Study on “Residential Prosumers in the European Energy Union”

JUST/2015/CONS/FW/C006/0127

Framework Contract EAHC/2013/CP/04

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1 Abstract

The *Study on Residential Prosumers in the European Energy Union* aims at gathering evidence and data on the drivers, regulatory aspects and economic performance in the area of small scale self-generation for residential consumers over the life-cycle of investment.

The study's results are presented in the form of overall conclusions with recommendations, intended to inform the European Commission's related policy and regulatory initiatives.

The focus of the study is on solar PV technology in the EU28, Norway and Iceland and it is structered as follows:

After setting the background, it first carries out a comparative analyisis of the existing regulatory framework in all target countries, covering procedural aspects, taxation, incentives and other forms of investment support.

Then it develops projections, modelling take-up of solar PV by households in each of the target countries over the period to 2030.

Furthermore, it offers insights on European consumers' experience with self-generation, on financial/non-financial drivers affecting their choice, by analysing primary data collected via one in-depth survey and one mystery shopping exercise.

Finally, it presents the design of a behavioural experiment aimed at assessing the abilities and skills of consumers to understand the offers for transitioning towards residential self-generation with solar PV, gaining insight into how they can make the best choice.

The study has been prepared by the Gfk Belgium-led consortium. Consortium members: Milieu Ltd, Cambridge Econometrics Ltd, Helion Research, COWI A/S, CentERdata.

2 Introduction

The *Study on Residential Prosumers in the European Energy Union*[1] has the following main objectives:

- Mapping the residential prosumers based on the type of renewable energy system used, with a focus on solar PV, and assessing whether and to what extent it is easy or difficult, beneficial or not, for household consumers to become prosumers, how long it takes to complete this transition, and what, if any, particular skills, tools or services they need to make it happen

- Mapping national policies for residential prosumers in each EU Member State by assessing the regulatory, administrative and taxation frameworks applied in each EU Member State, the predictability and stability of such frameworks

- Mapping the drivers and obstacles for residential prosumers by gathering their views on the drivers for their choice and by surveying whether they are able to make informed, rational and empowered choices, how easy or difficult it is for them to participate in the market for self-generation

- Making projections of the future (2020/2030) levels of residential self-generation uptake under a number of baseline regulatory regimes and scenarios, with a view to determine the regime that produces the best outcomes for household prosumers, and also to better understand the costs and benefits involved in each baseline regime

This report describes all the work carried out under the five main tasks and brings together the final results that were obtained under the different tasks, drawing conclusions and putting forward recommendations.

The five main tasks were the following:

Main Task 1 consisted of an overall integrated analysis of the market for residential prosumers in the EU28, Norway and Iceland, with focus on solar PV as a key self-generation renewable energy system. All results of the primary and secondary data collection and analysis were brought together and elaborated under this task to present the study's conclusions and put forward policy recommendations.

Main Task 2 consisted of an in-depth residential prosumers' opinion surveys carried out in the EU28 and Norway. Iceland had to be left out of the survey's geographic coverage, because of specific reasons that have been clearly explained in the relevant chapter of this report.

Main Task 3 consisted of the development of projections on the future (2020/2030) uptake of residential self-generation and the effects under a number of scenarios. To do this, the study relied on the collection and analysis of primary and secondary data on

[1] Study commissioned by the Directorate-General for Justice and Consumers (DG JUST), SPECIFIC CONTRACT No JUST/2015/CONS/FW/CO06/0127, implementing Framework contract No EAHC/2013/CP/04 Market studies

incentives and Feed-in Tariffs (or FiTs), administrative costs and burdens, taxes and network charges for residential self-generation etc. in the EU28, Norway and Iceland.

Main Task 4 consisted of a mystery shopping survey aimed at collecting primary data concerning the experience of mystery shoppers with the transition to residential self-consumption and storage in eight selected EU Member States, with a mix of bigger and smaller markets and coverage of the different geographic regions of Europe.

Main Task 5 consisted of the development of a model for a behavioural experiment suitable for assessing the abilities and skills of traditional consumers to understand the offers for transitioning towards residential self-generation and storage and to make the best choice for their consumption profile.

2.1 Structure of the report

This report is structured in the following manner:

- Introduction
- Background
- Comparative analysis of the legal framework for residential prosumers
- Baseline and projection scenarios
- Residential prosumers experiences, understanding and decision-making
- Behavioural experiment design
- Overall conclusions and recommendations

In the Background Chapter we describe the policy and regulatory scenario for prosumers, among the other energy consumers and players, in light of the latest developments in the "Clean Energy for All Europeans" or the so-called "Clean Energy Package". The package recognizes the fundamental role played by consumers in realising the full potential of the European energy market, and points out that the retail electricity market has to offer them the possibility to actively and beneficially participate in the energy transition process.

While the study's focus is on self-generation relying on solar PV as the main prosumer renewable energy system in the EU, the "Clean Energy Package" has in its broader scope various types of prosumers as well as other types of energy consumers. The "Clean Energy Package" aims at those types of prosumers who can help grid management.

The study highlights that solar PV prosumers are often still producing energy at peak supply times and are not able (or not induced) to consume the electricity they are producing at that time. This is one of the main reasons of the existing grid management problems related to their self-generation. These problems would need to be addressed within the broader framework of the policy and regulatory initiatives taken as part of the "Clean Energy Package" at the EU level.

Besides, the Background Chapter also sets the scope of the whole study in terms of geographic coverage and main renewable energy technology examined (solar PV) and explains the analytical angle of the entire study.

After setting the background, in the chapter dedicated to the comparative analysis of the legal framework for residential prosumers we examine the existing regulatory requirements applicable across the EU28, Norway and Iceland and covering a variety of aspects including the procedural ones, as well as taxation issues, incentives and other forms of investment support. Focus of the analysis is again on solar PV.

Furthermore, in the chapter dedicated to the baseline and projection scenarios, we explain in detail the methodology applied to estimate take-up of solar PV and we present the key results for the baseline rates of take-up and the scenarios.

The projection chapter is followed by the one dedicated to the analysis of the primary data collected with regard to residential prosumers experiences, understanding and decision-making process. We provide insights on consumers' experience with self-generation and on the financial/non-financial drivers of their choice.

Finally, a dedicated chapter illustrates the design of a behavioural experiment aimed at assessing the abilities and skills of traditional consumers to understand the offers for transitioning towards residential self-generation and storage and at gaining insight into how traditional consumers can make the best choice regarding self-generation with solar PV.

All results presented and discussed in the individual chapters constitute the basis of the overall conclusions and recommendations at the end of this report.

This report also includes an Abstract and a number of annexes:

- Annex on the cost effectiveness of investing in solar PV under Feed-in Tariffs and net-metering
- Annex on baseline take-up of residential solar PV
- Annex with all primary data collected in the survey and mystery shopping
- Annex list of all the documents and sources consulted in the study

Finally, the stand-alone Executive Summary provides a description of the purpose, methodology and findings of the study as well as a summary of our policy recommendations.

3 Background

In November 2016 the European Commission released its Communication on "Clean Energy for All Europeans" with new policy and regulatory initiatives[2], recognizing that consumers play a fundamental role in realising the full potential of the European energy market, and that the retail electricity market has to offer them the possibility to actively and beneficially participate in the energy transition process. Policy-makers need to take into account the fundamental changes in the role of energy consumers, the financial and non-financial considerations affecting their choice of self-generation, the advantages as well as the obstacles encountered by prosumers, and their interaction with other energy market participants.

The European Commission's new policy documents point out that in order to allow a clean and secure energy transition to take place, the design of new electricity market rules also needs to better reflect the role played by fast-evolving technologies. Europeans need to have better access to smart meters and clear bills, to real time monitoring of electricity prices, as well as to be better able to switch energy provider.

Various innovative solutions such as smart grids, smart homes, self-generation and storage technologies are available, but still not widespread. Consumers are not sufficiently informed or not incentivised to actively participate in the electricity market, they are still prevented from controlling and managing their energy consumption, saving on their bills and improving their comfort.

Besides, a comprehensive policy and regulatory framework is necessary to enable all willing consumers not only to self-generate, self-consume, but also to store their electricity and sell it back to the grid without facing barriers. As explained in detail in the chapter dedicated to the legal analysis, in Europe the regulatory framework related to compensation for feeding electricity into the grid varies substantially by country. In some cases prosumers are still either not allowed to feed back into the grid or they do not get compensated, or they get a poor deal for doing it. The whole system needs to become less burdensome, more flexible and more responsive to the way consumers produce and consume nowadays. The European Commission acknowledges that the newly adopted or revised legislation has to aim at facilitating energy consumers' transition to prosumers[3].

The Communication also has among its objectives that of enabling electricity markets in Europe to send clear price signals and freeing of any public intervention, unless with duly justified exceptions such as protecting vulnerable consumers.

The European Commission has identified the following priorities for policy and regulatory action, with the aim of enabling all consumers to generate, store and/or sell their own electricity based on retail market conditions while also taking into account the costs and benefits for the system as a whole:

- Providing consumers with clearer, more standardized electricity bills, where suppliers will have to more prominently display basic information, report energy costs, network charges and taxes/ levies in the same way for clarity;

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[2] The Communication on "Clean Energy for All Europeans" COM(2016) 860 final, 30.11.2016, put forward legislative proposals on energy efficiency, renewable energy, the design of the electricity market, security of electricity supply and governance rules for the Energy Union

[3] New electricity market design: a fair deal for consumers https://ec.europa.eu/energy/sites/ener/files/documents/technical_memo_marketsconsumers.pdf

- Making switching conditions easier, prohibiting all switching related charges, except for early termination fees on fixed term contracts, and using contracts that provide consumers with information on tangible advantages in return;

- Spreading the use of smart metering, by entitling every consumer to a smart meter equipped with common minimum functionalities and by requiring those Member States that are not planning to roll-out smart meters to assess the cost-effectiveness of a large-scale smart metering deployment on a regular basis;

- Empowering consumers and communities to actively participate in the electricity market and generate, consume and sell electricity back to the grid, taking into account the costs and benefits of the prosumers' active market participation for the system as a whole;

- Promoting energy demand management thanks to new technologies like smart homes, smart appliances and smart meters, in combination with electricity supply dynamic price contracts that consumers will be entitled to request with the smart meter from their supplier;

- Promoting consumers' engagement with an aggregator, by establishing a regulatory framework that makes it easier for aggregators to operate in the market;

- Promoting storage technology by making it benefit from appropriate pricing. This will allow its flexibility and usage to be adequately remunerated. The introduction of scarcity pricing and the strengthening of the price signal are all measures that can support longer-term investments in the technology.

The study examines the current situation of residential prosumers in the EU and looks at the ways ahead by assessing the opportunities and the obstacles towards the realization of the ambitious policy and regulatory goals described above. In doing so, it draws extensively from findings based both on primary and secondary data sources, it critically examines them and integrates them into an overall analysis, drawing conclusions and putting forward recommendations.

3.1 Objectives and scope of the study

The study's focus is on residential prosumers using renewable energy systems such as small-scale solar PV installations to generate electricity. The aim, as set forth in the Terms of Reference (or ToR)[4], is to provide insights to inform the policy initiatives in the area of small scale self-generation for residential consumers.

The study compares residential prosumers across the EU28, Norway and Iceland, examining evidence on the drivers, regulatory framework and economic performance of self-generation over the lifecycle of investment.

[4] TENDER SPECIFICATIONS FOR REQUESTING SPECIFIC SERVICES Request for Specific Services No JUST/2015/CONS/FW/CO06/0127 for the implementation of Framework Contract EAHC/2013/CP/04 for the provision of a study on "Residential Prosumers in the European Energy Union"

3.1.1 Scoping residential prosumers

The term "prosumers" broadly refers to energy consumers who also produce their own energy from a range of different onsite generators, but the focus of this study, as explained above, is primarily on residential prosumers using systems such as small-scale solar PV to generate electricity.

Figure 1 here below illustrates the typical solar PV rooftop residential installation with its key components, including the solar PV modules (right), the inverter (the electronic device or circuitry that changes direct current, or DC, to alternating current or AC) and the home fuse box. Besides, Figure 1 illustrates the position within the home electrical system of the optional storage technology (battery) as well as of the single, bi-directional meter that can measure current flowing in two directions from and into the grid (net-metering).

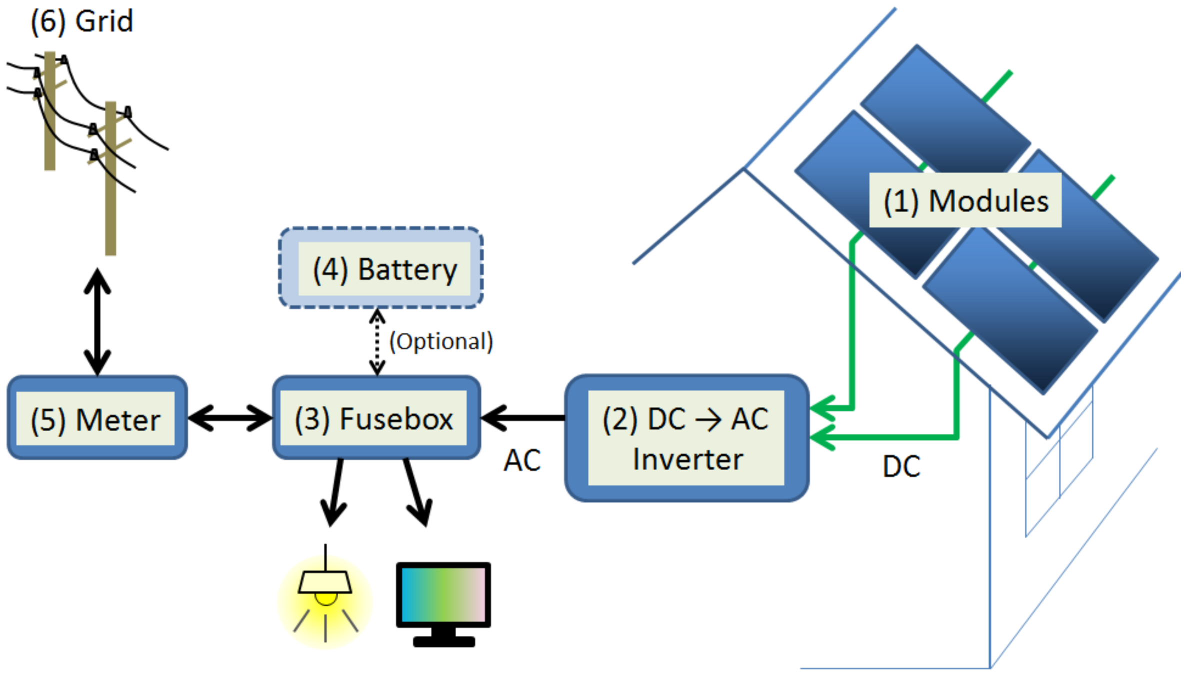

Figure 1. Scheme of a residential solar PV system[5]

<u>Feeding electricity back into the grid</u>

Residential prosumers have installations to produce electricity for their own use while they also have the possibility to feed the surplus that they do not consume into the grid.

In the course of the project implementation, particularly in the comparative legal analysis, we observed differences between EU Member States with regard to the regulatory framework for prosumers who want to feed electricity into the grid. In particular, the issue of economic compensation came to our attention.

Across Europe, the situation with regard to remuneration for feeding electricity into the grid is not uniform and different rules apply: in many countries Feed-in Tariffs are (still) available, alongside net-metering, or the electricity fed into the grid can benefit from

[5] Solar Cells and their Applications Second Edition, Lewis Fraas, Larry Partain, Wiley, 2010

premiums. Besides, other forms of support are available depending on the country, including green certificates, tax reductions, loans and investment support. Details have been illustrated in the chapter dedicated to the comparative legal analysis and in annex to this report.

Our analysis focuses on residential prosumers with small-scale solar PV installations, who auto-consume part of their self-generated electricity and feed the remaining into the grid. Based on a review of recent literature[6], and particularly in the analysis carried out in Chapter 5, in all EU Member States we assumed that 47% of electricity generated is self-consumed and the remaining 53% of electricity is exported to the grid.

<u>Residential prosumers installation size</u>

In view of our focus on residential self-generation through small-scale solar PV, our research also aimed at finding the definition of "small-scale" installation.

The chapter dedicated to the comparative legal analysis illustrates that the situation varies extensively across Europe and there is no commonly shared definition. Some EU Member States define residential prosumers in relation to the size or the capacity of the installation by indeed stating that it has to be "small", but without further specifying the size. Besides, when the generation capacity is used as a cap in prosumer-related national legislations, it is not the same in the different countries.

A recent International Energy Agency (IEA) study defined prosumer installations below 10kW as belonging to the residential category[7]. As again illustrated in the chapter dedicated to the comparative legal analysis, some EU Member States define residential prosumers by setting a cap of 10kW. However, based on our research, at present residential prosumer installations across Europe are generally lower than 10kW.

Our analysis showed that it is still difficult for consumers to know exactly how much solar PV installed capacity they need to best meet their consumption requirements; they might seek advice from solar PV installers or energy suppliers. According to Eurostat, in 2014 the average per capita electricity consumption in the residential sector in the EU28 was 1,549 kWh[8].

In the UK, the average solar PV system installed in the country is 3.5kW, which at 90% will produce approximately 3,150kWh of electricity, and an average household uses approximately 4,800kWh[9].

Figure 2 below shows the annual average electricity consumption in Belgium and compares different types of households across the country's regions.

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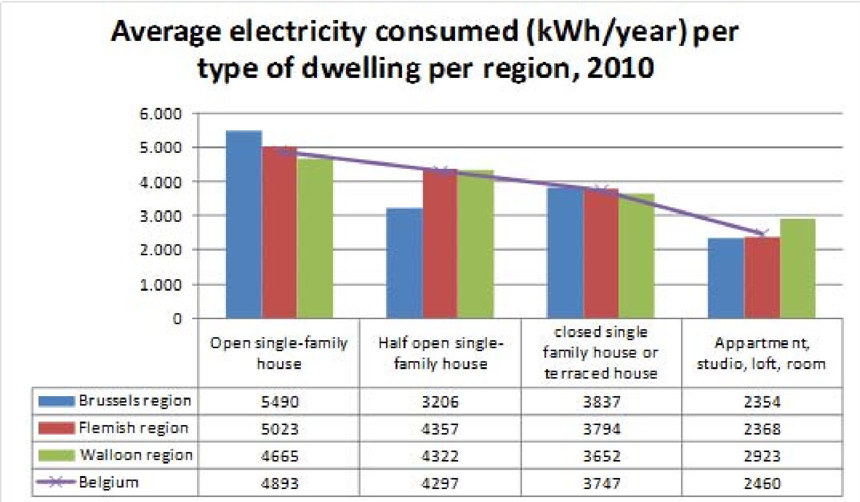
[6] Parsons Brinkerhoff (2015), 'Small-Scale Generation Costs Update'; V. Bermudez (2017), 'Electricity storage supporting PV competitiveness in a reliable and sustainable electric network'.
[7] Residential prosumers – Drivers and Policy Options, IEA, 2014 http://iea-retd.org/wp-content/uploads/2014/06/RE-PROSUMERS_IEA-RETD_2014.pdf
[8] http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_and_heat_statistics
[9] http://www.thegreenage.co.uk/tech/the-cost-of-a-solar-pv-system/

Figure 2: (Source: Energy Consumption Survey for Belgian Households[10])



	Open single-family house	Half open single-family house	closed single family house or terraced house	Appartment, studio, loft, room
Brussels region	5490	3206	3837	2354
Flemish region	5023	4357	3794	2368
Walloon region	4665	4322	3652	2923
Belgium	4893	4297	3747	2460

Furthermore, one German respondent in our mystery shopping exercise pointed out that the energy supplier told him that the average household consumption in the country was around 3500 kWh/year. This estimate is higher than the average data provided by Eurostat for Germany back in 2014[11], but the fact that three years have elapsed since then should also be taken into account.

3.1.2 Country coverage: the EU28, Norway and Iceland

Each task of this project has been carried out covering the EU28, Norway and Iceland, with the following three exceptions:

- The in-depth residential prosumers survey conducted under Main Task 2 covered the EU28 and Norway.

Concerning Iceland, our efforts to build up a meaningful sample of respondents via online panels proved vain. We also were not able to conduct the survey via the country's stakeholder organizations, as we obtained no or negative feedback from them. Here below is the most comprehensive answer that we received:

There are fairly few prosumers in this country (read: Iceland). In the early 20th century farmers in certain areas managed to construct small hydropower plants for their own farm, many of them were in isolated areas. Yet, when economies of scale became the rule, these small operators disappeared. One or two might still be functional. Then there may have been some farms or small communities which used diesel generators, but those are mostly gone now. Today, there are few wind mills being set up by farmers or small industries. These wind mills are probably producing cheaper energy than offered by the National Power Company. There are also ideas that small streams can be utilized for

[10] Study accomplished under the authority of Eurostat, Federal Public Service Economy, SMEs, Self-Employed and Energy, VEA Flemish Energy Agency, SPW Service Public de Wallonie, IBGE-BIM Brussels Environment, 2012

11http://ec.europa.eu/eurostat/statistics-explained/index.php/File:Electricity-consumption-of-households-per-capita-2014.png *producing energy for small operators, who then can sell their overcapacity to the big company[12].*

The above feedback is confirmed by a recent IEA report, which points out that a high penetration of non-prosumer renewable energy generation may limit the potential of prosumer development, and Iceland's Renewable Energy Action Plan confirms that renewable energy resources already account for the country's 99.9% of electricity production and 99% of heating production respectively.

