

sector (training and education, procurement of investigative analytical computer kits for the analysis of digital evidence, …)

ii. Regional cooperation in this area

Regional cooperation in the field of energy security has existed for many years, within which neighbouring countries jointly plan cross-border connections for powerlines, gas pipelines and oil pipelines. The cooperation of transmission system operators has its formal basis in EU regulations and grid rules: the Croatian transmission system operator and operators from all neighbouring countries are part of the same regional security centre, and the cooperation consists of joint implementation of security analyses, capacity calculations, short-term adequacy forecasts and joint supply disruption planning.

In accordance with the Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC (Text with EEA relevance.) (OJ L 158, 14th Jun 2019) regional risk preparedness plans will be jointly developed and bilateral measures will be proposed and implemented as necessary.

Pursuant to Article 23 of the Regulation 2019/943

Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast) (Text with EEA relevance.) (OJ L 158, 14th Jun 2019), ACER adopted at the end of 2020 a methodology for assessing the adequacy of generation facilities at European level, i.e. on the scope of the activities of the ENTSO. This methodology is based on the so-called probabilistic approach where different conditions in the power system are analysed, depending on climatological conditions (35 historical climatological years are taken into account) and the availability of thermal power plants. The final result of the assessment is the statistical indicators of LOLE (Loss of Load Expectation) and EENS (Expected Energy not Served) for which each country defines limit values. These analyses are carried out at the national, regional and continental level, all with the aim of increasing the security of electricity supply and more efficient integration of new generation plants into the electricity system.

iii. Financial measures in this area at the national level, including EU support and use of EU funds, if applicable.

The use of EU cohesion policy funds, the Connecting Europe Facility (CEF), the Modernisation Fund and the Innovation Fund is expected.

3.4 Dimension: the internal energy market

3.4.1 Electricity Infrastructure

i. Policies and measures to achieve the targeted level of interconnection referred to in Article 4 (d)

As stated in section 2.3, with regard to further increase of cross-border capacity by 2030, no specific requirements are set. The possible construction of new interconnections will depend on market opportunities and positive cost-benefit analyses.

Further increase of NTC values at individual borders will be achieved by planned removal of restrictions on the internal network. The economic operator is CTSO, and investments in internal grid enhancements are approved by CERA.

ii. Regional cooperation in this area

Described in the context of regional cooperation in the "energy security" dimension.

iii. Financial measures in this area at the national level, including EU support and use of EU funds, if applicable.

The project related to the revitalization and reconstruction of the existing energy infrastructure is of strategic importance for the Republic of Croatia. Co-financing from EU funds is envisaged through the National Recovery and Resilience Plan (NPOO) for their realization.

3.4.2 Energy transmission infrastructure

i. Policies and measures relating to the elements of section 2.4.2, including, where applicable, specific measures to facilitate the implementation of Projects of Common Interest (PCIs) and other key infrastructure projects.

UET-1 Development of the electricity transmission grid

Financial measure; implementation 2021 - 2030

Objective and description of the measure: CTSO is responsible for the management, operation, maintenance, development and construction of the electricity transmission network in the Republic of Croatia and obliged to develop and adopt ten-year, three-year and one-year investment plans for the development of the transmission network every year. At the time of adoption of this document, the 10-Year Transmission Grid Development Plan 2022--2031 has been in force, and during the entire period of implementation of this document, annual amendments to the ten-year development plan will be made.

Activities: according to the 10-Year Transmission Grid Development Plan

Funds needed for implementation: €1.13 billion

Sources of funding: electricity transmission fee; participation of new users in creating technical conditions in the grid for connection of their plants; EU funds (Structural, Innovation and Modernization Fund), NPOO

Executive body: CTSO

Monitoring body: Ministry of the Economy and Sustainable Development

Impact: safe and reliable operation of the transmission grid

Monitoring method: Reports to CERA

Connection to other dimensions: decarbonisation - RES, energy efficiency, energy security

Notes: In addition to the financial resources needed to cover the costs of building the transmission network, it is necessary, through the electricity transmission fee, to provide financial resources for system services with an emphasis on balancing the system. The provision of services is achieved, inter alia, through the procurement of ancillary services (most of which relate to balancing services for frequency and power regulation), the cost of which is preliminary estimated at a total amount of around EUR 50 million per year.

Also, it is necessary, through the electricity transmission fee, in order to eliminate the expected congestion in the transmission network, to provide financial resources for the redispatching of production facilities to eliminate periodic restrictions in the transmission network. The amounts of funds will depend on the level of RES integration in Croatia and the region and the development of the transmission network, and is expected to grow in the future.

UET-2 Development of the gas transmission system

Financial measure; implementation 2021 - 2030

Objective and description of the measure: Planning the development of the gas transmission system is carried out through the development of the 10-year plan for the development of the gas transmission system. In accordance with the Gas Market Act (OG Nos. 18/18 and 23/20), the transmission system operator is obliged to prepare a ten-year plan for the development of the transmission system and submit it to CERA for approval every two years. At the time of preparation of this document, the 10-Year Gas Transmission System Development Plan of the Republic Croatia 2021-2030 has been in force. The plan will be continuously updated throughout the implementation period of this document.

Activities: according to the 10-Year Transmission Grid Development Plan

Funds needed for implementation: 903 million euros + 749 million euros with the construction of the Ionian-Adriatic gas pipeline and the southern gas interconnection with BiH.

Funding sources: Society funds and European funds

Executive body: Plinacro

Monitoring body: MESD

Impact: safe and reliable operation of the gas transmission system.

Monitoring method: Reports to CERA

Connection to other dimensions: Decarbonisation - RES, energy efficiency, energy security.

UET-3 Equipping the gas transmission system for the future possibility of transmission of up to 100% hydrogen

Financial, environmental and technical measure; implementation 2021 - 2030

Objective and description of the measure: This measure includes the project of planning and reconstruction of gas nodes and safety and measuring equipment for the reception and addition of decarbonized gases to the gas transmission system. This includes the development of a 'smart gas network' including advanced digital systems and components, control systems, sensor technologies, gas flow and quality management devices (compressors, gas flow control kits, reconstruction and chromatography equipment, etc.), to enable interactive and intelligent monitoring, measurement, quality control and management of the reception and transmission of decarbonised gases. The implementation of the project will enable the reception and mixing of decarbonised gases (biomethane and hydrogen) into the gas transmission system, which will reduce greenhouse gas emissions and facilitate the transition to a transmission system that will transport 100% of decarbonised gases in the future. The project will contribute to the achievement of the objectives set by the European Green Deal. The implementation of this measure is expected in the next 10-15 years, and according to the first indicative estimates, the required investments amount to 54 million euros.

In accordance with Annex II 3.(a) of Regulation (EU) 2022/869 of the European Parliament and of the Council of 30 May 2022 on guidelines for trans-European energy infrastructure, amending Regulations (EC) No 715/2009, (EU) 2019/942 and (EU) 2019/943 and Directives 2009/73/EC and (EU) 2019/944, and repealing Regulation (EU) No 347/2013 (OJ L 152, 3rd Jun 2022), the project belongs to the category of trans-European energy infrastructure for hydrogen: '*Pipelines for the transport of hydrogen, mainly under high pressure, including converted natural gas infrastructure, which provides access on a transparent and non-discriminatory basis to a larger number of network users*'.

This Project is part of the Croatian hydrogen network, and through other planned projects (H2 interconnection HR-HU (HYD-N-1255), H2 interconnection HR-SLO (Lučko-Zabok-Rogatec) HYD-N-619, H2 supply system Croatia-North HYD-N-1274 and H2 supply system Croatia-South HYD-N-1307), together with other projects in accordance with the provisions of the Croatian Hydrogen Strategy from 2021 to 2050 will enable the cross-border transport of renewable hydrogen between Croatia, Hungary and Slovenia. It will also be part of an indispensable link in the regional hydrogen transmission network from a potential terminal for liquid hydrogen on the island of Krk, from Eastern Europe, the Balkans and the countries of the southern and eastern Mediterranean to the end users of hydrogen in Croatia and the growing regional and European hydrogen market. The project contributes to Corridor E (Eastern and Southeastern Europe) of the European backbone of the hydrogen network.

The implementation of the project will enable the adaptation of the existing Croatian gas transmission system for hydrogen transport and will enable the increase of hydrogen transmission capacity on the existing interconnections with the neighbouring EU Member

States (Croatia/Slovenia and Croatia/Hungary), as well as on potential future interconnections. In addition, it will allow the transport of gases from all production sites and allow the transmission of hydrogen across the borders of EU Member States, as well as an increase in the transmission capacity of hydrogen by more than 10% for all repurposed or newly built H2 interconnections, compared to the situation before the implementation of the project.

The project will enable the transmission of hydrogen produced by electrolysis, which will help integrate renewable energy sources and help balance electricity transmission and distribution systems. A new optical communication cable will be laid in the same pipeline channel, which will enable the expansion of the existing optical telecommunications network.

The project will be part of Croatia's smart gas network and will be able to transport 100% of hydrogen. Its implementation and management systems will use state-of-the-art information solutions, innovative technologies and cybersecurity. By the stage of complete transition to 100% hydrogen transport, the project will allow transport, i.e. mixing other renewable gases such as biomethane, in different percentages.

It will enable market integration, security of supply, the development of the hydrogen market and the reduction of natural gas consumption and the reduction of CO_2 emissions.

Activities: equipping existing gas pipelines and other assets related to the gas network for the possibility of mixing (bio)methane and hydrogen.

Funds needed for implementation: 54 million euros

Funding sources: Society funds and European funds

Executive body: Plinacro

Monitoring (supervisory) bodies: MESD

Impact: Market integration, inter alia through connecting existing or new hydrogen networks of EU Member States and ensuring interoperability of connected systems; security of supply and flexibility of the gas system; sustainability, including reducing greenhouse gas emissions by increasing the use of renewable hydrogen or low-carbon hydrogen, with a focus on hydrogen from renewable sources; integration of renewable and low-carbon gases into the gas network; possibility of flexibility and seasonal storage of energy from renewable sources.

Monitoring method: Reports to CERA

Measure implementation indicator: security and functionality of gas transmission system management, flexibility of gas system, interoperability of connected systems

Connection to other dimensions: Decarbonisation - RES, energy efficiency, energy security.

Connection to climate change adaptation: decarbonisation, the possibility of mixing, measuring and monitoring the volume of decarbonised gases in the gas transmission system.

Research and development: Not in society itself (possible innovative solutions from service providers).

ii. Regional cooperation in this area

Due to the fact that the energy transmission infrastructure of the Republic of Croatia is connected to the systems of neighbouring countries, full technical and operational compliance with the operators of those systems is required, which is regulated by the relevant documents.

It is planned to integrate the Croatian gas transmission system with the gas transmission systems of all neighbouring countries comprehensively, and already in the preparatory phase of interconnection projects, the gas transmission system operator is intensively cooperating with the transmission system operators of those countries.

Other opportunities for regional cooperation in the context of energy transmission infrastructure are described in the framework of regional cooperation in the energy security dimension.

iii. Financial measures in this area at the national level, including EU support and use of EU funds, if applicable.

In the next period, a number of interventions are planned for the construction of new facilities in the CTSO transmission network, for which co-financing from the National Recovery and Resilience Plan (NPOO) is envisaged, through EU funds. In addition to EU funds, a number of projects will be co-financed by new network users in accordance with the applicable legal regulations.

3.4.3 Market integration

i. Policies and measures relating to the elements referred to in Section 2.4.3.

Connecting the day-ahead markets at the border between Croatia and Slovenia and Croatia and Hungary had significant effects on increasing the liquidity of the Croatian Power Exchange (CROPEX), increasing the possibilities of energy placement and price harmonization. The legislative and institutional framework for achieving the defined objectives of cross-border market integration is adequate and no specific measures need to be implemented. The activities initiated by the Transmission System Operator (CTSO) and the Electricity Exchange (CROPEX) through IBWT and EU XBID projects are expected to continue. The course and speed of implementation of regional market integration in Southeast Europe will depend on the readiness of institutions in neighbouring countries, especially in neighbouring non-EU countries (Serbia and BiH). In addition, Intraday Auctions (IDA) will be carried out across Europe to enable the pricing of cross-border capacity within the intraday timeframe, as well as to adapt the new market integration that allows variable renewable energy producers to offer their energy on the basis of more reliable production forecasts, thus reducing the imbalance caused by intermittence of variable RES.

The implementation of 15-minute products in the intraday and day-ahead market is also foreseen. Currently, 15-minute products in the intraday market are already used at certain borders (BE-NL, BE-DE, NL-DE, AT-DE, AT-HU, AT-SI, AT-SK, HU-SK, HU-RO and BG-RO). The idea is for Croatia to join by Q1 2025. In line with the EU Clean Energy Package (CEP), the Single Day-Ahead Coupling (SDAC) is preparing to move the day-ahead market auction from a

resolution of 60 min to 15 min, which implies a product offer of 15 min. Big Bang approach - one go-live for all trading zones (30 min for Ireland, 15 min for all other zones).

Market integration will also significantly contribute to the goal of increasing the competitiveness and liquidity of the wholesale market. The non-discriminatory legal framework and the independence of the transmission system operator, with adequate oversight by regulators, are crucial for increasing the number of market participants and competitiveness in the area of supply.

Additional measures and activities need to be taken to enable the active participation of end consumers (customers) and other grid users in the electricity market, in particular in the provision of flexibility services.

ii. Measures to increase the flexibility of the energy system with regard to the production of energy from renewable sources such as smart grids, aggregation, demand management, storage, distributed energy generation, mechanisms to dispatch, re-dispatch and restrict services and real-time price signals, including the introduction of intraday market coupling and cross-border balancing markets

UET-4 Enabling the implementation of pilot demand response projects in the distribution network

Research and technical measure; implementation 2023 - 2030

Objective and description of the measure: It is necessary to establish a regulatory safe test environment for the implementation of demand response projects in the distribution network. The proposal was to amend the Ordinance on general conditions for the use of the network and electricity supply with a proposal containing the provisions of the regulatory safe test environment (regulatory sandbox/experiment).

Activities for the implementation of the measure: In July 2022, CERA drafted a proposal for the Ordinance on the quality conditions of electricity supply ("OG", 84/22), which will enable and regulate the implementation of pilot projects in the distribution network.

Funds needed for implementation: All activities are carried out within the regular operations of CERA

Sources of funding: CERA's budget

Executive Body: CERA

Monitoring (supervisory) bodies: MESD

Monitoring method: It is not possible to monitor the direct effects of this measure

Connection to other dimensions: energy efficiency, development of the internal energy market

Research and development: Yes. Within this measure, some research needs to be carried out, so the measure is related to the research and development dimension.

Name of the measure: Analysis of the impact of pilot demand response projects on the distribution network

Objective and description of the measure: Implementation of pilot projects and analysis of their impact on the distribution network

Activities for the implementation of the measure:

- HEP DSO will define the points in the network where it will analyse the impact of demand response projects
- a public call for the implementation of demand response projects will be published
- the impact of pilot projects on the distribution network will be analysed
- in cooperation with CTSO, the impact of pilot projects on the transmission network will be analysed and a proposal for coordination between DSO and CTSO will be made
- the results of the implementation of pilot projects will be publicly presented to interested stakeholders

Funds needed for implementation: -

Sources of funding: Budget HEP DSO, NPF, ESIF

Executive body: HEP-DSO

Monitoring (supervisory) bodies: CERA

Monitoring method: It is not possible to monitor the direct effects of this measure

Connection to other dimensions: energy efficiency, development of the internal energy market

Research and development: Yes. Within this measure, some research needs to be carried out, so the measure is related to the research and development dimension.

iii. Measures to ensure non-discriminatory participation of renewable energy sources, demand response and storage, including through aggregation, in all energy markets

UET-5 Development of the national balancing market

Regulatory measure; implementation 2023 - 2025

Objective and description of the measure: The aim is to increase competition in the national balancing market and to enable all users of the transmission and/or distribution network to participate in the national and EU balancing market. The deadline for the adaptation and adoption of all by-laws and their application in accordance with the requirements of the Electricity Market Act (OG No. 111/2021) is 2023.

Activities for the implementation of the measure: In order to open the balancing market, in June 2018, the Croatian Transmission System Operator d.d. launched a pilot project entitled "Ensuring the power reserve of tertiary regulation through manageable consumption". From 14th December 2020, in accordance with the provisions of the Rules on the balancing of the

electricity system (CTSO 11/2019, hereinafter: ROBES), the procurement procedure of the mFRR reserves of power and/or balancing energy for the security of the system is carried out by public tendering as an improvement to the current pilot project. Public tenders for the provision of an mFRR reserve of power and/or balancing energy for system security shall be conducted in accordance with the Tender Rules for the provision of an mFRR reserve of power and/or balancing energy for system security (CTSO 11/2020).

Executive body: Manufacturers, system operators, aggregators

Monitoring body: CERA

Monitoring method: Number of participants active in the balancing market

Connection to other dimensions: Energy efficiency, development of the internal energy market

Progress towards the goal: All transmission and distribution network users, aggregators and other electricity market participants capable of doing so may participate in the balancing market. Additional liberalisation and market upgrades, as well as integration into EU markets, are expected in 2023 and 2024.

iv. Policies and measures to protect consumers, especially vulnerable and, where applicable, energy poor consumers, and to improve the competitiveness and contestability of the retail energy market

Measures on the protection of vulnerable consumers (UET-8 and UET-9) are elaborated in Chapter 3.4.4. As a measure to strengthen competitiveness, measures UET-5, UET-6 and UET-7 are foreseen.

v. Description of measures to enable and develop demand response including those addressing tariffs to support dynamic pricing

UET-6 Elaboration of a regulatory framework for active participation of grid users in the electricity market

Informational and regulatory measure; implementation: 2023 - 2025

Objective and description of the measure: In order to enable the active role of grid users in the electricity market, it is necessary to accordingly amend and supplement the existing regulatory framework, including the implementing rules. The introduction of the aggregator as a market participant and enabling the launch of pilot projects for the provision of ancillary services will analyse in detail the services that users can provide to the distribution or transmission system operator. It will also analyse the potential for the provision of ancillary services and flexibility services through demand response, the needs of the system operator for ancillary services and their possible types, scope, mode and period of provision. Obstacles to the use of ancillary services will be identified and ways to remove them will be suggested. The implementation of this measure will also take into account new technologies (battery tanks, electric vehicle charging stations, etc.), whose wider application also requires the amendment of the regulatory framework.

Activities: developing a regulatory framework for new energy markets; developing a regulatory framework for an independent aggregator; developing a regulatory framework for the provision of ancillary services

Funds needed for implementation: regular work of state bodies

Executive body: Ministry of Economy and Sustainable Development and bodies responsible for adopting implementing regulations

Monitoring body: Ministry of the Economy and Sustainable Development

Impact: The emergence of aggregators in energy markets; the emergence of new energy markets

Monitoring method: Reports from CERA

Connection to other dimensions: Decarbonisation - RES, energy security

Research and development: User involvement; advanced technologies for users; development of RES; energy storage; system flexibility

UET-7 Introduction of advanced systems for measuring consumption and management of measurement data

Financial measure; implementation 2021 - 2030

Objective and description of the measure: In order to enable the further development of the electricity market and the active role of electricity buyers in the markets, it is planned to introduce advanced metering devices, measurement data management systems and systems at the consumption level.

Activities: According to the Ten-Year Transmission Grid Development Plan

Funds needed for implementation: EUR 274 million

Funding sources: Electricity distribution fee; participation of network users; EU funds (Structural, Innovation and Modernisation Fund), NRRP

Executive body: HEP-DSO

Monitoring (supervisory) bodies: CERA

Impact: Enabling the active role of customers in the electricity market, digitalization and improvement of DSO operations, support to the electricity market, establishment of a single system for managing metering data, reduction of electricity losses (energy efficiency and reduction of unauthorized electricity consumption)

Monitoring method: reports to CERA, approval and monitoring of the implementation of the Ten-Year Distribution Network Development Plan

Measure implementation indicator (indicator): implementation (by years) of the comprehensive installation plan for the advanced measurement infrastructure system

Connection to other dimensions: decarbonisation - RES, energy efficiency, energy security

Connection to climate change adaptation: customer participation in the electricity market including the provision of flexibility services

Research and development: User involvement; advanced technologies for users; development of RES; system flexibility

3.4.4 Energy poverty

i. If applicable, policies and measures for the achievement of objectives set out in 2.4.4.

In order to achieve the objectives set out in 2.4.4, the following measure will be implemented in the period from 2021 to 2030:

UET-8 Implementation of the Programme for the reduction of energy poverty

Information and financial measure; Implementation 2021 - 2030

Objective and description of the measure: Development of programmes to combat energy poverty, alleviate energy poverty and the degree of vulnerability to it; establishment of an energy poverty monitoring system

Activities: Within the Programme for the reduction of energy poverty, capacity building will be continued through local info centres, and energy poor citizens as well as citizens at risk of energy poverty will be provided with adequate information and advice on energy efficiency measures that contribute to the reduction of energy poverty and on opportunities of co-financing activities in this area. Furthermore, indicators necessary to monitor the energy poverty will be identified and a monitoring system will be established through the already existing system for collecting data on household consumption and habits (Croatian Bureau of Statistics). On the basis of data, a possible extension of criteria for gaining the status of vulnerable energy customers will be analysed. Also, the implementation of energy efficiency measures in energy poor households will be co-financed, such as replacement of household appliances by "old for new" system, upgrade or replacement of heating systems (improvement of the efficiency of heating systems and replacement of energy generating products (in particular electricity and fuel oil)) with systems that are environmentally and economically more favourable and more energy-efficient, and above all, with systems that use renewable energy sources, and the implementation of other technical energy efficiency measures will also be co-financed. The programme will elaborate in detail the above-mentioned measures and, if necessary, develop other measures as well as the possibility of their implementation within the energy efficiency obligation system for suppliers. A model to cover energy costs will be developed and implemented within the Programme. The model will determine the level of assistance needed for households facing the problem of meeting energy costs, based on the amount of energy required to meet the minimum standard of living. The Long-term Renovation Strategy (2050) will provide measures to combat energy poverty through the energy renovation of buildings, as well as criteria for identifying vulnerable groups of citizens at risk of energy poverty. These measures will be further elaborated in the Programme of Energy Renovation of Multifamily Housing 2021-2030 and in the Programme of Energy Renovation of Family Houses 2021-2030

Funds needed for implementation: Not estimated. Preliminary assessment will be possible after the development of the Plan.

Funding Sources: Energy Efficiency Obligation Scheme payer funds, EU funds

Executive body: Competent ministry for energy

Monitoring (supervisory) bodies: The competent ministry for energy

Impact: Establishment of a system for monitoring energy poverty and the vulnerability to it; capacity building to alleviate energy poverty; the establishment of models to cover energy costs; reduction of immediate energy consumption and consequent reduction of CO_2 emissions in energy-poor and at-vulnerable households

Monitoring method: CBS publications; The realized savings are monitored and proven by using bottom-up methods according to the Ordinance on the system for monitoring, measurement and verification of energy savings

Connection to other dimensions: decarbonisation - emissions; decarbonisation - RES; energy efficiency

Research and development: energy efficiency in buildings; energy efficiency in heating and cooling; smart cities and communities

UET-9 Implementation of the Programme for Combating Energy Poverty, which includes the use of renewable energy sources in residential buildings in assisted areas and areas of special state care for the period up to 2025

Informational and financial measure; Implementation 2022 – 2025

Objective and description of the measure: alleviation of energy poverty and the degree of threat in buildings owned and operated by the Ministry of Physical Planning, Construction and State Assets, in which residents are not able to participate in the financing of necessary repairs

Activities: In the framework of the Programme for Combating Energy Poverty, which includes the use of renewable energy sources in residential buildings in assisted areas and areas of special state care for the period 2023-2027, 413 residential buildings were identified for the needs of the Programme, and 407 work-listed buildings and 12 additional ones were included, but 22 were included in other units, giving a total number of 397 buildings. The priorities for renovation were determined according to the observed shortcomings of buildings, and the possible savings of energy for heating and primary energy that will be achieved by renovation of buildings were estimated. The total includes 387 buildings, with a total area of 297,575 m², the renovation of which requires an investment of 297 to EUR 47 million. The total possible primary energy savings on all buildings is 27 GWh per year. The programme also foresees the use of renewable energy sources, especially photovoltaic systems, whose total potential can ensure the production of electricity at the site for own consumption in the amount of about 4,360 MWh per year, which will reduce CO_2 emissions by about 691 tons per year.

Sources of financing: Recovery and resilience mechanism, state budget (remaining available funds collected on the basis of a solidarity fee for an endangered energy buyer), funds of the obligors of the energy efficiency obligation system, EPEEF, EU funds.

Executive body: MPPCSA, SDUOSZ, EPEEF

Monitoring bodies: MESD-NKT

Impact: comprehensive renovation of buildings in assisted areas and areas of special state concern; building capacity to alleviate energy poverty; establishing a model to meet energy costs; reducing immediate energy consumption and consequently reducing CO_2 emissions in energy-poor and vulnerable households.

the estimated savings in final consumption in 2030 are 0.55 PJ (13.10 ktoe; 151.80 GWh); the estimated reduction in CO_2 emissions in 2030 is 34.80 ktCO_2; cumulative energy savings in the period up to 2030 3.29 PJ (78.86 ktoe; 910.80 GWh); cumulative reduction in CO_2 emissions by 2030 $_{208.78\ kt}CO_2$.