- For the mystery shopping exercise conducted under Main Task 4, a selection of 10 countries was proposed by the project consortium and then agreed upon with the European Commission at the project's inception phase, in line with the ToR requirements.

The mystery shopping exercise looked at the experiences of consumers when becoming residential prosumers, or in other words in the transition to residential self-consumption and its different options: maintaining the connection to the grid (and feeding electricity into it) or disconnecting from the grid. In terms of self-generation technology the focus of the exercise was solar PV. To gather meaningful results we selected among the more mature markets, i.e. those countries where solar PV has spread more rapidly also thanks to the incentivizing policies that were put in place in the past years[13]. Besides, we also added to the selection a number of countries with smaller markets, to cover all the European geographic regions (North, West, South and East).

- Finally, in some specific cases in the study, after collecting results for all the EU28, Norway and Iceland, we discussed with the European Commission to further focus on the countries where solar PV markets are already more mature, and on countries with smaller yet interesting markets, mainly countries in Eastern Europe. Every time we took this approach we indicated it clearly in this report.

3.1.3 Solar PV technology

The European Commission's recent policy document "New electricity market design: a fair deal for consumers"[14] highlights that the EU's electricity system is changing profoundly and rapidly, the share of electricity produced by renewable sources has soared to 29% and it is expected to grow up to 50% in 2030, and much of the electricity will come from variable and less predictable sources such as solar and wind. As a result, market rules need to be adapted to facilitate this development, increase the flexibility of the system and ensure security of electricity supplies.

As already explained, in terms of technology this study mainly focuses on solar PV, while also presenting findings on others[15.] Europe is still the world leader in electricity generation from solar PV, although the main growth centres of PV capacity have now moved to Asia[16].

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[12] Natturuvernd is an organization that provides consumer advice and awareness activities on eco-friendly and green lifestyle including in the energy sector

[13] Renewables 2016 Global Status Report, Ren21, http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf

[14] https://ec.europa.eu/energy/sites/ener/files/documents/technical_memo_marketsconsumers.pdf

[15] The consumer survey also collected data on heat-pumps, wood pellet stove, micro combined heat and power (CHP) and micro wind turbine technology

[16] http://www.europarl.europa.eu/RegData/etudes/STUD/2016/556968/IPOL_STU(2016)556968_EN.pdf

By 2015, total solar PV capacity in the EU28 reached almost 100GW[17], of which around 16GW[18] is estimated to have been installed by households. In 2016, we estimate that almost 17GW residential solar PV was installed in the EU[19, 20].

Besides, while in general costs of various renewable energy technologies have decreased in the past years, solar PV is still the cheapest available in Europe. In the most competitive markets, prices of residential solar PV systems have fallen by over 70% between 2008 and 2014. The European situation is in line with the global outlook described by the International Renewable Energy Agency (IREA), i.e. an 80% cost reduction of solar PV between 2009 and 2015[21.]

Falling solar PV prices coupled with high retail electricity prices have made it possible for residential prosumers in some EU Member States to achieve grid parity[22].

Achieving grid parity[23] is generally considered to be the point at which an energy source becomes a contender for widespread development without the need for subsidies or other governmental support. Nonetheless, according to behavioural insights, apart from financial drivers there are also a number of non-financial, so-called behavioural drivers, influencing the choice of becoming prosumer. Recent IEA research confirms this point[24.] Our findings also confirm this point.

A key question is under what conditions solar PV residential self-generation can further develop and become widespread if not incentivised. To try and answer this, our analysis had to take into account the various drivers affecting consumers' choice within the evolving policy and regulatory environment.

Differences in national policies and physical conditions, e.g. the availability of roof space for solar PV installations, the share of building owners vs tenants, the conditions of the electricity grid, also play a role in the decision-making process of those who switch to self-generation.

Furthermore, when examining the issue of grid parity, differences in prosumer type should also be taken into account. In the case of commercial or industrial prosumers, grid parity is more difficult to achieve because they enjoy lower retail electricity prices compared to residential prosumers. Besides, solar PV capital costs, maintenance costs etc. for these types of prosumers are different from those of residential ones.

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[17] Eurostat (2015)

[18] Estimate based on residential Solar PV capacity data from national governments and analysis by CE Delft (2016).

[19] As national data, in most cases, is only available for 2015, the estimate for 2016 is the first year of the model solution in Chapter 4. It is based on the cost calculation (described in Section 4.1) and on known policies in place in that year.

[20] Although the 2016 estimate suggests that residential Solar PV capacity in the EU is still growing, it is growing at a considerably slower rate than in previous years, due to reduced policy support and because households that view Solar PV most favourably have already invested in it

[21] The Power to change: Solar and Wind cost reduction potential to 2025, International Renewable Energy Agency, 2016

[22] Deutsche Bank Market Research, Solar Industry, 2015 https://www.db.com/cr/en/docs/solar_report_full_length.pdf

[23] Grid parity means that when all (capital and other) costs of the solar PV system over its lifetime are taken into account, the system produces electricity that costs the same or less than the electricity from the grid

[24] Residential prosumers – Drivers and Policy Options, IEA, 2014 http://iea-retd.org/wp-content/uploads/2014/06/RE-PROSUMERS_IEA-RETD_2014.pdf

Retail electricity prices include grid fees as well as taxes and other levies. Thus, even when self-generated electricity is cheaper than electricity bought from the grid, this does not necessarily mean that self-generation is economically advantageous, as electricity generation costs in many cases are still above the wholesale price.

Therefore, while representing an important milestone, achieving grid parity is not the main and only driver of becoming prosumer and cannot be considered as the key factor determining the widespread development of solar PV installations.

Besides the difference between the costs of self-generation and the costs of buying electricity from the grid, the extent to which self-consumption of locally produced energy is profitable for individuals depends on other factors. These include the share of electricity generated that is consumed onsite and the conditions for feeding surplus electricity into the grid (such as metering options, and, in most countries, incentives).

For self-consumption to be profitable, the timing of electricity generation and electricity consumption is essential.

Larger residential prosumers (apartment buildings) and commercial prosumers have higher rates of self-consumption because they often need more energy during the day, when they produce it. However, in the case of individual residential prosumers, the electricity is often mainly consumed in the evening, therefore not when it is produced, and storage devices are not widespread yet. Under the current conditions therefore in most countries self-consumption without any support can be profitable only if high rates of it are reached. This can be achieved if the demand pattern can be shifted to better match the supply pattern of solar PV generation. Alternatively, the widespread development of storage options would require lower priced technologies.

Self-consumption could be improved via the following options:

- Energy demand management, or demand-side response, is the modification of consumer demand for energy, encouraging the consumer to use less energy during peak hours, or to move the time of energy use to off-peak times such as night time and weekends. It is however contingent on the roll-out of smart metering and availability of real-time electricity price signals

- Decentralized energy storage allows storing the electricity for later use. As the technology is still expensive and its use is not widespread, electricity is usually “stored” in the grid. The alternative option of using electric vehicles (or EVs) as energy storage is also not widespread (though there are examples in Denmark and in the UK[25]).

- Other technology innovations such as smart meters, for example, are still not widespread across Europe and different EU Member States have adopted different policies based on their national cost-benefit assessment, as illustrated in the chapter dedicated to the legal analysis.

In conclusion, the challenge of EU’s policy-making is to put in place an optimal, comprehensive regulatory framework that promotes the further development of

[25] For instance with vehicle-to-grid charging systems (V2G) see http://www.power-technology.com/features/featuretwo-way-street-getting-vehicle-to-grid-charging-off-the-ground-4943392/

residential self-generation via solar PV systems, by fully taking into account the different, both financial and non-financial drivers affecting consumers' choices in the non-uniform European policy and regulatory landscape.

3.1.4 Comparative approach

Our comparative analysis of residential prosumers carried out by country highlights the financial versus non-financial drivers affecting the choice to self-generate electricity, examining the evidence and data, the regulatory framework and economic performance of self-generation over the lifecycle of investment.

Comparing countries

A comprehensive comparative legal analysis by country has been carried out by focusing on the following aspects:

- Costs related to permitting requirements
- Costs related to grid access
- Financial incentives for feeding electricity into the grid
- Tax reductions, loans and other forms of investment support

This analysis shed light on the main financial factors that have an impact on the decision-making process of becoming prosumer in Europe. It showed that much of the current complexity is due to the lack of uniformity of the regulatory frameworks across Europe.

In addition, our analysis of baseline and projections in the different EU Member States shows the economic performance of self-generation over the life-cycle of investment.

First-hand data collected in the in-depth survey of residential prosumers and in the mystery shopping exercise show the financial and non-financial drivers affecting the decision to become prosumer.

Different countries were compared taking into consideration their individual features and specific situation in terms of residential prosumer-related policy and rules, they were not grouped in any category. As mentioned above, in some cases certain countries were identified as more mature markets. Besides, a selection of ten countries was done only for the mystery shopping exercise, while still ensuring the even coverage of all geographic regions of Europe.

Comparing drivers

A key question today is whether residential self-generation can further expand in the future without incentives and this can partly be answered by examining the drivers affecting consumers' choices.

There are surely other factors that play an important role in the further expansion of residential self-generation, but they were not the focus of the study, because they each would require a separate, dedicated analysis. For example, EU Member States' broader energy policy considerations and choices, which take into account the interests of a variety of market players such as energy suppliers, grid operators, technology suppliers etc. Recent reports[26] show that EU Member States hold different views on smart metering

[26] Commission Staff Working Document: Cost-benefit analyses & state of play of smart metering deployment in the EU-27 Accompanying the document Report from the Commission Benchmarking

roll-out because their cost-benefit assessment is based on their different national conditions.

This study examined the impact of financial and non-financial drivers on prosumers' choice by looking at their experiences, their behaviour, their understanding and expectations within the different national conditions based on EU Member States' existing national regulatory frameworks.

Previous studies on residential prosumers have also adopted the analytical approach of looking at financial vs non-financial drivers affecting their choice. However, the relevance of this study, as required in the ToR, is that:

- It focuses on the entire EU28 plus Norway and Iceland;
- It relies extensively on first-hand consumers' feedback based on large sample sizes, by utilizing a variety of primary data collection tools such as the survey and the mystery shopping.

Besides, this study builds upon and confirms precedent research conducted by GfK, also via a survey[27] that focused on consumers' attitudes, opinion and experiences with renewable energy systems, including solar PV. The survey encompassed their awareness and knowledge of available technologies, the type of information they seek and the sources they use to gather information, the drivers and barriers in the purchase of renewable technology.

Financial considerations or drivers typically include the upfront cost of installation, borrowing costs, the scale of the financial benefit (in terms of reduced electricity bills and available incentives) and the expected rate of return (and payback period) for the investment.

Besides, households' investment decisions are also influenced by non-financial factors, including views about the aesthetics of rooftop solar PV, perceptions of time requirements and disruption related to installing solar PV, environmental values, desire for greater autonomy and prestige, as well as current trends and fashions. In addition to values and underlying preferences towards solar PV there are technological factors that may make solar PV investment more desirable, for example ownership of an electric vehicle, smart meters or battery storage and demand response technologies.

In relation to these financial and non-financial drivers of investment, there is considerable heterogeneity among households, both across EU Member States and within each EU Member State. For example, whilst some people live in dwellings with large, south-facing roofs, in regions with high solar insolation, where solar PV investment is very cost-effective, other households live in dwellings that are not as well suited to solar PV (and therefore face higher costs per kW installed). Furthermore, differences in values and preferences mean that some households are more accepting of solar PV than others.

smart metering deployment in the EU-27 with a focus on electricity, 2014 http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014SC0189

[27] CLEAR WP2.1: Consumer survey 1 – Attitudes, opinion, drivers and barriers and satisfaction with regard to Renewable Energy Systems, 2014

Comparing residential prosumers with other types of energy consumers

Although the study primarily focuses on residential prosumers, some information on other types of energy consumers has been included whenever possible and if it contributed to shed light on the specific system applied to residential prosumers. The other types of energy consumers are:

- traditional consumers
- commercial and industrial prosumers

Carrying out a comprehensive, comparative analysis of the electricity market conditions applicable to all different types of energy consumers proved not feasible within one single study, it would have required developing an extensive, dedicated analysis of each consumer type, and it would have ultimately broadened too much the study's scope.

In line with the main focus set in the ToR and in the project proposal, all project tasks were built and carried out around the central theme of residential prosumers. Based on discussions with the European Commission at the First Interim Report meeting, we decided to proceed by assessing case-by-case the utility and feasibility of the comparison of residential prosumers with other energy consumers. The comparison would be carried out:

- when comparable data and information became available during the analysis of residential prosumers; and
- when it was considered to be meaningful within the main focus of the study

Besides, finding a commonly shared definition of "commercial prosumers" and "industrial prosumers" proved challenging.

We ultimately chose to keep as a reference the IEA's definition of commercial and industrial prosumers[28], which is based on the capacity of the solar PV installations. In Europe solar PV installations are generally tracked by installed capacity rather than by building type, and each country defines commercial buildings and collects and publishes commercial building-related energy data differently.

Based on this approach:

- Installations over 10kW and below 250kW can be considered to be commercial
- Industrial installations are considered to be above 250kW
- Installations of 10kW in size and below can be defined as residential prosumers[29], though the average household installed capacity across Europe is lower that this cap, as explained above.

It has in any case to be noted (as shown in the following chapters of this report) even those capacity caps set by some EU Member States for "residential prosumers" vary and are not always in line with the above described approach.

Besides choosing a reference definition, establishing a common benchmark to develop the comparison also proved very challenging, because different types of energy consumers benefit from different policy measures that put them already at the start in not easily comparable positions.

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[28] Commercial Prosumers – Development and Policy Options, IEA, 2016
[29] Residential prosumers – Drivers and Policy Options, IEA, 2014 http://iea-retd.org/wp-content/uploads/2014/06/RE-PROSUMERS_IEA-RETD_2014.pdf

For example, retail electricity rates tend to be lower for commercial and industrial prosumers compared to residential ones, with rate structures having a higher percentage of fixed charges. Besides, commercial and industrial prosumers achieve higher self-consumption rates or potential than residential prosumers. The viability of unsubsidized commercial prosumers is not clear as at present there are only limited examples (e.g. Germany, Italy and Spain). While industrial prosumers are considered not an economically viable option in many European markets without incentives, they also benefit from significantly lower electricity retail prices. Finally, rooftop solar PV is often insufficient to meet the electricity needs of a commercial building even during peak generation, so it is possible that commercial buildings may defect from the grid to join stand-alone or multi-user micro-grids, but it is not anticipated that micro-grids will diffuse broadly within the next several years.

The IEA developed separate, dedicated studies on the different types of prosumers, thus evidencing that it is not feasible to address the comparison in a comprehensive manner within one single study with a primary focus on one type of prosumers, as it is in our case.

As an example, Figure 4 below, shows some of the main comparable issues in broad terms, which to be fully developed would require separate dedicated analysis.

We share therefore the IEA's view that, just as with residential prosumers, the complexity of the interaction between drivers and national conditions suggests that policymakers need to conduct specific, dedicated analysis of commercial and industrial prosumers, to be able to formulate adequate strategies within the broader prosumer-related policy and regulatory initiative[30.]

[30] http://iea-retd.org/wp-content/uploads/2016/04/RE-COM-PROSUMERS-Report.pdf

Figure 4: Commercial prosumers vs residential prosumers[31]

Legend	Description		Comparison of Commercial Prosumer Competitiveness to Residential
	PV system costs	Green	PV installed costs are lower
	Electricity prices and rate structure	Red	• Retail electricity rates tend to be lower (in OECD countries) • Rate structures have a higher percentage of fixed charges (e.g. demand charges)
	Onsite demand and self-use ratio	Green	• Commercial buildings are able to achieve higher self-use ratios because their available rooftop area is small compared to their overall load and/or because they can optimize their systems size downward to serve their minimum daylight demand without a significant economy of scale penalty. • In many cases, peak demand of commercial buildings matches peak PV production time, which contributes to the higher self-use ratio compared to residential prosumers
	Behavioural drivers	Yellow	• Commercial return on investment requirements are higher than residential • Commercial decision making processes are complex and may either enable or constrain PV adoption
	Technology drivers	Green	In jurisdictions with high demand charges, PV and battery systems configured to shave peak can improve the economic case for commercial prosumers.
	National conditions	Yellow	• There is significant commercial roof space available for PV development • The share of owner-occupied space in the commercial sector is lower than in the residential sector
	T&D operators Incumbent generators	Yellow	Both residential and commercial prosumers may pose challenges to incumbent owners of electricity infrastructure, although commercial PV may have a lower negative impact while at the same time creating new opportunities for utility business models.

Green: Advantage for commercial prosumers

Yellow: Unclear influence on commercial prosumers

Red: Disadvantage for commercial prosumers

3.2 Main tasks and methodology used

The ToR required the following project structure:

- Main Task 1 – Overall integrated analysis of the regulatory framework for residential prosumers in the EU28 plus Norway and Iceland
- Main Task 2 – In-depth survey of residential prosumers to be carried out in the EU28 plus Norway and Iceland, and comparative analysis of the results
- Main Task 3 – Projections of the future (2020/2030) levels of residential self-generation uptake and welfare effects under a number of baseline regulatory regimes and scenarios, based on collection and analysis of incentives and feed-in-tariffs, administrative costs and burdens, taxes and network charges for self-generation in the EU28, Norway and Iceland
- Main Task 4 – Mystery shopping exercise on residential self-consumption services and products to be carried out in a selection of at least 8 countries

[31] http://iea-retd.org/wp-content/uploads/2016/04/RE-COM-PROSUMERS-Report.pdf

- Main Task 5 – Development of a model for a behavioural experiment suitable for aspects related to the transition of traditional household consumers towards self-generation

The analytical angle of each task was aligned with the one chosen for the entire study, to make it possible to feed all results into the overall analysis, draw conclusions and put forward recommendations. This meant that each task adopted the same approach:

- The scoping of residential prosumers illustrated in the Background chapter
- The European coverage (EU28, Norway and Iceland) with focus on selected EU countries in some instances
- The solar PV technology focus
- The analysis of financial and non-financial drivers

In the following sections we describe the methodology adopted in each task, while the detailed findings and conclusions of each task are described in the separate dedicated chapters of the study.

3.2.1 Main Task 1: overall integrated analysis of the regulatory framework

This task consisted as a first step in the in-depth analysis of the legislation adopted by each of the EU28, Norway and Iceland, to regulate - within the broader scope of renewable energy-based electricity generation - residential prosumers.

Firstly, detailed country reports were compiled by national experts who were also specifically briefed on the background, contents and objectives of the study.

For a consistent, uniform approach, each country report was developed by providing detailed answers to a set of questions organized in the form of a template validated by the European Commission.

For an easier-to-read approach, each country report included a summary fiche presenting the main aspects of the national regulatory framework to make it easier to compare findings across Europe.

After completion of the country legal reports, the comparison was built on the basis of the following criteria, in line with the analytical approach chosen for the entire study:

- Criteria 1: Definition of residential prosumers
- Criteria 2: Financial implications related to the conditions to feed electricity into the grid
- Criteria 3: Costs related to permitting requirements and grid access
- Criteria 4: Financial incentives including tariffs, tax reductions, other forms of investment support

While providing evidence for all EU28, Norway and Iceland, in some instances the analysis especially highlighted legal aspects of the more mature markets, where solar PV has developed more rapidly, compared to smaller markets with different regulatory environments. As explained above, this approach was also adopted in other tasks and therefore it was also part of the comparative approach by country of the entire study.

The first aim of the comparative legal analysis was to show if and how the existing legal frameworks across Europe regulate the definition of residential prosumers, in particular:

- If the definitions clearly include both generation and consumption
- If they refer to the generation capacity and/or the installation size

- If they specify the activity of feeding into the grid

Setting a clear scope of prosumers for this study was the basis to develop our evidence gathering and analysis under the other project tasks. We have already explained our scoping approach in the above section.

The second aim of the comparative legal analysis was the identification of the financial aspects regulated by law that might affect the choice to become residential prosumer across Europe. This also allowed us to develop the analytical approach of the other tasks and of the entire study, i.e. the assessment of financial and non-financial drivers of consumers' decision to self-generate electricity.

The financial drivers were then examined under all project tasks, in those dedicated to secondary data analysis as well as in those focusing on primary data collection. The role of incentives and investment supports in the future development of residential prosumers was in particular shown in the conclusion and recommendations of the chapter dedicated to the baseline and projection analysis.

The non-financial drivers were more specifically examined in the in-depth survey of residential prosumers and in the mystery shopping exercise, and were also factored into the design of the behavioural experiment.

The comparative legal analysis also shed light on the diversity and lack of uniformity of the regulatory frameworks across Europe, contributing to the study's conclusions and recommendations on the need for regulatory action that would lead to a truly EU-level policy for the development of residential prosumers.

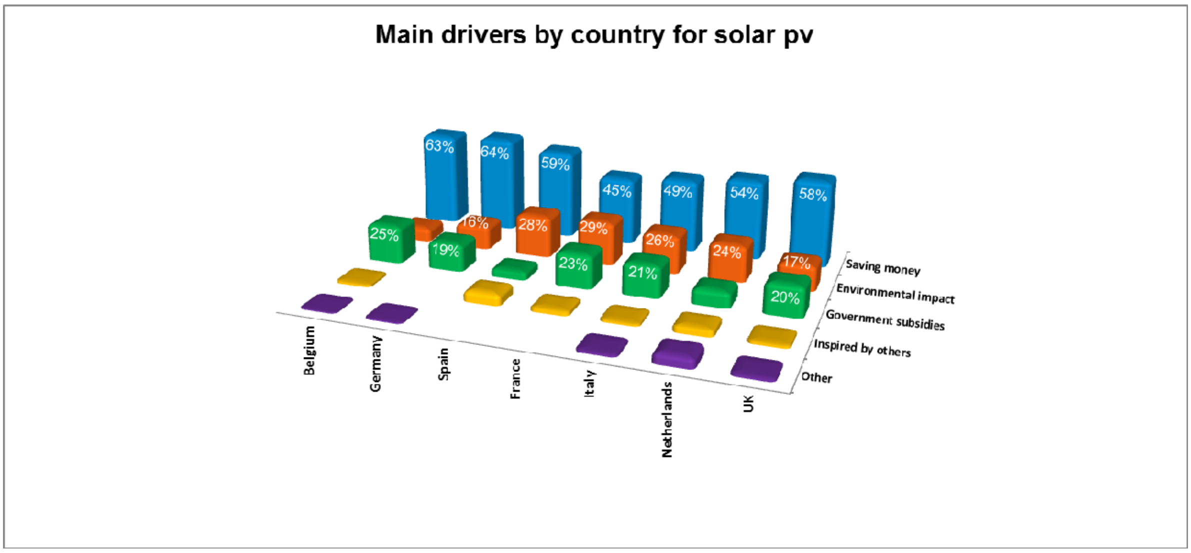
Data presentation matrix

Under Main Task 1 we developed a data presentation matrix to be used to show country-specific information based on the data collected in the entire study.

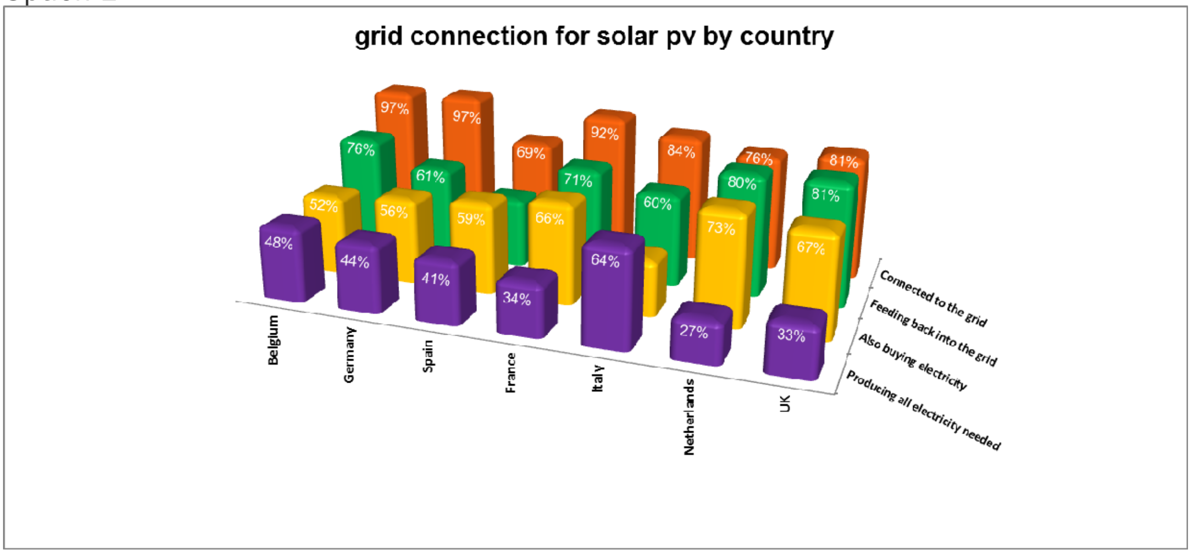
Here below we present two examples of data visualization by country and with a focus on solar PV technology.

Figure 5: Data presentation matrix

Option 1



Option 2



The above examples as well as other visualization options can be used to show various combinations of data gathered for each country covered in the study.

3.2.2 Main Task 2: In-depth residential prosumer survey

The methodology adopted to carry out the in-depth residential prosumers survey allowed us to collect a vast amount of data through online panels set up in all target countries, with the only exception of Iceland, where we were not able to build a panel of respondents. However, we do not consider this as being an indication of methodological weakness.

As explained here in the Background and further below in the survey-dedicated chapter, previous studies suggest that Iceland's wide adoption of renewable energy resources which already produce over 90% of the country's electricity, does not encourage the development of alternative self-generation. In addition, Iceland is mostly powered by hydro and geothermal, which apart from small-size hydro plants, would not be as suitable as solar PV for individual self-generation.

Once identified the sample size for each national panel, the fieldwork was conducted under stringent methodology and all preparatory and implementation steps were closely monitored.

The content of the survey questionnaire was developed together with the European Commission, so as to make sure that the study's requirements in terms of evidence to be gathered and analytical approach would be best met.

Once collected, data were analysed and findings presented in easy to read comparative tables. The analysis and comparative tables were developed in line with the analytical approach of the entire study, as illustrated under the methodology of Main Task 1. We focused on the following comparative angles:

- By country – all EU28 and Norway, adding the option of grouping countries into more mature markets and smaller ones
- By technology – as the main focus of the study was on solar PV, we organized data tables by comparing the different technologies, and in some case by highlighting only the answers given to different questions on solar PV
- By driver – we examined the evidence gathered by focusing on the financial and non-financial considerations affecting the residential self-generation choice, and we presented all responses by sub-groups under the two main categories of drivers

The survey primary data collected by applying this methodology were fed into the overall integrated analysis as explained above. They contributed to shed light, by country:

- On consumers' experience with the financial costs and benefits of their self-generation choice, as well as
- On the role of non-financial considerations such as environmental concerns, social perceptions, technology awareness, leading to their prosumer choice.

3.2.3 Main Task 3: Price collection and projections

The purpose of Main Task 3 was to model take-up of solar PV by households in each of the EU28, Norway and Iceland over the period to 2030, based on extensive data collection.

In the baseline projections, it was assumed that existing financial support for self-generation would continue. Future technology scenarios were developed to assess the impact of factors affecting cost and consumer preferences on take-up of solar PV.

Specifically, the scenarios assessed the impact of:

- A gradual phase out of policy support over the period to 2020
- Relaxation of EU anti-dumping legislation in 2017
- Growth in the number of households owning a plug-in electric vehicle

Modelling take-up of solar PV required consideration of the interaction between the financial and non-financial drivers of investment across all households, which are in different circumstances, facing different costs/benefits and with different preferences. By modelling the variation in financial and non-financial drivers of investment across the entire population, an estimate can be formed for the proportion of households for which solar PV is both cost-effective and desirable, given their underlying preferences.

The interaction of financial and non-financial drivers has been explained above, in the section dedicated to comparing drivers.

The methodological approach applied in Main Task 3 involved firstly estimating the total technical potential for solar PV in each EU Member State. As explained above, developing projections of take-up of solar PV required information about consumer preferences and the cost-effectiveness of investment and, in the next stage, the distribution of households according to these two criteria were derived. Then, for each year up to 2030, under specific assumptions about CAPEX and OPEX costs, policy support, future electricity prices and consumer preferences, we estimated the proportion of households for which investment is an attractive option. The share of investment that does take place relative to the share that is deemed attractive (according to the model calculations) is calculated based on the latest year of data available and is used to calibrate the model (accounting for other factors not captured within the model, such as imperfect information across households).

3.2.4 Main Task 4: Mystery shopping

The mystery shopping exercise aimed at investigating the experiences of consumers with becoming residential prosumers, or in other words with the transition to residential self-consumption and its different options: maintaining the connection to the grid (and feeding back or not the electricity into it) or disconnecting from the grid.

The requirement of the ToR was to carry out this exercise in at least 8 selected countries, with a mix of bigger and smaller markets and a distributed coverage of the geographic regions of Europe. Since the exercise focus was on solar PV technology, to gather meaningful results we chose among the more mature markets, i.e. those countries where solar PV has spread more rapidly also thanks to the incentivizing policies that were put in place in the past years and in some cases are not available any longer[32]. Besides, we also added to the selection a number of countries with smaller markets, and we also ensured that we in the end covered all four European geographic regions (North, West, South and East).

The exercise was carried out following a strict methodology for fieldwork, both in the preparation and in the implementation phase.

Before launching fieldwork, the selection and preparation of the mystery shoppers was conducted to ensure that they met the training requirements and possessed the right skills. Meanwhile, the questionnaire and the assessment sheet were developed, then they were validated by the European Commission to make sure that they fully met the requirements in terms of objectives and that they fully reflected the analytical angle of the study, as illustrated in the above section dedicated to Main Task 1. Results gathered via the mystery shopping exercise fed into the overall analysis particularly as they contributed first-hand consumers' perspective on the following topics of the study:

- Costs and procedure to become prosumer – a financial consideration affecting their choice
- Pros and cons in interacting with and/or switching energy supplier
- Consumer experience with the (lack of) comprehensive information and satisfactory assistance offered by the energy supplier: a non–financial driver affecting the choice to become prosumer (first-hand findings here added to the evidence gathered via the survey)

[32] Renewables 2016 Global Status Report, Ren21, http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf

- Consumer experience with the energy supplier's feedback on costs of and procedures for installing solar PV – also a possible financial consideration in the choice to become prosumer
- Consumer experience with the energy supplier's feedback on feeding self-generated electricity into the grid

Findings were presented, similarly to those of the survey in easy-to-read tables, which can be found in annex to this report.

Finally, as part of the methodology, it was decided to conduct the mystery shopping exercise through phone calls rather than via visits in person. This approach was chosen because it was considered that most of the energy suppliers normally offer information service to their vast numbers of customers not in their office premises. However, in a number of cases mystery shoppers reported that they were unable to even reach out to an operator answering the energy supplier's client service phone, and therefore were not able to conduct the exercise. This methodological issue was solved, as it is foreseen in mystery shopping that some so-called "location issues" might arise. Details are provided in this report's dedicated chapter.

3.2.5 Main Task 5: Behavioural experiment

This task consisted of the design of a behavioural experiment without actual data collection, aimed at:

- Assessing the abilities and skills of traditional consumers to understand the offers for transitioning towards residential self-generation and storage
- Gaining insight into how traditional consumers can make the best choice regarding self-generation with solar PV panels
- Gaining insight into how easy or difficult it is for traditional consumers to find and assess information on self-generation and storage (and how much information can be digested)

The behavioural experiment design consisted of two parts: experimental and post-experimental survey.

The experimental part focuses on how consumers choose solar panels and whether these choices are influenced by the way in which the information is presented (structured vs. unstructured). This already provides some insight into how easy or difficult the decision to become prosumer is for consumers and identifies the most important product characteristics for consumers. The post-experimental survey measures barriers and drivers in the decision-making process, including consumers' beliefs (e.g., cost/benefit beliefs).

4 Comparative legal analysis of the national frameworks for residential prosumers in the EU28, Norway and Iceland

In this chapter, we provide a comparative analysis of the legal and regulatory frameworks supporting residential prosumers in the development of successful renewable energy systems (or RES) projects across Europe.

As explained in the Background chapter, the term "prosumers" broadly refers to energy consumers who also produce their own energy from a range of different onsite generators. The focus of this study is primarily on residential prosumers using systems such as small-scale solar PV to generate electricity.

Residential prosumers are considered to be regular households that consume and produce their own energy, through the likes of small-scale PV systems. Some studies have also recently suggested that a more robust definition of electricity prosumers would incorporate elements such as the ability to react to dynamic pricing, the use of demand response, and integration with smart grid infrastructure[33].

However, as our comparative analysis shows, a common definition of prosumers that at least incorporates, basic elements such as self-production and self-consumption, or generation capacity "caps", is still missing due to the widely different approaches adopted by various EU Member States.

The active participation of consumers in the energy market can be greatly stimulated by adopting adequate legislation and best practices. The electricity market offers consumers the possibility of participating actively in the European Union's energy transition. This requires a fundamental change in the role of the consumer on the electricity market[34]. The European Commission has prepared new legislation in this field under the above-mentioned Clean Energy package[35], including the Commission Communication on Clean Energy for All Europeans[36] or the new Renewable Energy Directive for the period after 2020. The latter aims to facilitate the transition of energy consumers to energy prosumers by enabling them to self-consume without undue restrictions, access necessary information and be remunerated for the electricity they feed into the grid[37].

It recognises that while the implementation of the EU's ambitious Paris climate change Agreement depends, to a large extent, on the successful transition to a clean energy system, consumers should benefit from increased access to more secure, clean, and competitive energy. The Commission proposes to reform the energy market to empower consumers and enable them to be more in control of their choices when it comes to

[33] Bremdal, A Prosumer Oriented Business in the Energy Market, 2011. IMPROSUME Publication

[34] Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. Communications (2015) 340 final

[35] https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition.

[36] Commission Communication on Clean Energy For All Europeans, COM (2016) 860 final, 30.11.2016

[37] Art 21-Article 24 of the proposal for a Directive on the promotion of the use of energy from renewable sources (recast) COM (2016) 767 final/2 23.2.2017

energy. For citizens, it means better information, possibilities to become more active on the energy market, and to be more in control of their energy costs[38].

4.1 Methodological approach of the comparative legal analysis

Our analysis has been carried out on the basis of the information gathered through two main methodological tools:

- National-level country reports, prepared in the first phase of the project and covering the EU28, Norway and Iceland. While all national reports have been taken into account, in some cases our legal analysis further focused on the reports of selected key countries, where the market for solar PV is already more mature, in line with the analytical angle of the entire study. These countries are: Belgium, The Netherlands, France, Germany, Italy, Spain and the UK. In addition, a second group of countries have been further identified for a more focused analysis, as they were considered a future potential growing market. They are mostly located in Eastern Europe, therefore an entire geographic coverage can be ensured. They are: Hungary, Poland, Croatia, Slovenia, Czech Republic, Bulgaria, Slovakia and Portugal. The national reports mapped the legal and regulatory framework by country, through a harmonised set of questions that made results comparable.

- National-level country fiches summarising the key findings of the country reports and including an expert assessment ranking the level of favourable conditions for the take-up of prosumers, also based on specific harmonised criteria.

The results arising from our comparative analysis present the key findings of the national regulatory frameworks highlighting the approaches to the definition of prosumers, the financial implications of the use of the electricity produced and/or fed to the grid, the use of incentives (including taxes), the costs for permitting, grid access, and network charges. The approach adopted for the completion of each of these steps is briefly described below.

3.1.1 Approach to the national reports and country fiches

The country reports presented the legal and regulatory framework regarding the conditions applied to residential prosumers of electricity from RES sources, covering all stages from installation to generation, consumption, metering, billing and feeding of the electricity into the grid. They were based on a standardised template, to ensure comparability of data, prepared by Milieu Ltd in consultation with the European Commission.

The template included guidelines with basic information on the Union Energy policy related to prosumers, the objectives of the project and of the specific national report. It provided a questionnaire to collect information on the legal and regulatory basis at national level covering the following issues:

1. Clear definition of residential prosumers;
2. Clear allocation of responsibilities to specific competent bodies on issues affecting prosumers;
3. Permitting requirements for prosumer installations, namely permits, application fees and one-off costs;
4. Conditions to sell or feed the electricity produced in surplus;

[38] Commission Communication on Clean Energy For All Europeans, COM (2016) 860 final, 30.11.2016

5. Grid access: principles and rules applied to prosumers, network costs and charges;
6. Rules for the use of metering systems and billing;
7. Financial incentives including taxes or tariffs;
8. Barriers;
9. Legal framework recognising legal entity for the establishment of energy communities and particularly energy cooperatives;
10. Complaint procedures.

The analysis in each country report aimed at comparing the systems, measures and methods applied to them and providing insight on the most beneficial systems and methods from the residential prosumer's point of view. Findings were then fed into the overall analysis of the entire study, where we examined the financial and non-financial considerations affecting the self-generation choice.

At the project's inception phase, several pilot country reports were developed covering five Member States (Cyprus, France, Finland, Croatia, Slovakia), to test the methodology and template and to provide the national experts with concrete examples as to better understand the guidelines and structure to follow for their national research.

The country reports were based on desk research, supplemented with information from interviews of key national stakeholders, when necessary. The national-level desk research was conducted by the national experts who, in addition to reviewing relevant legislation, referred to:

- EU policy documents, such as the "Clean Energy Package" of November 2016 including the Commission Communication on Clean Energy For All Europeans[39]; or the previously adopted Framework Strategy for Resilient Energy Union with a Forward-Looking Climate Change Policy (2015)[40] or the report from IEA-RETD Residential Prosumers – Drivers and Policy Options[41];
- Other non-scientific sources, such as publications by EU consumer organisations;
- Academic and legal literature at national level including comparative analysis.

In order to complement the findings of the national research and gather more practical data and information, most national experts interviewed key stakeholders selected on the basis of the specific situation of the Member States and of the type of information needed according to the results of the desk research. The full list of national experts is available upon request. The findings of the national reports were then summarised in the country fiches, assessing the measures in place in each country according to their favourable impact on prosumers. The national experts applied common criteria to the assessment, as provided for in the guidance and template document.

3.1.2 Criteria of the comparative legal analysis

The country reports showed the diversity of the existing legal and regulatory measures across the EU28, Norway and Iceland. The comparative legal analysis was based on the identification of the most relevant criteria evidencing areas for future development under the EU's energy policy. The following criteria were chosen:

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[39] Commission Communication on Clean Energy For All Europeans, COM (2016) 860 final, 30.11.2016
[40] Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. Communications (2015) 340 final
[41] Residential Prosumers – Drivers and Policy Options, IEA-RETD, September 2014. http://iea-retd.org/wp-content/uploads/2014/09/RE-PROSUMERS_IEA-RETD_2014.pdf

- Criteria 1: Definition of residential prosumers and indicators used to reflect the concept of small installations/micro-generation (caps);
- Criteria 2: Financial implications related to the conditions to feed and sell electricity into the grid;
- Criteria 3: Costs related to permitting requirements (application of fees and one-off costs) and grid access (network costs and charges);
- Criteria 4: Financial incentives including tariffs, tax reductions, other forms of investment support.

This chapter illustrates, in detail, the results under each of the selected criteria and finally draws conclusions on the legal comparative analysis with recommendations in relation to the development/review of the legal framework.

4.2 Comparative legal analysis

4.2.1 Criteria 1: Definition of residential prosumers

EU level legislation for the energy sector does not define residential prosumers. The term "prosumer" is a contraption of "producer" and "consumer". In this context, the term is used to define energy consumers who also produce their own energy from a range of different onsite generators; mainly from renewable energy sources.

The European Parliament has called for a common EU definition of prosumers. The European Economic and Social Committee also called for the European Commission to draw up a framework definition of prosumers covering essential common elements, such as the size of the installation, individual and collective power generation, ownership of the installation and the issue of power generation surpluses[42].

The "Clean Energy Package", presented on 30 November 2016, partly responds to these requests. The proposal for a Directive on common rules for the internal market in electricity[43] contains a definition of "household customer" who purchases electricity for his own household consumption, excluding commercial or professional activities. In addition, it provides for a definition of "active consumers" meaning individual customers or groups of jointly acting customers who consume, store or sell electricity generated on their premises, including through aggregators, or participate in demand response or energy efficiency schemes, provided that these do not constitute their primary commercial or professional activities. These definitions have also been taken into account in the analysis carried out by our country experts while drafting the national reports.

Additionally, the EPRS Briefing of November 2016 also defined prosumers as the energy consumers producing partly or fully the energy they consume[44] from a range of different onsite generators, among others photovoltaic systems[45].

- Methodology

[42] Opinion on Prosumer Energy and prosumer Power Cooperatives, EEXC, October 2016
[43] Proposal for a Directive on common rules for the internal market in electricity, COM (2016) 864 final, 30.11.2016
[44] See technical proposal, p. 43
[45] See tender specifications, p. 3

Based on the national reports, we proceeded to compare the situation in the different Member States when defining residential prosumers as follows:

Firstly, we analysed whether there was a definition of residential prosumers and/or of prosumers in the national regulatory framework and whether that definition was included in specific provisions of the legal and regulatory framework or, on the contrary, it was part of the private sector code (legal basis for the definition).