Monitoring method: CBS publications; The realized savings are monitored and proven by using bottom-up methods according to the Ordinance on the system for monitoring, measurement and verification of energy savings

3.5 Dimension: research, innovation and competitiveness

i. Policies and measures relating to the elements referred to in Section 2.5.

The state will increase investment in research, innovation and competitiveness, as well as investment in knowledge transfer and the development of knowledge and innovation-based technologies through policies and measures related to science and research, and those related to the development of competitiveness. Support programmes in the field of research, development and innovation, and in the development of knowledge and innovation-based technologies, shall include the award of grants and vouchers until the implementation of strategic or pilot projects. Specific programmes and financial instruments, including loans and state aid schemes, are also being developed for entrepreneurs.

IIK-1 Establishment of a system for identifying and monitoring the achievement of research, innovation and competitiveness objectives

Organizational measure; implementation 2024

Objective and description of the measure: Development and establishment of a system for monitoring progress in the field of research and development, innovation and competitiveness related to the Energy Union; establishment of identifiers, in order to establish the monitoring of scientific research/research and innovation activities, regardless of the source of funding, with a common set of basic data: project duration, eligible costs, project participants, budget, sources of financing, area of action, project description, planned and achieved performance indicators, thematic priority area S3 and thematic priority of the Energy Union (if applicable).

Activities: define methodology, identifiers, link to existing databases, data entry, testing, information

Impact: Established system for identifying and monitoring innovation, research and competitiveness

IIK-2 Establishment of systematic financing of research and development projects

Organizational measure; implementation 2024 - 2030

Objective and description of the measure: The measure creates preconditions for the continuous and systematic implementation of research and innovation and the strengthening of research capacities and plans to implement and co-finance research and innovation projects, including larger (strategic) scientific research projects, with large amounts of funding. It elaborates objectives, indicators and establishes a system for monitoring the achievement of goals and indicators in the field of research and development, innovation and competitiveness related to the Energy Union; it develops criteria for grouping research teams (e.g. through cooperation of several research institutions) and private partners, and connecting scientific and research teams in the field of natural, technical, biomedical and biotechnical sciences with research teams in the field of social sciences and humanities in order to strengthen the transdisciplinary approach to solving key societal challenges related to the Energy Union.

Activities:

- Defining the objectives of financing public and private research and innovation related to all dimensions of the Energy Union, the amount of financing and the dynamics of publication of thematic tenders (one-year and multi-year)
- Regular launch of thematic tenders for research and development projects related to the Energy Union
- Co-financing of projects accepted in EU tenders

Impact: Established system of continuous financing of scientific research projects and cooperation between science and economy; Implemented scientific research projects priority for the Republic of Croatia

IIK-3 Fostering competitiveness in the field of the low-carbon economy

Financial measure; implementation 2021 - 2030

Objective and description of the measure: The measure encourages increased competitiveness in the field of low-carbon products and services, by co-financing entrepreneurial activities related to the Energy Union

Activities: It will continue to support entrepreneurs throughout the development stages of their business - from the research and development of the idea through to commercialization and marketing, and intellectual property protection all in the area of low carbon products and services. Cooperation with scientific and research institutions and increased private investment in R&D will be encouraged. One possible activity is to fund the Proof of Concept as a mechanism to support the transfer of research results from the public to the private sector to create new products and services.

Funds needed for implementation: to be determined subsequently

Executive body: HAMAG-BICRO, MSE, MESD

Monitoring body: MSE and the Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change

Impact: Low carbon products and services marketed

Monitoring method: reports of the Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change

Connection with other dimensions: The measure is linked to all dimensions of the Energy Union as it encourages entrepreneurship in all areas relevant to the Energy Union

Connection to climate change adaptation: The measure encourages entrepreneurship in areas relevant to climate change adaptation.

IIK-4 Encouraging the transfer of knowledge and technologies from science to the economy system with an emphasis on low-carbon technologies

Financial measure; implementation 2021 - 2030

Objective and description of the measure: The measure encourages the development of technology transfer offices or related organizational units in public scientific organizations and science and technology parks with the aim of transferring knowledge and developing technologies that will contribute to the development of a low carbon economy.

Activities: Providing annual support to public scientific organizations for the establishment of development companies or subsidiaries resulting from the results of scientific research; providing support for cooperation between entrepreneurs and the science system, business meetings, business consulting; preparation of business plans; pre-money valuation and mentoring the preparation of high value projects and infrastructure projects; mentoring the development of business plans and pitching to investors, financing of experts on protection of intellectual property rights; financing grants for projects in the concept validation phase, etc. with a focus on sustainable technologies that contribute to low carbon development.

IIK-5 Encouraging the work of scientific centres of excellence established in the field of natural, technical, biotechnical and biomedical sciences

Financial measure; implementation 2021 -2030

Objective and description of the measure: The measure encourages the continued work of established Centres of Excellence and those whose work has been positively evaluated in the periodic evaluation process with a view of a further development a low carbon economy

Activities: Support for industrial and experimental research of scientific Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change, with a view of further upgrading on the results of research funded in the 2014 financial period.-2020

Executive body: MSE

Impact: results of industrial and experimental research in the field of low carbon development

Monitoring method: Reports on the work of the CRE, which are submitted annually to the MSE.

IIK-6 Capacity building to encourage research and innovation and increase competitiveness in the field of low-carbon economy

Capacity building; implementation: 2020 – 2030

Objective and description of the measure: Capacities of institutions involved in stimulating and monitoring research, innovation and competitiveness in the low carbon economy will be built

Activities: The activities relate to three different levels of action: - the first part relates to the activities of bodies responsible for planning and implementing public policies related to research and development activities. This primarily applies to the Ministry of Science and Education and other national bodies such as the Croatian Academy of Sciences, the National Council for Science and Higher Education and others. The second part relates to strengthening the capacity to encourage and monitor research at the level of individual scientific research institutions. The third part concerns the selection of relevant research topics under the relevant TPP S3.

Representatives of all bodies involved in the implementation of measures IIK 1-5 will be supported to participate in lectures, workshops, working group meetings, study tours with the aim of international integration and capacity building in setting goals, defining indicators and monitoring the achievement of set goals in the context research, innovation and competitiveness in the low carbon economy.

Support for participation in working bodies and working groups and committees of relevant European and international organizations (IEA, etc.), programmes (SET Plan, ETIP, EERA, Horizon Europa, Eureka, etc.), European Partnerships under the EU Framework Programme for the research and innovation in relevant Pan-European networks and consortia. If necessary, the transfer of know-how with other EU Member States and other stakeholders within the Republic of Croatia will be organized.

Funding sources: technical assistance, means gained from the auction of emission allowances (EPEEF), ESI funds

Executive body: HAMAG-BICRO, MSE, MESD

Monitoring body: MESD and the Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change

Impact: Capacities in bodies responsible for stimulating research, innovation and competitiveness in the area of low carbon technologies

Monitoring method: reports of the Committee for intersectoral coordination for policy and measures for mitigation of and adaptation to climate change

ii. Collaboration with other Member States in this area, including information on how the objectives and policies of the Strategic Energy Technology Plan (SET) are transposed into the national context

The Republic of Croatia has been included in the steering group of the European Strategic Energy Technology Plan (SET-Plan) since 2015 and covers all ten key activities. The link between SET Plan activities at European and national levels will be ensured through capacity building foreseen under measure IIK-6.

At a regional workshop held in Ljubljana in July 2019, as the topic of regional cooperation within the dimension of research, innovation and competitiveness scientific and research cooperation with the possibility of expanding were proposed, regarding the following topics:

- energy storage,
- digitization of energy systems and grids,
- energy communities,
- advanced grids,
- RES rich systems,
- integration of energy systems (electrical, gas, thermal, transport)
- removal, storage and use of CO_2,
- hydrogen,
- energy poverty
- consumer behaviour.

iii. Financial measures in this area at the national level, including EU support and use of EU funds, if applicable.

Scientific and research project stimulating entrepreneurship will be funded from national, European Structural and Cohesion Funds for the period 2021 - 2027, the Innovation Fund and directly from the European Union budget, with priority given to low carbon projects.

In addition, financial support is needed for research projects applying to relevant international tenders, which increase the knowledge needed to create a green and competitive low carbon economy in which resources are used more efficiently and whose objectives are aligned with priority topics. The themes of the projects will be identified in line with national priorities. Financial support will be provided as a percentage based on own co-financing of projects, for the costs of organizations registered in the Republic of Croatia.

SECTION B: ANALYTICAL BASIS

4 CURRENT SITUATION AND PROJECTIONS WITH EXISTING POLICIES AND MEASURES

4.1 Projected evolution of main exogenous factors influencing energy system and GHG emission developments

i. Macroeconomic forecasts (GDP and population)

The most important factors influencing energy system and GHG emission developments are demographic and economic movements.

The number, dynamics and spatial distribution of population according to different demographic and economic characteristics are the basic determinant of steering overall development. The official census published on the website of the Croatian Bureau of Statistics was used as a source in 2021, while the value in 2050 was taken from Eurostat and the values between were obtained by linear interpolation.

Also, projections of economic trends in the period up to 2050 have been made. For the development of the projection of gross domestic product (GDP) *Gross Domestic Product* (GDP) of the Republic of Croatia was used official data published on the website of the Croatian National Bank for 2021, while the remaining years were obtained using the projected real growth rates.

Table 4-1. Trajectories of economic parameters based on medium demographic projections

Components	2021	2025	2030	2040	205G
GDP, constant prices, billion EUR	57,232	60,401	64,363	72,872	83,388
GDP, index, 2021 = 100	100	105,5	112,5	127,3	145,7
GDP per capita, constant prices, thousand EUR	15	16	17	20	25
GDP per capita, index 202. = 100	100	107,4	117,0	138,6	166,3
Population, in millions	3,87	3,81	3,72	3,56	3,39

Source: Croatian National Bank / Eurostat

The projection of GDP and economic structure movements is based on the existing observed trend of GDP movements, employment and labour productivity, demographic projections and the existing economy structure.

ii. Sectoral changes expected to affect the energy system and greenhouse gas emissions

The projection of final consumption of all forms of energy was made using a *bottom-up* approach that provides an insight into structural changes in the area of energy use in various sectors (e.g. industry, households, services, transport), which are necessary to achieve the climate change mitigation goals.

LEAP (The Low Emissions Analysis Platform[25]) software tool was used to analyse final energy consumption. LEAP is a complex and versatile software system for integrated energy planning and climate change mitigation assessment, developed by the Stockholm Environment Institute (SEI). LEAP supports a wide range of different modelling methodologies: on the energy consumption side, it is possible to apply bottom-up modelling techniques, end-use consumption techniques or macroeconomic top-down modelling. In this study, the technique of **end-use** modelling was applied in such a way that for each sector and subsector the current and future need for useful energy was determined according to the purposes, and then, with the application of appropriate efficiency technologies and the predicted representation of energy sources, the final energy consumption was calculated.

The LEAP tool is designed to enable scenario analyses that allow policymakers to determine and then evaluate alternative scenarios by comparing energy needs, their societal costs and benefits, and their environmental impacts. In the LEAP tool there is a possibility to describe individual policy measures which can then be combined in different combinations and permutations into alternative integrated scenarios. This approach allows policymakers to assess the impact of individual policies, as well as the interactions that occur when multiple policies and measures are combined. For example, the effects of a measure to improve the thermal insulation of a facility in combination with a measure to replace the primary energy source (space heating technology) may be less than the sum of the effects of the two measures if considered separately.

In the energy model developed for the purposes of this document, two scenarios are defined. The first, the **Scenario with Existing Measures (WEM)**, represents the future trends of energy flows in line with the expected improvements in technology and structural changes in energy consumption and production driven mainly by market principles and without the active role of the Republic of Croatia in the design and implementation of energy-climate measures. The second, **the Supplementary Measures Scenario (WAM)**, assumes the implementation of an active policy in support of the energy transition. This implies the implementation of the measures elaborated in this document.

The main determinants of changes in the energy sector applied in making projections of final consumption of all forms of energy are the following:

[25] Heaps, C.G., 2021. *LEAP: The Low Emissions Analysis Platform.* [Software version: 2020.1.54] Stockholm Environment Institute. Somerville, MA, USA. https://leap.sei.org

- increasing energy efficiency in all parts of the energy chain (production, transport / transmission, distribution and consumption of all forms of energy) and applying the principle of energy efficiency as a first recourse;
- switching as many activities as possible to the use of electricity (where technologically feasible and long-term cost-effective);
- the increasing profitability of investing in RES technologies, due to the expected fall in the prices of these technologies and the rise in the prices of emission permits.

In addition to sector-specific measures, the analysed scenario for the development of the energy sector also takes into account the effects of regulatory measures, which will have cross-sectoral effects. This primarily concerns the establishment of a functional system of energy efficiency obligations for energy suppliers in accordance with Article 7 of Directive 2012/27/EU on energy efficiency.

In addition, energy efficiency is also expected to be increased on the energy production side by the construction of new cogeneration plants and gas-fired power plants (TPPs) with higher efficiency and an increase in the share of RES. In the area of transmission and distribution of electricity and heat, further losses are expected to be reduced to the level of developed energy systems by 2030.

The assessment of future energy consumption takes into account the impact of expected climate change on the ways and dynamics of consumption of different types of energy. For example, expected changes in temperature and weather conditions can affect the use of energy for space heating and cooling and seasonal energy consumption.

Energy consumption and driving parameters (e.g. population size and structure, GDP structure, etc.) were processed at the state level.

Starting from the availability of local resources and sources of primary forms of energy, the possibilities of meeting the needs of all forms of energy (e.g. thermal, electric, natural gas, biomass, etc.) were analysed. For grid systems (e.g. electricity, natural gas), the analysis and optimization of the operation and development of the system of production, transmission / transport and distribution of energy to end-users on a minimum cost basis were carried out, taking into account the environmental impact limitations (including greenhouse gas emissions), strategic determinants in the area of security of energy supply and the impact of participation in the operation of the regional market (possible cooperation in the exploitation of regional energy potential and sharing of infrastructure). The availability and condition of the existing energy infrastructure, the required replacement of elements and the construction of new elements in the system (e.g. power plants, powerlines, pipelines, etc.) were taken into account.

The PLEXOS model was used for the long-term optimal construction plan and to optimize electricity systems and district heating systems (in the part of thermal energy production), as well as to analyse/confirm the feasibility of operating the ES on an hourly basis in selected characteristic years.

iii. Global energy trends, international fossil fuel prices, carbon pricing within the EU ETS

In the analysis of electricity supply options, fuel prices recommended by the European Commission were used[26]. This document recommends the use of harmonised estimates of individual input parameters in the Member States, as well as the presentation of monetary values converted into EUR2020 (previously used EUR2016). For this conversion, the values of the ESTAT HICP (Harmonized Indices of Consumer Prices) index were used. In the event that a Member State uses other values, it is necessary to indicate the reasons, differences, as well as to carry out a sensitivity analysis in accordance with the recommended harmonised values of the selected parameters.

International fuel prices

Table 4-2 and Figure 4-1 show estimated fuel prices by 2050. The values for the period 2018 to 2021 are historical.

Table 4-2. Estimated fuel prices by 2050

EUR_{2020}	Crude oil EUR/GJ	Crude oil EUR/toe	Crude oil EUR/barrel	Natural gas (NCV) EUR/GJ	Natural gas (NCV) EUR/toe	Coal EUR/GJ	Coal EUR/toe
2018	10,9	454	62	7,8	325	3,0	126
2019	10,2	425	58	4,5	189	2,1	87
2020	6,4	268	37	3,1	130	1,6	67
2021	10,5	438	60	15,1	634	3,8	157
2022	15,4	643	88	33,2	1391	5,3	220
2023	15,4	643	88	24	1005	4,2	176
2024	15,4	643	88	14,6	611	3,2	132
2025	15,4	643	88	13,2	554	3,1	128
2030	15,4	643	l88	11,3	473	3,1	130
2035	15,4	643	88	11,3	473	3,1	131
2040	16,3	680	93	11,3	473	3,3	139
2045	17,6	738	101	11,3	473	3,5	146
2050	19,7	824	112	11,8	494	3,7	153

Source: EU Recommended parameters for reporting on GHG projections in 2023

Figure 4-1. shows the expected trend of fuel prices by 2050, and compared to 2021 (the last year before major disturbances and changes in prices on the energy market).

[26]Recommended parameters for reporting on GHG projections in 2023, Version after consultation of WG2 under the Climate Change Committee on 10th March 2022, sharing of draft recommendations on 30th March 2022 and consultation of National Experts designated by members of WG2 on 26th April 2022, EUROPEAN COMMISSION DIRECTORATE-GENERAL FOR CLIMATE ACTION

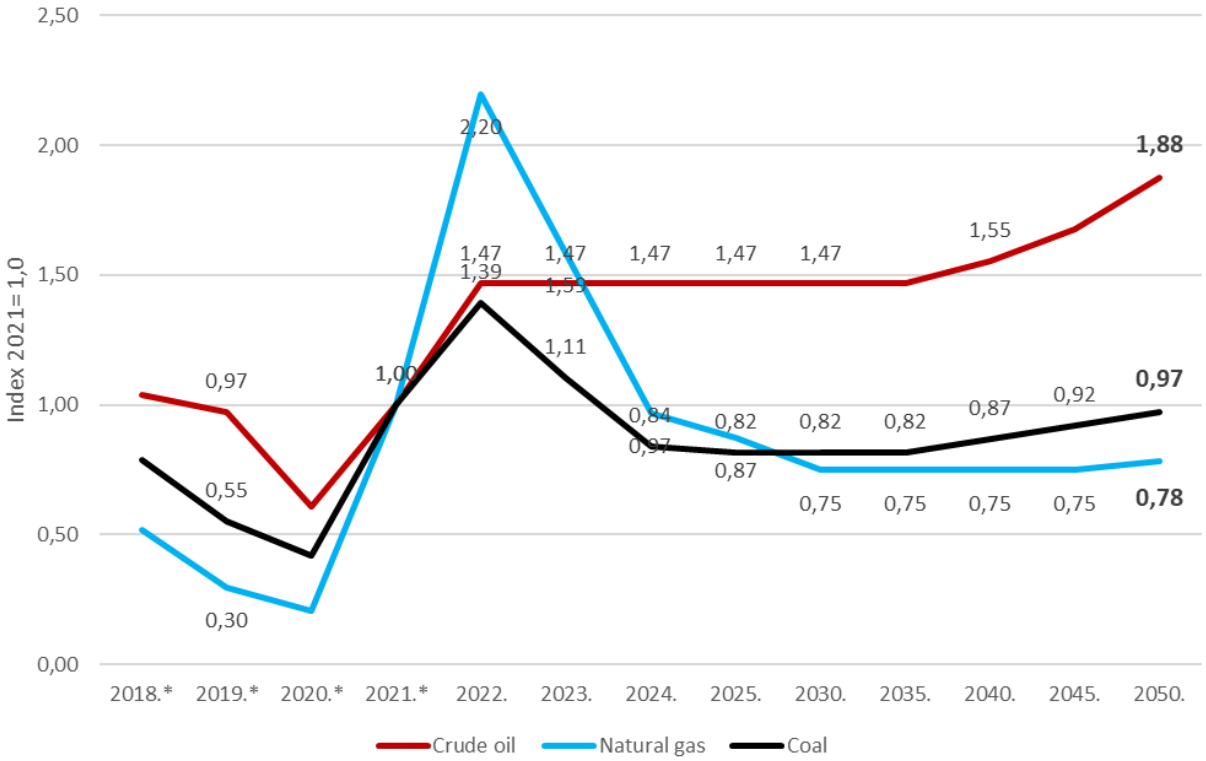


Figure 4-1. Fuel price change index until 2050

Source: EU Recommended parameters for reporting on GHG projections in 2023

For natural gas, it is recommended to conduct a sensitivity analysis within the limits of the expected lowest and highest price, as shown in the table and figure below.

Table 4-3. Natural gas price projection

EUR2020	Natural gas (NCV) – low price		Natural gas (NCV) – high price	
	EUR/GJ	EUR/t	EUR/GJ	EUR/t
2024	14,6	611	15,4	643
2025	5,0	209	14,6	611
2030	6,7	281	13,8	579
2035	7,4	308	13,1	547
2040	8,6	361	13	544
2045	9,3	391	13,2	553
2050	9,5	397	13,8	577

Source: EU Recommended parameters for reporting on GHG projections in 2023

According to the low cost scenario, a significant drop in the price of natural gas is expected from 2025 (market stabilisation and infrastructure realisation). By 2050, no significant change in the price of natural gas is expected.

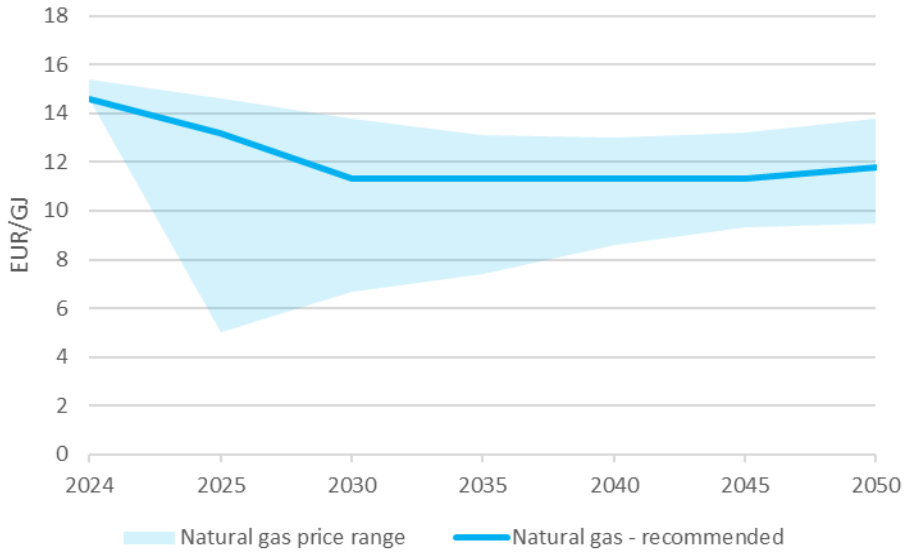


Figure 4-2. Recommended natural gas price range for sensitivity analyses

Table 4-4 shows fuel prices according to the estimates of the International Energy Agency[27].

Table 4-4. Fuel price estimates according to IEA WEO 2022

EUR$_{2020}$								
Product	**Scenario**	**Unit**	**2021**	**2030**	**2035**	**2040**	**2045**	**2050**
Crude oil	Stated Policies	EUR/barrel	56,6	67,6	69,3	72,6	74,6	78,3
	Announced Pledges			52,4	51,5	51,5	50,7	49,8
Natural gas (EU*)	Stated Policies	EUR/MBTu	7,8	7,0	7,0	7,1	7,3	7,6
	Announced Pledges			6,5	6,0	5,5	5,2	5,2
Coal (EU*)	Stated Policies	EUR/t	98,9	49,7	54,4	53,9	52,8	53,0
	Announced Pledges			51,5	47,2	45,8	44,8	44,0
* - prices relevant for EU								

Source: IEA World Energy Outlook 2023

The above estimates show that the EU's fuel price recommendations are well above the prices estimated in IEA WEO 2022.

For nuclear fuel, a constant price of EUR 0.50/GJ is estimated, and for biomass EUR 4.6/GJ.

Emission allowance prices in the European Trading System

For all power plants using fossil fuels, it is assumed that they participate in the European Emissions Trading System. For the purposes of the preparation of the national energy climate plans, the European Commission has prepared recommended price levels of emission

[27] IEA World Energy Outlook 2022

allowances by 2050, which are presented in the table below. As in the case of fuel prices, all amounts are expressed in euros from 2020.

Table 4-5. Recommended emission allowance prices by 2050

Emission unit prices	2021	2025	2030	2035	2040	2045	2050
NEKP - EC Recommendation EUR2020/t CO_2, Scenario with existing measures (WEM)	54	80	80	82	85	130	160
NEKP - EC Recommendation EUR2020/t CO_2, Scenario with additional measures (WAM)	54	80	80	120	250	360	410

Source: EU Recommended parameters for reporting on GHG projections in 2023

Two trajectories for the development of emission permit prices were recommended, one for the *WEM (With Existing Measures*) scenario and the other for the *WAM (With Additional Measures*) scenario.

iv. Changes in technology cost

Expected trends of specific investments in electricity generation technologies for the period 2020-2050 have been taken from IEA WEO 2022, for the EU territory. The option of coal-fired thermal power plants was not considered, while for natural gas-fired thermal power plants, possible construction of a carbon capture and sequestration system (CCS) was envisaged. Expected specific investments are shown in the following table.

Table 4-6. Expected specific investments in power plants

Technology	2021	2030	2050
	Specific investment EUR2020/kW		
CCGT	824	824	824
CCGT + CCS	2556	2473	1814
OCGT	412	412	412
Nuclear	5441	4205	3710
Solar PV (large)	668	437	338
Solar PV (buildings)	923	627	495
Wind power plants (land)	1311	1245	1195
Wind power plants (sea)	2506	1649	1237
Biomass and biogas	3092	3009	2927
Geothermal plants	2350	2267	2102

Source: IEA WEO 2022

Natural gas-fired thermal power plants are not expected to make technological progress, except in the context of the development of carbon collection and storage. For nuclear power

plants, the possibility of making greater use of this technology within reaching global emissions reduction targets was assumed (the estimate presented relates to projects to be implemented in Europe). With regard to the Small Modular Reactors (SMR) option, the commercialization of this option is not likely before 2035 and costs are unknown.