We then analysed the type of definition based on two main indicators:

- whether a greater weight is given to the concept of generation or to the concept of consumption
- whether it referred to the capacity of power generation and to the installation size (known as the capacity cap)

This section aims to present the measures adopted by the different countries to define the concept of residential prosumer. The section assumes that a clear definition in the legal system could have a favourable impact in the development of residential prosumers. Given that there is no recognised baseline definition of residential prosumers, our methodology is based on the existence of a definition in the national legislation or not. It is assumed that when the definition of "residential prosumers" is provided in their laws, the countries' regulatory frameworks have a favourable impact on the development of prosumers. In addition, as none of the Member States has defined the concept of residential prosumer, the equivalent concepts used in the legislation are presented. However, no comparative assessment is possible in relation to the impact of each equivalent concept used in each of the national legal frameworks.

- Legal basis for the definition of residential prosumers

None of the countries analysed include a regulatory definition of the specific term residential prosumers and none of them have a piece of legislation to specifically fully regulate prosumers.

Several Member States include a reference to the residential aspect in the definition. The Lithuanian legislation on RES, for example, defines 'household consumer' as the consumer that produces energy for their household needs (residential prosumers) or the needs of their economic activity. This is similar to the definition contained in the proposal for a Directive on common rules for the internal market in electricity[46] which contains a definition of 'household customer'. In Hungary, the legislation refers to "household power plant" which incorporates the residential aspect through the reference to household but it does not include a reference to the consumer element of the term prosumer. The definition is linked to the production of electricity by a micro power plant, which we develop further below.

Several countries such as Norway and Poland, use the term "prosumer" in their legal and regulatory framework. Poland introduced an amendment to the RES law in 2016 and Norway has adopted new legislation in 2017 to define prosumers as end-users with consumption and production behind the connection point. However, the vast majority of countries use equivalent concepts in their legal or regulatory framework such as self-

[46] Proposal for a Directive on common rules for the internal market in electricity, COM (2016) 864 final, 30.11.2016

consumption or auto-consumption, self-production, self-supplier or autonomous producer. In Romania, the legislation refers to active consumer.

While most countries covered in the study define and regulate prosumers under different types of legislation, few of them do not have any legally binding definition. Belgium-Flemish Region, Ireland and Romania only have definitions developed by the energy distributor or system operator in private codes that do not have any legally binging character. Romanian legislation defines active consumers under the recently adopted national Energy Strategy.

None of the countries analysed have a piece of legislation specific to prosumers. Most of them have introduced provisions in existing legislation regulating Electricity Sector or RES to define prosumers and/or to regulate those aspects that are specific to prosumers. For example, the respective definitions are included in the RES legislation in countries such as Austria, Germany and Croatia. Austria defines it in the Green Power Act, Germany in the German Renewable Energy Act, and Croatia defines the concept of prosumer under the Act on Renewable Energy Sources and High Efficient Cogeneration, even though it has similar definitions under general Electric sector legislation. However, other countries such as France, The Netherlands, Latvia, Slovakia, Sweden or the UK define and regulate prosumers in general Energy or Electricity law. Others, such as Lithuania, use both laws, which include the definition in both the RES law and Energy law. Likewise, Spain has introduced a specific provision in the Law of the Electric Sector to define self-consumption but regulates it through new provisions in the Law on Renewable Energy. Similarly, in Greece, the definition and regulatory measures on prosumers are found in the Ministerial Decision establishing the Special Programme promoting PV systems on buildings, especially on lofts and rooftops and the Ministerial Decision on installation of RES units by self-producers with energy offsetting which are implementing measures of the existing RES Law 3468/2006, or the new Law 4414/2016 establishing a New support scheme for renewable energy system and cogeneration power plants.

- Definition of residential prosumers

As explained above, after carrying out the analysis of the legal basis for the definition of prosumers, we then analysed the type of definition based on the following indicators:

- Whether a greater weight is given to the concept of generation or to the concept of consumption;
- Whether it referred to the capacity of power generation and to the installation size (known as the capacity cap).

Each indicator is addressed separately here below.

1st indicator: the generation and consumption elements

The first indicator aims to present those Member States that define the concept in relation to their consumption or production aspect. There is no qualitative judgement on each of the approaches taken because, as the analysis shows, it does not have any consequences on the quality of the support system to prosumers.

Some of the countries analysed refer to self-consumption or auto-consumption (Austria, Bulgaria, Denmark, Spain, France, Lithuania, The Netherlands and Portugal). In Austria, self-consumption is defined in opposition to other uses 'electric energy produced by a plant which is not fed into the public network' and in Bulgaria it is the 'energy for self-consumption'. In Portugal, self-consumers are defined in relation to renewable energy as the persons who produce energy through renewable sources for self-consumption. The

Spanish definition of self-consumption is interesting because it combines the three elements of consumption, production and connection to the grid and refers to 'consumption of electric energy from generation installations that belong to the consumer or from installations that are connected to the consumer through a direct line of electric energy connected to the grid'. In France, the key defining element seems to be the ownership of the installation and the fact that the self-consumer, as a producer, consumes for himself all or part of the electricity produced by his facility. Similarly, Denmark refers to 'consumer installation'. Additionally, whilst in The Netherlands the self-consumer is related to renewable energy, in France the production does not necessarily need to be from renewable sources. The French legislation distinguishes between individual and collective self-consumption. However, cooperatives are excluded from the definition of collective self-consumption. Lithuania defines it as household consumers, or as public or financial institutions, that produce electricity from renewable energy resources for their own needs and/or performance of economic activity and that have a right to supply unused electricity into electricity networks under the Law on RES.

In several Member States (Belgium-Wallonia, Cyprus, Greece, Italy, Latvia and Luxembourg), the term self-producer is generally defined as the 'physical or legal person producing electricity mainly for its own use'. Greece's Law 3468/2006 specifies this general definition requiring the producer to generate power from RES or HECHP units, mainly for their own use and channel any surplus power into the grid. The Italian legislation provides a definition of self-producer covering not only residential prosumers, but also other types such as energy communities or industrial prosumers and defines it as 'the natural or legal persons who produce electricity and use it for no less than 70% a year for their own use or for the use of the company subsidiaries, as well as for use of members of electricity production and distribution cooperatives referred to in Article 4, number 8 of law 6 December 1962, n. 1643, for members of the consortia formed for the production of electricity from renewable energy sources and for the supply authorized uses in industrial sites prior to the effective date of this decree'. Latvia defines an autonomous producer as a merchant, energy supply merchant or a natural person generating electricity, heat or cooling energy required for their own consumption or for local heating or cooling purposes. In Germany and Slovenia, the term used is self-supplier; in Slovenia, the term is understood as owner of an installation for the self-supply of electric energy from renewable sources of energy. In Germany, self-supply is not related to electricity from renewable energy sources and is defined in opposition to the energy fed into the grid. According to the German Renewable Energy Act, self-supply means the consumption of electricity which a natural or legal person consumes for him/herself in the immediate vicinity of the electricity-generating installation which is operated by him/her and where the electricity is not fed into a grid. In Croatia, the equivalent term to prosumer includes both aspects, consumption and production, and refers to an "end consumer with its own production". Similarly, in Norway, prosumers are end-users with consumption and production behind the connection point. Likewise, the definition of prosumers in Poland, as adopted in 2016, under the amendment to the RES law, covers the final recipients of electric energy on the basis of a comprehensive agreement, who produce electric energy only from renewable energy sources in a micro-installation in order to use it for their own purposes and are not associated with their business activity.

In Romania, the legislation refers to active consumers who are defined as an energy consumer who is also an energy producer, who is able to optimize the time of consumption by injecting energy from production into the network in accordance with the instant price of energy which can alter the load curve flattening the tips and filling the gaps. The legislation also refers to final consumers of energy who produce electricity at their place of consumption by using small power generation units such as wind, photovoltaic, diesel, natural gas in cogeneration, hydro, etc.

Several of those countries that define prosumers in relation to their production element, refer to the installation size or generation capacity. Prosumers are related to small scale generation of electricity, for example, Hungary defines a 'household power plant' as a 'micro power plant connected to a low-voltage system'. Ireland and the UK refer to "micro-generation". Similar terms used are "micro-source" (Czech Republic), "micro-producers" (Estonia), "small-scale production" (Finland), "small-scale electric power plants" (Iceland), and "small source for generation of renewable electricity" (Slovakia). Other Member States, such as Spain, use the generation capacity to determine the legal conditions and requirements to be applied to residential consumers, versus those registered as producers, in terms of their economic activity or other type of consumers.

2nd indicator: the maximum generation capacity of the prosumer's installation

Several Member States define residential prosumers in relation to the size or the capacity of the installation by stating that it has to be small. We have grouped the countries based on similar generation caps.

Several Member States define residential prosumers in relation to the size or the power capacity of the installation. For example, Ireland defines micro-generation as a source of electrical energy that operates in parallel to the Energy distributor (ESB Networks) and is rated up to and including 6kW at low voltage (230 Volt) when the grid connection is single phase and 11kW at low voltage when the grid connection is three-phase. In Poland, a micro-installation is a renewable energy source installation with a total installed capacity of not more than 40kW connected to the grid of rated voltage of less than 110 kV or with generating capacity of combined heat greater than 120 kW but not bigger than 600 kW.

In the UK, microgeneration is the generation of electricity of up to 50kW and/or 45kW of heat from a low-carbon source. A similar cap is used in other countries such as in Sweden, which applies different legal conditions to micro-production and the Electricity Act defines small generation installation as those producing electricity with a capacity of up to 43.5 kW and which do not need to pay a charge for feeding electricity into the grid; they have to subscribe to a fuse of 63 amperes. Furthermore, the Energy Tax Act establishes that the energy tax does not apply to installations with generation capacity below 50 kW or to a legal person who owns an installation with generation capacity of less than 50kW that has not been fed into the grid.

In Denmark, the installations that can benefit from net settlement include domestic small wind turbines of 25 kW or less, PV solar panels of 50 kW output or less and CHP of 11kW or less. In Estonia, the definition of micro-producer includes residential prosumers and refers to a single-phase installation with a maximum nominal capacity of 3.68 kW or a triple-phase installation with a maximum nominal capacity of 11kW. In Finland, there is a distinction between small scale production and micro-scale production. A small-scale production relates to a power plant or a consortium of power plants whose nominal output is a maximum of 2 MW and micro-scale production relates to a power plant with a maximum of 50 KW that has been connected to a low-voltage network close to the consumer of the electricity and whose primary purpose is to produce electricity to the consumer. In Hungary, the household power plant is defined as a micro power plant connected to a low-voltage system with an interconnection capacity of less than 50 kV at a connection point.

Several countries use a capacity of 100kW as the cap for defining residential prosumers. Spain differentiates between 2 types of self-consumption or prosumers: Type-1 are non-entrepreneurial consumers with a generator destined to their self-consumption and connected to their own internal network and which are not registered as production installation regarding their economic activity. They also include low power installations under 100 kW. Type 2 prosumers are those consumers of energy associated to a production installation duly registered as an economic activity of electricity producers and connected to their internal network or connected to the grid through a direct line with the production installation. This can cover installations under and over 100 kW capable of generating an amount equal or lower than the additional power used (?) by the consumer. Norway's new legislation uses a similar parameter, stating that prosumers are end-users with consumption and production behind the connection point, where the input power (electricity fed into the grid) at the connection point shall never exceed 100kW. The amendment to the RES Law in Romania defines active prosumers as the natural and legal persons who hold units of electricity production from renewable sources with installed capacity below 100 kW per place of consumption. Similarly, in Iceland a "small-scale electric power plants" is an electricity power plant with a rated capacity of under 1MW, unless the energy produced is sold or transmitted into an electricity supply system. Similarly, the power plant would be considered a micro-power plant when it has a rated capacity below 100 kW.

Another group of countries use the 10kW capacity as the measurement to define residential prosumers. For example, in Lithuania residential prosumers are limited to an installed generation capacity of up to 10kW from renewable energy sources. Similarly, the Slovakia Energy Act defines a 'small source for generation of renewable electricity' intended primarily for self-consumption as a source with the generation capacity of up to 10kW. The Flemish system operator considers that a prosumer is the user of the electricity distribution network with an access point for usage from the low-voltage grid and with a decentralised production unit with an AC power less than or equal to 10 kW. Similarly, Czech legislation considers that a micro-source of electricity is an installation linked to the distribution system of low voltage with phase rated AC current up to 16 Amperes per phase including a maximum total installed capacity up to 10 kW (non-entrepreneurs).

In Malta, producers with 16 Amps per phase, single-phase or multi-phase, 230/400V AC solely from renewable sources of energy or cogeneration plant, are exempt from the requirement of an authorisation to construct the generation station and from the requirement to hold a licence.

In Slovenia, the maximum rated power of the household consumer installation must not exceed 11kW and must not exceed the connection power allowed for the building which it supplies. The household customer is the consumer owning the installation supplying the electricity from renewable sources for its own household consumption, in contrast to the consumption for performing commercial or professional activities for which the maximum connection power is less than 41 kW.

Portugal differentiates between 4 types of prosumers, with different legal and regulatory requirements and conditions applied based on the capacity to generate energy. The different types are: Less than 200 W; between 200 W and 1.5 kW, between 1.5 kW and 1MW or more than 1MW. The Netherlands considers that self-consumption implies a connection to the grid and a total transmission value of 3*80 Amperes.

The following table summarises the situation regarding the three elements of the definition of residential prosumers in the different countries covered by the study.

Table 1. Definition of residential prosumers (Source: own development)

Country	Legal basis	Generation/ consumption	Power Capacity cap reference
AT	In legislation	Self-consumption	
BE[W]	In legislation	Self-producer	
BE[F]	No legislation	No legal definition	<= 10 kW
BG	In legislation	Self-consumption	
CY	In legislation	Self-producer	
CZ	In legislation	Micro source	<= 10 kW non-entrepreneurs
DE	In legislation	Self-supplier	
DK	In legislation	Consumer installation	50 kW PV panels, 11 kW CHP
EE	In legislation	Microproducers	Max 3.68 kW (single phase) and 11 kW (triple phase)
EL	In legislation	Self-producer	10 kWp and 5 kWp for the NIIs
ES	In legislation	Self-consumption	Low power installations <100 kW
FI	In legislation	Small scale production	2MW Nominal output
	In legislation	Micro scale production	Max 50 kW
FR	In legislation	Self-consumption	100 kW
HU	In legislation	Micro power plan	50 kW interconnection capacity
HR	In legislation	End-user	
IE	No legislation	Microgeneration No legal definition	6kW at 230 Volt (single phased) 11 kW- low voltage (three phased)
IS	In legislation	Small scale power plant	Rated capacity <= 1MW
		Micro-power plant	<= 100 kW
IT	In legislation	Self-producer	
LI	In legislation	Household consumer	<= 10 kW
LU	In legislation	Self-producer	
LV	In legislation	Self-producer	
MT	No legislation	No definition	Generation capacity of less than 1500 kVA; 16 Amps per phase.
NL	In legislation	Self-consumption	3*80 ampere
NO	In legislation	End-user	<= 100 kW
PO	In legislation	Prosumer	40kW connected to grid; rated voltage up to 110 kW
PT	In legislation	Self-consumption	200 W; 200 W- 1.5 kW or 1.5 kW-1 mW or > 1 mW
RO	No legislation	Active consumer No definition in legislation	<= 100 kW
SI	In legislation	Self-supplier	11 kW and <= connection power
SK	In legislation	Small source of RES energy	<= 10 kW
SW	In legislation	Small generation installation	>=43.5 kW fuse 63 ampere; < 50 kW no energy tax
UK	In legislation	Micro-production	50 kW / 45 kW

4.2.2 Criteria 2: Financial implications related to the conditions to feed electricity into the grid

- Methodology

The definition of residential prosumers entails several key elements, including whether the electricity generated is used for consumption and/or for feeding into the grid. Most Member States incentivise prosumers by granting them, under specific legal provisions, the possibility to feed the surplus electricity generated back to the grid and obtain financial compensation through, for example, the likes of a net metering system. Some Member States allow residential prosumers to sell the electricity in excess to the grid at specific tariff prices. However, there are countries which do not provide any framework for prosumers to benefit from economic compensation for the electricity fed into the grid. In the sub-section below, we present the different options and the countries aligning to each of them.

The comparative analysis of this criterion is based on the examination of the legal framework in 18 selected Member States, in order to inform the economic and behavioural assessment of this study, while ensuring its basic consistency. Those countries are Austria, Belgium, Germany, Denmark, Spain, France, Italy, The Netherlands, the UK as key countries and Bulgaria, Czech Republic, Greece, Croatia, Hungary, Poland, Portugal, Slovenia, and Slovakia as potential markets. At the end of the section the situation is summarised through a table presenting the three different options according to their impact on the uptake of residential prosumers.

- Comparative of the financial implications for the prosumer related to the selling or feeding electricity produced

The majority of the countries refer to residential prosumers in relation to the use given to the electricity generated: consumption versus feeding it into the grid. In most cases, both uses are possible, but in some countries, prosumers are not allowed to receive any economic or financial benefit from the electricity fed to the grid. There are three different systems in EU Member States: some systems enable prosumers to feed the electricity to the grid but only if it is done for free, others offer prosumers regular compensation for their surplus electricity through a reduction in their energy bills, whilst some systems establish a financial retribution at a price of the electricity sold.

No financial retribution/compensation

The system of some of the selected countries does not allow prosumers to feed the energy surplus to the grid or to the distributor, or allows in but does not offer remuneration. In Slovakia, residential (non-entrepreneurs) prosumers may feed the electricity not consumed into the grid but do not receive payment for it. While the prosumer may receive a statement from the distribution systems operator acknowledging a reserved capacity, it can also request the prosumer to limit the generation of electricity in case the DSO cannot accept any more into the grid. Energy consumers generating as entrepreneurs are granted the capacity to be paid for the electricity generated and fed into the grid. They can enter into a contractual relationship with the distribution companies which agree to purchase electricity from renewable energy sources but only to cover distribution losses. Under certain conditions, distribution companies may be obliged to buy power that they do not require and resell it at market prices. The IEA recommended that Slovakia, as early as 2012, reassess its system. Currently, the distribution companies are unwilling to accept and pay for new electricity generated by prosumers. Similarly, in Spain, the type 1 installations (which are those assimilated to residential prosumers) do not have the possibility of getting compensation for the electricity discharged to the grid. The type 2 installations, or entrepreneurial prosumers, receive compensation for the electricity discharged to the grid as measured through the metering system of the installation. In Norway, prosumers are exempt from paying grid tariffs for feed-in electricity into the grid (similar to the Type-1 prosumer in Spain). In Slovenia prosumers are not reimbursed for the electricity that they produce in surplus and no Feed-in Tariff system is applied.

Croatia recognises three types of prosumers generating electricity from RES: prosumers not connected to the grid; those connected to the grid but without technical capacity to draw and feed the electricity from and into the grid; connected to the grid and with technical capacity to draw and feed the electricity from and into the grid. Those not connected to the grid cannot benefit from the specific tariff for the electricity that they feed into the grid, based on a special metering system for calculating the net electricity fed into the grid and the electricity drawn from the grid.

Compensation

In other countries, the metering system does not enable any remuneration to the residential prosumer, but provides for a compensation scheme between the excess of electricity generated and fed into the grid and the electricity purchased in other periods where the needs for electricity might be greater.

In Belgium, in both the Flemish and Walloon regions, there is no reimbursement for electricity produced in surplus. The prosumer can consume part of the electricity produced and the net surplus is automatically fed into the distribution network. The electricity meter provided by the electricity distributor deducts the electricity injected to the grid automatically and this is taken into account in the final invoice from the energy supplier. The compensation system in the Walloon regions enables a self-producer of green energy, with an installation of 10kW or less, to benefit from a compensation for the difference between the electricity drawn from the network and that injected into it. The compensation enables the prosumer to deduct the electricity fed into the grid from the energy consumption.

Prosumers in Denmark are able to sell electricity back to the national grid provided they have requested (and obtained) the net settlement to Energinet.dk. This leads to a compensation mechanism whereby the value of the energy fed back into the national grid is deducted from the cost of electricity taken from the grid by the prosumer.

In Greece, the Law 4001/2011 defines self-producer as a producer who generates power, mainly for their own use, and channels any surplus into the transmission or distribution system. The law 3468/2006 enables energy offsetting or compensating through the clearing of the power generated from a self-producer's installation with the energy consumed in a different installation of the same self-producer if it is located in the same or adjacent spaces. The net metering scheme provides that the electricity produced in small plants by self-producers is netted with the energy consumed. The netting is calculated in the clearing electricity bills issued by the electricity provider on the basis of the metering data provided by Hellenic Electricity Distribution Network Operator (DEDDIE). The energy surplus is carried throughout the monthly bills and at the end of the year; the surplus is fed into the grid without any compensation. Similarly, in Latvia, when the household transfers energy to the power grid, the amount is deducted from the invoice that the household receives for the next billable month. This is possible due to the use of the net settlement system based on a metering system that allows for net accounting of the electricity transferred and used. Slovenia's system is also based on offsetting measures of the electricity produced with the electricity provided by the distributor. There is no remuneration to the prosumer for the excess production. The prosumer does not sell the surplus electricity to the retail company. The amount of electricity fed into the grid can be used at a later stage, when the prosumer's self-supply does not meet its own demand. If, at the end of the billing period (calendar year), the net balance shows that the prosumer consumed more energy than they produced, the retail company will bill for the net difference. Similarly, residential prosumers in Lithuania participate in net-metering scheme and can supply the energy not used into the electricity network.

In The Netherlands, the prosumer may feed renewable energy into the grid and are, therefore, subject to billing conditions which must compensate the consumer for any surplus energy. The Electricity Act of The Netherlands sets out residential prosumers' rights; prosumers may feed self-produced electricity to the grid and receive compensation from energy suppliers determined on the basis of the net metering scheme data. Grid operators have to provide a contract to producers feeding electricity to the grid. The net metering system enables prosumers to pay only for the electricity they consume, including taxes. The energy bill indicates how much energy the prosumer has produced and how much energy the supplier has delivered. The difference is the net consumed which the supplier will invoice for. The conditions for participation in the net metering system are that the electricity has to be supplied and fed into the same connection and that the prosumer can be qualified as small user, with a connection of maximum 3*80 Ampere.

Remuneration/Capacity to sell the electricity

In other countries the legal framework is set up so that prosumers are remunerated or have the capacity to sell the surplus electricity that is fed to the grid.

In Austria, self-consumption is defined in relation to the electricity that is not fed into the public network. However, this does not mean that the surplus cannot be fed into the grid. The electricity that is fed into the grid in Austria is reimbursed by the Green Energy Handling Authority (OeMAG) on the basis of pre-determined tariffs for a guaranteed period of time (13 to 15 years) and it is VAT exempt up to an annual household income of 30,000 Euros.

In Bulgaria, the electricity fed into the grid can be sold at preferential prices (guaranteed price through a Feed-in Tariff) applied to energy from renewable sources which are of 130.6 Euros per MWh from PV installations with capacity up to 5kW installed on rooftops and facades, and 109.4 Euros per MWh for PV installations between 5kW and 30kW capacity installed on rooftops and facades.

In the Czech Republic, the definition of prosumers is based on whether the surplus of energy generated by the micro source of up to 10kW is fully consumed or partially fed and sold back to the grid. In 2014, the Czech Republic abolished the existing feed in tariff system. However, the ability for prosumers to feed electricity into the grid was introduced in 2016, when it was recognised that the income from feeding the surplus of electricity from installations without licence is not considered to be a business income. The surplus of energy generated by the micro/small sources can be fed to the grid and sold only if there is a contract on an annual discount regulating the contributions to the grid. If those contractual provisions exist, small PV sources of electricity up to 10kW may feed and sell the surplus electricity to the grid[47]. The price of the electricity fed to the grid is not regulated (as the Feed-in Tariff policy was phased out in 2014) and must be negotiated with the distribution company. However, in practice, this is rarely used. Similarly, in Hungary residential prosumers can sell the electricity not used on their own request and on the basis of a contract with the DSO. In Denmark, the excess energy not

[47] https://www.finance.cz/477630-vykup-fotovoltaicke-elektriny/

settled may also be sold and the price will be determined by agreement with a supplier based on the market price, which is dependent upon the time of sale and the current demand on the national grid.

Residential prosumers in Croatia may feed and sell the electricity into the grid if they are connected to it and have the technical capacity to feed in the electricity. Croatia applies specific tariffs to prosumers for the electricity they feed into the grid, which are lower than the price of the electricity drawn from the grid. Prosumers with capacity to feed in their surplus electricity need to sign a contract by which the prosumer is entitled to be compensated for the electricity fed into the grid. The electricity suppliers are obliged to accept the surplus electricity generated by the priority electricity producers that are registered as such, have a connection to the grid and a meter for netting the electricity consumed and fed. The priority electricity producers with a generation capacity of up the 30kW have the right to a guaranteed price for selling their electricity on the basis of the contract with the Croatian Energy Regulatory Agency (HERA), after being selected as the best bidders in a public tender.

In France, the prosumer is defined in terms of a self-consumer who is a producer of electricity and who consumes for himself all or part of the electricity produced. The electricity from renewable sources owned by prosumers can be sold to national or local distribution and supply companies through power purchase agreements and at a fixed price. However, the system has evolved in the last years and, since 2016, power purchase agreements are only available to small scale installations (such as solar PV on buildings with an installed peak power of 100 kW or less). Access to power purchase agreements requires renewable energy installations to have a certificate of compliance by an approved certification body and is limited to one in their lifetime. Furthermore, additional remuneration contracts are offered to selected projects under a tendering system available to installations of a capacity between 100-500 kW, where the producer consumes at least 50% of the annual production. However, when the excess electricity is not sold, Article L315-5 French Energy Code provides that electricity injected into the public distribution network in the context of an operation of self-consumption from an electricity production facility, whose maximum installed capacity is set up by decree, and which exceeds the consumption associated with that operation of self-consumption, is donated (*cédées à titre gratuit*) to the operator of the public distribution network to which the production facility is interconnected. Those injections compensate for the technical losses of the network.

Germany and Spain had similar systems which signify an increasing interest in the installation of PV systems by households typically placing them on the roof or hanging them out of a window. Both countries require self-producers of energy to register, unless they are micro scale systems whose produced electricity is used to offset a portion of on-site demand by the homeowner, rather than to gain the Feed-in Tariff rate. However, both systems have evolved differently.

In Germany self-supply is related to the consumption of electricity for oneself which is not fed into the grid. However, the metering system for self-suppliers enables the recording of the number of kilowatt/hour fed into the grid determining the amount to be remunerated according to the Feed-in Tariff established by the Renewable Energy Act. However, the system in Germany has changed in recent years. In the past PV was subject to high remuneration rates and all produced electricity had to be fed into the grid. This led to a massive increase in PV energy production in Germany in such a way that the distribution and transmission grids were overloaded.

The current 2015 Royal Decree of Spain, only Type 2 consumers registered as entrepreneurs can receive an economic retribution for the excess of energy. Electricity must not be consumed and fed into the grid determined according to the market price of the electricity at the time that it is discharged to the grid. However, residential prosumers (Type 1 consumers) in Spain can discharge electricity to the grid, but do not receive any remuneration.

In Italy, the 79/79 Decree recognises that each citizen and enterprise can produce energy to meet part of its needs, and can also sell the surplus energy to get income. The sale of the energy produced can be made to the national grid of Enel (and paid by the GSE), or to another end user as established by a resolution of the Energy Authority. The system in place is a mechanism of simplified purchase and resale arrangement (*ritiro dedicato*) where producers sell the electricity to the Electricity Service Operator (GSE) instead of selling it through bilateral contracts with the national Energy distributor (Enel) or directly on IPEX (Italian Power Exchange). This system is applicable to producers of RES and has been offered to prosumers since 2008 by GSE based on an agreement by which GSE purchases the electricity, resells it and feeds it into the grid at the zonal price or at a minimum guaranteed price. It also transfers the dispatch and transmission fees to distributors and to the TSO. However, this mechanism has an alternative, which is the use of the Net Metering scheme if the plant's capacity is 20 kW to 200 kW. This system is based on the balance of the energy fed in and consumed, whereby the plant operator pays the supplier for the electricity consumed, while GSE gives credit for the electricity fed in. This method can lead to a surplus on behalf of the plant operator according to the net balance which is calculated once a year. More specifically, the owner of such plants will receive a compensation equal to the difference between the value of electricity exported to the grid (e.g. for PV installations the energy fed in during daytime) and the value of the electricity consumed in a different period. If more energy is fed in than is consumed, this positive balance can compensate for a possible negative balance in the years that follow (*Article 6 par. 7 570/2012/R/efr*). Plant operators receive as much energy for free as they produce. In case the electricity fed into the grid is more than the one taken from the grid, plant operators are entitled to receive economic compensation, based on the formulas stated in the law.

In Luxembourg, the conditions applied to private individuals operating small solar installations for feeding energy into the grid are determined through the regulatory framework under which producers of renewable energy are allowed to sell their electricity (a purchase contract and an electricity supply contract).

In Portugal, prosumers are remunerated for the electricity fed into the grid. Portugal defines self-consumption on the basis of the production of electricity aimed at satisfying the producer's needs, without prejudice to the energy surplus being injected into the electric power network. The new framework for small production units up to 250 kW, which entered into force in January 2015, replaced the FiT scheme for micro- and mini-production and promoting self-consumption of renewable electricity. Prosumers in Portugal are remunerated monthly for the electricity fed into the grid on the basis of a contract with the DSO according to the energy provided in kW/h per month. The price is set through a bidding system based on a benchmark tariff set by the government and the average of the prices at closure of the Iberian Energy Market for Portugal in that month in Euros. No feed-in-tariff system is applied.

In Poland, the feed-in-tariff system was replaced by the net-metering system in July 2016. In accordance with the new system, electric energy placed in the grid by prosumers is annually settled with energy taken from the grid in a proportion of 1 to 0.7 for the systems above 10kW, and in a proportion of 1 to 0.8 for systems below 10kW. This means that for 1kW produced and not consumed by a micro installation above 10kW, the prosumer would get 0.7 kW from the grid. The UK has a remuneration system in place by which micro and small installations producing electricity from renewable sources are payed according to fixed tariffs.

In Romania, the newly adopted law recognises active consumers the possibility to sell surplus electricity to the grid which belongs to distribution operators, in view of covering their own technology consumption of the electric grid. They are also entitled to benefit from an electricity price set forth as per the ANRE Regulation. However, the tariff has not been set yet and therefore implementation is not yet possible.

The following table presents a summary of the situation as described above. The colour represents an assumption of the favourable impact of the measures on the uptake of residential prosumers where yellow is high, blue is medium and red is low.

Table 2: Financial implications related to the conditions to feed electricity into the grid (Source: own development)

Country	Feed electricity for free	Feed in & compensation e.g. net-metering	Feed in & remuneration or selling (e.g. market price/fix price/Feed-in Tariffs)
AT			X
BE	X	X	
BG			X
CZ	In practice		X
DE			X
DK		X	X
EL		X	
ES	X		X
FR			X
IT		X	X
HR			X
HU		X	
NL		X	
PL			X
PT			X
SL	X		
SK	X		X
UK			X

4.2.3 Criteria 3: Costs related to permitting requirements (application fees and one-off costs) and grid access/use

Methodology

In this section we review the regulatory framework behind fees and costs associated with the permitting, interconnection and network costs. In detail:

Indicator 1: The costs related to permitting (for buildings and production of energy) are one of the factors influencing the self-generation decision.

In November 2015, the European Commission launched a public consultation for the "preparation of a new renewable energy directive for the period after 2020"[48]. In Section 2, on "empowering consumers", the consultation document states that "provisions on simplified and streamlined procedures on permitting and grid connection in case of projects for self-consumption of renewable energy could be further enhanced".

Indicator 2: The cost related to grid access and the use of the grid is generally a challenge faced by prosumers in all Member States. While both prosumers and consumers benefit, in most cases, from access to the grid, they usually need to pay one-off costs for the connection to the network, for the use of the network and other network charges.

The results gathered through the reports on the 30 countries covered by the project, and in particular on the 15 Member States selected for a more in-depth comparison, provide a general overview of the different types of costs that prosumers are charged with in order to start generating energy for self-consumption. The analysis below focuses on the seven key countries selected within the framework of this project for their relevance regarding the RES policy; namely, Belgium, The Netherlands, France, Germany, Italy, Spain and the UK, together with those countries which have been identified as having a good market potential namely Hungary, Poland, Croatia, Slovenia, Czech Republic, Bulgaria, Slovakia and Portugal.

Based on the analysis of the relevant national reports, we have undertaken the following methodological steps:

- Firstly, we identified the main costs that prosumers have to face in order to start producing: building permits and fees related to application for energy production (for self-consumption)

- Secondly, we identified the costs which must be paid in each of the analysed countries when connecting to the network: connection costs or network taxes and charges.

The description of the measures and the costs faced by prosumers is based on the underlying assumption that measures entailing few or no permitting costs (indicator 1) and low or no network costs (indicator 2), or measures where prosumers benefit from a preferential treatment in relation to energy producers (regarding first step) or to traditional consumers (regarding the second step), will likely have a favourable impact on the development of prosumers.

1st indicator: Costs related to permitting

Building permit costs

Prior to starting operating and generating energy, prospective prosumers must request authorisation for constructing or/and placing the installations necessary for such generation.

Building permit consists of an official approval to proceed with a construction project and is aimed at ensuring that the project plan complies with the standards for energy use, including the safety rules applicable to the installation. The permit also ensures

[48] https://ec.europa.eu/energy/en/consultations/preparation-new-renewable-energy-directive-period-after-2020.

compliance with local, municipal and/or national legislation and policies in environment, land planning and energy matters. Building permit costs would typically cover not only the installation of solar PV systems (solar panels, for example), but also the cost of other technical devices that the production of energy entails.

However, most of the analysed countries do not require building permit costs for small installations such as PV panels in rooftops. For example, in The Netherlands, Germany, Malta, Portugal, Slovenia, Spain and in Belgium (Flanders region) the placing of PV systems at one's home does not require a building permit. In The Netherlands, the Ministry of Infrastructure and Environment has provided an online "environmental permit checker" (www.omgevingsloket.nl) for prosumers to know whether a permit is required for the type of renewable energy installation they wish to install[49].

In Poland, a construction permit is required for all types of installations or constructions, including power plants. Construction authorisations for permits should be requested from *starost* (head of a county) and decisions on construction conditions (*decyzja o warunkach zabudowy*) are issued by the executive branch of local governments - *voyt*, mayor or city president (*wójt, burmistrz, prezydent miasta),* depending on the size of the local community. Installations with total installed capacity lower than 40 kW or free-standing sun collectors are exempt from the building permit. In those cases, the prosumer only needs to notify public authorities about the installation. However, the setting up of micro installations needs to be carried out by qualified and certified experts who are subject to inspection, and can control whether the installation requires authorisation and complies with the standards for energy production. The administrative fees for issuing relevant decisions are relatively low in Poland, e.g. a fee for the issuance of a decision on construction conditions is around 30€ and for EIA , around 50€.[50]

In the UK, PV systems on domestic properties are generally considered 'permitted development'. Consequently, planning permission is not usually required as long as certain criteria are met (such as not protruding more than a maximum height above the plane of the roof). Exceptions to this include listed buildings and highly visible installations in conservation areas or in World Heritage sites.

In Belgium (Walloon region), there are exemptions from the requirement to obtain a building permit and licence to produce electricity. The building permit gives permission to build the requested structure and will be issued after it is determined that the structure will comply with planning regulations and spatial planning. The building permits are granted after a five-step procedure (three when no Energy Impact Assessment is required). Similar to other countries, no building permit is required for the installation of a solar panel if the solar installation does not derogate from the sectorial plan; supplies power to a building, construction or installation located on the same real estate; does not extend beyond the rooftop (Article 262, al. 2 CWATUPE). When a building permit is required, an application fee must be paid to the municipality delivering the permit. The municipality determines the amount of the allowance (approx. €25-€200). In the case where the solar power installation would derogate from the sectorial plan, this installation can be granted a building permit under the conditions that it supplies power to a building, construction or installation located on the same real estate, and that it respects the landscape (Art. 111 CWATUPE).

However, most countries require that small residential prosumers plants obtain a prior notification to start the installation. For example, Malta and Spain, require the operator to notify the competent authority prior to the construction, and submit the necessary information. In November 2015, Italy started a new procedure for the construction of small installations, named the "Simplified Procedure for the construction, connection and

[49] https://www.rijksoverheid.nl/onderwerpen/bouwregelgeving/inhoud/checken-of-vergunning-nodig-is-voor-ver-bouwen/vergunning-aanvragen-voor-ver-bouwen
[50] http://warunki-zabudowy.com.pl/ile-kosztuje-decyzja-o-warunkach-zabudowy/

start-up of small PV systems on the roofs of buildings". The bureaucratic process only requires the compilation and submission of a Single Application Form for both the construction and operation of generation plants using renewable energy sources as well as for the establishment of the connection cable. The capacity threshold for the application of the Single Authorization procedure for PV plants is above 20 kW and covers small plants installed on the roofs of houses, small businesses, small warehouses and apartment buildings. No fees or one-off costs are applied for the permit procedure. Similarly, in France, installations for self-consumption have to declare these facilities to the competent public distribution network operator, before the facilities go into operation and notify the energy self-consumed by the individual prosumer or the community final consumers. In Hungary, the establishment of household power plants is not subject to a building permit but the operator has to file a request with the electricity distributor, which does not entail any application fee or one-off cost.

Several countries, however, do require a construction permit and a one-off fee. In Croatia, the operator must acquire a construction permit. The provisions of the construction permit are laid down in the Construction Act. The issuance of the construction permit is coordinated with the issuance of the energy and operational permits referred to in the sections below. The construction permit is not specific to the energy sector and the Act, therefore, does not refer to generation of electricity and connection to the grid, focusing on the operational permits which address those two functions instead.

In Slovakia, those applying to become prosumers need a voucher (*Žiadosť o poukážku*), but they receive a 50% reimbursement once the small RES installation is built. Applicants must fill in the voucher or online form with the inventory number and worksheet number of the building, i.e. the family or apartment house where they plan to use the facility. A request for each type of installation and relevant device that the applicant plans to install must be submitted. The voucher includes alternatives on the type of equipment, the manufacturer and the production type, the number of units, the total output, and the devices for electricity production, as well as the capacity of the batteries. Based on the data selected by the applicant, the information system calculates the maximum value of the voucher[51] which is the basis for the calculation of the state financial assistance taking into account the effectiveness of the initiative of the consumer.

In the Czech Republic there are application fees but when prospective prosumers are submitting a request for a permit inside the framework of the "*Nova Zelena Usporam*" investment support program, they receive a financial support for about 50% of the whole costs. This programme was launched by the Ministry of Environment; it is administered by the public environmental fund of the Czech Republic and will run until 2021. It aims to support the energy-saving reconstruction of houses and apartment buildings, the replacement of unsuitable sources of heating and the promotion of renewable energy.

Fees related to the application for production of energy for self-consumption (including connection fees)

These fees relate to the prior authorisation or notification to the relevant authorities for the production of energy for self-consumption or feeding electricity to the grid, which usually entails costs.

Application fees to start operations are regulated at the national, regional and/or local level, depending on the authorities that have the competence of regulating energy production by residential prosumers. Local, state, and national governments may experience the erosion of energy tax revenues as a result of the growth of prosumers,

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[51] Information retrieved from http://zelenadomacnostiam.sk/sk/ziadost-o-poukazku/ (last accessed 20 April 2017)

which reduces retail sales that are subject to taxes and, therefore, reduces government revenues. The revenue generated through the application for production fees (and from the energy tax) is aimed at compensating public authorities for the costs they incur with the management system of energy production, which varies between Member States.

The majority of the Member States analysed do not require the payment of a fee for residential prosumers generating electricity when is mainly used for their own consumption, micro sources (solar PV plants installed in rooftops) and small sources with generation capacity below the cap as most of them are exempted from having an energy production permit or licence.

The Czech Republic, France, Germany, Hungary, Italy, Malta, Poland, Portugal, Slovakia, Slovenia, Spain or the UK do not require an energy permit or payment prior to the start of operations however, in most cases, the residential prosumers must notify the authorities. The majority have an energy tax applied on the basis of the energy consumed. However, in Portugal and Spain, the installation needs to be registered. As mentioned above, the single authorisation procedure in Italy for the start-up of PV solar systems in the roof tops of buildings replaces all the necessary permits and authorisations, including for the connection cable. Similarly, in Bulgaria, a simplified procedures and lower fees are applied to small RES installations (up to 30kW) in buildings already connected to the grid. In addition, they are exempt from the need to prepare an assessment of the available renewable resources on site.

In Croatia, the relevant framework requires an energy permit to generate electricity from RES (Articles 11 and 13 of the EMA), except when simple constructions (*jednostavne građevine*), i.e. PV systems installed on existing buildings, are at stake and provided they are connected to the same grid that the produced electricity is fed into; (Articles 9 and 10 of the Regulation "Use of Renewable Energy Sources and Cogeneration" (RESO) and Article 5, item 10 of the legally binding Ordinance on Simple and Other Constructions and Works[52] (OSC). The application for the permit is set out in Annex II of the RESO. In addition to the application, the prosumer must provide an analysis of the cost effectiveness of the connection of the generating facility to the grid. The application fee for all of the necessary permits (energy permit to generate electricity, but also the operation permit to connect to the grid as explained below) is set in accordance with the Act on Administrative Fees[53]. The fee is generally not prohibitive, as in most cases it is around 200 HRK (app. €25).

In the Czech Republic, there are application fees, but when prospective prosumers are submitting a request for a permit inside the framework of the "*Nova Zelena Usporam*" investment support program, they receive a financial support for about 50% of the whole cost. This programme was launched by the Ministry of Environment; it is administered by the public environmental fund of the Czech Republic and will run until 2021. It aims to support the energy-saving reconstruction of houses and apartment buildings, the replacement of unsuitable sources of heating and the promotion of renewable energy.

In Belgium-Wallonia, producing electricity requires holding a licence delivered by the ministry according to the Electricity Market Decree. Self-producers must hold a "limited licence for ensuring self-consumption". The requirements for obtaining that licence are laid down in the Order of 21 March 2002 on the licence for electricity production.