Further specific cost reductions are expected for RES sources, especially for solar power plants. No significant technological/cost progress is expected for large and small HPPs and biomass power plants.

Batteries

The possibility of building lithium-ion batteries is also foreseen for storing surplus electricity and providing flexibility services in the electricity system. The power-to-pack ratio is assumed to be 1:4 (i.e. a battery that can be charged or discharged in 4 hours). Specific investments are shown in Table 4-7.

Table 4-7. Specific investments in battery systems (4 hours of storage)

Component	EUR2020	2021	2030	2050
The cost of the battery-tank	EUR/kWh	171	124	61
The cost of the management system	EUR/kW	619	493	297
Fixed cost	EUR/kW	7.9	5.7	2.8
Variable cost	EUR/MWh	2.2	1.4	0.5
Total specific cost (4 hours)	EUR/kW	1304	990	541

Individual storage systems (i.e. end-user level) are assumed to be at least 20 % more expensive compared to high storage capacity batteries (system level). It is possible to build batteries at all voltage levels.

Hydrogen production technologies

For the production of hydrogen, it is assumed that all quantities will be produced by the electrolysis process. The expected costs of such a facility are shown in the following table. It is also necessary to predict the costs of the hydrogen tank, and the amounts shown are increased by 20%.

Table 4-8. Specific investments in hydrogen production facilities (electrolysis)

Item	Unit	2020	2030	2050
CAPEX (at the level of technology input)	EUR2020/kW_e	836	650	418
Efficiency (NCV)	%	64	69	74
OPEX (5 in relation to CAPEX)	%	1.5	1.5	1.5
"Stack" lifetime	h	95 000	95 000	100 000

Source: IEA G20 Hydrogen report: Assumptions, Revised version, December 2020

4.2 Dimension: decarbonization

4.2.1 Emissions and elimination of greenhouse gases

i. Trend of current GHG emissions and removals within the framework of the EU Emissions Trading System, the sectors covered by Effort Sharing Regulation, LULUCF and other energy sectors

The trend of GHG emissions in the Republic of Croatia is presented in Figure 4-3.

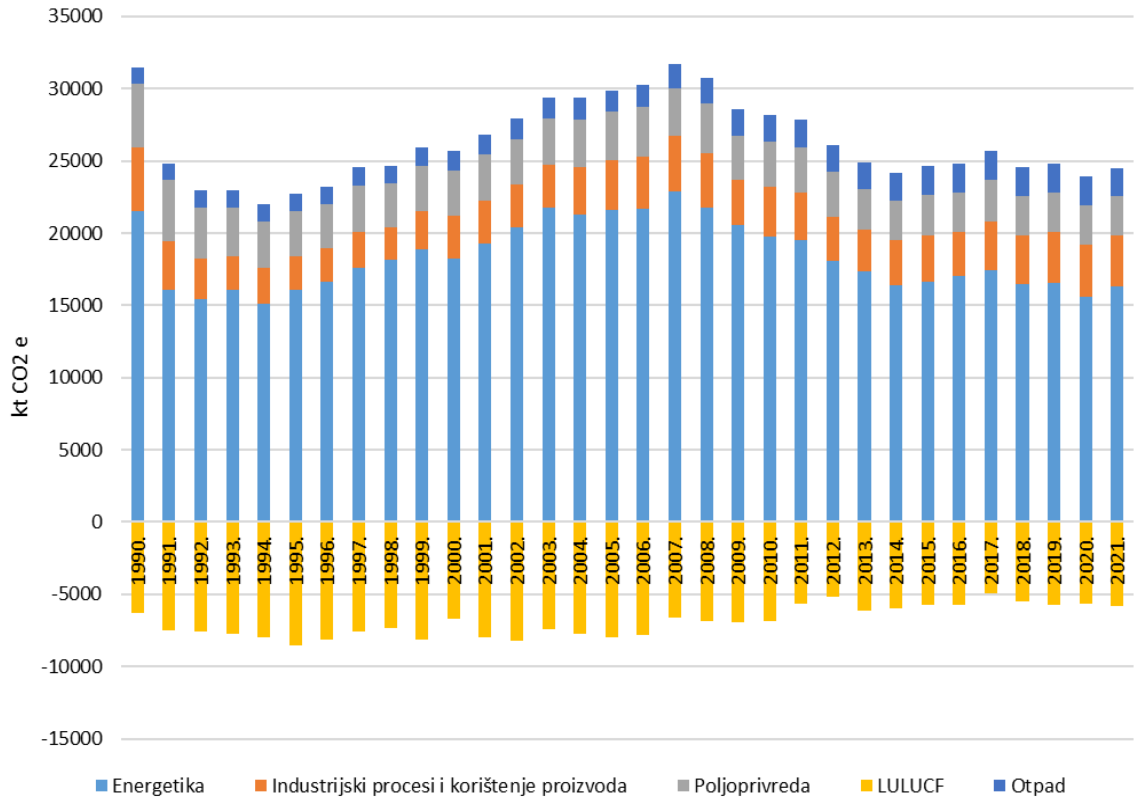


Figure 4-3. Trend of GHG emissions in the Republic of Croatia

Since 1st January 2013, plants in the Republic of Croatia participate in the EU Emissions Trading System for GHG. The emissions from ETS and non-ETS sectors are shown for the period from 2013 to 2021 (Figure 4-4).

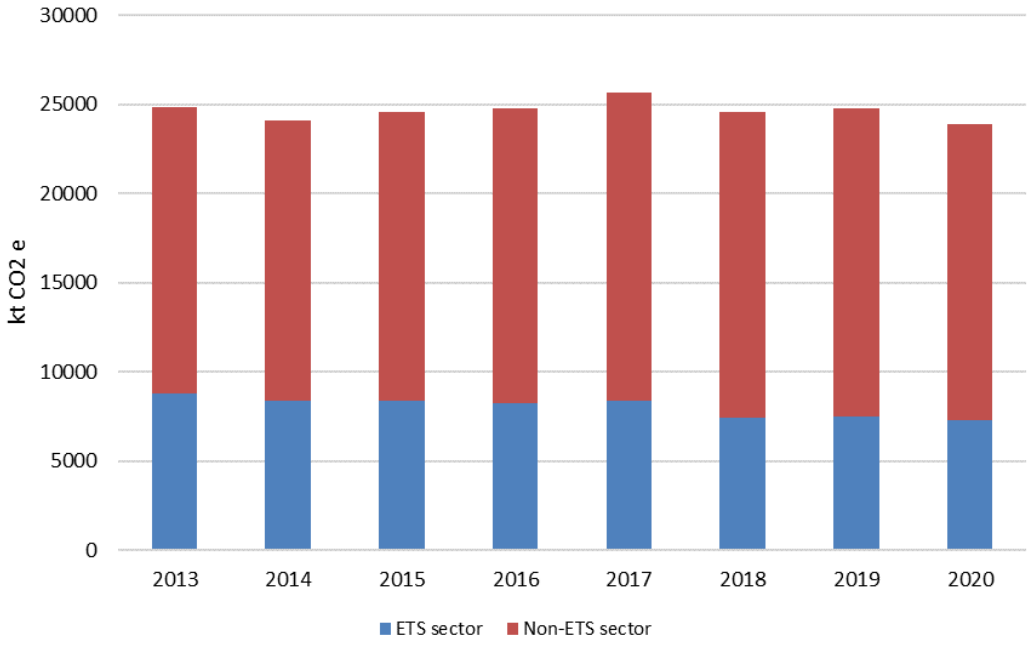


Figure 4-4. Trend of GHG emissions from ETS and non-ETS sectors in the Republic of Croatia

ii. Estimates of sectoral trends in addition to existing national and EU policies and measures at least until 2040 (including the estimates for 2030).

Estimates of GHG emissions by sectors with existing national policies and measures and EU policies and measures by 2040 are presented in Figure 4-5.

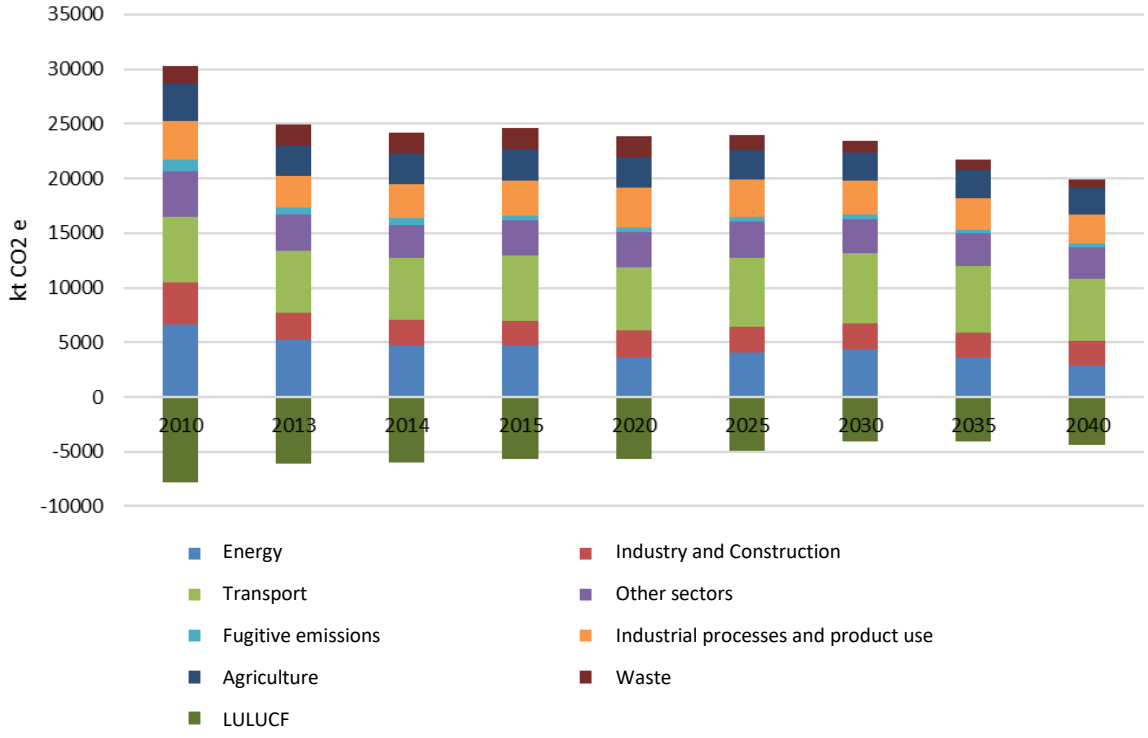


Figure 4-5. Projection of GHG emissions and sinks, with the existing measures – WEM scenario

4.2.2 Renewable energy

i. Current share of energy from renewable sources in final gross energy consumption and in different sectors (heating and cooling, electricity and transport) as well as by technology in each of these sectors

In the case of the scenario with existing measures (WEM), RES shares and forecasts with existing measures are presented below.

Table 4-9. Indicative trajectories of RES shares by 2030 in the scenario with existing measures (WEM)

Share RES, %	Achieved 2021	Projections 2030 (Scenario WEM)
In the gross final consumption of energy	31,7	35,0
In the final consumption of electricity	53,5	63,6
In the final consumption of energy for heating and cooling	38,0	40,0
In the final consumption of energy in transport	7,1	10,7

ii. Indicative estimates of trends with existing policies by 2030 (with an outlook to 2040)

The following figure shows the expected trajectories (shares) for the observed categories: total RES in the gross final energy consumption (Figure 4-6), RES in electricity (Figure 4-7), RES in heating and cooling (Figure 4-8) and RES in transport (Figure 4-9) for a scenario with existing measures (WEM).

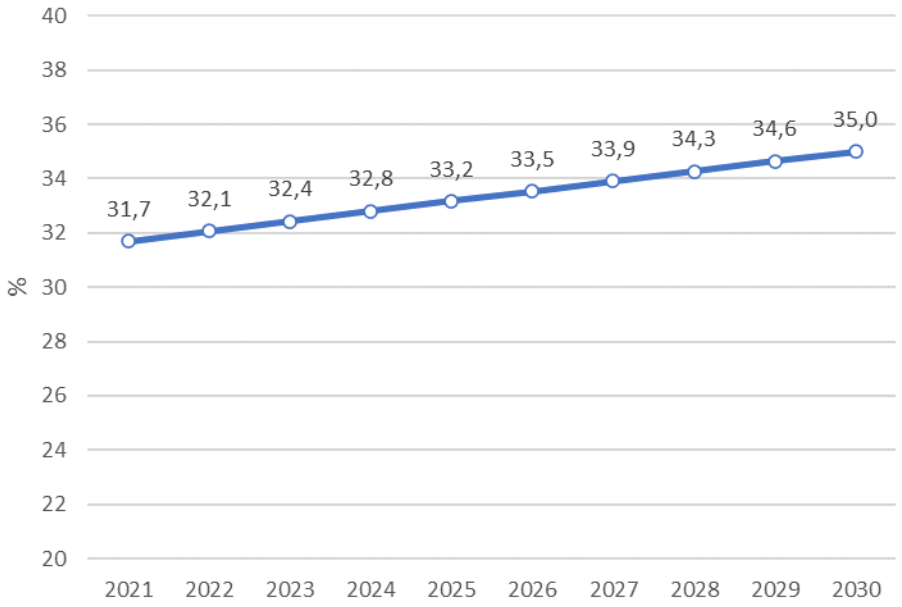


Figure 4-6. Indicative trajectory of RES shares in the gross final consumption of energy (WEM)

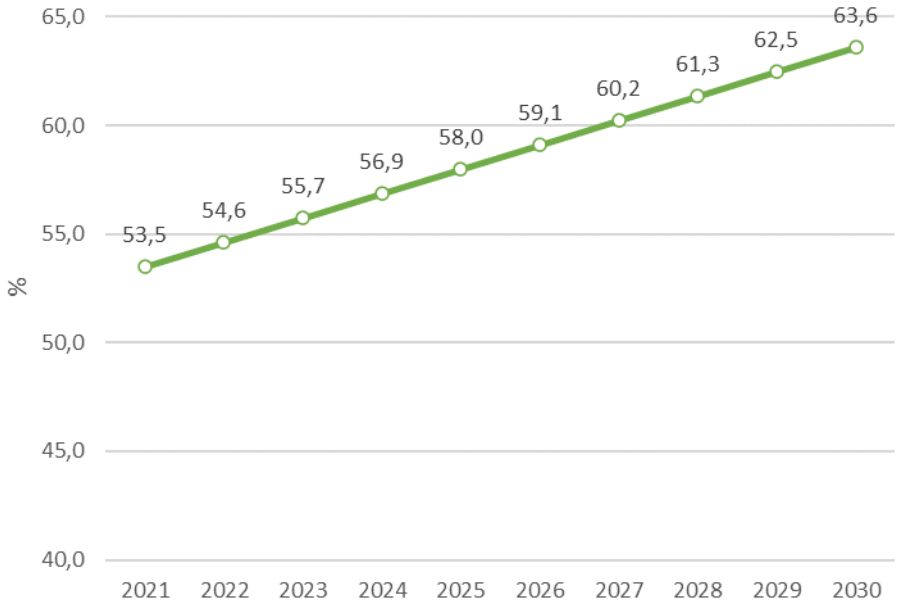


Figure 4-7. Indicative trajectory of RES shares in electricity (WEM)

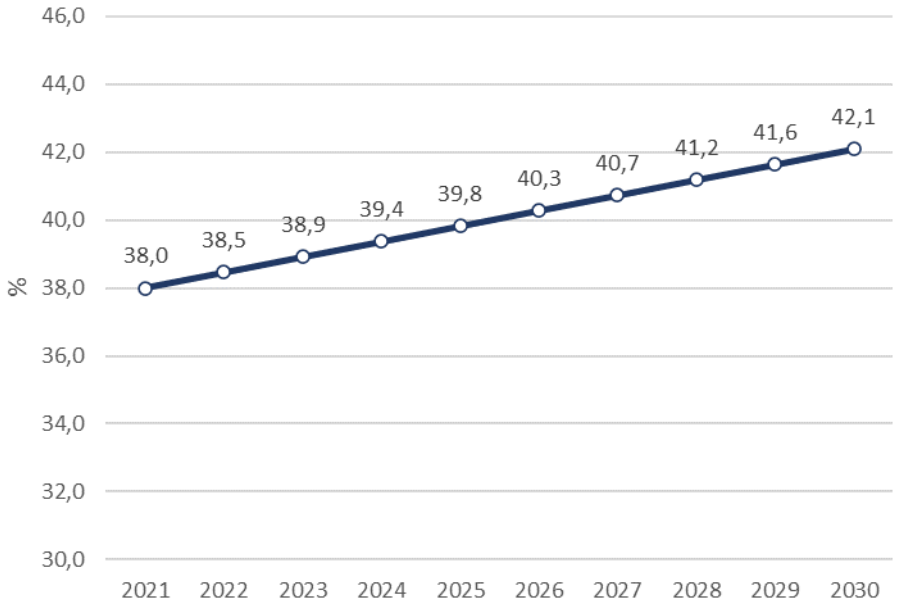


Figure 4-8. Indicative trajectory of RES share in heating and cooling (WEM)

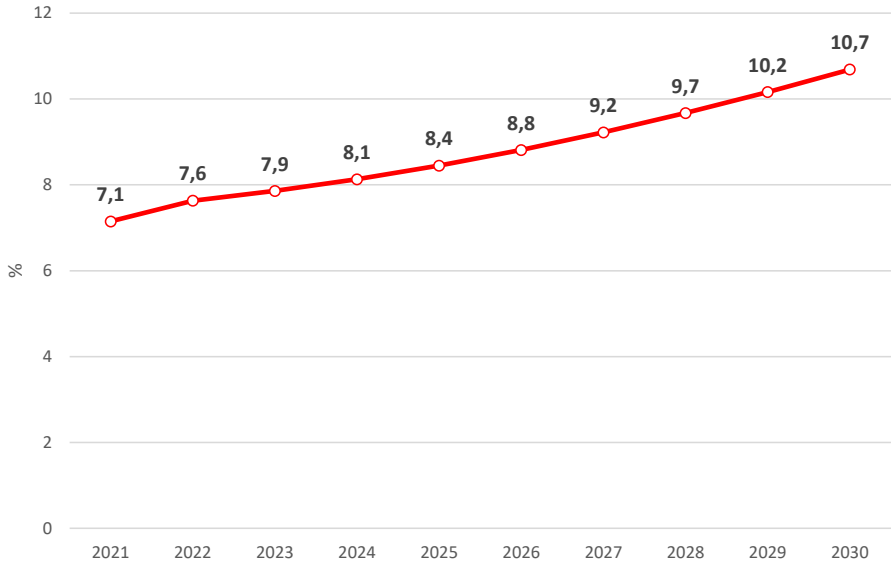


Figure 4-9. Indicative trajectory of RES share in transport (WEM)

Evaluated contributions of technologies for production of energy from RES for the scenario with existing measures are shown in Figure 4-10, and Tables 4-10 to 4-13.

Table 4-10. Estimated contribution of RES technologies to gross final energy consumption (WEM)

ktoe	**2021**	2022	2023	2024	2025	2026	2027	2028	2029	**2030**
Gross final RES consumption	**2304,5**	2341,3	2378,2	2415,0	2451,9	2488,7	2525,6	2562,4	2599,2	**2636,1**
Solar energy	**17,1**	17,8	18,5	19,2	19,9	20,6	21,4	22,1	22,8	**23,5**
Solid biomass	**1154,4**	1144,8	1135,3	1125,7	1116,2	1106,6	1097,1	1087,5	1078,0	**1068,4**
Gaseous biofuels	**0,5**	0,4	0,4	0,3	0,3	0,2	0,2	0,1	0,1	**0,0**
Liquid biofuels	**91,2**	91,0	90,7	90,5	90,2	90,0	89,8	89,5	89,3	**89,0**
Geothermal energy	**5,0**	5,0	5,0	4,9	4,9	4,9	4,9	4,9	4,9	**4,9**
Thermal energy from RES	**108,7**	122,8	136,9	151,0	165,1	179,2	193,3	207,4	221,5	**235,6**
Electricity from RES	**927,8**	959,6	991,5	1023,4	1055,3	1087,1	1119,0	1150,9	1182,8	**1214,7**

Table 4-11. Estimated contribution of technologies for RES in electricity (WEM)

ktoe	**2021**	2022	2023	2024	2025	2026	2027	2028	2029	**2030**
Final RES-e	**927,7**	959,6	991,5	1.023,4	1.055,2	1.087,1	1.119,0	1.150,9	1.182,8	**1.214,7**
HPP	**571,4**	569,6	567,7	565,9	564,0	562,2	560,3	558,5	556,6	**554,8**
WPP	**177,3**	202,3	227,3	252,3	277,2	302,2	327,2	352,2	377,2	**402,2**
PV	**12,8**	19,7	26,5	33,4	40,2	47,1	53,9	60,8	67,7	**74,5**
GE	**45,0**	45,2	45,4	45,6	45,8	46,0	46,3	46,5	46,7	**46,9**
TPP - solid and gaseous biofuels	**121,2**	122,9	124,6	126,3	127,9	129,6	131,3	133,0	134,7	**136,4**

Table 4-12. Estimated contribution of technologies for RES in heating and cooling (WEM)

ktoe	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Final RES-h&c	**1.285,1**	1.272,4	1.259,8	1.247,1	1.234,5	1.221,8	1.209,2	1.196,5	1.183,8	**1.171,2**
Solar energy	**17,1**	19,4	21,8	24,1	26,5	28,8	31,2	33,6	35,9	**38,3**
Solid biomass	**1.154,4**	1.122,7	1.091,0	1.059,3	1.027,5	995,8	964,1	932,4	900,7	**869,0**
Gaseous and liquid biogas	**0,0**	2,6	5,3	7,9	10,5	13,2	15,8	18,5	21,1	**23,7**
Geothermal energy	**5,0**	4,9	4,9	4,9	4,8	4,8	4,8	4,7	4,7	**4,7**
RES heat	**108,7**	122,8	136,9	151,0	165,1	179,2	193,3	207,4	221,5	**235,6**

Table 4-13. Estimated contribution of technologies for RES in transport (WEM)

ktoe	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Gross final RES in transport	**103,4**	**111,1**	**112,7**	**114,6**	**116,6**	**118,9**	**121,2**	**123,8**	**126,5**	**129,3**
Biofuels	**91,2**	88,0	88,4	88,7	88,9	89,0	89,1	89,0	89,0	**88,8**
Electricity from RES	**12,2**	23,0	24,4	25,9	27,7	29,8	32,2	34,7	37,5	**40,4**

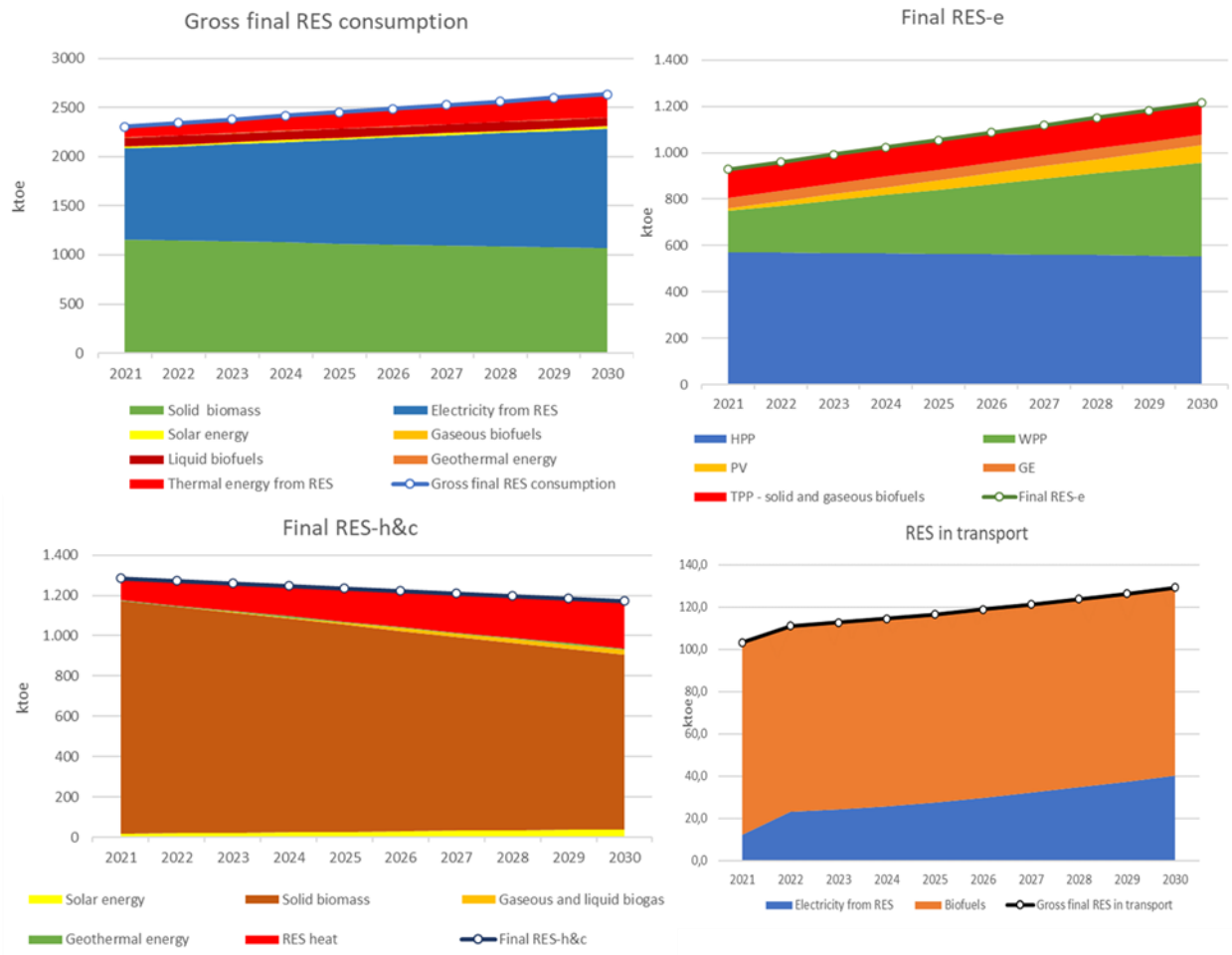


Figure 4-10. Estimated contribution of RES technologies by sectors (WEM)

The expected structure of electricity generation capacity in the Scenario with existing measures (WEM) is presented in Table 4-14 and in Figure 4-11.