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[52] Ordinance on Simple and Other Constructions and Works (*Pravilnik o jednostavnim i drugim građevinama i radovima*) ("O.G.", No. 79/14, 41/15 and 75/15) - HR - http://www.legalizacijagradnje.com/wp-content/uploads/2011/08/Pravilnik-o-jednostavnim-gra%C4%91evinama-i-radovima.pdf

[53] Act on Administrative Fees (*Zakon o upravnim pristojbama*) (8/96, 77/96, 95/97, 131/97, 68/98, 145/99, 30/00, 116/00, 163/03, 17/04, 110/04, 141/04, 150/05, 153/05, 129/06, 117/07, 25/08, 60/08, 20/10, 69/10, 126/11, 112/12, 19/13, 80/13, 40/14, 69/14, 87/14 and 94/14) - HR - http://www.zakon.hr/z/333/Zakon-o-upravnim-pristojbama

In The Netherlands, PV installations do not usually require permitting. However, a licence is needed whenever the prosumer or group of prosumers wish to sell renewable energy directly to other residential prosumers.

2nd indicator: Costs related to network charges (grid access and use)

Installation costs for PV systems include energy installation (e.g. PV solar panels) and the necessary transmission systems. Thus, they consist of hardware, such as modules and inverters, but also comprise "soft" costs such as labour, permitting[54], financing, and customer acquisition[55]. As described in the introductory section above, the prices of PV modules and inverters have dropped dramatically and it is projected[56] that hardware costs will continue to decline – although at a slower yearly rate than in the recent past – and that soft cost reductions will also occur in many countries as a result of efforts by industry and government.

The situation of installation costs in the Member States was not the subject of this analysis, but several country experts have referred to installation costs for prospective prosumers.

In Slovakia, consumers must pay at least 50% to 70% of the installation costs, unless the consumer relies on state financial support, such as the program "Zelena domacnostiam"[57]; a project funded via OP Environment 2014-2020 (30-50% funding support covering the cost of the RES installation). Zelena domacnostiam is the first stage of financial support aimed at the use of so-called small RES in houses and apartment buildings with a budget of 45 million euro. The total amount allocated for small RES installation support is 115 million euro for the period 2014-2020 from the EU and national sources[58]. In a similar vein, prospective prosumers in the UK are faced with an upfront cost to install the energy generation micro plant which ranges from 4,000 to 6,000 sterling pounds for an average of 21 sq of the roof space of an average family home. In the UK, this cost covers the cost of work and equipment used to make the connection.

Access to the grid

While the request for a connection point to the grid is generally required, there are no excessive costs related to it.

In the UK, in regards to smaller PV systems CHP, wind or hydro generation rated up to 3.68kW (16A) per phase at a single premises, the prosumer does not need to contact the Distributor Network Operator (DNO) prior to commissioning. The installer will need to carry out two key tasks on the prosumer's behalf in order to ensure connection to the grid: the generator must inform the DNO about the installation or any work to be undertaken and then submit an Installation Commissioning Confirmation Form within 28 days of commissioning the installation. For bigger systems above 4kW, the installer will need to get permission from the DNO in order to connect to the grid.

In Spain, the consumer requesting access to the connection point has to pay the costs to connect the installation to the supply connection point, the repowering of the electricity lines of the distribution company to the same level as that of the supply point and, if necessary, the repowering of the transformer of the distribution company to the same

[54] The permitting costs are analysed separately in the previous section.
[55] IEA-RETD, residential prosumers – Drivers and policy potions (re-prosumers), June 2014, p. 22.
[56] Ibid.
[57] See the project website: http://zelenadomacnostiam.sk/sk/domacnosti/10-krokov-k-podpore/
[58] http://zelenadomacnostiam.sk/sk/o-projekte-zelena-domacnostiam/

level as the power of the connection point. However, only the entrepreneur-prosumers (Type 2) pay the toll to access the transport and distribution networks for the discharge of the energy to the grid in Spain. Residential prosumers with installations which do not go beyond a produced amount of energy of 10 kW do not have to pay the toll of access to the network. Further, the prosumer needs to get an installation certificate, in order to conclude the contract of access to the grid with the distribution company. This involves covering the costs of an authorised technician to carry out the necessary tests to issue the certificate, tests which have to be validated by the competent authority. A first inspection and verification by the distribution company has to be paid by the Type 2 prosumer (entrepreneur) but not by the residential Type 1 prosumer.

Similarly, in Portugal the production or operating licence required for power plants, is replaced for micro- and small production unit plants by an exploitation certificate which involves some costs. In order to obtain this certificate, installations have to register in a centralised national register or registration system. This implies that a consumer can only commission an authorised installer after the registration is done and paid. After installation, the device still has to be inspected in order to receive an exploitation certificate and cover the costs. Once the exploitation certificate is obtained, the owner can conclude the electricity contracts which include the purchase contract for the excess electricity to be exported to the grid and the connection to the grid.

In France and Belgium, prospective prosumers must pay a connection fee but only when they go beyond a specific amount of produced energy. In Belgium (Wallonia region), any self-producer owning an installation with a capacity ≤ 10 kilowatt-peak (kWp) connected to the grid must pay a connection charge (or 'prosumer tariff') of €55 per kWp. This would mean a yearly charge of €110 for owners of 5 kWp installations and €385 for owners of 10 kWp installations[59]. In France, the scope of the exception is larger, given that facilities with an installed capacity of less than 100 kW are already exempted from paying any grid fee. The tariff to use the public electricity networks (*Tarif d'utilisation des réseaux publics d'électricité*) or TURPE is fixed and covers the costs of connecting to the network.

Similarly, consumers in the Czech Republic generating energy from sources connected to the grid are obliged to pay a one-off payment in order to connect to the distribution system. According to Czech law, the distribution system operator has a right to request payment in relation to the cost of connection, depending on the amount of requested reserved capacity. Connecting to low voltage distribution system costs in the range of 200-500 CZK (€7,50-€18, approx.). Prosumers generating energy from micro sources do not need to pay to access the grid, given that as one of the conditions for this type of installation is zero reserved capacity on the grid, thus zero (or, at least, negligible) input into the low voltage distribution system.

In Poland, Bulgaria and Malta there are no connection fees for the prosumer applying for the opening of a micro-installation. The costs are covered by the grid or network operator.

In Slovenia, an energy prosumer or building owner has to obtain consent to connect the device to in-house grid from the electricity system operator and sign a contract with the electricity provider for the self-supply of electricity. The requirements, fees and costs for self-consumption are the same as that of any household owner who wishes to connect his/her house to the public electricity grid and arrange for the supply of electricity. A *network charge* is a one-off charge which is paid for the connection of the household to

[59] http://www.guide-panneaux-photovoltaiques.be/une-nouvelle-redevance-pour-le-photovoltaique-quels-effets-sur-la-rentabilite/ . Also, owners of small installations (under 3 kWp) are exempt from this payment so for larger prosumer installations the charge is calculated for the capacity above 3 kWp.

the public grid and which is prescribed by the Law, SODO.[60] If the house is equipped with a one way meter, it has to be replaced with a new two-way meter with the additional cost.

In Italy, ooperators of renewable energy plants are entitled to be connected to the national electricity grid upon request. For that purpose, the grid operator is obliged to conclude a contract with the plant operator. The cost for connection of PV plants to the grid is divided into two tranches: the first at the request of the estimate, the second to the acceptance of the estimate. The first tranche operates in different tariffs depending on the input power required: 30€ (up to 6 kW); 50€ (between 6kW and 10 kW); 100€ (up to 50 Kw); 200€ (between 50 Kw and 100 Kw); 500€ (between 100 and 500 Kw); 1.500€ (between 500 and 1.000 Kw); 2.500€ (above 1.000 Kw). The second tranche is calculated taking into account the input power and the distances between the point of connection and transformation cabin. The minimum value resulting from the calculation of the applicable formulas will be the rate for the connection. Such rate is to be paid for 30% of the work before, 70% at the end of work, or paying all in one solution.

In Hungary, household power plants do not need to pay a fee for connecting to the electricity grid[61].

In Germany, there is guaranteed priority connection to the grid for renewable energy projects, with grid upgrade costs covered from ratepayers (rather than generators) (Article 8 EEG). This applies to prosumers but also to all renewable energy producers in general.

In Slovakia, based on the Act on the promotion of RES, energy entrepreneur-prosumers have to pay for access to grid to the distribution system operator (§5(2)). The Regulatory Office for Network Industries specifies the cost for accessing the grid which is set in the form of tariff. This tariff includes the cost of accessing the grid, distribution of electricity and losses during distribution[62].

Network costs (use of the grid)

Network costs represent an important cost for prosumers. The majority of the countries analysed have systems requiring prosumers to pay for the use of the grid.

Network costs, meaning monthly costs to enjoy the use of the grid, are fixed in Belgium (Wallonia region), The Netherlands, and Portugal, while they are variable in Bulgaria, Czech Republic, Germany, Croatia, Hungary, Italy and the UK. France, Slovenia and Spain have both types of costs.

In The Netherlands, the network costs to be paid by the prosumer are costs charged by the grid operator and energy supplier. Those charged by the grid operator (*netbeheerderskosten*) are maintenance-related and are fixed according to the amounts set every three years by the ACM[63]. In Portugal, production units for self-consumption producing more than 1.5Kw pay a fix monthly fee for each kW of installed power aimed at recovering part of the system costs. Under Article 8 *lit*. H Decree-law 153/2014, prosumers (except for those producing less than 200w) must support the cost of a civil liability insurance for repairing personal or material damage caused to third parties as a

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60 At http://www.elektro-ljubljana.si/Portals/0/Content/Dokumenti/Prikljucevanje/ELJ_Cenik-omreznine-za-prikljucno-moc-2016.pdf.

61 Zoltan Harsányi (E.ON) 'Presentation on household power plants'.

62 https://www.sse-d.sk/buxus/docs/dokumenty/domacnosti/cenniky/Rozhodnutie%20URSO%20c.%200013-2016-E%20Cennik%20distribucie%20elektriny%20na%20rok%202016.pdf

63 https://www.energievergelijken.nl/en/about-energy-in-the-netherlands/annual-energy-bill

result of the exercise of activities of production of electric power for self-consumption and small production.

In Hungary, this charge is collected by the grid provider and is not linked to the type of power plant in the household, but to consumption. The network charges are indicated on the electricity bill sent to the consumer and therefore, it is linked to the consumption of the consumer. The law specifies that in the case of household power plants where the capacity is measured in 'both ways', while discharging and taking electricity, the amount of the network charges depends on the ratio of these two operations. In the Czech Republic the connection charges for a RES installation are calculated in accordance with the deep-connection cost methodology and are in the range of 200-500 CZK/Amps (7,50 to 18€ approx.).

In Germany, since 2017, the EEG surcharge on final consumers for their energy or own energy supply is reduced in cases of self-consumption, in highly efficient CHP plants or in case of replacement of old existing installations (as provided for with detail in the German report). The EEG surcharge will be reduced to zero percent if the final consumer operates the electricity generating plant for self-consumption, as long as the electricity is consumed by the producer or under specific circumstances when it concerns old installations. According to Article 61a EEG 2017, the surcharge does not have to be paid if the household fully supplies itself with electricity from renewable energies and does not rely on payments of a market premium or a Feed-in Tariff for the electricity from its installation, which it does not consume or if electricity is generated from electricity generating plants with an installed capacity of 10 kilowatts maximum, for a maximum of 10 megawatt hours of self-consumed electricity per calendar year. This applies from the start-up of the electricity generating plant for a period of 20 calendar years plus the year of commissioning.

In Spain, there are fees associated with the system costs that include fixed and variable fees. Consumers have to pay the fees associated with the costs of the electricity system corresponding to the supply point as a contribution to the network cost. The fees are the so-called 'tax to the sun' (*impuesto al sol*) and the 'back-up toll' (*peaje de respaldo*)[64]:

- Fees associated with the costs of the electric system (regulated in Article 17 RD 900/2015): These fees are meant to compensate the costs of the electricity system which are not due to transport and distribution. These costs include, among others, the additional costs for the production of energy in the non-peninsular territories (Balearic Islands and Canary Islands), the compensation for renewable energy, the payment to electricity plants that support the electricity system when there are peaks of demand, the fee that has to be paid to the CNMC, etc.[65].
- Fees for other services of the system (regulated in Article 18 RD 900/2015): This is the payment for the back-up function that the electricity system has in place in case the self-consumption systems do not work. They are fixed.

In France, all users of the grid (both producers and consumers) must pay the tariff to use the public electricity networks (*Tarif d'utilisation des réseaux publics d'électricité*) or TURPE. This fixed charge represents the costs of connecting to the network and must respect specific rules: producers injecting electricity onto the grid and consumers using electricity from the grid pay a tariff that does not take into account the distance travelled by the electricity; the tariff is determined by the Energy Regulatory Commission (CRE) according to different elements including the voltage of the inter-connection and the

[64] Andreu, F., 2015, '10 keys to understand the Royal Decree on Self-consumption' (*10 claves para entender el Real Decreto de Autoconsumo*), available at http://solartradex.com/blog/10-claves-para-entender-el-real-decreto-de-autoconsumo/ (last accessed 21 December 2016).

[65] These costs are defined in Article 13 of Law 24/2013.

electricity consumption or injection[66]. Typically, the tariff paid by residential consumers for the use of the electricity distribution network is higher than the tariff paid by companies linked to the electricity transport network. Prosumers must thus pay the TURPE but, if their facilities have an installed capacity of less than 100 kW, they must pay the 'self-consumption TURPE', which is lower (see Article L315-3 French Energy Code).

In Slovenia the network charge (common to all energy producers) is prescribed by the Energy agency. For 2017, the network tax for households is the following (in EUR): a) a fixed part, which depends on connection power[67]: 0.77490 per 1 kW of connection power per month (which in case of an average household with 10 kW connection power amounts to EUR 7.749 / month); b) variable part (in relation to electricity consumption): 0.03889 / per kWh.

In Croatia, charges for the use of the system are imposed to cover the cost of reinforcement and operations and maintenance costs. These costs are not uniform; they are location specific and vary depending upon capacity available on the network. These charges have been levied by DNOs since 2005. The grid operator is required to give priority to energy produced from RES and from priority electricity producers defined pursuant to the applicable legislation. However, giving priority does not mean guarantee to purchase such generated electricity.

In Slovakia, the production of electricity from small RES installations with the generation capacity up to 10kW is supported through a national project funded from the Operational Programme Environment *'Zelena domacnostiam'* and Regional funds, where the Slovakian Innovation and Energy Agency is the implementing authority.

In the UK, there are on-going charges which cover the cost of reinforcement and operations and maintenance costs (system charges). These costs are not uniform; they are location specific and vary depending upon capacity available on the network. These charges have been levied by DNOs since 2005.

In Poland, network costs are determined by the connection agreement between the investor of a micro-installation and the grid operator. In Malta, the installation operator can request that the DSO makes modifications to the solar PV installation connection to the distribution system in order to use the electricity generated for self-use within the operator's premises. When this option is exercised, the installation operator must bear the costs of the modifications including those related to the metering and connection required by the DSO[68].

Financial guarantee to network operators

Prosumers may have to compensate network operators in instances of delays or non-compliance with contractual terms. In Bulgaria, financial guarantees are required to be paid to the network operator in instances of delays or non-compliance with contracts; however, they are not required for small installations (less than 30 kW). In Portugal, prosumers are expressly exempt from these guarantees.

4.2.4 Criteria 4: Financial Incentives: tariffs, tax reductions and other forms of investment support

[66] L. 341-2 and following of the French Energy Code

[67] Connection power is the maximum electrical power which can be used in the building at a given time. It is determined at the time of connection to the grid.

[68] Regulation 9 of the Feed-In Tariffs Scheme (Electricity Generated from Solar Photovoltaic Installations) Regulations.

- Methodology

Most policies at national level aiming to support the use of renewable energy sources focus on power generation. One of the most commonly used incentives by European countries to support the development of energy generation from RES, including the generation from prosumers, are Feed-in Tariffs applied to the electricity fed to the grid. Tendering schemes, net metering or net billing policies, green banks and green bonds represent other options that are gaining support from policymakers. In addition, reductions on taxes, charges or fees on renewable energy power have been introduced in an increasing number of countries[69].

However, there is no convergence or harmonised structured approach to financial incentives applied to prosumers or self-generation. Our analysis mainly focuses on the more mature markets, namely Belgium, The Netherlands, France, Germany, Italy, Spain and the UK, along with a second group of interesting markets in Eastern Europe, namely Hungary, Poland, Croatia, Slovenia, Czech Republic, Bulgaria Slovakia.

In some countries, where policy changes have been implemented recently, petitions have been submitted to the EU institutions in relation to legal certainty and compliance with EU energy law (as explained in the Conclusions chapter of the study). Details on recent changes are illustrated in the national reports annexed to the study.

Spain is an example of evolution of policy towards a reduction on the use of incentives for self-consumption. Spain succeeded in developing renewable power generation through a combination of Feed-in Tariffs and a market premium scheme applied until the beginning of the financial crisis in 2008. At the beginning of 2012, the Royal Decree-law 1/2012[70] included a moratorium on any support through Feed-in Tariffs for new installations producing electric energy via renewable energy sources created by Law 40/1994. In March 2013, the Royal Decree-law 9/2013[71] adopted urgent measures for the stabilisation of the electric sector eliminating the tariffs' annual adaptation to the inflation rate for existing installations set by Law 54/1997 increasing the operational costs and taxes. The market premium was phased out in 2013 without any substitution. Finally, the RD 900/2015 completed the process with specific measures reducing the economic incentives, with the remaining reduced Feed-in Tariff for existing renewable power plants stopped. Consequently, residential prosumers have no possibility of remuneration for electricity fed to the grid.

In 2009, Germany introduced a "self-consumption bonus" allowing solar power energy prosumers to receive a payment from the support scheme complementing a reduced Feed-in-Tariff rate for the power they did not feed into the grid but consumed at home. This system has however changed with the following amendments to the EEG. The bonus was phased out again in 2012, with some exceptions remaining, as self-consumption had become less expensive and more economically attractive. However, the economic

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[69] KPMG, Taxes and incentives for renewable energy, September 2015.

[70] Royal Decree-law 1/2012, of 27 January, suspending the retribution pre-allocation procedures and the economic incentives for new installations producing electric energy from cogeneration, renewable energy sources and waste (*Real Decreto-ley 1/2012, de 27 de enero, por el que se procede a la suspensión de los procedimientos de preasignación de retribución y a la supresión de los incentivos económicos para nuevas instalaciones de producción de energía eléctrica a partir de cogeneración, fuentes de energía renovables y residuos*) State Gazette BOE-A-2012-1310 available at https://www.boe.es/buscar/act.php?id=BOE-A-2012-1310.

[71] Royal Decree-law 9/2013, of 12 July, adopting urgent measures to guarantee the financial stability of the electric system (Real Decreto-ley 9/2013, de 12 de julio, por el que se adoptan medidas urgentes para garantizar la estabilidad financiera del sistema eléctrico), State Gazette BOE-A-2013-7705, available at https://www.boe.es/diario_boe/txt.php?id=BOE-A-2013-7705.

attractiveness of small-scale self-production and consumption of electricity continues due to the reduced EEG surcharge established by the Renewable Energy Act for small installations generating power for self-consumption and the absence of grid charges.

Adopting a methodological approach, we initially identify the type of incentive measures that European Countries have adopted in order to support the take up of residential prosumers, namely: Feed-in Tariffs, premiums etc. As a second step, countries have been grouped according to the type of measures applied to support the development of prosumers in their country. Those measures are assessed more positively in relation to their impact to promote residential prosumers' development when the incentives are applied specifically to residential prosumers than where incentives are applied to RES in general.

- Overview of the financial incentives

Feed-in Tariffs

Some jurisdictions have opted to encourage self-consumption by offering Feed-in Tariffs on the electricity fed to the grid or a small premium above the regulated Feed-in Tariff to encourage self-consumption. This approach relies either on automated home energy management systems (e.g. to dispatch electric heating/cooling systems) or on individual prosumer response to price signals.

France and The Netherlands have Feed-in Tariff systems established under their regulatory framework. In France, the Feed-in Tariffs are paid through power purchase agreements to stimulate demand for most renewable energy technologies. Since 2016, the tariff for installations of up to 9kW is higher reaching €23.93/kWh as shown in the table below[72]:

Table 3

Type of integration bonus	Capacity (kWh)	Feed-in Tariffs (€-¢/kWh)
Full integration	0-9	23.93
Simplified integration	0-36	12.47
	36-100	11.89
Non-integrated	< 12,000	5.51

In The Netherlands, the SDE+ programme, established by the *Decree on the stimulation of sustainable energy production* (SDE Decree), set up a financial instrument providing Feed-in Tariff subsidies for all types of renewable energy projects. Residential prosumers are only eligible for it as a group or community (e.g. as a cooperative)[73]. Only companies and not-for-profit organisations (e.g. cooperatives) are eligible for the Feed-in Tariff contrary to the previous programme where individual prosumers were eligible. The programme's focus switched from small-scale to industrial-scale renewable energy production in order to speed up technological development and assist with reaching the 2020 renewables targets[74]. The Feed-in Tariff subsidy covers the difference between the wholesale market price of electricity and the cost/price of electricity originating from

[72] Eco Infos Energies Renouvelables, 2016, *Tarif rachat électricité photovoltaïque du 1 octobre 2016 au 31 décembre 2016*, viewed 8 February 2017 http://www.les-energies-renouvelables.eu/conseils/photovoltaique/tarif-rachat-electricite-photovoltaique/

[73] http://english.rvo.nl/subsidies-programmes/sde

[74] https://zoek.officielebekendmakingen.nl/dossier/31763/kst-31239-103.html

renewable sources (for electricity, gas, and heating purposes; Article 2 (1) SDE Decree)[75] in order to cover for the difference of production cost in relation to other sources of energy such as fossil fuels over a time lapse of 8, 12 or 15 years (depending on the type of technology)[76].

In addition, the scheme operates on the basis of applications for projects of all categories of renewable energy technologies with deadlines bi-yearly in four phases, with the amount of subsidy increasing per phase. It is granted on a 'first-come first-serve basis' which benefits more advanced and cheaper technologies[77].

The Feed-in Tariff in the UK was introduced in 2010, offering a fixed payment for 20 to 25 years to households generating electricity from microgeneration installations for every unit of energy they generate and feed into the grid. The tariffs depend on the technology and whether the household is an individual or a community. In 2011, the tariff for small solar PV was reduced by half. This change was contested at the Supreme Court and was temporarily rescinded until April 2012. New installations are subject to a new system of caps from February 2016.

Similarly, in Italy the feed-in-tariff system has offered simplified purchase and resale arrangements (*ritiro dedicato*) to small PV energy producers since 2008. The electricity generated and not consumed is sold to the electricity service operator, GSE, at a guaranteed price. This system is an alternative to the net metering (*scambio sul posto*) described below.

Malta does not apply specific tariffs to prosumers drawing electricity from the grid. Residential prosumers pay the normal prices for consumption of electricity from the grid. However, electricity generated by solar PV installations was supported through a Feed-in Tariff but was abolished in 2016.

In Bulgaria, the promotion of renewable energy involves several measures including a Feed-in Tariff system with a guaranteed payoff of the generated electricity which is purchased on preferential prices determined by law; with long term contracts of about 20 years for solar PV. These long term contracts are not applied to small installations of less than 30 kW who declare that their production will be for self-consumption.

In Germany, the legal and regulatory framework has changed and the financial incentives to RES and to prosumers have decreased. The economic attractiveness of small-scale self-production and consumption of electricity has significantly increased in recent years, particularly due to the EEG surcharge and grid charges established by the Renewable Energy Act.

Germany has a system based Feed-in Tariff where a reduced rate is applied for the power not fed into the grid but consumed at home[78]. In 2009, a "self-consumption bonus" was introduced, allowing solar power energy producers to receive a payment from the support scheme based on the energy consumed. The bonus was, however, phased out again in 2012 as PV technology became more mature and less expensive. Therefore, it was economically more attractive for prosumers to consume all or a portion of their own electricity instead of feeding all PV power into the grid, given that the tariff, plus the reduced costs for electricity purchased from the grid (EEG surcharge), guaranteed a surplus. As of 2014, Feed-in Tariffs were gradually no longer fixed by the government, but determined by auction. The amendments introduced in 2017 establish that small renewable installations under a capacity of 750kW are excluded from the

[75] http://www.res-legal.eu/search-by-country/netherlands/
[76] http://english.rvo.nl/sites/default/files/2016/04/Brochure-SDE-plus-2016_spring.pdf
[77]http://www.beuc.eu/publications/beuc-x-2016-003_jmu_current_practices_in_consumer_driven_renewable_electricity_markets.pdf
[78] Kerstin Tews, 'Mapping the regulatory features underpinning prosumer activities in Germany – The case of residential photovoltaics', 2016.

auctioning process and are still subject to fixed Feed-in Tariffs. For PV, Feed-in Tariffs are capped once a total capacity of 52 GW is reached (at the end of 2015 PV capacity was 40 GW).

A policy evolution in the incentives has been observed in Spain, which succeeded in developing renewable power generation through a combination of Feed-in Tariffs and a market premium scheme applied until the start of the financial crisis. From the beginning of 2012 to 2015, a series of measures, such as a moratorium on the support of new installations, as well as the phasing out of the annual adaptation to the inflation rate for existing installations, of the market premium and of the Feed-in Tariffs for existing renewable power plants has occurred[79]. Similarly, in 2014 the Czech Republic abolished the existing feed in tariff system, and in July 2016 Poland replaced the Feed-in Tariff system with the net-metering system. In Slovenia and Belgium, prosumers are not reimbursed for the electricity that they produce in surplus and no Feed-in Tariff system is applied. In Portugal, the new framework for small production units up to 250 kW, which entered into force in January 2015, replaced the Feed-in Tariff scheme for micro- and mini-production and promoting self-consumption of renewable electricity. While prosumers are remunerated for the electricity fed into the grid through a bidding system based on a benchmark tariff set by the government, no feed-in-tariff system is applied.

Compensation mechanisms

In Belgium, prosumers are not reimbursed for the electricity that they produce in surplus on the basis of Feed-in Tariffs. Most prosumers possess a regular electricity meter from Eandis which counts in kilowatt hours (kWh) and determines the final invoice from the energy supplier. When there is an electricity surplus, the counter counts backwards. This means that the actual use and injection are measured separately, but that the electricity meter automatically deducts the injection from the total usage.

Small self-producers that have a production unit of green energy with a capacity of ≤ 10KW benefit from a deduction of the injected energy from the self-producer's energy consumption or from compensation for any positive surplus of energy injected into the network after the subtraction of the energy taken from the network[80]. The compensation enables the energy injected from the self-producer's energy consumption to be deducted, provided that certain pre-requisite requirements are in place:

- Preliminary request for green certificates from the CWaPE;
- Orientation study or detailed study by the network operator;
- Individual authorisation by the CWaPE in case a direct line is considered;
- Registration and certification of the installation as "certified installation of green electricity" by the Walloon Commission for Energy ('CWaPE');
- Request for green certificates and labels of guaranteed origin to the CWaPE.

In order to benefit from green certificates and labels of guarantee of origin needed for the compensation, the self-producer (prosumer) needs to request the connection to the distribution network preceded by a study assessing the feasibility of the project. This would eventually lead to a connection contract specifying rights and obligations. Further, the installation has to obtain a certification under the certificate of guarantee of origin granted by one of the qualified bodies.

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[79] ibid
[80] Art 6bis of Decision 30 November 2006.

Regarding the retribution or compensation that prosumers may receive from feeding back into the grid in Spain, only consumers adhering to Type 2 self-consumption will receive such compensation[81]. Under RD 900/2015, only consumers who adhere to Type 2 can receive an economic retribution (*compensación económica*) for discharging energy back to the grid[82]. They will receive remuneration for the excess energy, which shall be paid at the market price at the time (hour) that it is discharged to the grid. Type 1 residential self-consumers can discharge energy back to the grid but will not receive any kind of economic retribution for it[83]. Furthermore, the Plan on Renewable Energy 2011-2020 (PER)[84] foresees a compensation mechanism. The periods where the demand surpasses the offer are compensated with the excess stored energy from periods where the offer surpasses the demand. This mechanism receives the name of net balance (*balance neto*). This system circumvents the need to add storage systems to the installations, avoiding the extra costs that such systems entail and increasing the efficiency of distribution and transport networks[85].

In Italy, producers of renewable energy of small capacity can decide to use the net metering system (*scambio sul posto*) where the plant operator pays the supplier for the electricity consumed and the GSE gives credit for the electricity fed in. The PV plant owner will receive compensation equal to the difference between the value of electricity fed into the grid during daytime and the value of the electricity consumed in a different period. Since 2015 this system requires operators to pay an annual fee for the cost of management, verification and control.

In July 2016, Poland replaced the Feed-in Tariff system with the net-metering system as the basis for a compensatory system. The electricity placed in the grid by prosumers cannot be sold but is annually settled jointly with the energy taken from the grid. This means that for feeding back the surplus of non-consumed energy (e.g. when the prosumer is not able to consume the generated energy due to his absence), the prosumer will receive a rebate for the energy drawn from the grid. The settlements are made by energy companies on the basis of the readings of the measuring and billing system mounted in individual micro-installations. Therefore, no specific tariffs are foreseen for prosumers.

In Malta, according to Regulation 8 of the Feed-in Tariffs Scheme (Electricity Generated from Solar Photovoltaic Installations) Regulations, the DSO can offset amounts due by the installation operator for the supply of electricity against the amounts due to the installation operator for exporting electricity to the system. Therefore, the compensation that prosumers have for the electricity fed into the grid is that the surplus generated is deducted from their electricity bill, which means that they might pay less compared to conventional consumers. Regulation 9 provides for the sale of electricity after the expiry of the period of guaranteed payment of the Feed-in Tariff. The installation operator can request that the DSO affect the necessary modifications to the solar PV installation connection to the distribution system to enable the installation operator to use the electricity generated from the solar PV installation for his or her own use, and to be compensated for any exported electricity at the applicable rate at the time and as provided in the Fourth Schedule (EUR 0.08,9 per kWh for the year 2016). Where the

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[81] Article 14 (3) RD 900/2015.
[82] Article 14(3) RD 900/2015.
[83] Mendoza Losana, A.I., 2015, 'The royal decree on electricity self-consumption or the paradox of having to pay to generate energy' (*El real decreto de autoconsumo eléctrico o la paradoja de pagar por generar energía*), Gomez-Acebo&Pombo, available at http://www.gomezacebo-pombo.com/media/k2/attachments/el-real-decreto-de-autoconsumo-electrico-o-la-paradoja-de-pagar-por-generar-energia.pdf (last accessed 6 December 2016).
[84] IDAE, 'Plan on Renewable Energy 2011-2020' (Plan de Energías Renovables 2011-2020, PER), adopted by Council of Ministers on 11 November 2011, available at: http://www.idae.es/uploads/documentos/documentos_11227_PER_2011-2020_def_93c624ab.pdf
[85] IDAE, PER 2011-2020, 'Executive Summary' (*Resumen Ejecutivo*), p. XLII, and pp. 537-39.

installation operator does not use this option, the DSO will continue to purchase all of the electricity generated by the solar PV installation and exported to the distribution system and will reimburse the installation operator for electricity at the rate established in the Fourth Schedule.

Premiums

In order to comply with the European Commission's Guidelines on State aid for environmental protection and energy 2014-2020, the Energy Transition Law in France created an additional remuneration mechanism (or Feed-in Premium or FiP) (*complément de rémunération*)[86]. According to this scheme, EDF has the obligation to conclude, where producers request it, a contract offering additional remuneration for facilities meeting specific regulatory requirements, including those producing renewable energy. PV installations with an installed peak power of 100 kW or less are therefore eligible for additional remuneration. In general, contracts on additional remuneration can last up to 20 years. Furthermore, facilities can benefit from such a contract only once, although facilities producing renewable energy may conclude more than one contract on additional remuneration where they meet specific requirements[87]. Generally, the calculation of additional remuneration depends on the renewable energy sector and the type of facilitie, and is done either through regulatory orders or public bids.

However, some of the rules applicable to additional remuneration mechanisms and guarantee of origin may constitute obstacles to the development of prosumers and energy cooperatives. Pursuant to Article R314-32 of the French Energy Code, in order to benefit from a Feed-in Premium, a producer of renewable energy must waive his right to obtain the issuing of a guarantee of origin for the electricity produced by his facility during the duration of the contract. Even once the contract is terminated, the producer cannot ask, transfer, obtain or use guarantees of origin for the production of their facility. Various actors, including the CRE, energy cooperatives, and national deputies, have opposed this provision[88].

In Croatia, producers of electricity from RES are encouraged by the RES law (ARES) to generate electricity from RES through financial incentives such as premium tariffs (sustav poticanja tržišnom premijom) and guaranteed prices (*sustav poticanja zajamčenom otkupnom cijenom*) applicable only to production facilities with installed capacities of 30 kW or less. These incentives are mutually exclusive. Financing for these incentives comes partially from the funds collected as part of the fee for incentivising the production of electricity generated from RES (Article 11(5) of the EMA, Article 37 of the ARES and Regulation on the Fee for Incentivising Production of Electricity from Renewable Energy Sources and Cogeneration[89] (RFE)). The RFE sets the fee at 0.035 kn/kWh[90].

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[86] See Articles L314-18 to L314-27; Articles D314-23 to D314-25; Articles R314-26 to R314-52 French Energy Code and Order No 2016-682 of 27 May 2016 pertaining to purchase obligation and additional remuneration.

[87] Article L314-21 French Energy Code.

[88] Délibération de la Commission de régulation de l'énergie du 9 décembre 2015 portant avis sur le projet de décret relatif au complément de rémunération mentionné à l'article L. 314-18 du code de l'énergie; Assemblée Nationale, November 2016, *Rapport ratifiant les ordonnances n° 2016-1019 du 27 juillet 2016 relative à l'autoconsommation d'électricité et n° 2016-1059 du 3 août 2016 relative à la production d'électricité à partir d'énergies renouvelables et visant à adapter certaines dispositions relatives aux réseaux d'électricité et de gaz et aux énergies renouvelables (n° 4122).*

[89] Regulation on the Fee for Incentivising Production of Electricity from Renewable Energy Sources and Cogeneration (*Uredba o naknadi za poticanje proizvodnje električne energije iz obnovljivih izvora energije i kogeneracije*) ("O.G.", No. 128/13) - HR - http://narodne-novine.nn.hr/clanci/sluzbeni/2013_10_128_2778.html

[90] 'kn' is an abbreviation for the Croatian currency Kunas.

To benefit from premium tariffs, prosumers must acquire the status of priority electricity producer provided that they are in a Registry, have a connection to the grid, have a meter enabling calculation of net electricity fed into de grid and meet all the requirements set out in the construction permit. Therefore, producers of electricity that are not connected to the grid are not eligible for premium tariffs. This premium tariff is set in the contract between the electricity producer/prosumer and the Croatian Energy Market Operator (HROTE), which is concluded following a public tender that is published once a year. The premium tariff may be granted to numerous electricity producers. The supplier is required to calculate, once a month, the bill for the prosumer by deducting electricity fed into the grid from the electricity drawn from the grid. The priority electricity producer with generation capacity of up to 30kW has the right to the guaranteed purchase price provided a contract is concluded with HERA after being selected as best bidder in a public tender (Article 34 of the ARES).

The Walloon region in Belgium has established an annual premium (during the first five years) by the network operator to the self-producer. The amount of the premium is set by the law (CWaPE) on the basis of a published methodology that guarantees a return on investment of 8 years[91]. Furthermore, an additional premium is offered to protected clients and self-producers with a precarious income in order to ensure, as well as a ROI of 8 years, a rate of return of 6.5%.

In Italy, the Conto Energy regime applying a premium tariff specifically to PV plants for 20 years from the moment they become operational has been terminated.

Taxes

Certain countries have imposed a reduced surcharge or tax on self-consumed energy. In August 2014, Germany revised its existing surcharge system which was previously applied only on electricity generated and fed into the grid, in order to cover all electricity consumed, hence also including self-consumed electricity. However, for self-suppliers the amount of the surcharge to be paid was less than the general surcharge. In 2015, it was 30% of the general EEG surcharge, growing to 35% in 2016, and 40% in 2017. In addition, household self-consumers (with capacity less than 10kW) pay less EEG surcharge as they only pay it for the electricity they purchase from the grid[92] which is less than other installations since they produce part of the electricity they consume whereas all other installations purchase all the electricity they consume for which they pay both the price and EEG surcharge.

The system of surcharge has changed in the recent amendment of the EEG[93] and only existing self-supply installations, as well as new small solar systems on house roofs up to a size of 10 kWp for self-consumption will remain fully exempt from the EEG surcharge, for example in case the electricity is generated from plants with a capacity of 10 kilowatts maximum, for a maximum of 10 megawatt hours of self-consumed electricity per calendar year. This applies from the start-up of the electricity generating plant for a period of 20 calendar years plus the year of commissioning. If they undergo substantial modernisation, then existing installations will be permanently granted a reduction of at least 80% of the surcharge; i.e. they will normally pay a maximum of 20% of the EEG surcharge. For new installations, the EEG surcharge will apply to self-supply installations although it will be reduced to 40% for new RE plants and highly efficient CHP installations.

[91] CWaPE, « Principes – Qualiwatt », http://www.cwape.be/?dir=6.2.01 (last accessed on 23.02.2017); CWaPE, « Methodologie – Qualiwatt », http://www.cwape.be/?dir=6.2.07 (last accessed on 23.02.2017).
[92] Ibid.
[93] For an overview of the old legislation and (old) self-consumption bonuses see https://www.clearingstelle-eeg.de/beitrag/1990 (in German only).

Thanks to the net metering system (not mandatory), prosumers in The Netherlands only pay for the energy they consume and are taxed on the energy they consume. The calculation of how much energy the prosumer will be taxed for is part of the 'netting' (*salderen*) procedure. Legal uncertainty exists as regards the energy tax to be paid for renewable energy generated by a large installation outside of one's home (e.g. a wind turbine). The law does not provide solutions to the situation where two different energy suppliers would supply energy to a consumer (i.e. the official energy supplier and a cooperative owning a wind turbine). The only option being used today is that the cooperative sells the energy produced by the wind turbine to the energy supplier, who then sells it back to the members of the cooperative. A common practice in The Netherlands is for wind cooperative members to own 'wind shares' (*winddelen*), meaning that they own a part of the wind turbine and are entitled to a share of the energy it produces. Due to this legal gap, owners of wind shares are required to pay energy tax on the energy produced by the wind turbine they co-own, since it is delivered to them by the energy supplier[94]. This has been criticised as an obstacle to the further adoption of wind energy, although these types of prosumers have recently become eligible for tax deductions (more information provided below). Furthermore, the owning of a share in a wind turbine is also perceived of as constituting 'property' by the tax services, the value of which needs to be declared to the tax services on a yearly basis[95].

In France, private individuals used to be able to enjoy tax credit schemes for the installation of solar PV or domestic wind turbines. However, as of 1 January 2016, these schemes do not exist[96]. Furthermore, according to the French Customs Code, electricity consumers and self-consumers are liable to pay the 'Participation to the electricity public service' (Contribution au service public de l'électricité or CSPE)[97]. Self-producers, whose annual production does not exceed 240 GW, are exempt from this tax, but ionly if they consume all of their production[98]. The current Bill on self-consumption aims to create a specific exception to the payment of the CSPE for all situations of self-consumption when the production capacity installed is less than 1,000 kW[99].

French law foresees the application of specific rules to prosumers whose facilities have an installed capacity of less than 100 kW (Article 2 Energy Transition Law). For instance, Article L315-3 French Energy Code provides that the CRE 'establishes specific tariffs for the use of public networks of electricity distribution for consumers participating in self-consumption operations where the installed capacity of the production facility supplying them is less than 100 kW.' However, in its Opinion of 13 July 2016 on the Project of Ordinance pertaining to Self-Consumption of Electricity,[100] the CRE opposed the creation

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94 https://www.energieleveranciers.nl/upload/File/Zonnestroom%20en%20de%20Nederlandse%20wetgeving_AgentschapNL.pdf

95 https://www.energieleveranciers.nl/upload/File/Zonnestroom%20en%20de%20Nederlandse%20wetgeving_AgentschapNL.pdf

96 Eco Infos Energies Renouvelables, 2016, *De quelles aides financières pouvez-vous bénéficier pour un équipement d'autoconsommation énergétique ?*, viewed 8 February 2017 http://www.les-energies-renouvelables.eu/conseils/autoconsommation/aides-financieres-equipement-autoconsommation-energetique/

97 Article 266 *quinquies* C French Customs Code.

98 Rapport n° 285, 2017, p. 25.

99 Commission Mixte Paritaire, 2017, Annexe au Rapport, Projet de Loi ratifiant les ordonnances n° 2016-1019 du 27 juillet 2016 relative à l'autoconsommation d'électricité et n° 2016-1059 du 3 août 2016 relative à la production d'électricité à partir d'énergies renouvelables et visant à adapter certaines dispositions relatives aux réseaux d'électricité et de gaz et aux énergies renouvelables.

100 Déliberation de la Commission de régulation de l'énergie du 13 juillet 2016 portant avis sur le projet d'ordonnance relative à l'autoconsommation d'électricité.

of specific categories of tariffs, 'which could freeze the structure of tariffs for the use of the public electricity networks in the long run.'[101]

In Belgium, prosumers are subject, like any other electricity consumer, to an energy supply tariff, which is calculated on the basis of the energy used and a network tariff – for the transport and distribution of energy, calculated on the basis of energy usage. The incentive relies on the fact that the energy consumed from the grid by the prosumer is lower and, therefore, both tariffs are reduced. In addition, a system for tax deduction for solar PV was established at federal level[102] but was phased out without compensation at regional level. It should also be noted that municipalities may introduce their own taxes or subsidies on the renewable electricity generated. In the Flemish Region, nearly one in three municipalities gives local subsidies for solar energy; usually a percentage of the investment cost with a ceiling of 250 EUR to 1,000 EUR[103]. In practice, this limit is always achieved and so it actually constitutes a fixed premium.