Table 4-14. Estimated power plant capacities in the scenario with existing measures (WEM)

MW	Nuclear	Hydro	Gas	Fuel oil	Coal	Biomass	Biogas	Geothermal	Wind	Integrated solar	Non-integrated solar	Total
2021	348	2.201	840	344	210	95	59	10	987	83	55	**5.232**
2030	348	2393	1079	0	210	145	59	68	2296	520	346	**7.464**
2040	348	3790	1819	0	0	195	59	168	3394	866	578	**11.217**
2050	0	3882	1784	0	0	195	59	238	7761	1.057	704	**15.680**

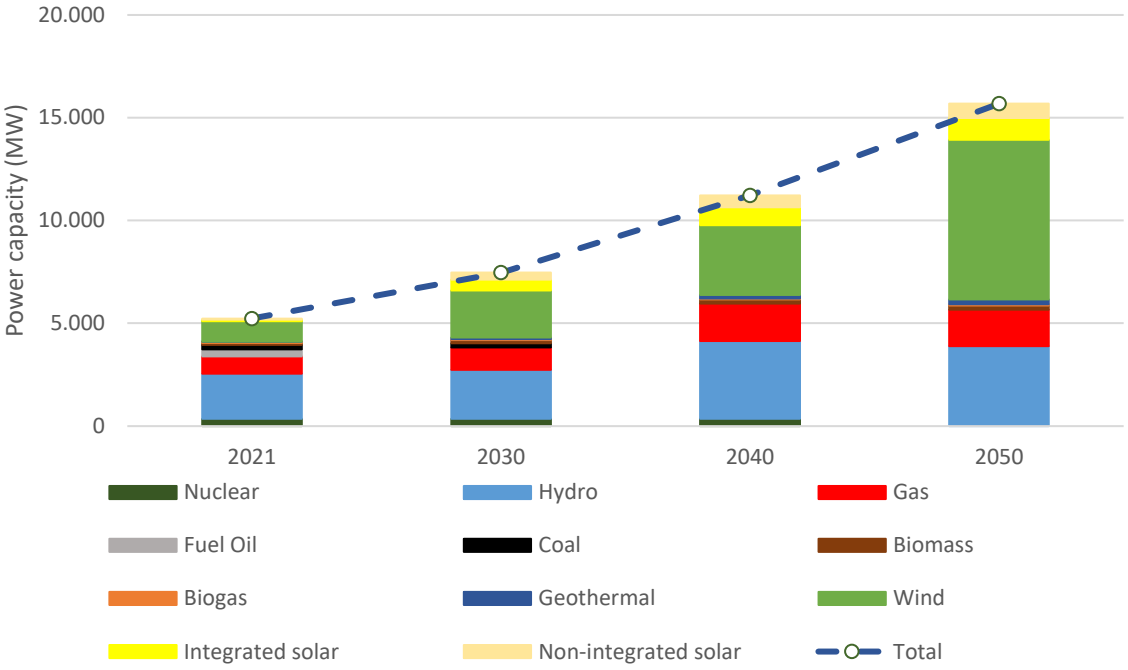


Figure 4-11. Estimated powerplant capacity in the scenario with the existing measures (WEM)

4.3 Dimension: energy efficiency

i. Current primary and final energy consumption in the economy and by sector (including industry, residential, service and transport)

The most recent data on energy consumption in the Republic of Croatia available at the moment of drafting this plan are for 2021 and are presented in Table 4-15 and Table 4-16.

Table 4-15. Structure of primary and final energy consumption by sectors in 2021 (balance according to the EUROSTAT methodology)

2021	PJ	ktoe
TOTAL ENERGY CONSUMPTION	360,0	8,597,5
Transformation losses	25,9	619,1
Operational consumption	18,8	448,2
Transport and distribution losses	10,1	241,2
Non-energy consumption	17,2	411,8
PRIMARY ENERGY CONSUMPTION	342,7	8.185,8
FINAL ENERGY CONSUMPTION	292,2	6.979,6
Industry	49,7	1.186,1
Transport	89,9	2.148,0
Residential	102,2	2.441,0
Service	35,5	847,8
Agriculture and forestry	9,8	234,8
Fishery	1,0	23,7

Table 4-16. Structure of primary and final energy consumption by energy-generating products in 2021 (balance according to the EUROSTAT methodology)

2021	PJ	ktoe
TOTAL ENERGY CONSUMPTION	360,0	8.597,5
Coal and coke	17,4	415,5
Liquid fuels	119,2	2.848,0
Natural gas	101,7	2.429,2
Renewable energy sources	105,5	2.519,1
Waste non-renewable	1,9	45,2
Electricity	14,3	340,6
Thermal energy	0,0	0,0
FINAL ENERGY CONSUMPTION	292,2	6.979,6
Coal and coke	4,3	103,2

Liquid fuels	112,8	2.693,7
Natural gas	48,7	1.163,2
Renewable energy sources	53,7	1.282,1
Waste non-renewable	1,9	45,2
Electricity	59,4	1.418,9
Thermal energy	11,4	273,3

Source: Annual Energy Review – Energy in Croatia 2021, Ministry of the Economy and Sustainable Development, December 2022

ii. Current potential for the application of high-efficiency cogeneration and efficient district heating and cooling

The potential indicators for the application of high-efficiency cogeneration and efficient district heating and cooling are taken from the document "Comprehensive assessment of the potential for efficient heating and cooling in Croatia according to Annex VIII of Directive 2012/27/EU", from July 2021, which was developed for the needs of the Ministry of the Economy and Sustainable Development in accordance with Article 14 (1) of Directive 2012/27/EC.

The established overall (theoretical) potential for high-efficiency cogeneration plants in the Republic of Croatia is observed through two scenarios of shares of future consumers of DHS coupled with high-efficiency cogeneration: reference and SIM scenario. The reference or BAU scenario (BAU – business as usual) implies development with the application of existing measures, while the SIM scenario (SIM - scenario with integrated measures) takes into account additional measures.

Table 4-17. Total annual delivered energy at the entrance to the distribution network of district heating systems in 2019, 2030 and 2050 – SIM scenario

Energy source/technology	2019	SIM-2030	SIM-2050
DHS- natural gas (boilers, CHP, high-efficiency CHP)	1.677,0	911,9	437,4
DHS-fuel oil boilers	34,7	0,0	0,0
DHS-biomass boilers	3,8	7,0	13,3
DHS-high efficiency cogeneration on biomass	105,5	150,0	256,3
DHS-Solar energy	2,1	24,8	33,5
DHS-geothermal energy		422,3	477,1
DHS-heat pumps - electricity		14,2	24,2
DHS-heat pumps - RES from the environment		48,3	82,1
DHS-waste heat from the industry		15,0	22,7
DHS-heat from thermal treatment of waste		130,0	195,8
TOTAL	**1.823,0**	**1.723,5**	**1.542,3**

The scenario with integrated measures in 2030 and 2050 respectively envisages the following measures:

- complete shutdown of fuel oil boilers (by 2030),
- complete shutdown of cogeneration using natural gas,
- significant reduction of natural gas boilers,
- increasing high-efficiency cogeneration using biomass,
- significant increase in the use of geothermal energy,
- use of heat from thermal treatment of waste (significant potential in densely populated urban areas),
- use of compression heat pumps water/water (the figure shows the operating electricity and heat taken from the environment),
- use of waste heat from industry (a small part),
- use of solar energy (a small part).

iii. Projections taking into account existing policies, measures and energy efficiency programmes, as described in 1.2. (ii), for primary and final energy consumption by sector by 2040 at least (including projections for 2030)

Projections of primary and final energy consumption in the period from 2021 to 2040, taking into account only existing policies, measures and energy efficiency programmes are presented in Figure 4-12.

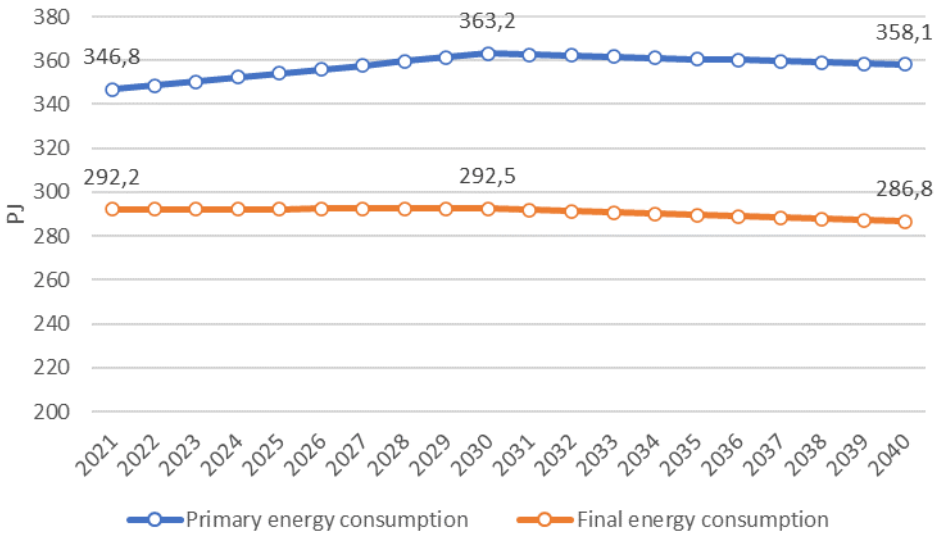


Figure 4-12. Trajectory of energy consumption until 2040 with existing policies, measures, and energy efficiency programs (WEM)

iv. Cost-effective levels of minimum requirements in terms of energy efficiency resulting from national calculations, according to Article 5 of Directive 2010/31/EU

Minimum energy performance requirements of buildings are determined by cost-optimal method in accordance with Article 5 of Directive 2010/31/EU on the energy performance of buildings in 2013 and 2014, for residential buildings (single-family and multi-dwelling) and non-residential buildings (offices, educational buildings, wholesale and retail trade buildings, hospitals, hotels, restaurants and halls)[28]. The energy performance is determined through maximum permissible primary energy for buildings, using a number of additional parameters that define more precisely the behaviour of a building (required energy, thermal transmittance of the external envelope, share of RES, performance level of the technical building systems and others). During 2018, a new cycle of cost optimization of minimum requirements for the energy performance of buildings was initiated by using dynamic calculation methods of the energy performance of buildings and by comparing values with the national algorithm for calculating the energy performance of buildings in order to align requirements with market changes and new available technologies and in order to elaborate the calculation method and determine the energy performance of buildings. The results of this cycle should be available and implemented in the regulation by the end of 2021, including the determination of gap in relation to current requirements and measures to bridge that gap.

4.4 Dimension: energy security

i. Current mix of energy sources, domestic energy sources, dependency on imported energy, including relevant risks

Electrical Grid

The actual responsibility for supplying the ES of the Republic of Croatia, that is, securing sufficient quantities of electricity, lies with several entities, namely:

- Suppliers who are obliged to settle their contractual obligations to customers, in particular HEP-Supply as the largest commercial supplier and HEP Elektra as the universal and guaranteed supplier,
- HEP-DSO for the procurement of electricity needed to cover losses in the distribution grid,
- CTSO for the procurement of electricity needed to cover losses in the transmission grid and the technical works related to the procurement of electricity for balancing the system.

The most significant responsibility of CTSO regarding the security of supply and self-sufficiency of the system is to maintain a high level of transmission network availability, i.e. particularly

[28] All reports under Article 5 (2) of Directive 2010/31 / EU and Article 6 of Regulation (EU) 244/2012 of 16th January 2012 on the levels of minimum energy performance requirements for buildings and building elements listed are available on the MCPP website: http://mgipu.hr/default.aspx?id=12841 (date of access: 27/11/2018)

the interconnection lines, and to maintain/increase the cross-border transmission capacity at all borders in order to technically enable the import of lacking quantities of electricity in the power system of the Republic of Croatia and the exchange with neighbouring countries. It should be noted that the possibility of importing energy into the Croatian power system does not depend solely on CTSO, but also on other system operators. The available cross-border transmission capacity can be used by all market participants, not just those who import energy into the Croatian electricity system.

As there are enough production facilities in the broader region according to ENTSO-E data, and given the existing satisfactory liquidity of the electricity stock exchanges in the region, the preliminary conclusion is that the lacking amounts of electricity will need to be procured over the next period through market transactions, whereby the existing cross-border transmission capacity is estimated as high enough to support the expected level of imports, and secure operation of the Croatian ES.

An exception to the foregoing conclusion may occur only in case of a serious crisis in the broader European area when, due to the simultaneous threat to sufficiency of the electricity system in several countries, the ability to procure electricity from imports would be limited. Such a scenario has not yet occurred, but a certain, albeit low, likelihood of such an event or a series of simultaneous disadvantageous events should not be ignored. According to the current situation in the electricity exchanges, it is possible to expect intermittent periods of extremely high electricity prices (> 200 €/MWh) either due to increased consumption (for example, in the case of very cold weather), or temporary unavailability of production facilities (failures, accidents), i.e. their reduced production capacity (calm weather without sun and wind, possible restrictions in gas supply, etc.). In accordance with the requirements of the ENTSO-E and the network rules of the Croatian transmission system, the Croatian Transmission System Operator has adopted a Plan of protection of the electricity system from large disturbances. It is a document with specific technical and organizational measures which need to be taken in order to restore the system from faulty operation or system failure to normal operation, and in total includes:

- a way of announcement of a major disturbance,
- a way to activate a large disturbance protection plan,
- measures and procedures for protection of the electricity system from large disturbances,
- plan for underfrequency load shedding of the electricity system,
- plan for limitation of electricity consumption and emergency load shedding of the electricity system,
- plan for reestablishment of the electricity system,
- issuing instructions to the authorized person of the transmission system user and the authorized person of the distribution system operator,
- informing the operators of neighbouring transmission systems,
- mutual reporting and communication with the neighbouring transmission system operators, the authorized users of the transmission grid and the authorized operator of the distribution grid,
- guidelines for the re-establishment of the power supply,
- reference to working procedures,

- reporting major disturbances and
- analysis of major disturbances.

ii. Projections of trends with existing policies and measures at least by 2040 (including projections for 2030)

The structure and expected production of primary energy for the Scenario with existing measures (WEM) are presented in Table 4-18. and Figure 4-13.

Table 4-18. Expected primary energy production - WEM scenario

PJ	Liquid fuels	Natural gas	Renewable energy resources	Non-renewable waste	Total
2021	26,3	26,1	111,4	1,9	165,7
2030	30,3	32,2	122,5	1,6	186,5
2040	32,3	27,9	145,6	1,3	207,1

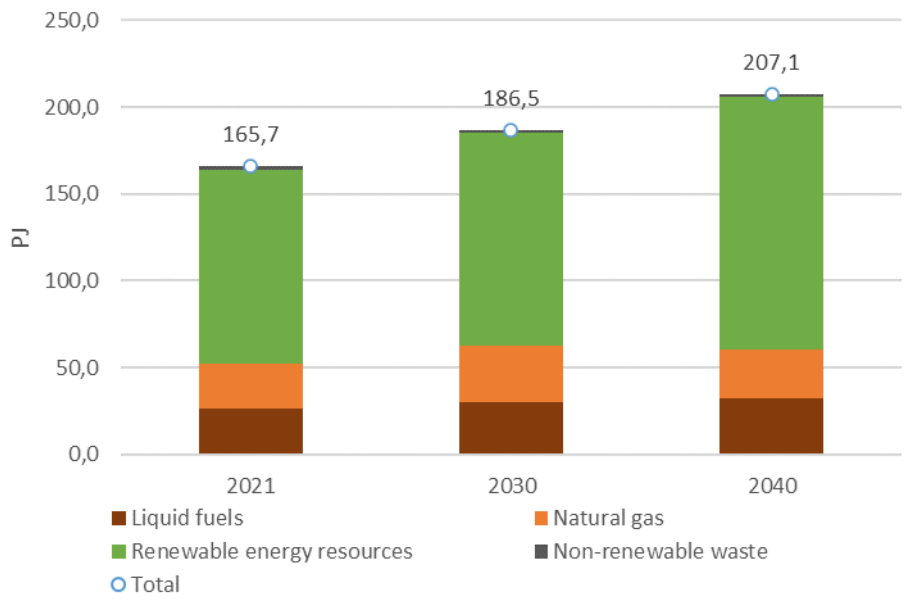


Figure 4-13. Expected primary energy production (WEM)

The structure and expected total energy consumption (production + import - export) for the Scenario with existing measures (WEM) are shown in the following table and figure.

Table 4-19. The expected total energy consumption (WEM)

PJ	Coal	Liquid fuels	Natural gas	Renewable sources	Non-renewable waste	Electricity	Total
2021	17,4	119,2	101,7	105,5	1,9	14,3	360,0
2030	13,8	128,5	107,3	122,5	1,6	9,1	382,8
2040	4,1	114,1	97,3	148,8	1,3	11,7	377,3

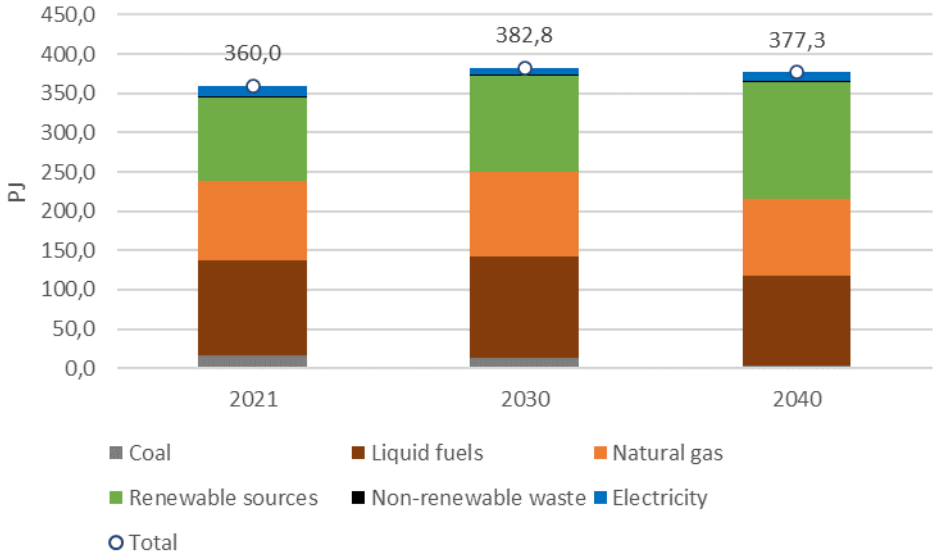


Figure 4-14. The expected total energy consumption (WEM)

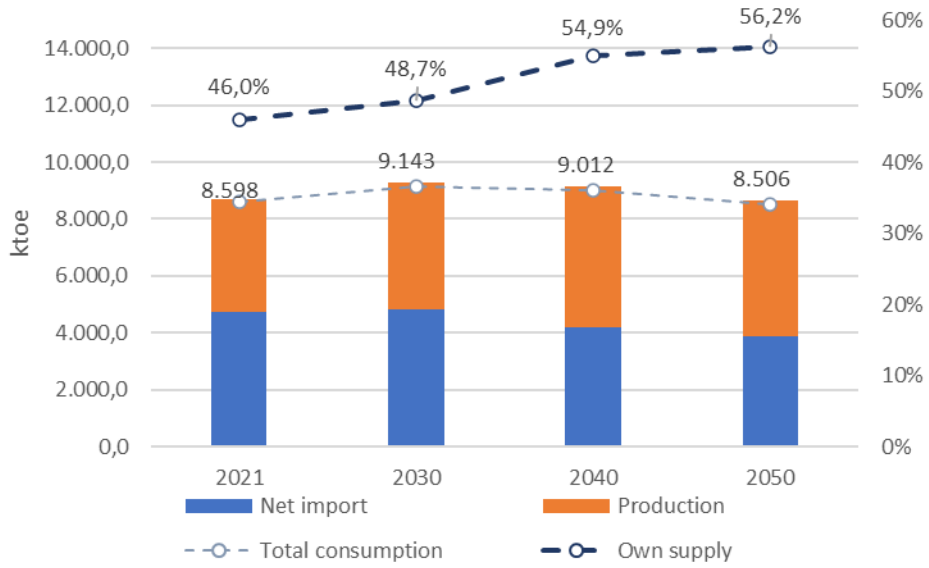


Figure 4-15. Total energy consumption and own supply (WEM)

4.5 Dimension: the internal energy market

4.5.1 Electricity interconnection

i. Current interconnection level and main interconnectors

The Croatian electricity system is connected with 400 kV, 220 kV and 110 kV voltage levels to the systems of neighbouring countries. With 400 kV transmission lines (a total of seven

transmission lines of which three are double and four are single), the Croatian electricity system is connected to the following systems:

- Bosnia and Herzegovina (400 kV transmission line Ernestinovo - Ugljevik and 400 kV transmission line Konjsko - Mostar),
- Serbia (400 kV transmission line Ernestinovo - Sremska Mitrovica 2),
- Hungary (2x400 kV transmission line Žerjavinec - Heviz, 2x400 kV transmission line Ernestinovo - Pecs) and
- Slovenia (2x400 kV transmission line Tumbri - Krško, 400 kV transmission line Melina - Divača).

The interconnectivity between the Croatian system and neighbouring ENTSO-E members is achieved also with eight 220 kV transmission lines. In addition, the Croatian system is connected to the environment at 110 kV level as well (a total of 18 transmission lines in permanent or periodic operation).

Given that the level of electricity exchange with neighbouring systems is affected by the pronounced dependence of the production portfolio in Croatia on hydrology, the increasing share of wind farms with also very variable production and variable prices in the wholesale electricity markets in the environment, the power of exchange towards neighbours is also highly variable. However, the total exchange with neighbouring systems is still significantly lower than the total capacity of exchange, so the utilization factor of individual interconnectors (the ratio of transmitted energy and the multiplication of time and installed power) varies between 0 and 50%, with an average estimate of 35%. Most interconnectors are under a low load most of the time.

In 2021, about 11.5 TWh entered the Croatian electricity system, and about 7.2 TWh came out. The largest exchange is performed with the electricity system of Slovenia and Bosnia and Herzegovina, which is expected given the very high level of installed interconnected capacities. With BiH alone, Croatia has as many as 21 interconnectors, and with Slovenia 8 interconnectors. Quantities of electricity exchanged with neighbouring countries (Slovenia, Hungary, Serbia and Bosnia and Herzegovina) in 2019, 2020 and 2021 are shown in Figure 4-16.

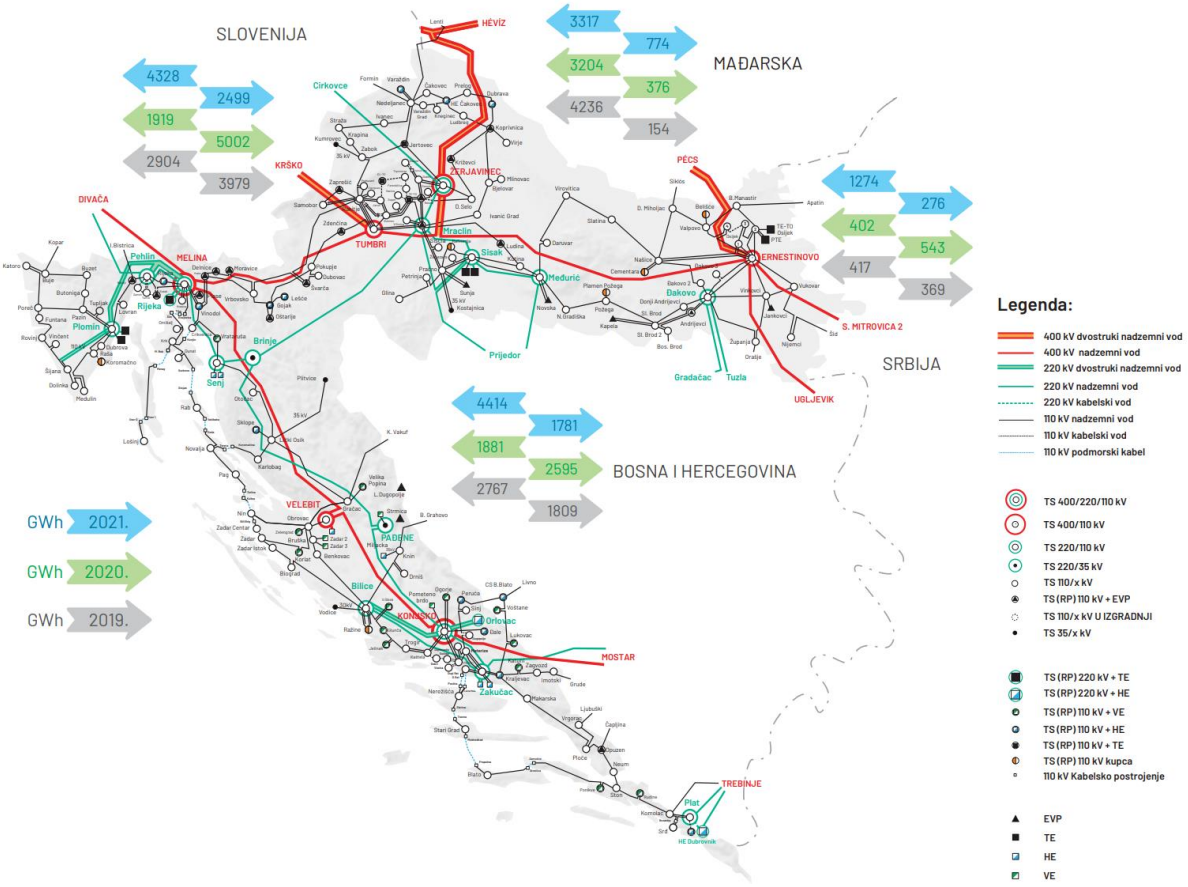


Figure 4-16. Exchange of electricity with neighbouring countries in 2019, 2020 and 2021

Source: HOPS

Good interconnection with neighbouring systems enables significant export, import and transit of electricity through the transmission grid, and places the Republic of Croatia in the position of an important link between the electricity systems of Central and Southeastern Europe.

ii. Projections for requests to increase the number of connecting lines (including projections for 2030)

Regarding additional new interconnectors, at the level of ENTSO-E, the possibility and justification of the construction of the following lines are currently analysed:

- 400 kV transmission line Đakovo (Republic of Croatia) – Tuzla (Bosnia and Herzegovina);
- 400 kV transmission line Đakovo (Republic of Croatia) – Gradačac (Bosnia and Herzegovina);
- 400 kV transmission line Žerjavinec/Drava (Republic of Croatia) – Heviz 2 (Hungary);
- 400 kV transmission line Ernestinovo (Republic of Croatia) – Sombor (Republic of Serbia).

However, their possible realization is not realistic in the short or medium term and depends on a large number of factors, and above all on the development of the future electricity market and the integration of RES into the ES of the entire region.

After 2030, it is possible to build a new 400 kV transmission line Lika - Banja Luka , which would further connect the ES Croatia and ES BiH. Technical-economic analyses of the justifiability of its construction are already prepared.

4.5.2 Infrastructure for energy transmission

i. Key characteristics of the existing transmission infrastructure for electricity and gas

The electricity transmission grid on the territory of the Republic of Croatia consists of overhead lines and cables, substations and other high voltage equipment/plants that are in operation under the voltage levels of 400 kV, 220 kV and 110 kV. The transmission grid connects power plants and larger consumer centres, or distribution grid, through several possible directions with the aim of achieving a satisfactory level of security of supply to customers with the electricity of the prescribed quality.

The total length of high voltage overhead lines and cables of the above-mentioned voltage levels is currently around 7,800 km, and the grid contains around 200 substations of 400/220/110 kV, 400/110 kV, 220/110 kV and 110/x kV. The backbone of the transmission grid is 400 kV grid that connects the wider Osijek, Zagreb, Rijeka and Split areas, a significant number of large production facilities is connected to 220 kV grid that connects certain regions within the country, while 110 kV grid connects local areas and serves to supply the distribution grid or large customers directly connected to this voltage level, where part of power plants/generators is connected also to 110 kV grid.

The transmission grid is managed by CTSO d.o.o. that is also responsible for developing the transmission grid, as well as for guiding and managing the entire electricity system. All this is conducted from the National Dispatch Centre (NDC) and four regional management centres. The balancing of the system is also under the management of CTSO, as well as the supply of ancillary services for the system that enable the achievement of equivalent production and electricity consumption within a specific period, or maintenance of the frequency at the prescribed level, as well as cross-border power/energy exchange according to the operational rules of the European transmission system operators (ENTSO-E), maintenance of prescribed voltage conditions in all parts of the grid, or compensation of reactive energy within the system, re-establishment of power supply after major disruptions or system failures, or island power plant operation on electrically isolated areas after major disruptions.

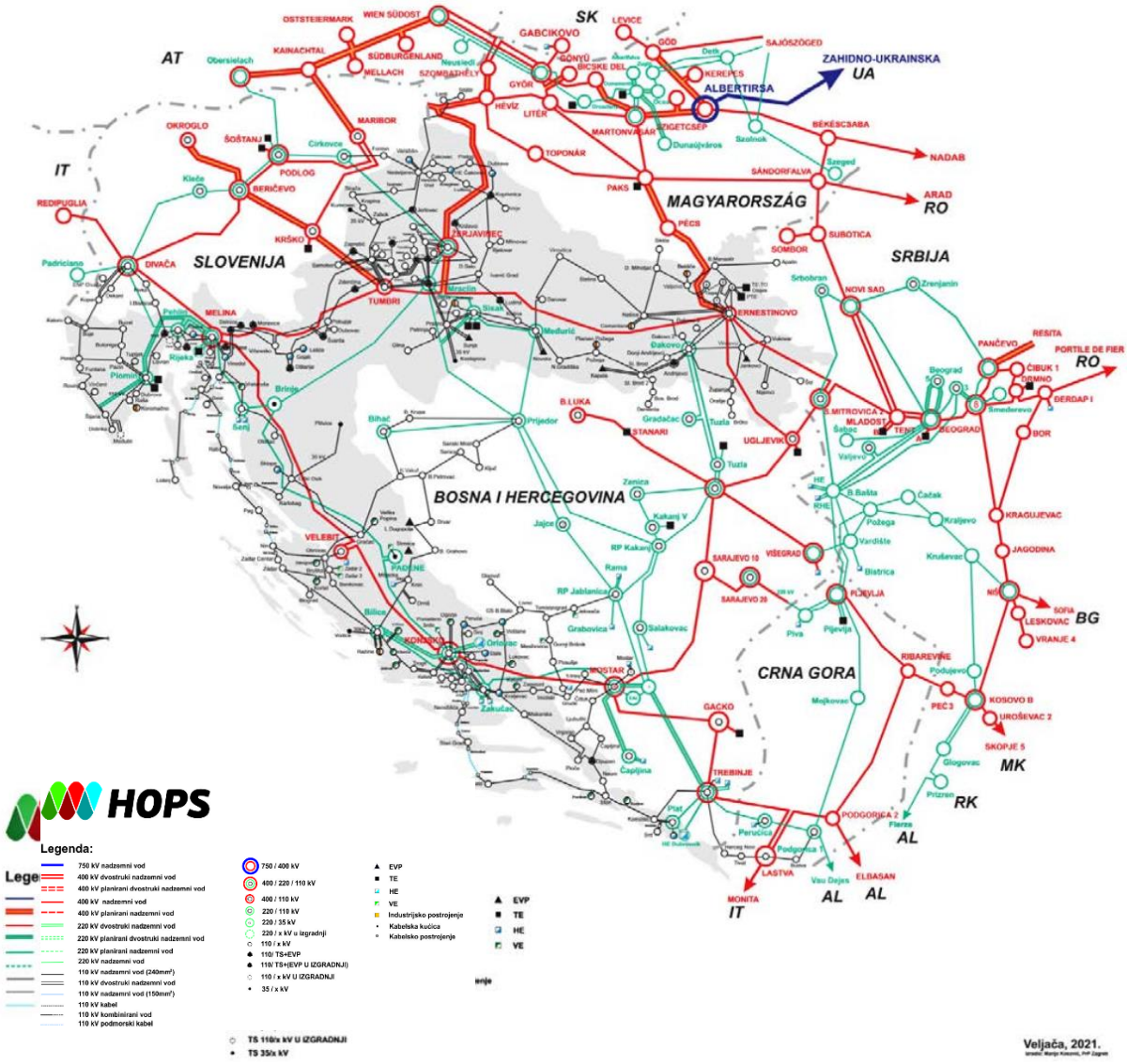


Figure 4-17. Croatian electricity system transmission grid with surroundings

Source: HOPS

The transmission grid topology (form) is currently determined in accordance with the actual spatial distribution of electricity consumption, locations of existing power plants, market conditions in Croatia and its surroundings, and the prescribed grid planning and operational management of the system. The transmission grid is designed so that in the event of a single disruption of line, transformer or generator, the transmission of electricity of the prescribed quality will not be prevented in any part of the country. With the existing amounts of basic input parameters that are important for the planning and operation of the transmission grid in the amount of around 3 100 MW of peak load, 17 TWh of electricity consumption per year, annual energy imports of around 7 TWh, transmission for third parties in the amount of up to 7 TWh and connection to the transmission grid of power plants of a total power of around 4 600 MW, the construction of the transmission grid can be considered satisfactory, which is manifested in very rare system disruptions (in the past, only local disruptions of certain parts of the system occurred rarely) and low annual amounts of electricity that was not supplied

from the transmission grid (order of magnitude up to 1 GWh). The frequency is stable, and its usual and extraordinary deviations are within the prescribed limits.

The installed transmission capacity of interconnectors exceeds the peak load of the electricity system many times over. Figure 4-18 shows the ratios of installed power of interconnectors and the peak load, that is, installed production capacity in European countries. By both of these criteria, Croatia is among the best connected countries in Europe, along with other small systems with relatively low levels of load and installed power of power plants.

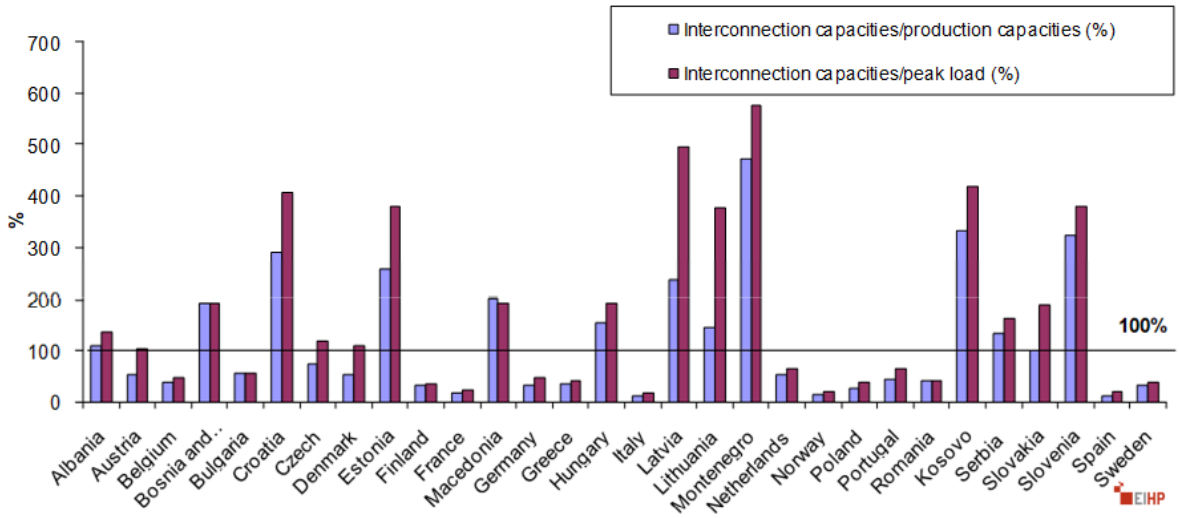


Figure 4-18. Installed power of interconnectors and installed power of production in relation to peak load in European countries

An unfavourable characteristic of the transmission grid is the relatively high proportion of old plants and grid units, especially the 110 kV and 220 kV voltage levels, which CTSO plans to systematically renew and revitalize in the coming period. Nonetheless, the existing reliability indicators are at a very high level with a relatively low amount of annual electricity losses (below 500 GWh) given the high transits to which the grid is exposed.

In recent years, variability in the availability and activity of production plants in the territory of the Republic of Croatia has been observed, caused primarily by market reasons (first the non-competitiveness of domestic power plants such as TPP Rijeka, TPP Sisak A and B, TPP Plomin 1, and then after the extreme increase in prices, their re-competitiveness and reactivation, such as TPP Rijeka, which was reactivated after almost 8 years). Therefore, the sufficiency/security of supply for customers largely depends on the import of electricity whose capabilities are conditioned by the availability of cross-border transmission capacities and the amounts of those capacities that are made available to market participants and whose values cannot be independently influenced by CTSO. The recent introduction of a new (so-called flow-based instead of the former NTC) cross-border transmission capacity allocation mechanism in the EU is expected to significantly increase network throughput and increase available cross-border transmission capacities.

The gas transmission system in the Republic of Croatia is composed of a total of 2,544 km of gas pipelines available to the transmission system operator (PLINACRO). Gas in the gas transmission system is withdrawn through eight connectors at input measuring stations, of which four connectors receive gas from the production fields located on the territory of the Republic of Croatia, two connectors receive gas from import supply routes, one connector receives gas from the LNG terminal and one connector withdraws gas from the underground gas storage facility.

The transmission of gas from the transmission system is carried out through 201 connectors at 156 output measuring reduction stations. The gas transmission system of the Republic of Croatia reached a significant level of development regarding capacities and the distribution on almost 95% of the territory of the Republic of Croatia, as well as regarding the connection with gas systems of neighbouring countries, technological reliability and operational safety. The gas transmission system enables gas to be delivered to 19 counties. The gas transmission system of the Republic of Croatia is shown in the figure below.

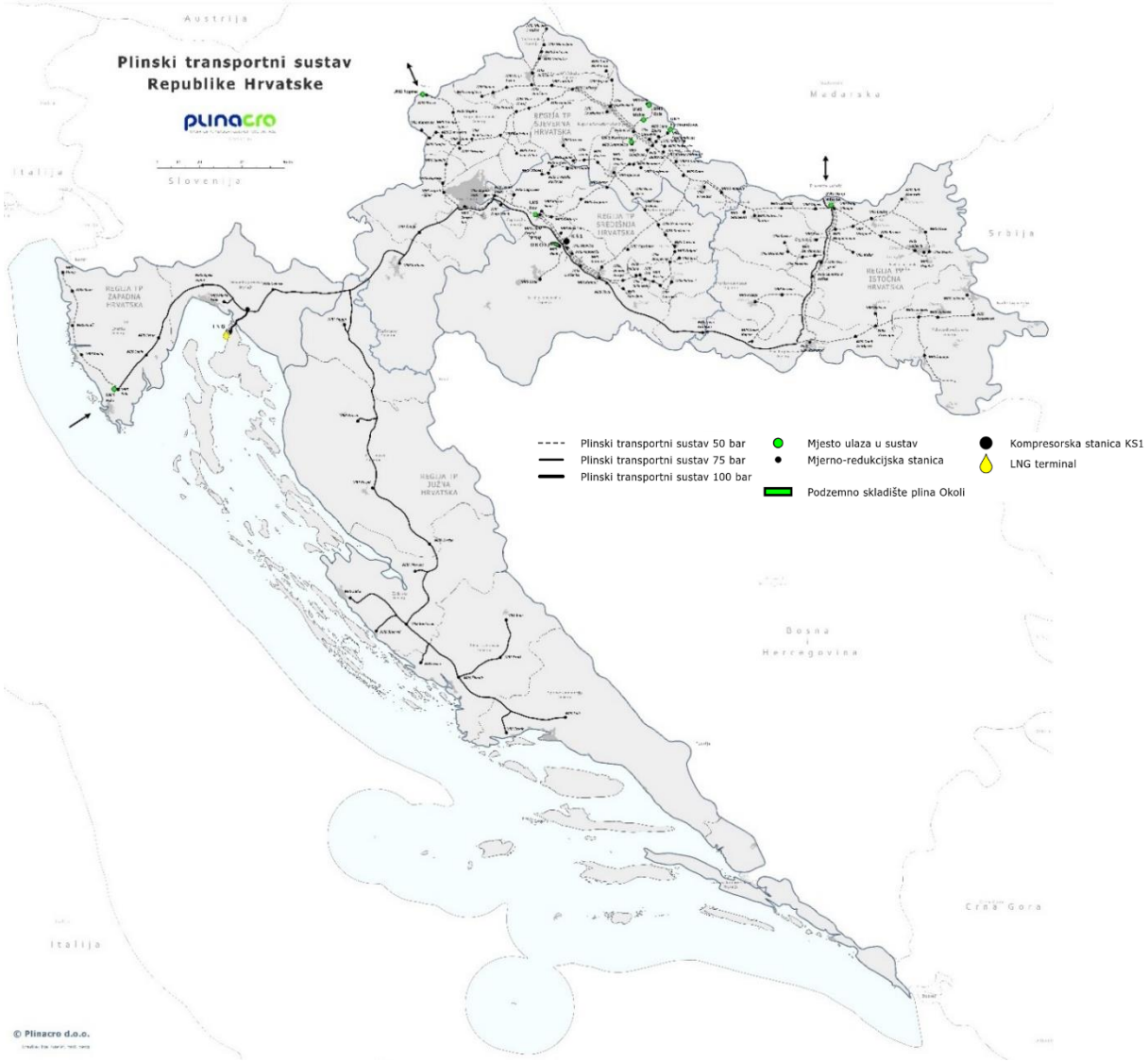


Figure 4-19. The gas transmission system in the Republic of Croatia

Source: PLINACRO

In 2021, 31.71 TWh of natural gas was transported through the system, of which 27.75 TWh from inputs of the transmission system to output measuring reduction stations, and the remainder of 3.96 TWh was transported to the underground gas storage facility. In 2021, the largest transport in the amount of 130 GWh/day was achieved at the level of the transport system.

ii. Projections regarding the requirements for expansion of the grid at least by 2040 (including projections for 2030)

Having in mind the expected accelerated integration of RES and projected energy transition with the aim of reducing greenhouse gas emissions, the **electricity transmission grid development** should be determined taking into account the following:

- peak load at the level of transmission grid level is planned in the amount of around 2900 MW in 2020 and around 3200 MW in 2030,
- for possible development scenarios, the construction of new hydropower plants and associated connections to the transmission network in the amount of 250 MW by 2030 and an additional 1650 MW by 2040 is planned,
- for possible development scenarios, the construction of new gas blocks/block with a total capacity of 160 MW by 2030 is envisaged,
- construction of over an additional 1345 MW in wind farms, which is an increase compared to the existing construction of wind power plants of 948 MW,
- construction of over an additional 460 MW in solar power plants connected to the transmission network,
- remain in the TPP Plomin 2 until the observed period, and continue to take over the half of the production of NPP Krško.

According to the preliminary assessment, the total investment in the transmission grid (including connectors for new conventional power plants, wind farms and solar power plants, as well as other various costs identified in the ten-year development plan of the transmission grid for the period 2022--2031), having in mind the above-described input assumptions, would amount to around 1.13 billion euros in the ten-year period.

Figure 4-20. Foreseen topology of 400 kV and 220 kV grid on the territory of the Republic of Croatia in 2031

Source: HOPS

Investment-demanding network reinforcements, including those contained in the official ten-year transmission network development plan for the period 2022-2031, are the following:

- increase of transmission power of 220 kV transmission line Senj-Melina and 220 kV transmission line Konjsko - Krš Pađene - Brinje in the medium-term by replacing ACSR conductors with HTLS conductors, in order to receive the production of WF and SPP in the Dalmatia area,
- increase in the transformation capacity in SS Konjsko by installing a third 400/220 kV transformer, as well as by equipping the associated 400 kV and 220 kV transformer fields

- increase in the transformation capacity in SS Velebit by installing an additional 400/110 kV transformer, as well as equipping the associated 400 kV and 110 kV transformer fields
- construction of new 400 kV transmission line Konjsko - Lika in the long-term in order to continue with the construction of WF and SPP, and extension of 400 kV switchyard Lika foreseen as part of the connector to the HPP grid Senj 2,
- construction of (2x)400 kV transmission line Lika - Melina in order to remove possible restrictions in the transmission of production of HPP, WF and SPP in the area of Dalmatia and Lika towards the wider Rijeka area,
- formation of at least two to three "zone connectors" or 400/110 kV substation, appropriately connected to 400 kV and 110 kV grid, through which the energy produced by WF and SPP would be transmitted through 400 kV grid in remote areas, in the case where 110 kV grid can no longer take over the entire production of these power plants (locations foreseen for "zone connectors" are the wider Drniš/Knin and Sinj areas, but final locations will depend on the locations and powers of new WF and SPP foreseen for the connection to the transmission grid)
- construction of SS 220/110 kV Vodnjan 2x150 MVA, and increasing the 2x110(220) kV transmission line Plomin – Vodnjan to 220 kV,
- revitalization of 220 kV interstate/interconnection lines Đakovo – Gradačac, Đakovo – Tuzla and Zakučac – Mostar,
- after 2030, it is possible to build a new 400 kV transmission line Lika - Banja Luka , which would further connect the ES Croatia and ES BiH.

Since CTSO is responsible for the reliability and availability of the electricity supply system, the correct coordination of production, transmission and distribution systems and the operation of the electricity system in a way to ensure the security of electricity supply, in the future, it will have to follow the functioning of the electricity system with an increased level of integration of variable sources of electricity, inform competent institutions in a timely manner in the event of any endangerment of the security of electricity supply and propose possible application of permitted mechanisms to develop production capacities.

It is necessary to point out that any investment in the transmission network should be envisaged by the current Ten-year plan for the development of the transmission network.

Planning the development of the gas transmission system is carried out through the development of the 10-year plan for the development of the gas transmission system. The transmission system operator is obliged to prepare a ten-year transmission system development plan and submit it to CERA for approval every two years. At the time of preparation of this document, the 10-Year Gas Transmission System Development Plan of the Republic Croatia 2021-2030 The plan will be continuously updated throughout the implementation period of this document.

Taking into account the expected trends in the future consumption of natural gas, the expected changes in the seasonal characteristics of consumption and peak loads, the need for new quantities of gas from imports, obligations under EU regulations and the expected development of the gas transmission system in the wider and narrow region, strategic

determinants of the future development of the gas transmission system of the Republic of Croatia are:

- supply security obligations and according to the infrastructure standard (N-1 criterion) in accordance with Regulation (EU) 2017/1938 concerning measures to safeguard the security of gas supply (SOS Regulation),
- necessary diversification of supply and increase of efficiency of the transport system,
- increasing the internal security of the transmission system and
- allowing gas transmission to neighbouring countries.

Obligations on security of supply and infrastructure standard:

Strategic projects that meet the obligation under the infrastructure standard are projects that increase capacity at the entrance to the gas transmission system. The construction and commissioning of the liquefied natural gas terminal on the island of Krk ensured a new natural gas supply route and diversified routes and sources of natural gas supply, which significantly increased the security of natural gas supply in the Republic of Croatia, but also a prerequisite for gas transport to neighbouring countries, which indirectly leads to an increase in the efficiency of the gas transmission system.

Gas transmission system for the diversification of supply and the increase of efficiency of the transmission system

Further development of the gas transmission system in order to strengthen the diversification of gas supply includes the expansion of the capacity of the liquefied natural gas terminal, the construction of evacuation gas pipelines and the construction of the Ionian-Adriatic gas pipeline for the supply of gas from the Caspian region or the eastern Mediterranean. The Ionian Adriatic Pipeline (*IAP*) would allow the supply of gas from the Trans-Adriatic Pipeline (*TAP*) to Croatia and countries in the region and possible transport to Hungary, Slovenia and Bosnia and Herzegovina.

The current gas supply capacity from the LNG terminal is limited by the capacity of the existing transmission system. Therefore, first of all, it is necessary to build the Zlobin-Bosiljevo gas pipeline (58 km), and then the Bosiljevo-Sisak-Kozarac gas pipeline (122 km) and Kozarac-Slobodnica gas pipeline (128 km) for gas transport to Hungary, as well as the Lučko-Zabok-Jezerišće-Sotla gas pipeline (70 km) for gas transport to Slovenia. The construction of these pipelines will enable the full utilization of the capacity of the expanded liquefied natural gas terminal and increase the transport of gas through the Croatian gas transmission system, which will consequently increase the efficiency of the Croatian gas transmission system itself.

Procurement for the Ionian-Adriatic gas pipeline can begin in the first quarter of 2024, and construction can be completed within four years. Procurement for all other projects can start immediately (it has already started for the Zlobin-Bosiljevo gas pipeline). Projects can be built within 2.5 to 3 years or in 2026 at the latest, except for the second phase of the interconnection to Hungary (Kozarac-Slobodnica gas pipeline), the completion of which can be estimated for 2027.

Gas transmission system for internal operational security of supply

The transmission system that serves as an internal security of supply will provide a more stable and secure supply of those gas-powered areas from gas pipeline branches that have only one power source, and will allow for the creation of internal loops that increase security of supply.

Gas transmission system for export

The transmission system in the function of export is referred to as the gas pipeline systems of relatively minor regional influence connecting the gas systems of Croatia, Bosnia and Herzegovina and Slovenia.

Gas pipelines systems Lička Jesenica-Bihać, Zagvozd-Imotski-Posušje (the so-called southern gas interconnection) and Slobodnica-Bosanski Brod would enable gas supply to neighbouring Bosnia and Herzegovina, while the Umag-Koper gas pipeline would enable the connection of Istria and southern Slovenia. The construction of these pipelines depends primarily on the interest of neighbouring countries and the economic justification for their construction. Procurement for the southern gas Interconnection with Bosnia and Herzegovina can start immediately, and construction can be completed within three years.

All of the above projects are listed in the 10-Year Gas Transmission Grid Development Plan of the Republic Croatia 2021-2030. The final investment decision is necessary for their realization. All these pipelines will be able to transport hydrogen when hydrogen production sources and market conditions for hydrogen consumption are developed.

4.5.3 Electricity and gas markets, energy prices

i. Current situation of electricity and gas markets, including energy prices

Electricity

In Croatia, there is the CROPEX power exchange with possibility of day-ahead and intraday trading. In December 2015, CROPEX became NEMO (*Nominated Electricity Market Operator*), i.e. an exchange with the right and responsibility to participate in the implementation of day-ahead and intraday market coupling processes at the EU level. Connecting Croatia with the EU market at the day-ahead level should be realized through the IBWT (*Italian Borders Working Table*) project, and at the intraday level through the EU XBID (*Cross Border Intra Day*) project. In addition to connecting with the EU market, cooperation between CROPEX and the transmission system operator from Bosnia and Herzegovina (NOS BiH) has been initiated on the implementation of the cross-border interconnection of the day-ahead markets of Croatia and Bosnia and Herzegovina. Furthermore, there are certain initiatives for the development of a regional power exchange in Southeastern Europe based on the Nord Pool exchange model.

Since 19th June 2018, the Croatian day-ahead market has been connected to MRC (Multi-Regional Coupling) day-ahead market, i.e. to the uniform European day-ahead market via the Croatian-Slovenian border. Since 8th June 2022, the CORE project has connected the day-ahead markets at the Croatian and Hungarian border. With the already connected day-ahead markets of CROPEX and BSP, the day-ahead markets of CROPEX and HUPX will change the

distribution of daily capacity at the Croatian-Hungarian border, in such a way that it will be allocated through the market coupling mechanism and the involved exchanges. With the implementation of the CORE project, the daily capacity for market integration at the Croatian-Slovenian and Croatian-Hungarian borders will be calculated using the Flow-Based method.

As the electricity market is completely open, all customers are free to choose their preferred supplier and freely negotiate the price of electricity. Achieved electricity prices for household and business (industry) end customers, according to Eurostat consumption categories, are presented below.

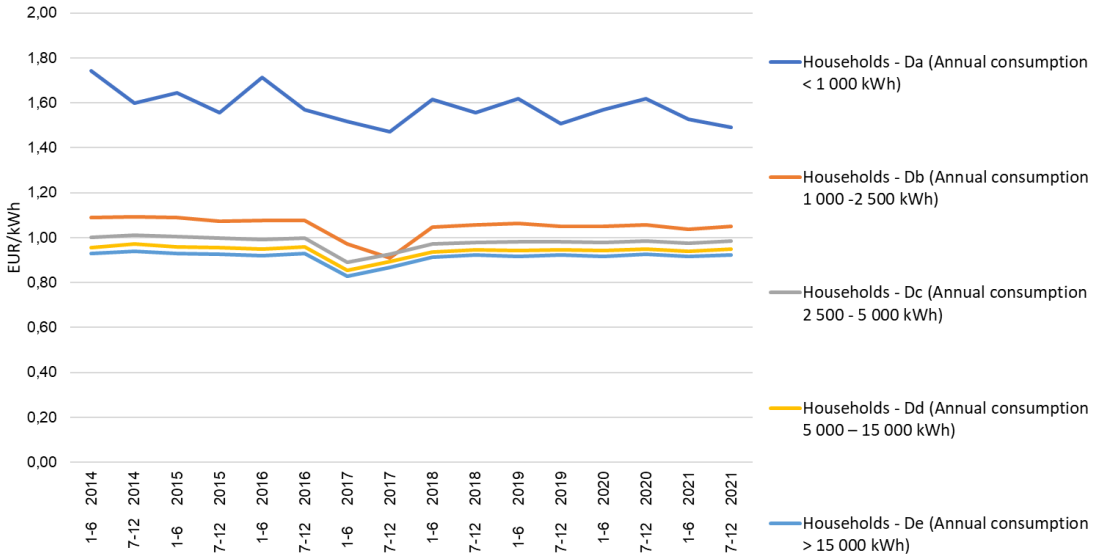


Figure 4-21. Electricity prices for household end customers in Croatia

Source: Energy in Croatia 2021

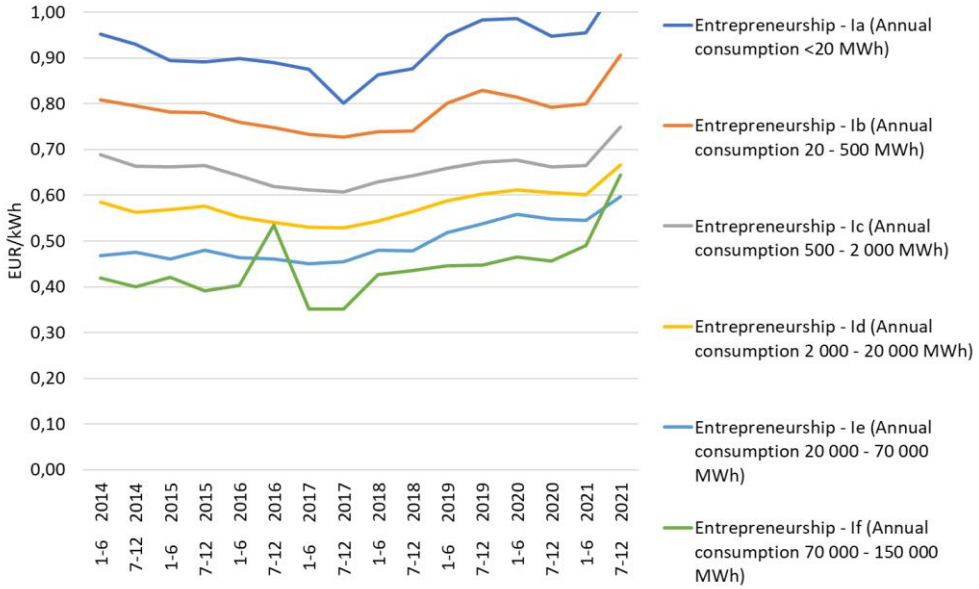


Figure 4-22. Electricity prices for business end customers in Croatia

Source: Energy in Croatia 2021

The ECO balance group is regulated by the Act on Renewable Energy Sources and Highly Efficient Cogeneration (OG No. 138/21) and consists of electricity producers and other entities performing the activity of electricity generation, which are entitled to incentive pricing in accordance with the agreements on the purchase of electricity with the Market Operator and the right to a guaranteed purchase price on the basis of an agreement on the purchase of electricity at a guaranteed purchase price. In addition to the aforementioned electricity producers, all other privileged electricity producers may be members of the ECO balance group and thus assume all rights and duties in the ECO balance group except for the acquisition of electricity at the regulated purchase price.

The Act on Renewable Energy Sources and High-Efficiency Cogeneration defines the market operator as the leader of the ECO balance group with the obligation to run the ECO balance group in such a way that it is separate from other activities within their competence, while respecting the principles of transparency, impartiality and independence. The market operator is obliged to plan the production of electricity for the ECO balance group and to report the contractual schedules of the ECO balance group in accordance with the production plan of the ECO balance group.

The obligations of the members of the ECO balance group are regulated by the Rules for the Management of the ECO balance group adopted by the Market Operator with the prior consent of the ministry responsible for energy and the opinion of the Croatian Transmission System Operator d.d. and HEP – Distribution System Operator d.o.o. The members of the ECO balance group are obliged to submit the data and documentation necessary for the planning of electricity production for the ECO balance group in accordance with the Rules for the Management of the ECO balance group.

The market operator is obliged to bear the costs incurred by calculating the balancing energy according to the transmission system operator, due to the deviations in hourly electricity production plans from the realized hourly electricity deliveries of the ECO balance group. The costs of the balancing energy of the ECO balance group shall be borne by the Market Operator from the funds for the payment of incentives and monthly collected funds from the members of the ECO balance group whose connected power of the production plant exceeds 50 kW.

The level of balancing energy costs of the ECO balance group depends on the divergence of the hourly EE production plans from the realized hourly deliveries of the EE ECO balance group and is calculated in accordance with the Methodology for determining the prices for the calculation of balancing electricity to entities responsible for the divergence, which is issued by the Croatian Energy Regulatory Agency.

Natural gas

Historical prices of natural gas for household and business final customers are presented below, according to Eurostat data. Shown natural gas prices for household customers include value added tax (VAT), while natural gas prices for industrial customers are expressed without VAT.

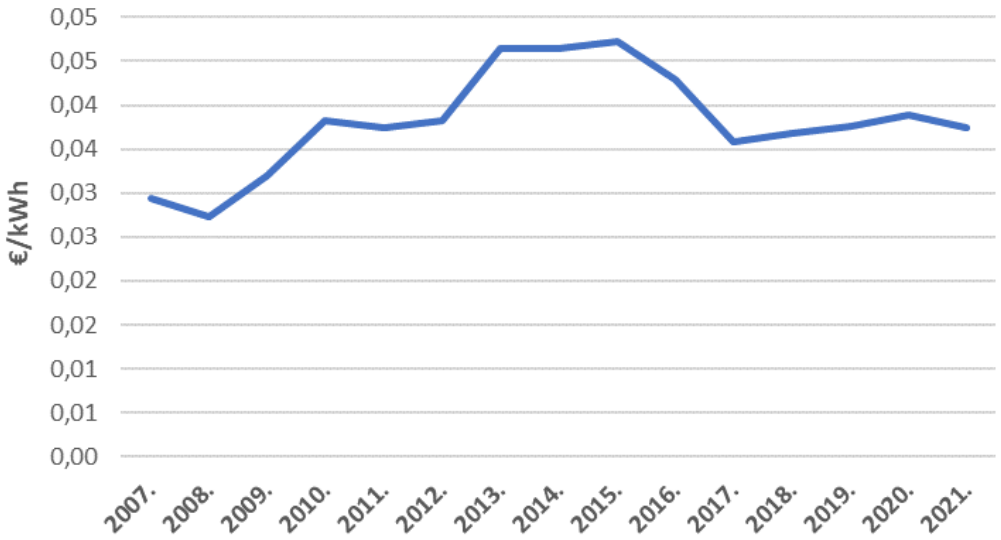


Figure 4-23. Natural gas prices for household customers in Croatia

Source: Eurostat

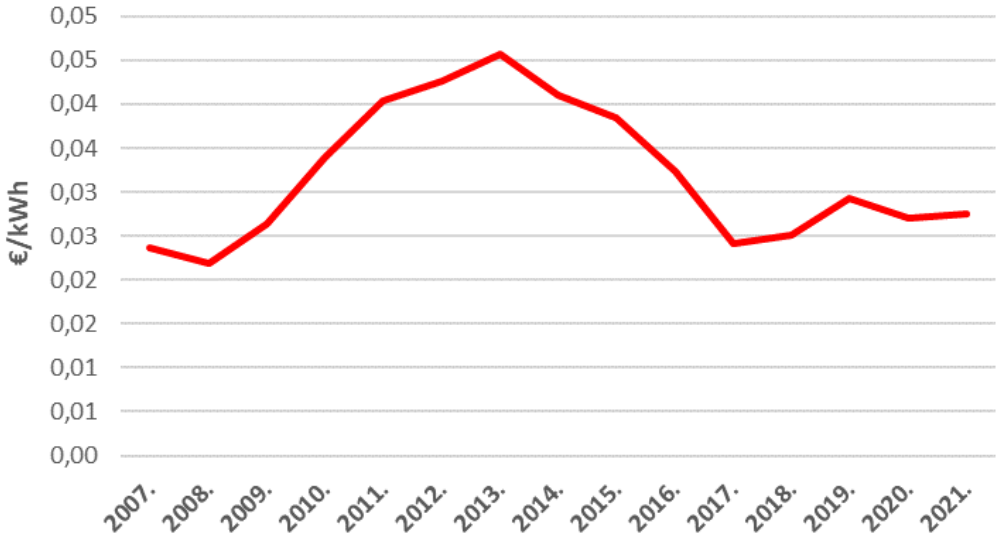


Figure 4-24. Natural gas prices for business customers in Croatia

Source: Eurostat

4.6 Dimension: research, innovation and competitiveness

i. Current situation of low-carbon technologies and, to the extent possible, their position on the global market

Smart specialization strategies enable the identification of priorities for investing in knowledge-based investments in sectors where the country or region has comparative advantages. The development of low-carbon technologies in Croatia in the period 2016-2020 was supported by the Smart Specialization Strategy of the Republic of Croatia for the period from 2016 to 2020. [21], these technologies were mostly within the thematic priority area of energy and sustainable environment, and in the draft proposal of the Smart Specialization Strategy until 2029, the thematic priority area was smart and clean energy.

Advantages and capacities are identified in the Smart Specialization Strategy of the Republic of Croatia for the period from 2016 to 2020. In Croatia there are the following:

- industrial capacities related to the electrical equipment for ES (e.g. voltage and distribution transformers, rotary machines, wind turbines, photovoltaic panels) and the accompanying industry for building large structures of metal and concrete (shipyards),
- the tradition and experience in the design and construction of power plants, transmission lines, substations and control systems with very good global export potential,
- natural resources suitable for the production of energy from renewable sources (water resources - construction and equipment of hydropower plants, biogas plants that can take over residues from the Croatian agricultural sector, wind that can be used for further technological upgrades and investments in wind power plants and similar),

- a number of educational institutions and university programmes where students are educated in the area of production, engineering and maintenance,
- a number of public and private research organisations with proven capabilities in this field that can support and enhance the competitiveness of industry through R&D, and there is significant IRI potential among large and small and medium-sized enterprises
- the existing market requiring upgrade and expansion of production capacities.

The strategy states that research is needed on the following topics:

- development of models, methods of integral carbon control, improved calculations of emissions/sinks, emission/sink estimates, application of calculations using the overall lifecycle method,
- research of technologies, technical and non-technical measures to reduce emissions and increase sinks in all sectors (energy, transport, agriculture, forestry, waste management, and industrial processes)
- exploration of possibilities for use, storage, transportation and geological storage of CO_2
- research on links between mitigation of climate change and adaptation to climate change and interaction with other environmental constituents
- development of integral models of impact assessment of policies and measures to mitigate climate change on the economy, environment and society
- research on sociological aspects of climate change, development of models and methods of raising visibility and public awareness of climate change
- research into the potential of biomass, biomass production, biomass utilization and related socio-economic aspects
- exploring the potential of all renewable energy sources, the costs and benefits of their use, their impact on the environment, nature and Natura2000
- study of integrated solutions, energy efficiency, renewable energy sources across sectors, optimization models for smart cities, green cities and urban infrastructure
- research of advanced grids and smart systems
- developing concepts and planning for smart cities
- research related to the construction of a circular economy, the introduction of a system for the management and utilization of resources, energy and carbon footprint management system
- research into sustainable urban mobility, cooperative, intelligent and automated transport solutions
- research into the possibilities of increasing carbon sequestration on forestry and agricultural land and possible innovative measures in animal husbandry.

Major technological advances are expected in the application of ICT technologies in all sectors, with particularly great impact in energy and transport sectors. The development of energy storage systems, electric vehicle and battery infrastructure, autonomous systems in various sectors and robotics will play a decisive role.

The Croatian Bureau of Statistics collects data on the foreign trade of the Republic of Croatia, and publishes the aggregated data according to the national classification of activities and by

sectors. Currently, there is monitoring of exports of all products under the nomenclature under Commission Implementing Regulation (EU) 2017/1925 of 12 October 2017 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff (OJ L 282, 31st Oct 2017), but specific low-carbon products need to be defined and reported on separately.

ii. Current level of public and private research and innovation spending on low-carbon technologies, current number of patents and current number of researchers

According to the 2017 estimate, gross domestic expenditure on research and development Gross Domestic Expenditure on Research and Development (GDERD) was 0.86% of GDP. By 2020, a target of 1.4% of GDP share has been set and 1.25% has been achieved. At the EU level, the goal was to reach 3% of gross domestic R&D expenditure by 2020, and reaching this goal in Croatia according to the proposal of the Smart Specialization Strategy by 2029 is projected by 2030.

The State Bureau of Statistics monitors gross domestic expenditures for research and development by sectors ((i) business sector, (ii) state and private non-profit sector and (iii) higher education) and fields of science. According to the latest data (for 2021), out of a total of HRK 5.5 billion (EUR 725 million) invested in research and development, 46.5% of investments were from the business sector, 32.3% were investments in higher education and 21.1 % refers to state and non-profit sector investments.

In addition, the CBS publishes annual progress towards the Sustainable Development Goals, including Goal 9 Industry, Innovation and Infrastructure. According to the latest indicators in 2021, 0.93% of the active population is employed in research and development (in 2016, this share was 0.64%), the gross added value in the sector of environmental goods and services is 1.47% (2016: 1, 52%) and the number of applications submitted to the European Patent Office increased (27, compared to 16 in 2016).[29]

Within the framework of the data on the basis of which the Central Bureau of Statistics publishes these aggregated data, it will be necessary to determine the areas of research and development relevant to low-carbon development and to report on them separately.

In 2018, 136 patent applications were submitted to the State Intellectual Property Office (hereinafter: DZIV), of which 121 applications were submitted by domestic applicants and 15 applications by foreign applicants. Of the total number of applications from domestic applicants, 84.3% were submitted by natural persons and 15.7% by legal entities, while for foreign applicants, natural persons submitted 60.0% and legal entities 40.0% of applications. Considering the number of applications in the period from 2013 to 2018.

In 2022, 130 patent applications were filed. Of these, 122 applications were submitted by domestic applicants, and eight by foreign applicants. Of the total number of applications by domestic applicants, 45.1% of patents were applied for by natural persons, and 54.9% by legal

[29] https://podaci.dzs.hr/media/atbjbcfy/sdg-2023_hr.pdf; https://www.epo.org/about-us/annual-reports-statistics/statistics/2021/statistics/patent-applications.html

persons. Among foreign applicants, both natural and legal persons had a share of 50.0% of applications.

According to the technical field, in 2022 the largest share of applications was in the field of chemistry (35.0%), followed by the field of general mechanical engineering (33.1%), while the smallest number of applications was from other fields (6.8%). According to the International Classification of Patents, which enables the identification of the technological base of patents and the sector in which their application is most likely in 2022, the largest share of patent applications was in area B Production procedures, transport (27.8%).

In 2022, 51 patents were recognized in the national procedure. Of these, 44 patents are from domestic applicants, and seven from foreign applicants. Of the total number of recognized domestic patents, 61.4% are patents of natural persons, and 38.6% are patents of legal entities. Among foreign applicants, 71.4% were recognized patents of legal entities, and 28.6% patents of natural persons.[30]

In order to monitor innovations relevant to the low-carbon transition, it will be necessary to identify relevant areas and report on them separately. Out of the total number of patent applications by domestic applicants in 2018, the largest share of applications came from Continental Croatia 64.5%, Adriatic Croatia 35.5%. In 2022, three fifths of patent applications and more than four fifths of recognized patents refer to domestic applicants from the City of Zagreb and Adriatic Croatia: of the total number of patent applications by domestic applicants in 2022, 36.8% were filed by applicants from the City of Zagreb, and 23.8% applicants from Adriatic Croatia. Among the recognized patents, in 2022, 43.2% were granted to applicants from the City of Zagreb, and 40.9% to applicants from Adriatic Croatia.[31]

Patent statistics provide information on the success of research, development and innovation activities in selected areas of technology. The number of patents is one measure of the ability to discover new opportunities and activities within the country, and translate knowledge into potential economic benefits.

[30] https://podaci.dzs.hr/2023/hr/58335

[31] https://podaci.dzs.hr/2023/hr/58335

iii. Breakdown of current price elements that make up the three price components (energy, grid, and taxes and fees)

Electricity

The structure of the price of electricity consists of the market part and the regulated part (Figure 4-25). The regulated part is prescribed by law and is the same for all suppliers. It applies to charges for the use of the transmission and distribution grid, the fee for renewable energy sources and high-efficiency cogeneration, the compensation for vulnerable customers (paid only by customers in the household category) and other excise duties. The market share of the price of electricity varies from supplier to supplier and is defined by the electricity supply contract.

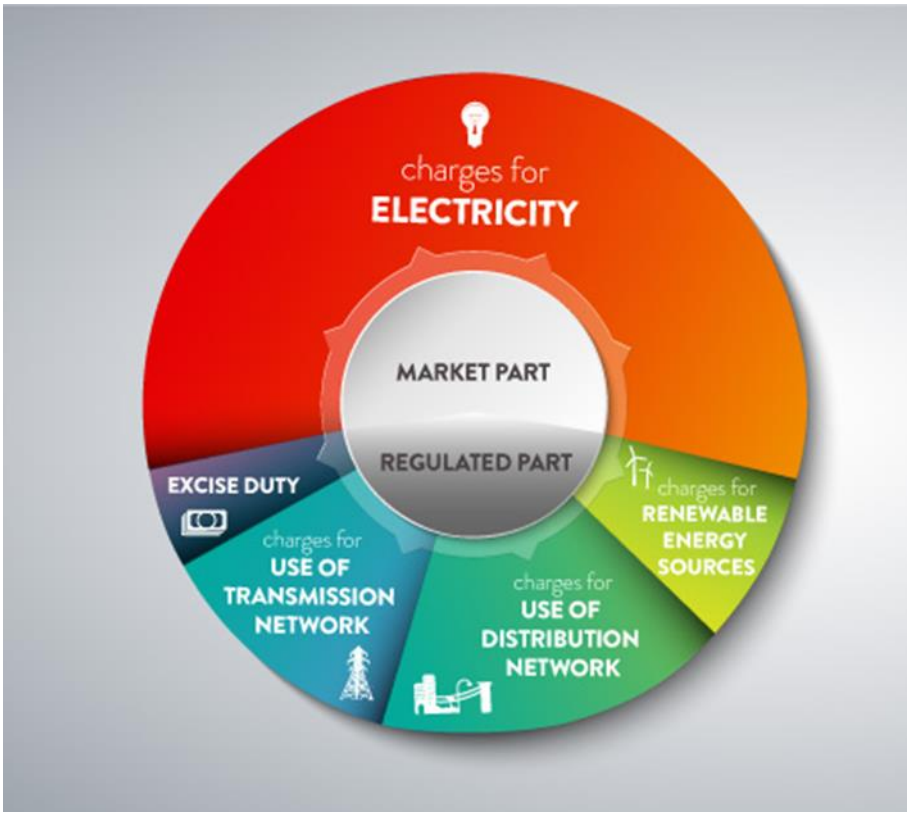


Figure 4-25. Retail electricity price structure

Source: HEP Opskrba

All end customers of electricity in Croatia have the right to choose their supplier and negotiate the price of electricity with them. The price of electricity in the Republic of Croatia varies depending on the supplier the end customer chooses. The electricity supplied is calculated according to three tariffs:

- higher daily tariff (VT) which is calculated every day from 7 a.m. to 9 p.m. in the wintertime period and from 8 a.m. to 10 p.m. in the summertime period;
- lower daily rate (NT) which is calculated in the remaining time;
- a single daily tariff item (JT) lasts every day between 0 am and 24 am.

Figure 4-26. shows the structure of the total price of electricity for end customers in the Republic of Croatia according to EUROSTAT's consumption classes in 2021, where:

- **IF** – a very large industry with a consumption of 100,000 MWh/year, a peak load of 15 MW and a consumption ratio day/night of 52/48 (tariff system VN entrepreneurship – White)
- **IE** – large industry with a consumption of 24,000 MWh/year, a peak load of 4 MW and a day/night consumption ratio of 63/37 (tariff system MV (35 kV) business – White)
- **ID** – medium industry with consumption of 2,000 MWh/year, peak load of 0.50 MW and consumption ratio day/night 63/37 (tariff system SN (10 kV) business – White)
- **IB** - medium-sized enterprise with consumption of 150 MWh/year, peak load of 0.05 MW and consumption ratio day/night 68/32 (tariff system NN enterprise - Red)
- **DC** – Medium households with a consumption of 3.5 MWh/year. and with a day/night consumption ratio of 66/34 (NV household tariff system – White).

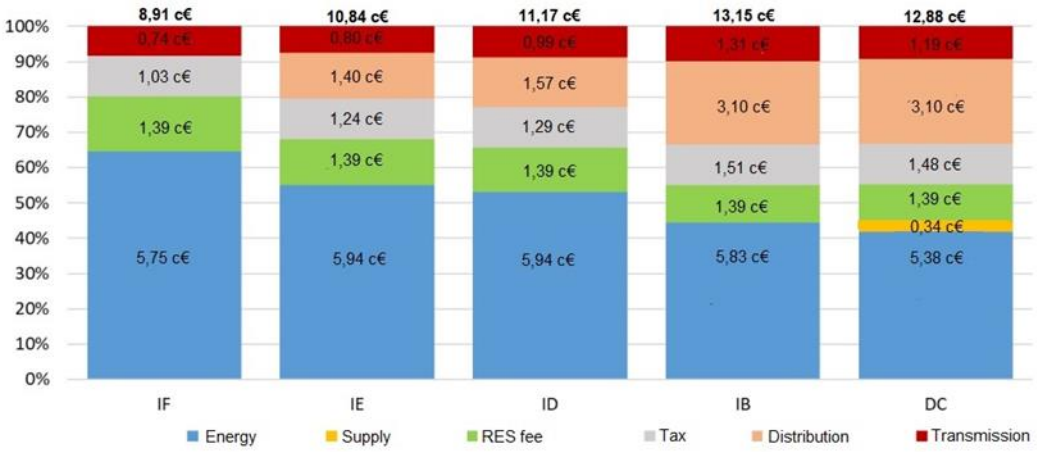


Figure 4-26. Structure of the total electricity price for end customers in the Republic of Croatia according to EUROSTAT consumption classes in 2021

Source: HOPS, HEP-ODS, HEP ELEKTRA, suppliers on the market

Pursuant to the Act on Amendments to the Value Added Tax Act (OG 115/16), from 1st January 2017 the new, reduced, value added tax (VAT) rate for the supply of electricity, including fees associated with that delivery, is applied. The current 25% VAT rate, which was valid until 31st December 2016, changed to the 13% rate, which is valid from 1st January 2017.

Natural gas

The basic elements of the price of gas are the supply price and the price of gas transmission, the price of gas storage, the price of gas supply and the price of gas distribution. Transport, distribution and the public service of gas supply and guaranteed supply, as well as gas storage are regulated by the respective Methodology of determining the amount of tariff items and the Decision on the amount of tariff items issued by CERA.

The Methodology of determining the price of non-standard services for gas transmission, gas distribution, gas storage, acceptance and shipment of LNG and public service of gas supply regulates the price structure of non-standard services of regulated activities.

In accordance with the Methodology of determining the price of balancing energy of the gas system, the gas market operator daily determines the price of positive and negative balancing energy of the gas system.

Wholesale procurement price for public service and guaranteed gas supply

The price of gas procurement is defined according to the Methodology for determining the amount of tariff items for the public gas supply service and guaranteed supply.

The price of acceptance and shipment of liquefied natural gas

Tariffs for acceptance and dispatch of LNG are determined by the Methodology of determining the amount of tariff items for acceptance and dispatch of LNG, adopted by CERA. For the calculation of tariff items for the reception and dispatch of LNG, a regulatory account model for a regulatory period of 5 years will be used.

Cost of gas transmission

The price of gas transmission is determined on the basis of the Methodology of determining the amount of tariff items for gas transmission and the Decision on the amount of tariff items for gas transmission. The price of gas transmission is expressed through a fee for the usage of the transmission system. The amount of the fee is determined and paid according to the total contracted capacity of the transmission system of each individual user for each month, including transactions on the secondary market and overruns calculated for each connection for each gas day for each individual user based on the measured quantities of gas transported. The capacity can be contracted at the level of year, quarter, month, day and, only on interconnections, an hour.

Gas storage price

The working volume of one Standard Bundled Unit (SBU) is set at 50 GWh, and users lease the service of the standard bundled unit on an annual/multi-year basis.

Gas storage fees are defined by the Decision on the amount tariff items for gas storage (OG 122/16) issued by CERA on the basis of the Methodology of determining the amount tariff items for gas storage.

Cost of gas supply for public service of gas supply and guaranteed supply

Tariff items for gas supply are determined by the Methodology of determining the amount of tariff items for the public service of gas supply and guaranteed supply.

The final price of gas supply consists of the tariff item for the amount of gas delivered (Ts1) and a fixed monthly fee (Ts2). The amounts of tariff items for the public service of gas supply for suppliers in the public service obligation are determined by the Decision on the amount of tariff items for the public service of gas supply.

Gas distribution price

Tariff items for gas distribution for the regulatory period 1st October 2022 to 31st December 2026 are defined by the Decision on the amount of tariff items for gas distribution, which

states the amounts of tariff items for gas distribution for energy operator. The final price of gas distribution consists of the tariff item for the amount of distributed gas (Ts1) and a fixed monthly fee (Ts2). Tariff items Ts1 are defined for each individual distributor in 12 tariff models (TM) depending on annual consumption, while tariff items Ts2 are prescribed in the same amount for all distributors.

Gas selling prices

The average selling price of gas on the wholesale market in the Republic of Croatia, excluding VAT, in 2021 amounted to 0.0373 EUR/kWh, which is 109% more than in 2020, when it amounted to 0.0179 EUR/kWh.

The average retail price of gas in the Republic of Croatia for end customers in the category of entrepreneurship in 2021 amounted to 0.0389 EUR/kWh (excluding VAT), which represents an increase of 79.9% compared to 2020, while the average sales price of gas excluding VAT for end customers in the category of households using the public gas supply service amounted to 0.0360 EUR/kWh, which compared to 2020 represents an increase of 0.3%.

iv. Description of energy subsidies, including those for fossil fuels

In the Republic of Croatia, a system to encourage the use of renewable energy sources for the production of electricity was introduced in 2007. RES electricity producers received FITs for the kilowatt-hour of electricity produced, depending on the renewable energy source used and technology, in accordance with the Tariff System for the production of electricity from renewable energy sources and cogeneration (Official Gazette 33/07, 63 / 12, 121/12, 144/12, 133/13, 151/13, 20/14, 107/14, 100/15), where the subsidy is equal to the difference between the FIT and the market price of electricity. Plants for which an FIT contract has been concluded will continue to receive the contract price for the duration of the contract (12 years for contracts concluded until 2013, i.e. 14 years for contracts concluded after 2013).

Since 2016, the Act on Renewable Energy Sources and High-efficiency Cogeneration has come into force, which envisaged the so-called premium system as part of an incentive framework.

Another type of energy subsidies in the Republic of Croatia is excise duty exemptions, as prescribed by the Excise Duty Act. Excise duty exemptions are provided for unleaded motor gasoline and blue dyed diesel for agricultural, fishing, aquaculture and navigation purposes. Beneficiaries of this right exercise this right under special regulations on the basis of a permit and a fuel card issued by the authority competent for agriculture and fisheries, or the authority competent for agriculture and fisheries, or the authority competent for maritime affairs. Each beneficiary is assigned a corresponding approved annual quantity of blue dyed diesel for dedicated consumption - a quota.

In addition, the same law provides for the use of energy products and electricity for non-excise purposes, such as:

- energy generating products used as motor fuel n air transport (excluding private flights),
- energy generating products used as motor fuel for navigation, including fishing and electricity produced on board (excluding the use of crafts and vessels for private purposes),

- energy generating products used by the energy generating products and electricity producer in their production facilities for the further processing or production of other energy generating products and electricity (unless used as motor fuel for vehicles),
- energy generating products used for the joint production of heat and electricity in a single process (cogeneration),
- energy generating products used in mineralogical processes,
- in cases of dual use of energy generating products - if used as a heating fuel and simultaneously for purposes other than propulsion or heating (use of energy generating products for chemical reduction, in electrolytic and metallurgical processes),
- energy generating products used for purposes other than motor or heating fuel; and
- natural gas used in households and natural gas used as motor fuel for vehicles and in other specific cases described in the law.

The same Act provides for the possibility of reimbursement of excise duty on diesel used in the commercial transport of goods and passengers purchased in forms of non-cash payment in the Republic of Croatia, for persons registered for the commercial transport of goods and passengers established in the European Union. The excise duty refund is determined in the amount of the difference between the excise duty valid on the day of purchase of diesel fuel in the Republic of Croatia and the minimum prescribed excise duty on diesel fuel, amounting to EUR 330, which is then converted into the national currency. Beneficiaries of the right to refund are obliged to enter in the register of beneficiaries of the right to refund of excise duty on diesel fuel in the commercial transport of goods and passengers. The purpose of this type of refund is to reduce the cost of domestic carriers and increase their competitiveness in the European market.

It can be concluded that most energy subsidies are aimed at increasing energy efficiency and the use of renewable energy sources, which will continue in the future, while respecting state aid restrictions. A smaller part of energy subsidies is related to exemptions from excise duties in transport and agriculture. In order to determine the dynamics of the abolition of subsidies primarily on fossil fuels, it is necessary to carry out an analysis of the current system of subsidies, to establish accompanying social programmes that will reduce the impact on the poorest citizens and to define a plan for their abolition. The analysis of the current system of measures would have to be carried out by the end of the second quarter of 2026. In addition to the above, the analysis would cover the economic impact of phasing out fossil fuel subsidies, performance indicators and a detailed plan for phasing out subsidies. The competent authorities responsible for the implementation of this measure are the Ministry of Economy and Sustainable Development and the Ministry of Finance.

5 ASSESSMENT OF IMPACTS OF PLANNED POLICIES AND MEASURES

5.1 Effects of planned policies and measures described in Section 3 on the energy system and greenhouse gas emissions and greenhouse gas removal, including comparison with projections based on existing policies and measures (as described in Section 4).

i. Projections of energy system trends and greenhouse gas emissions and removals as well as, where relevant, emissions of air pollutants in accordance with Directive (EU) 2016/2284 under planned policies and measures, including relevant Union policies and measures, at least until ten years after the period covered by the plan (including projections for the last year of the period covered by the plan)

Projections of the most important energy and climate indicators, taking into account the expected sectoral changes by 2030, are presented below:

- The expected overall reduction in greenhouse gas emissions is from 25.6% (WEM) to 34.1% (WAM) by 2030, compared to 1990 levels.
- Immediate energy consumption of 292.5 PJ (WEM), or 274.2 PJ (WAM) in 2030 is expected
- The renovation rate in the period 2021 to 2030 is growing from the current 0.7% per annum for the period 2014-2019 in steps of 1.1% to 3.0%, reaching a 10-year average of 1.6%. The rate of abandonment of the existing building stock is significantly increased, as evidenced by the increase in temporarily unoccupied units in the period between two consecutive censuses.
- The penetration of electric and plug-in hybrid vehicles, whose share in vehicle sales reaches 10% in 2030, is expected
- Increase in the share of renewable energy sources in gross final energy consumption to 42,5% by 2030
- Decarbonisation of electricity production by increasing the share of renewable energy sources to 73.6% by 2030

Increasing energy efficiency is strongly present in all sectors of consumption, with the strongest effects expected in the building sector and transport.

In the building sector, a continuation of good practices and strengthening of energy efficient of all buildings (residential and non-residential) is expected, targeting renovation according to the nZEB standard, which also implies a greater utilization of RES (photovoltaic systems, solar thermal collectors, biomass boilers, heat pumps).

Projections of greenhouse gas emissions from mobile and stationary energy sources in the Republic of Croatia are presented in Figure 5-1. The scenario with existing measures (WEM) and the scenario with additional measures (WAM) are shown.

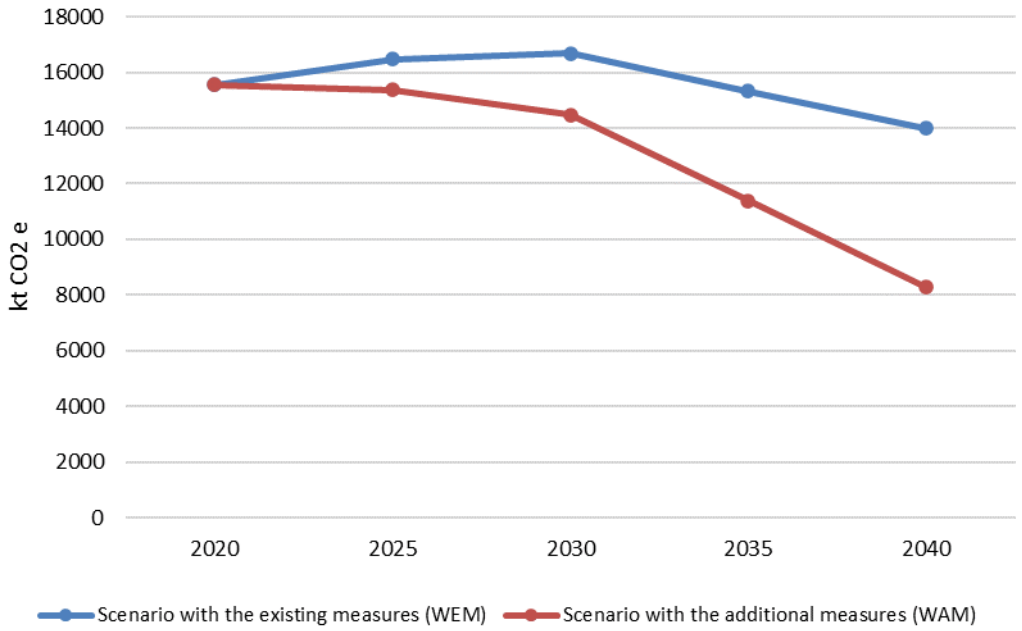


Figure 5-1. Greenhouse emissions projections for the scenario with existing measures (WEM) and scenario with additional measures (WAM) - energy sources

The potential of additional measures to reduce emissions by energy sector is illustrated in Table 5-1, and it represents the difference between emissions from scenarios with existing and additional measures.

Table 5-1. Greenhouse gas emission reduction potential of additional measures, mobile and stationary energy sources

CO_2 e emission reductions (kt)	**2025**	**2030**	**2035**	**2040**
Production and transformation of energy	387,38	774,76	1.057,85	1.340,93
Industry and construction	206,16	412,32	835,84	1.259,37
Transport	190,65	381,30	1.152,76	1.924,22
General consumption	314,01	628,01	905,48	1.182,95
Fugitive emissions	0,05	0,10	0,28	0,46
Emission reduction potential - energy sources	826,68	1.653,35	3.446,23	5.239,10

Projections of greenhouse gas emissions from mobile and stationary energy sources in the Republic of Croatia are presented in Figure 5-2.

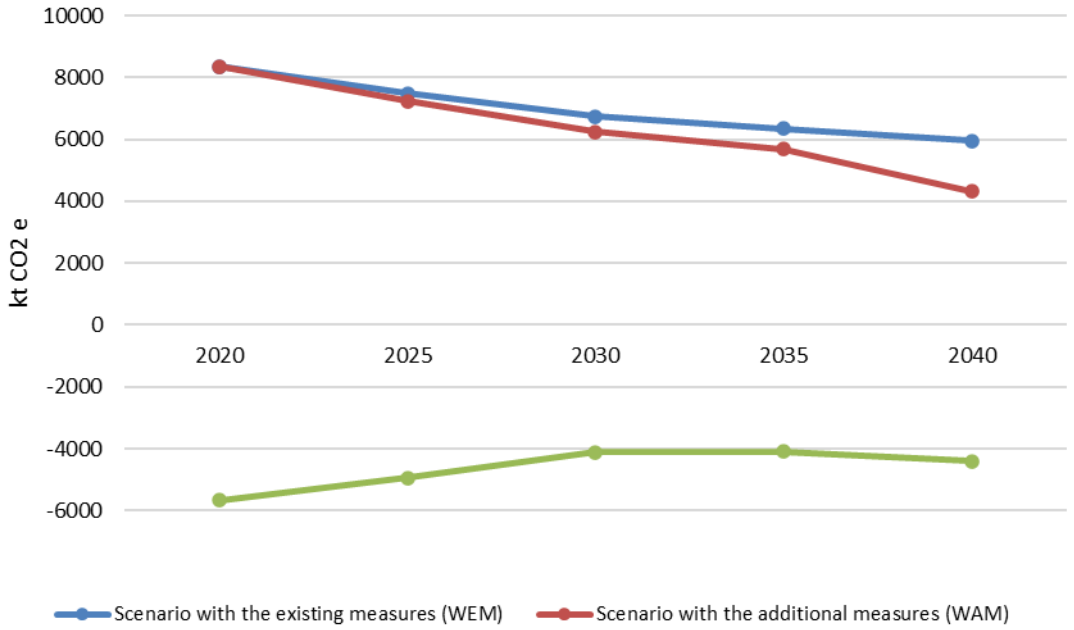


Figure 5-2. GHG projections for the scenario with existing measures (WEM) and scenario with additional measures (WAM)- non-energy sources

The potential of additional emission reduction measures for non-energy sectors is shown Table 5-2, and represents the difference between the greenhouse gas emissions of the existing measures scenario (WEM) and the additional measures scenario (WAM).

Table 5-2. Greenhouse gas reduction potential for additional measures, non-energy sources

CO_{2e} emission reductions (kt)	**2025**	**2030**	**2035**	**2040**
Industrial processes and product use	10,60	203,86	272,26	1216,00
Agriculture	147,08	190,70	241,12	293,46
LULUCF*	0	0	0	0
Waste	90,79	108,20	138,91	121,05
Emission reduction potential - non-energy sources	248,47	502,76	652,29	1630,51

** WAM Scenario equals WEM Scenario*

Total greenhouse gas emissions in the Republic of Croatia are shown Figure 5-3. The trend of historical emissions and expected emission reductions for the Existing Measures Scenario (WEM) and the Additional Measures Scenario (WAM) is presented. Greenhouse gas emissions in 2030 would be 25.6-34.1% lower than 1990 levels.

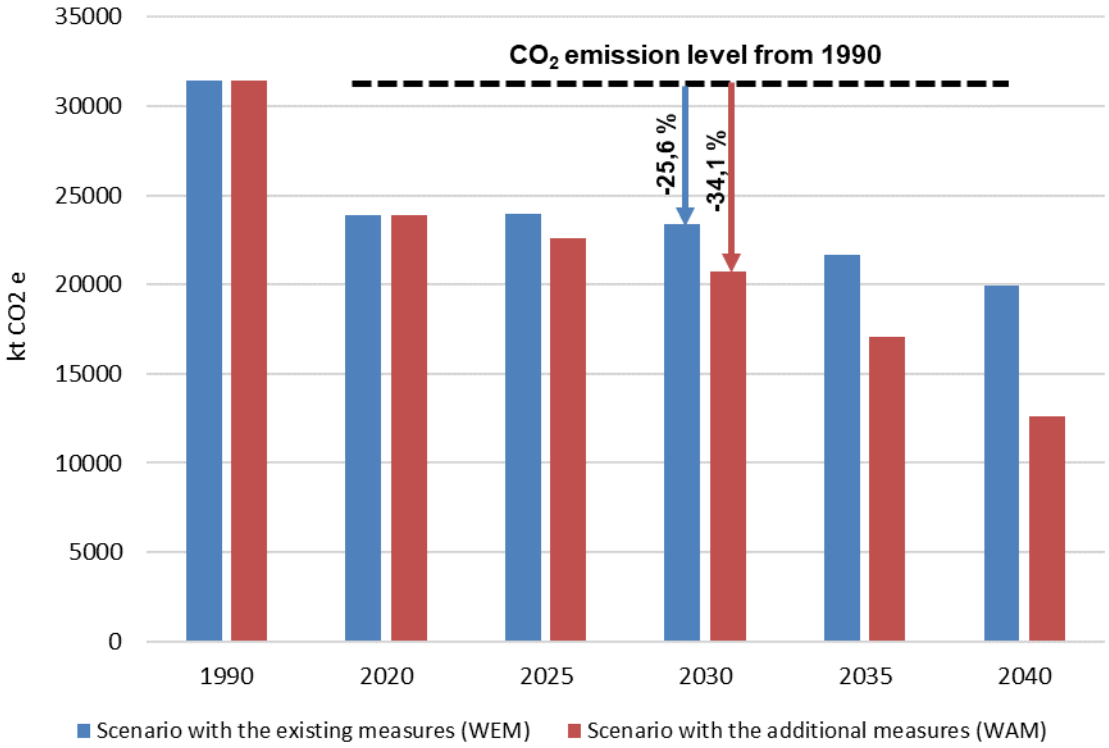


Figure 5-3. Projection of total greenhouse gas emissions for the scenario with existing measures (WEM) and the scenario with additional measures (WAM)

The Republic of Croatia does not fulfil the obligation to reduce greenhouse gas emissions from the non-ETS sector in the existing measures scenario for 2030 (-16.7% compared to 2005), while with the scenario with additional measures it fulfils this obligation. The reduction in emissions from the non-ETS sector would range from 6.7% to 17.1% by 2030, compared to 2005 emissions (Figure 5-4).

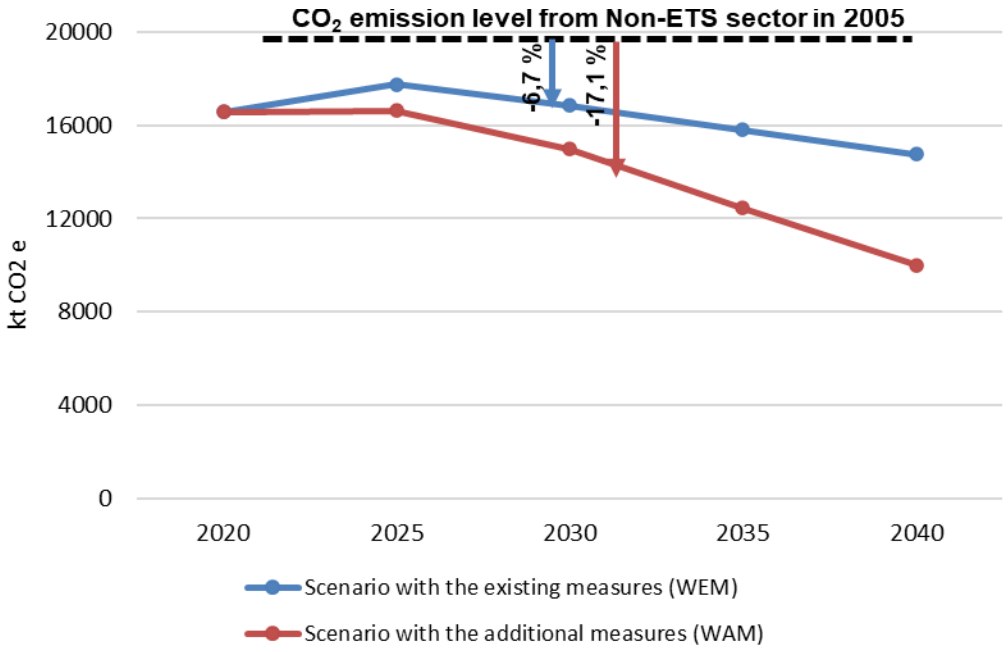


Figure 5-4. Projection of greenhouse gas emissions from sectors outside of ETS for the scenario with existing measures (WEM) and the scenario with additional measures (WAM)

Emission reductions in the ETS sector would be 43.0-50.2% in 2030 compared to 2005 levels. The projection of greenhouse gas emissions for the ETS sector is shown in Figure 5-5.

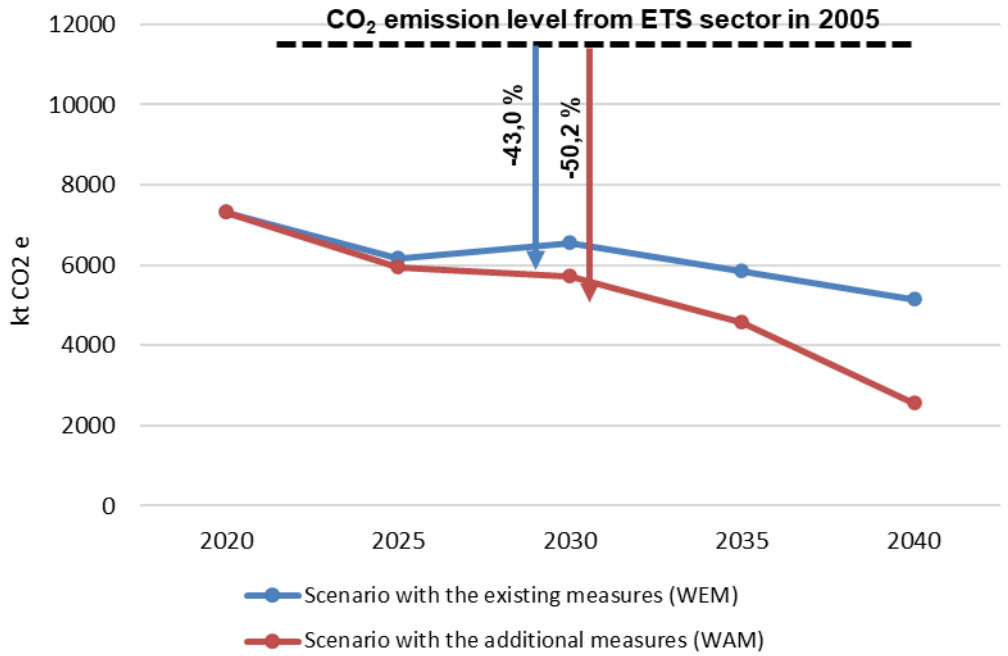


Figure 5-5. Projection of greenhouse gas emissions from the ETS sector for the scenario with existing measures (WEM) and the scenario with additional measures (WAM)

For the scenario with existing measures (WEM) and scenario with additional measures (WAM), greenhouse gas emissions for international air transport have also been calculated, based on

the energy balance data for the projection period 2020-2040. The GHG projections are equal for both scenarios analysed (Table 5-3).

Table 5-3. Greenhouse gas emissions from international air transport

CO_{2e} (kt) emission	2025	2030	2035	2040
International Air Transport (WEM = WAM)	352,61	404,66	388,50	424,39

ii. Assessment of policy interactions (interaction between existing and planned policies and measures in one dimension and interaction between existing and planned policies and measures of different dimensions) at least until the last year of the period covered by the plan, in particular to fully understand the impact of energy efficiency/energy savings policies to determine the size of the energy system and reduce the risk of lost investment in the area of energy supply

The description of each measure indicates the dimensions to which the measure in question has an effect.

iii. Assessment of the interactions between existing policies and measures and planned policies and measures, as well as between those policies and measures and the Union's climate and energy policy

The description of each measure indicates the dimensions to which the measure in question has an effect.

5.2 Macroeconomic and, to the extent possible, health and environmental impacts, employment and education impacts, social and skills impacts (in terms of costs and benefits, as well as cost-effectiveness) of the planned policies and measures described in item 3 at least up to the last year of the period covered by the plan, including a comparison with projections made on the basis of existing policies and measures

The macroeconomic effects were analysed on the basis of an estimate of total investments in the period from 2021 to 2050. Total investment is estimated at EUR 115.0 billion, of which EUR 36.5 billion in 2024-2030 and EUR 78.5 billion in 2031-2050. The analysis assumes that the investments are linearly spread over the years, i.e. that an average of EUR 5.2 billion is invested annually in the first period, or EUR 3.9 billion in the second period.

Macroeconomic effects are calculated by input-output analysis based on the input-output table for the Republic of Croatia. The analysis takes into account the direct and indirect, multiplicative, effects of investments that are disaggregated by different estimates into individual activities (out of a total of 65 activities), which are in the symmetric input-output table, given the specificity of each investment. Direct effects include additional employment, i.e. income, in the sectors producing goods and services to meet the additional final demand. Indirect effects include indirect employment, i.e. income, of other sectors that increase production levels to deliver the intermediate inputs required for production in the sector that directly supplies output for final demand. The input-output model covers the existing technological links between 65 different activities i.e. sectors of the Croatian economy.

The results of the analysis are divided into two periods: 2024 to 2030 and 2031 to 2050.

In the first analysed period from 2024 to 2030, with an estimated annual investment of 5.22 billion EUR employment would increase by about 105,000 employees, added value by 3.05 billion EUR/year, and GDP would increase by 3.63 billion EUR/year

In the period between 2031 and 2050, with an estimated annual investment of EUR 4.26 billion, employment would increase by about 168,100, added value by EUR 2.57 billion annually, and GDP would increase by EUR 3.63 billion .EUR

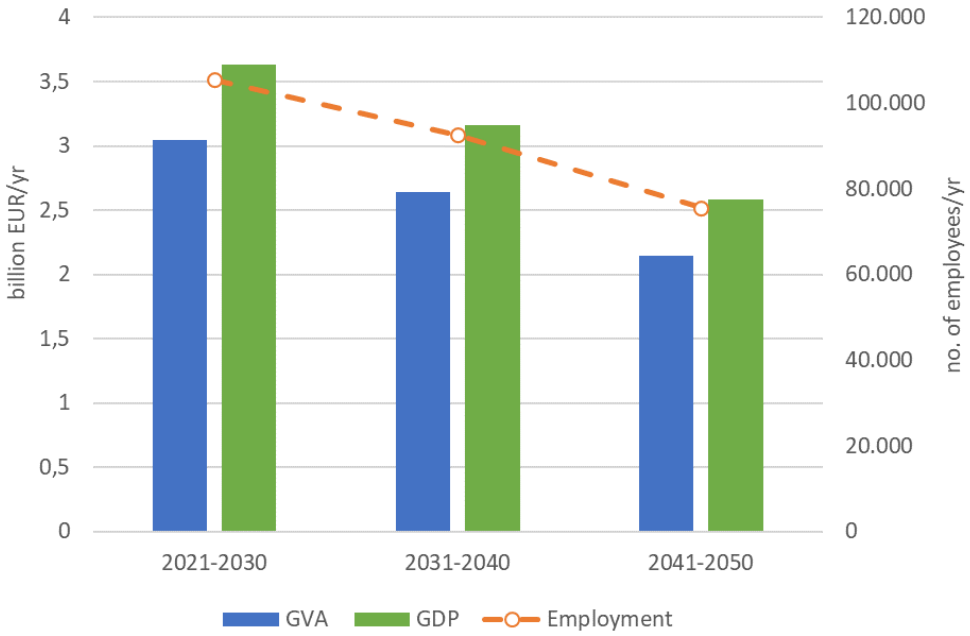


Figure 5-6. Absolute annual effects of investments by periods

The analyses carried out and the results obtained indicate the significant macroeconomic effects of the integrated national energy and climate plan on the Croatian economy, shown through its impact on GDP and employment, both overall and by sectors.

The conducted analysis is to a certain extent limited by the availability and quality of the required input data, which primarily refers to the disaggregation of total investments by sectors of the Croatian economy and the ratios of imported and domestic components by sectors. Input-output analysis is a static analysis and does not take into account future changes in technological links between different industries.

5.3 Overview of required investments

i. Existing investment flows and forecasts of future investments in relation to planned policies and measures

Table 5-4 and 5-5 show an estimate of total investments for the period 2024-2030 as well as for the period 2031-2050.

Table 5-4. Assessment of necessary investments in the energy sector until 2050

Million EUR	2024–2030	2031–2050
Production of electricity	3.738	15.349
Electricity transmission	872	2.500
Distribution of electricity	1.439	4.200
Heating industry	1.008	510
- infrastructure (network)	38	-
- geothermal energy	770	290
- solar systems	90	20
- heat pumps	110	200
Solar thermal systems (except those used in heating)	140	200
Transport and distribution of natural gas	1.679	54
Hydrocarbon research	3.225	1.900
Construction - energy renovation of buildings	6.249	21.489
Construction - nZEB new construction	15.624	26.544
Traffic	1.261	3.667
- road traffic	492	1.540
- railway traffic	13	47
- maritime traffic and inland navigation traffic	52	180
- air traffic	52	182
- public transport and integrated transport	320	1.120
- production of low-carbon fuels	332	599
Production of hydrogen	191	732
Production of biomethane	69	74
Geothermal energy (except for that used in heating)	340	260

Heat pumps (except for those used in heating)	480	720
Extraction and geological storage of CO_2	14	280
Reduction of fugitive emissions	179	-
Total	**36.507**	**78.479**

Table 5-5. Estimate of the required investments in the non-energy sector by 2050

Million EUR	2024–2030	2031–2050
Industrial processes and product use*	2	4
Agriculture	585	570
Waste	165	-
Total	**752**	**574**

** Estimation of total investments related only to non-energy sources and product use projects. Investments in projects of industry energy sources and the construction of CCS systems are shown as part of the energy sector (Industry and construction).*

The largest investments are expected in the construction of nearly zero energy buildings and houses and electricity generation plants (the majority of which will be investments in plants using renewable energy sources). In terms of the necessary incentives, the greatest need will be in the energy renovation of the existing building stock.

ii. Sector or market risk factors or barriers in the national or regional context;

The most important risks are related to delays in the implementation of regulatory measures and insufficient funds to implement financial measures.

These risks will be minimized by continuous monitoring of the implementation of measures and, if necessary, corrective action.

iii. Analysis of additional support from public finances or sources to fill the gaps identified under subitem ii.

The measures will be implemented through the financing or co-financing of projects from 1) public funds in the form of funds planned in the city or municipal budgets of local government units, 2) private funds, and 3) national and international sources of financing for energy efficiency and renewable energy projects, which include credit and grants.

Given that the volume of necessary investments often exceeds the capacity of the public sector, it is encouraged to direct private financial flows to the financing of project activities and investments in infrastructure development, which is in line with the objectives of sustainable financing of the European Union. Private interest in sustainable investment has increased significantly in recent years, as has the use of available EU funds to finance a variety of energy and climate transition projects.

National funding sources include funds and banks based in Croatia, which specialize in financing projects in the energy and transport sectors. In addition to classic forms of lending, there are also grants available to investors. It is important to mention that commercial banks

have also recognized the investment potential in this sector, as evidenced by the launch of credit lines for energy efficiency and renewable energy projects. One of the largest sources of financing at the national level is the *Environmental Protection and Energy Efficiency Fund*, which was established as an extra-budgetary fund with the aim of financing national energy programs. *The Croatian Bank for Reconstruction and Development (HBOR)* is a development and export bank established with the purpose of lending to the reconstruction and development of the Croatian economy, which enables the provision of financial support and encourages investments in environmental protection projects, energy efficiency and the use of renewable energy sources.

The benefits of using EU funds to finance project activities are contained in the possibilities of financing a wide range of project activities, from the lowest levels of technological readiness (TRL), which include basic research and the formulation of a technological concept, to demonstration activities and successfully proven technologies (competitive production). Depending on the desired and targeted results, a diverse profile of applicants is acceptable for project financing, from public sector bodies and organisations for research and dissemination of knowledge to private applicants from the economy, especially small and medium-sized enterprises for which calls for financing of individual project activities are often dedicated and targeted and available.

EU funding for project finance and private and public funding should be combined and used synergistically to create new opportunities for businesses and investors together. EU funding sources should act as a catalyst for the effective mobilisation and distribution of private and public funds for sustainable investment. In line with the objectives of the European Green Deal, the financing of programmes and projects in the energy and transport sectors in general is ensured under **the Multiannual Financial Framework (MFF) for the period** 2021-2027 and the **NextGenerationEU instrument (NGEU)**. From both sources of funds, individual financial mechanisms and instruments are available that enable financing for the energy sector and sustainable project activities.

The "Next Generation EU - NGEU" instrument introduced the Recovery and Resilience **Mechanism (Recovery and Resilience** Mechanism). *Recovery and Resilience Facility (RRF*), which will allow Member States, through their own national recovery and resilience plans, to use grants and loans to finance reforms and related investments that accelerate recovery and increase the resilience of the economy and society. The Recovery and Resilience Mechanism aims to mitigate the economic and social consequences of the coronavirus pandemic and make European economies and societies more sustainable, resilient and prepared for the challenges and opportunities of the green and digital transition. The mechanism is based on six pillars: green transition; digital transformation; economic cohesion, productivity and competitiveness; social and territorial cohesion; resilience of health, economic and social sectors and institutions; and policies for the next generation. Croatia's **National Recovery and Resilience Plan (NPOO)** is aligned with national strategic development documents, as well as with European priorities focused on the digital and green transition, which are based on the modernisation of the economy and society based on greater investment in innovation and new technologies.

The Connecting Europe Facility (CEF) is a financial instrument established to further invest in the construction of new and upgrade existing transport, energy and telecommunications infrastructure, from which Member States can finance projects on the nine corridors of the

Trans-European Transport Network (TEN-T) Core Network. The total CEF allocation for transport for the period 2021-2027 is EUR 25.81 billion. In the field of transport, CEF 2.0 will promote interconnected and multimodal networks for the development and modernisation of rail, road and maritime infrastructure, as well as inland waterway infrastructure, and contribute to safe mobility. All EU Member States, international organisations, research centres, local and regional authorities, etc. can apply for CEF funding.

Horizon Europe is the European Union's Framework Programme for Research and Innovation for 2021-2027, and is one of the Union's key instruments to strengthen the European Research Area, strengthen European competitiveness, steer and accelerate the digital and green transition, European recovery, preparedness and resilience. This makes it the most ambitious and also the largest transnational research and innovation framework programme in the world.

The specific objectives and pillars that make up the Global Challenges and European Industrial Competitiveness programme structure support the creation and transfer of new knowledge, technologies and sustainable solutions with a view to fostering the competitiveness of Member States' industries and strengthening the impact of research and innovation in the implementation of Union policies. Particular emphasis has been placed on encouraging the development of innovative solutions in small, medium-sized and start-ups and in society, with the aim of addressing global challenges. In addition, activities under the third pillar of Innovative Europe shall encourage the development, transfer and deployment of all forms of innovation, in particular in SMEs, while contributing to the other specific objectives of the Programme.

The first strategic plan of Horizon Europe 2021-2024 set out strategic guidelines to guide investment in the first four years of its implementation, based on:

- promoting open strategic autonomy by leading the development of key digital, development and new technologies, sectors and value chains
- restoration of European ecosystems and biodiversity and sustainable management of natural resources
- a digital road to Europe as the first circular, climate-neutral and sustainable economy
- building a more resilient, inclusive and democratic European society.

Within the aforementioned, the possibility of using funds for research, development and innovation activities for the use of alternative fuels is evident.

Funds allocated to the Republic of Croatia for the financial period 2021-2027 in current prices amount to more than EUR 14 billion from the MFF and slightly more than EUR 11 billion from the NGEU. A significant part of these funds refers precisely to the funds that will be implemented in accordance with the Regulation laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund and the European Maritime, Fisheries and Aquaculture Fund, as well as financial rules for them and for the Asylum, Migration and Integration Fund, the Internal Security Fund and the Financial Support Instrument in the field of border management and

visa policy (Common Provisions Regulation/ CPR)[32]. Funding from **the European Regional Development Fund (ERDF)** is possible for infrastructure investments; research and innovation, productive investments in SMEs and investments aimed at preserving existing and job creation, equipment, software and intangible assets, and networking, cooperation and exchange of experience. The **Cohesion Fund (CF)** supports investment in transport and the environment, with a particular focus on renewable energy and investment in TEN-T. In the Republic of Croatia, investments in support of the construction of infrastructure for the use of alternative fuels are foreseen under the ***Operational Programme Competitiveness and Cohesion 2021-2027*. (OPCC)** funded by the European Regional Development Fund and the Cohesion Fund under the EU Cohesion Policy.

Building on the European Fund for Strategic Investments, the **InvestEU** programme aims to attract investment from the private sector, including investments in sustainable energy and transport, to provide economies in these regions with new sources of growth. This programme establishes an EU guarantee of around EUR 26.2 billion, allowing investment partners to take on greater risks and support projects they would otherwise have given up. The EU guarantee is targeted at four areas: sustainable infrastructure (EUR 9.9 billion), research, innovation and digitalisation: EUR 6.6 billion, SMEs (EUR 6.9 billion), social investment and skills (EUR 2.8 billion). All four areas will include projects to support a just transition towards climate neutrality in the EU.

In addition to the financial instruments and mechanisms defined in the Regulation for the use of EU funds related to support to alternative fuels infrastructure, the following sources of funding are also available:

The Innovation Fund is one of the largest funds for innovative low-carbon technologies, supporting the vision of a climate-neutral Europe by 2050[33]. The Innovation Fund aims to boost low-carbon investment in all Member States to accelerate Europe's transition to a first climate-neutral continent. The Innovation Fund shall support projects demonstrating highly innovative technologies, processes or products with significant greenhouse gas emission reduction potential. It is intended for projects that are in a high degree of readiness and can quickly bring new solutions to the market. Support is provided to projects under 4 thematic areas: Innovative production and use of renewable energy sources, including component production, Carbon capture and utilisation, and carbon capture and storage (CCU and CCS), Energy-intensive industries, including carbon-intensive products and Energy Storage, including component production plants.

The **Modernisation Fund** supports investments in line with the climate and energy objectives of the European Union by 2030, i.e. investments that are in line with the Paris Agreement[34]. Based on the analysis of investment needs, investment maturity, policy priorities and the

[32]Regulation (EU) 2021/1060 of the European Parliament and of the Council of 24 June 2021 laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, the Just Transition Fund and the European Maritime, Fisheries and Aquaculture Fund and financial rules for those and for the Asylum, Migration and Integration Fund, the Internal Security Fund and the Financial Support Instrument in the field of border management and visa policy

[33]Legislative framework of the Innovation Fund

[34]COMMISSION IMPLEMENTING REGULATION (EU) 2020/1001 of 9 July 2020 laying down detailed rules for the application of Directive 2003/87/EC of the European Parliament and of the Council as regards the operation of the Modernisation Fund supporting investments in the modernisation of energy systems and the improvement of the energy efficiency of certain Member States

impact and potential for the use of other sources of financing, the Modernisation Fund will finance investments in Croatia from the following sectors: i) industry, ii) transmission and distribution networks, iii) heat and electricity production and iv) transport. The Transport priority area will be covered by two different multiannual programmes in the form of regular calls for proposals: Electric Vehicle Charging Infrastructure and Hydrogen Vehicle Charging Infrastructure. For charging electric vehicles, potential applicants are owners of apartments, holiday homes, summer residences, small and medium hotels, camps, and public and private parking companies. To charge hydrogen vehicles, potential applicants are companies operating in the fields of transport and oil/chemistry. For the supply of ships with electricity from the mainland, potential applicants are port authorities or concessionaires for performing port activities.

The JustTransition Mechanism is the most important tool for a just transition towards a climate-neutral economy. While all regions will need financial assistance, as foreseen in the Investment Plan for the European Green Deal, the 2021-2027 mechanism will mobilise at least EUR 100 billion in targeted support to mitigate the socio-economic consequences of the transition in the hardest-hit regions. The mechanism will stimulate the necessary investments to help workers and communities that depend on the fossil fuel industry. In addition, the EU budget allocates significant resources through instruments directly relevant to the transition[35].

The Just Transition Mechanism will cover three main sources of funding:

1. **The Just Transition Fund, which will receive** EUR 7.5 billion in new EU funds and is one of the priorities set out in the Commission's proposal for the next long-term EU budget. In order to be able to withdraw their share of the Fund, Member States should, in dialogue with the Commission, draw up territorial plans for a just transition and identify the territories in need of assistance. More funds are available from the European Regional Development Fund and the European Social Fund Plus, and they will also provide additional funds at the national level. The total value of these funds will be EUR 30-50 billion, which will mobilise even more investment. Grants from the Just Transition Fund are primarily earmarked for regions. In particular, it will support workers to develop skills and competences for the labour market of the future and help SMEs, start-ups and incubators to create new economic opportunities in these regions. Investments in the clean energy transition, such as investments in energy efficiency, will also be supported[36].
2. A specific programme for a just transition under the InvestEU programme, which will mobilise investments worth up to EUR 45 billion.
3. The public sector lending facility with the involvement of the European Investment Bank, supported by the EU budget, will enable the mobilisation of investments of EUR 25-30 billion. This instrument will provide loans for the public sector, for example for investments in district heating networks and building renovation.

The Just Transition Mechanism not only offers funding through the Just Transition Platform, the Commission will provide technical support to Member States and investors and involve

[35]Memo: More on the Investment Plan for the European Green Deal and the Just Transition Mechanism

[36]Proposal for a Regulation on the Just Transition Fund

relevant communities, local authorities, social partners and NGOs. The Just Transition Mechanism will include a strong governance framework based on territorial plans for a just transition.

With the new Regulation, the LIFE Programme fully supports the objectives of the European Green Plan in transforming the EU into an equal and prosperous society with a modern, resource-efficient and competitive economy with no greenhouse gas emissions in 2050 and where economic growth is decoupled from resource use. [37] In the new 2021-2027 programming period, LIFE is divided into two areas, each with two sub-programmes:

1. **Environment workstream:**
   - 'Nature and Biodiversity' sub-programme
   - 'Circular economy and quality of life' sub-programme
2. **Area Action in the field of climate:**
   - "Climate Change Mitigation and Adaptation" Sub-programme
   - 'Clean Energy Transition' sub-programme.

Financial envelope for the implementation of the LIFE programme for the period from 2021-2027 amounts to **EUR 5 432 000 000 and, in** accordance with the Regulation, LIFE can provide different types of grants for different types of projects (standard action projects, strategic nature projects, strategic integrated projects, technical assistance projects and coordination and support actions). The co-financing rate through the LIFE Programme is up to 60% of the total eligible costs, i.e. up to 75% for priority species from the Nature and Biodiversity sub-programme, while the eligible applicant is each legal entity registered in the territory of the European Union: public bodies, private commercial organizations and non-profit organizations.

Other international sources of funding

Other international sources of financing include specialised funds and foreign-owned banks, which have special lines dedicated to energy efficiency and renewable energy projects. The two most active European financial institutions, the European Investment Bank (EIB) and the European Bank for Reconstruction and Development (EBRD), have been present in Croatia for a long time as financial partners on major infrastructure projects.

The European Investment Bank is a non-profit European Union financial institution specialising in the long-term financing of projects supporting EU development policy. EIB-funded projects are not closely specialised in one sector, so it is possible to obtain funding for a variety of infrastructure projects, including energy efficiency and renewable energy projects.

European Local Energy Assistance (ELENA) is a technical assistance service launched in cooperation with the European Commission and the European Investment Bank at the end of 2009. Technical assistance will be provided to cities and regions in the development of

[37] Regulation (EU) 2021/783 of the European Parliament and of the Council of 29 April 2021 establishing a Programme for the Environment and Climate Action (LIFE) and repealing Regulation (EU) No. 1293/2013 (Text with EEA relevance) (Oj L 172, 17th May 2021)

projects from the energy sector that contribute to the *20-20-20* initiative and the Covenant of *Mayors* .

The European Bank for Reconstruction and Development (EBRD) is an international financial institution dedicated to assisting transition countries in their transition to a market economy and democratic order. The beneficiaries primarily come from the private sector, but the EBRD also works closely with regional banks to finance projects in the public sector. The EBRD funds projects in the fields of agriculture, energy efficiency and energy supply, industrial production, local community infrastructure, tourism, telecommunications and transport.

The European Investment Bank (EIB) and the German Development Bank (KfW) launched, with the support of the European Commission, the **Green for Growth Fund – Southeast Europe** at the end of 2009. The primary objective of the Fund, which operates in the countries of Southeast Europe, is to encourage the development of a financial market aimed at lending energy efficiency and renewable energy projects.

5.4 Effects of planned policies and measures described in Section 3 on other Member States and on regional cooperation at least until the last year of the period covered by the plan, including comparison with projections based on existing policies and measures

i. To the extent possible, effects on the energy system of neighbouring countries and other Member States in the region

Cross-border and regional integration of energy markets is expected to lead to lower energy and energy generating product prices. At the same time, greater integration of variable renewable energy sources into national electricity systems will cause increased variability in cross-border electricity flows, which will require the construction of more robust transmission grids and possibly the construction of new interconnectors, which may reduce the quality of electricity delivered to customers and potentially compromise the stability of the system's operation for an expected lower inertia and higher speeds of frequency change. Quality problems and reduced system inertia are expected to be addressed on a European level.

ii. Effects on energy prices, utilities and energy market integration

The changes that are expected in the energy sector are economically viable and will not ultimately entail higher costs. In doing so, the nature of costs will change - investment costs will increase and operating and energy costs will be reduced.

Ultimately, energy markets will be fully integrated, both geographically - at the level of the European Union and neighbouring countries, as well as sectorally - there will be an interconnection of the electricity, heat, gas and transport sectors.

iii. If relevant, effects on regional cooperation

It will be necessary to further strengthen cross-border and regional cooperation in all dimensions of the Energy Union.

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AMPEU – Agency for Mobility and EU Programmes

ATMIP - Agency for Transactions and Mediation in Immovable Properties

ACLMT - Agency for Coastal Lines and Maritime Traffic

CHA - Croatian Hydrocarbon Agency

ASHE - Agency for Science and Higher Education

GDP - Gross Domestic Product

CEF - Connecting Europe Facility

DHS – District Heating System

SIPO- State Intellectual Property Office

CBS– Croatian Bureau of Statistics

ES – electricity system

ERDF - European Regional Development Fund

EnU – Energy efficiency

ESCO - Energy Service Company

ESIF – European Structural and Investment Funds

ETS - Emissions Trading System

EU – European Union

FI – Financial instruments

FRL - Forest Reference Level

EPEEF – Environmental Protection and Energy Efficiency Fund

HAMAG-BICRO - Croatian Agency for SMEs, Innovation and Investments

CBRD –Croatian Bank for Reconstruction and Development

HPP - Hydroelectric Power Plant

HEP - Hrvatska elektroprivreda - Croatian Electrical Utility Company

Hep DSO – Hep Distribution System Operator d.o.o.

CERA - Croatian Energy Regulatory Agency

CCE – Croatian Chamber of Economy

HHI - Herfindahl-Hirschman Index

CTSO – Hrvatski operator prijenosnog sustava d.d. - Croatian transmission system operator

CEMO - Croatian Energy Market Operator

CSF - Croatian Science Foundation

HTLS - High Temperature Low Sag

IAP - Ionian Adriatic Pipeline

ICT - Information and Communication Technologies

IEA - International Energy Agency

IPCC - Intergovernmental Panel on Climate Change

ISEM - Energy Management Information System

LULUCF – Land Use, Land Use Change and Forestry

MSP– Ministry of State Property

MPPCSA – Ministry of Physical Planning, Construction and State Assets

MAF - Ministry of Agriculture and Forestry

MSE – Ministry of Science and Education

MESD: Ministry of Economy and Sustainable Development

NEEAP– National Energy Efficiency Action Plans

NFAP – National Forestry Accounting Plan

NCB - National Coordination Body

NPF - National Policy Framework for the Establishment for the Deployment of Alternative Fuels Infrastructure of the Republic of Croatia

NPOO - National Recovery and Resilience Plan 2021- 2026

NTC – Net Transfer Capacity

nZEB – Nearly Zero Energy Building

DSO - Distribution System Operator

RES – Renewable Energy Sources

OPCC - Operational Programme Competitiveness and Cohesion 2014-2020

PCI – Projects of Common Interest

SPP - solar power plant

SECAP – Sustainable Energy and Climate Action Plan

SMiV - System for Measuring and Verifying

CNG – compressed natural gas

TPP - thermal power plant

CHPP - Combined Heat and Power Plant

TYNDP – Ten-Year Grid Development Plan

UN – United Nations

UNFCCC - United Nations Framework Convention on Climate Change

LNG – Liquefied Natural Gas

WF - wind farm

HEC– high-efficiency cogeneration

GPP – Green Public Procurement

10 APPENDICES

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