According to the RES Law in Poland, the surplus of electric energy fed by the prosumer to the grid as compared to the energy taken by the prosumer from the grid shall not be considered as an income in the meaning of the income tax law for legal persons. This means that the energy surplus generated by the prosumers is not subject to income tax. However, the energy taken from the grid by the prosumer, which is subject to the settlement in accordance with the RES Law, is considered to be the usage of energy produced by the prosumer, in the meaning of the Excise Tax Law. This means that the energy used by the prosumer is subject to the excise tax (e.g. for solar PV panels this is around 60 PLN per year (appx. 12 EUR) or 20 PLN (5 EUR) per 1 MWh).[104]

In Spain, the Law 15/2012 on financial measures for the sustainability of electricity[105] sets a common energy tax for all installations producing electricity[106], whether they are owned by a natural or a legal person. The taxable base is the total amount that the producer gets for producing electricity and feeding it to the grid in the tax period of the

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[101] [Author's translation] The original version provides: 'La CRE n'est toutefois pas favorable à la création de catégories tarifaires spécifiques qui pourraient à terme figer la structure des tarifs d'utilisation des réseaux publics d'électricité'.

102 Since 1 January 2003, certain energy-reducing investments could rely on a tax deduction, from which the owner or tenant could benefit (*Wet van 10 augustus 2010*, B.S. 20.09.2001). From the fiscal year 2010, the Economic Recovery Act (*Economische herstelwet van 27 maart 2009*, B.S. 07.04.2009) provided for the spreading of the tax reduction over four years for houses having at least five years. This is especially interesting for expensive investments, such as installing a PV system. For expenses in 2010, 40% of the investment is eligible for tax reduction, with a limit of 3,600 EUR for solar water heaters and photovoltaic solar panels. This 'enhanced' deduction was abolished for expenses from the tax year 2011.

[103] Ultrasolar, *Fotovoltaïsche zone-energie*, viewed 12 January 2017, http://www.ultrasolar.be/belastingvermindering-particulieren,. However, Vlaams Energieagentschap, *Zoek uw subsidie*, viewed 11 January 2017, http://www.energiesparen.be/subsidies/subsidiemodule includes a very user-friendly way to search for subsidies per municipality and, from a quick search, no municipality could be found that still had subsidies available for PV panels.

[104] Opinion of the Institute for the Renewable Energy about the adopted law on renewable energy sources – investments in RES micro installations cost-effective only for entrepreneurs (*Opinia Instytutu Energetyki Odnawialnej o uchwalonej ustawie o odnawialnych źródłach energii - Inwestycje w mikroinstalacje OZE opłacalne tylko dla przedsiębiorców*), available at: http://ieo.pl/pl/aktualnosci/1090-opinia-instytutu-energetyki-odnawialnej-o-uchwalonej-ustawie-o-odnawialnych-zrodlach-energii-inwestycje-w-mikroinstalacje-oze-oplacalne-tylko-dla-przedsiebiorcow

[105] Law 15/2012, of 27 December, on financial measures for the sustainability of electricity (Ley 15/2012, de 27 de diciembre, de medidas fiscales para la sostenibilidad energética), State Gazette BOE-A-2012-15649, available at https://www.boe.es/buscar/act.php?id=BOE-A-2012-15649&p=20131227&tn=1 (last accessed 21 December 2016).

[106] Article 4 Law 15/2012.

calendar year[107]. The tax is set at seven per cent and would only be payable if the produced electricity is fed into the grid. Type 1 prosumers are exempted from this tax. In addition, the Spanish RD 900/2015 recognises for prosumers the benefit of a special reduction of the tariff related to the cost of upgrading the grid to compensate for the extra energy generation they feed into the grid.

VAT Tax

The VAT tax system is based on the interpretation of the European Court of Justice ruling on the Fuchs case108 (C-219/12), which established that the operation of a photovoltaic installation (i.e. solar panel), feeding energy into the grid and obtaining 'income' (i.e. compensation) for this activity on a continuing basis from the energy supplier, constitutes an 'economic activity.' The term 'income' in this context refers to the remuneration that the prosumer receives from the supplier in exchange 'for the activity' he is carrying out (i.e. feeding energy into the grid)[109]. The Netherlands has established a system whereby the VAT of solar panel purchases is refunded, including the one applied to the installation of solar panels.

Similarly, in Poland, the RES Law sets out specific tax provisions applicable to prosumers who are exempt from the VAT and income tax. The RES Law establishes that the activity carried out by a prosumer shall not be considered to be an economic activity nor as a provision of services or selling in the meaning of the VAT Law and, therefore, prosumers are exempted from the VAT[110]. In Hungary the National Tax and Customs Administration of Hungary (*Nemzeti Adó-és Vámhivatal* - NAV[111]) establishes the following principles on the applicability of VAT to the electricity fed into the grid as a taxable product:

- The fact that the household power plant feed electricity back into the grid, does not automatically mean that the electricity should be subject to value added tax.
- As a general rule, household power plants are not obliged to pay value added tax, if they produce electricity mainly for self-consumption and only occasionally feed the energy back into the electricity grid.
- As a general rule, household power plants are obliged to pay the value added tax, in cases where the household power plant was originally established with the aim of producing almost exclusively electricity surplus. In these cases, the quantity of the energy produced regularly exceeds the quantity of the energy which could be self-consumed. According to NAV in these cases the household power plant provides economic activity as specified under Article 6(1) of Act CXXVII of 2007 on value added tax (*2007. évi CXXVII. törvény az általános forgalmi adóról*[112]) and thus should be subject to the obligation of paying value added tax.

Other countries apply a reduced VAT. In France, tax credits and reduced VAT schemes exist for the installation of complementary technology relevant to self-consumption, such

[107] Article 6 Law 15/2012.
[108] http://curia.europa.eu/jcms/upload/docs/application/pdf/2013-06/cp130075en.pdf
[109] http://curia.europa.eu/juris/document/document.jsf?docid=138693&doclang=EN
[110] Article 4(8) and (9) of RES Law
[111] NAV website, available at: http://nav.gov.hu/.
[112] Act CXXVII of 2007 on value added tax (*2007. évi CXXVII. törvény az általános forgalmi adóról*), available at: http://njt.hu/cgi_bin/njt_doc.cgi?docid=111467.329438.

as home energy monitoring systems[113]. In Italy, photovoltaic and wind energy plants are eligible for a reduced VAT of 10% instead of the general 20%. This tax benefit applies to enterprises, professionals and private persons. The UK applies a VAT reduction on energy saving items. The good and services tax is reduced from 17.5% to 5% for certain goods and services including microgeneration systems. In addition, residential prosumers are exempt from income tax on revenue from electricity sale.

Subsidies or support to investments

In addition, in Germany, the Neighbour solar supply "Mieterstrom" model (or on-site direct wire mini PPAs) has developed recently. In this model, an energy provider offers to supply the residents of a building with solar PV electricity from the building's roof. If there is adequate take-up, the provider installs the solar PV system. From a legal perspective, the solar electricity is not considered to have been supplied via the public grid even if technically speaking it is using the cables and wires in the building. The residents receive cheaper electricity than if they paid the retail electricity price and the provider receives a return on investment in the solar PV system.[114]

In France, the Energy Code provides for participatory investment (*investissement participatif*) in renewable energy production projects. Specific joint-stock companies and cooperative societies may offer a share or part of their capital to natural persons residing on the same territory as the site of production and local public authorities.

In The Netherlands, an Investment subsidy for sustainable energy (*Investeringssubsidie duurzaam energie; ISDE*) has been made available from 2016 to 2020, which subsidises the purchase of solar panels, water heaters, heat pumps, biomass boilers and pellet stoves[115]. In Portugal the new Plan for Energy Efficiency promotes investment in equipment.

In addition, companies and entrepreneurs investing in renewable energy projects in The Netherlands are entitled to a tax regulation mechanism called the Energy Investment Allowance (Article 3.42 in conjunction with Article 3.43 Income Tax Act), which is not made available to residential prosumers[116]. It is important to note that provinces and municipalities are free to set up their own financial incentive programmes for renewable energy projects. For instance, the province of Gelderland provides the *Energiebespaarlening* (energy saving loan) to its residents. Thanks to this scheme, residents investing in clean-energy technologies in their homes, such as solar panels, can borrow money at a favourable interest rate. The loan amount is maximum 25,000 euros and 75% of the amount can be invested on one technology (the remaining 25% should be invested on other types of installations)[117].

In the Czech Republic, the *Nova Zlena Usporam* programme is an investment support scheme for the reconstruction of houses and apartment buildings promoting renewable energy, including the installation of solar and PV systems for up to 50% of the installation costs.

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[113] See RES Legal, 2016, *Promotion in France*, viewed 8 February 2017 http://www.res-legal.eu/search-by-country/france/tools-list/c/france/s/res-e/t/promotion/sum/132/lpid/131/
[114] See F. Zuber, "The Mieterstrom neighbour solar supply model in Germany', available at http://www.pv-financing.eu/wp-content/uploads/2017/02/pv_inancing_webinar_feb_2017.pdf
[115] http://www.rvo.nl/subsidies-regelingen/investeringssubsidie-duurzame-energie
[116] http://www.rvo.nl/subsidies-regelingen/energie-investeringsaftrek-eia/kom-ik-in-aanmerking
[117] http://www.gelderlander.nl/algemeen/economie/lenen-voor-energiebesparing-1.4794266

Loans to renewable energy projects[118] are awarded in Croatia through the Fund for Environmental Protection and Energy Efficiency (*Fond za zaštitu okoliša i energetsku učinkovitost*)[119] and the Croatian Bank for Reconstruction and Development (*Hrvatska banka za obnovu i razvitak*)[120]. These loans are not limited to producers of energy from RES connected to the grid.

The national strategy for Energy Renewables (PER) in Spain proposes a programme of direct subsidies for low-power wind energy technologies (power equal or lower than 10kW) destined for self-consumption. For this purpose, annual programmes granting public subsidies up to a maximum amount per installation depending on the ratio €/kW should be launched. The same kind of subsidies programmes are foreseen for low-power self-consumption PV projects[121]. These programmes aim to achieve the technical-economic feasibility and the commercial take-off of these typologies of projects.

The UK Green Deal, implemented from January 2013, facilitates loans for the capital cost of various energy efficiency measures, including micro generation for residences and businesses. The loans are to be paid back at a fixed rate with bill savings automatically added to the property's energy bill.

Malta also has an investment grant scheme whereby domestic plants generating electricity from solar energy are eligible[122].

The following table presents a summary of the situation as described above. The colours represent the assessment of the measures in relation to their favourable impact on the development of residential prosumers where yellow means that the impact is favourable, blue is medium and red is low favourable impact.

Table 4: Overview of financial incentives (Source: own development)

Country	Feed-in Tariffs	Compensation	Premiums	Taxes		Subsidies
BG						
BE				On energy consumed		
CZ						
DE	For consumption					
ES		Type 2		Type 1		
FR				VAT reduction		
HU				VAT exemption		
HR						
IT				VAT reduction		
MT						
NL				On energy consumed	VAT refunded	
PL						
PT						
SL						
UK				VAT reduction		

[118] http://www.res-legal.eu/search-by-country/croatia/single/s/res-e/t/promotion/aid/loan-environmental-fund/lastp/359/ and http://www.res-legal.eu/search-by-country/croatia/single/s/res-e/t/promotion/aid/loan-in-the-hbor-bank-scheme/lastp/359/, accessed on 5 December 2016.
[119] http://www.fzoeu.hr/en/home/
[120] https://www.hbor.hr/en/
[121] IDAE, PER 2011-2020, p. 260 and pp. 557-558 and pp 388-389.
[122] Malta: Overall summary, http://www.res-legal.eu/search-by-country/malta/

4.3 Conclusions

From the comparative legal analysis, it is clear that there is no harmonised regulatory framework regulating residential prosumers, meaning that countries across Europe have taken very different approaches.

No Member State has a definition of the precise term ‘residential prosumers’. However, countries have adopted equivalent concepts, which may focus either on the production or consumption element of being a prosumer. Several of the countries that define prosumers in relation to their production element, refer to the installation size or generation capacity. Generation capacity caps, when used to determine the scope of national measures, differ across countries. A group of countries uses the 10kW capacity cap to define residential prosumers (in line with the IEA, as illustrated in the study’s Background chapter).

While there is no harmonised definition of prosumer at Union level, there is no evidence that this may have prevented the design of effective policies, attractive enough to convince energy consumers to start producing the energy that they need. However, the non-homogeneous definitions of prosumers and of generation capacity caps (where applicable), trigger the application of different types of measures and financial incentives to residential self-generation, which makes a cross-Europe comparison impossible.

The majority of the Member States have simplified procedures for setting up residential prosumer installations. Member States generally enable prosumers to feed the surplus electricity back into the grid. However, in several Member States there is no possibility for residential prosumers to benefit economically from the excess of electricity produced, not consumed and fed into the grid. Some Member States have developed remuneration schemes on the basis of a fix tariff while others have set up a compensation system based on net-metering. Few Member States enable prosumers to sell the electricity fed into the grid.

Countries across Europe differ extensively in terms of the financial incentives adopted for prosumers. There is no strong harmonised structural approach to prosumer support that takes prosumers’ specificity and interests fully into account and, in most Member States, the regulatory framework has evolved rapidly overtime. As highlighted in the study, adjustments of available incentives in some Member States have already prompted reactions. Alongside net-metering, most countries promote renewable energy sources through Feed-in Tariffs, or premiums with specific measures tailored to prosumers. While some countries, such as Germany and Spain, have successfully applied these mechanisms to encourage the use of renewables in general or prosumers uptake in particular, some of these measures have been phased out. In Germany, the scheme has evolved to provide incentive measures to residential prosumers that consume the electricity generated rather than feeding it into the grid.

Other Member States (e.g. France) have set up a system of complementary measures from Feed-in-Tariffs coupled with premium payments. In addition, tax reductions, as well as capital subsidies and loans or other forms of investment support, are available but again their form and shape varies broadly across Europe. It is worth noting that the European Court of Justice ruling on the *Fuchs* case[123] (C-219/12), has established that the operation of a photovoltaic installation (i.e. solar panel), feeding energy into the grid and obtaining ‘income’ (i.e. compensation) for this activity on a continuing basis from the energy supplier, constitutes an ‘economic activity.’ The term ‘income’ in this context

[123] http://curia.europa.eu/jcms/upload/docs/application/pdf/2013-06/cp130075en.pdf

refers to the remuneration that the prosumer receives from the supplier in exchange 'for the activity' he is carrying out (i.e. feeding energy into the grid)[124]. On that basis, The Netherlands, Poland and Hungary have developed schemes explicitly exempting prosumers from the payment of VAT of solar panels.

The Netherlands has established a scheme that ensures that the VAT of solar panel purchases is refunded, including that applied to purchasing and installing solar panels. In Poland, the RES Law sets out specific tax provisions exempting prosumers from the VAT and income tax. The RES Law establishes that the activity carried out by a prosumer shall not be considered to be an economic activity nor as a provision of services or selling in the meaning of the VAT Law and, therefore, prosumers are exempt from the VAT. Hungary exempts household power plants of paying VAT if they produce electricity mainly for self-consumption and only occasionally feed it back into the grid. France, Italy and the UK have VAT reduced systems.

In general, incentives have played an important role in promoting the development of self-generation, especially in the more mature solar PV markets. Incentives have also been widely utilized in other countries where the market is not yet mature. For instance, in Slovakia, the building permit cost is reimbursed by the State, if and when the energy producing facilities are effectively constructed. In the Czech Republic, application fees are paid, but when prospective prosumers request a permit in the framework of the "Nova Zelena Usporam" investment support program, they receive a financial support which amounts to 50% of the whole costs. In Poland, Bulgaria and Malta there are no connection fees for the prosumer applying for the opening of a micro-installation.

A common, comprehensive definition of "residential prosumers" could be a catalyst for the development of a clear and strong EU policy and regulatory framework supporting consumers' self-generation while respecting the subsidiary principle described under Article 194(2) TFEU, and the Member States' right to determine their choice of energy sources and the general structure of their energy mix. An EU-level framework could focus on the establishment of a portfolio of carefully designed incentives, tailored to the different situations and the consequences of the different measures applied overtime such as the increase of energy cost for traditional energy consumers if the uptake of prosumers increases. Consumer behaviour is motivated not only by financial incentives, but also considerations about energy savings or the environment and, hence, all aspects should be taken into account when developing the appropriate regulatory framework. Further to the financial incentives, the measures designed should aim at supporting the development and uptake of new technologies with an environmental objective. However, the development of such technologies has proven to be slow due to the combination of financial factors (high costs) and national energy policy choices.

[124] http://curia.europa.eu/juris/document/document.jsf?docid=138693&doclang=EN

5 Baseline and projection scenarios

As explained in the Background chapter, since residential solar PV technologies became commercially viable in the early 2000s, the costs of solar PV have fallen considerably and the potential benefits of investment have become more widely understood, leading to rapid growth in capacity in the EU. By 2015, total solar PV capacity in the EU28 reached almost 100GW[125], of which around 16GW[126] is estimated to have been installed by households. In 2016, we estimate that almost 17GW residential solar PV has been in installed in the EU[127, 128].

The increase in installed residential solar PV capacity since 2000 is partly due to policy measures that were introduced to encourage investments, which contribute towards meeting national climate commitments and renewables targets. The policy support mechanisms boosted the cost-effectiveness of solar PV, creating further incentives to invest. In addition to electricity bill savings, policies introduced in many EU Member States meant that prosumers were also compensated for surplus electricity fed back into the grid (via reductions in future energy bills, under net-metering, or direct export tariff payments or feed-in tariffs or premiums). In recent years, as highlighted also in the chapter of this study dedicated to the comparative legal analysis, some Member States[129] have reduced the level of support available to prosumers, due to large reductions in the capital costs of solar PV, squeezed government budgets and insufficient grid storage or demand-side response measures to smooth out peaks in electricity supply.

The purpose of this study's Main Task 3 was to model take-up of solar PV by households in each EU Member State, Norway and Iceland over the period to 2030.

In the baseline projections, it is assumed that existing financial support for self-generation is continued. Future technology scenarios have been developed to assess the impact of factors affecting cost and consumer preferences on take-up of solar PV. Specifically, the scenarios assess the impact of:

- A gradual phase out of policy support over the period to 2020
- Relaxation of EU anti-dumping legislation in 2017
- Growth in the number of households owning a plug-in electric vehicle (or EV)

This chapter explains the methodology applied to estimate take-up of solar PV and presents the key results for take-up rates in the baseline rates and scenarios.

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125 Eurostat (2015)
126 Estimate based on residential Solar PV capacity data from national governments and analysis by CE Delft (2016).
127 As national data, in most cases, is only available for 2015, the estimate for 2016 is the first year of the model solution. It is based on the cost calculation (described in Section 4.1) and on known policies in place in that year.
128 Although the 2016 estimate suggests that residential Solar PV capacity in the EU is still growing, it is growing at a considerably slower rate than in previous years, due to reduced policy support and because households that view Solar PV most favourably have already invested in it.
129 For example, in Spain, or in the Czech Republic, Feed-in-Tariffs were phased out in 2013, following two years of strong growth in installed solar PV capacity, or in the UK where Feed-in Tariff rates were cut substantially in 2016.

5.1 Methodology

5.1.1 Overview of approach

The methodological approach applied in Main Task 3 involved developing a spreadsheet-based model of annual solar PV investments.

To develop projections of take-up of solar PV requires information about the distribution of consumer preferences and the cost-effectiveness of investment. For each year up to 2030, under specific assumptions about CAPEX and OPEX costs, policy support, future electricity prices and consumer preferences, these distributions are used to derive the share of households for which investment is an attractive option. The investment shares are calibrated using the latest year of data and are then applied to estimates of total technical potential for solar PV in each Member State, to derive take-up in each year.

The following sections describe key aspects of our methodology, including: the key drivers of investment in residential solar PV, the derivation of total potential residential solar PV capacity and our modelling approach for take-up of solar PV.

5.1.2 Investment drivers

As explained in the Background chapter, when deciding whether to install rooftop solar PV, households must weigh up a multitude of financial and non-financial factors to assess whether investment is worthwhile. Financial-related considerations include: the upfront cost of installation, borrowing costs, the scale of the financial benefit (in terms of reduced electricity bills and available policy support) and the expected rate of return (and payback period) for their investment. Households' investment decisions are also heavily influenced by non-financial factors, including: views about the aesthetics of rooftop solar PV panels, perceptions of time requirements and disruption related to installing solar PV, environmental values, desire for greater autonomy and prestige, as well as current trends and fashions. In addition to values and underlying preferences towards solar PV there are technological factors that may make solar PV investment more desirable (for example, ownership of an electric vehicle, smart meters or battery storage and demand response technologies).

In relation to these financial and non-financial drivers of investment, there is considerable heterogeneity among households, both across Member States and within each Member State. For example, whilst some people live in dwellings with large, south-facing roofs in regions with high solar insolation, where solar PV investment is very cost-effective, other households live in dwellings that are not as well-suited to solar PV (and therefore face higher costs per kW installed). Furthermore, differences in values and preferences mean that some households are more accepting of solar PV than others.

Modelling the take-up of solar PV requires consideration of the interaction between the financial and non-financial drivers of investment across all households, in different circumstances, facing different costs/benefits and with different preferences. By modelling the variation in financial and non-financial drivers of investment across the entire population, an estimate can be formed for the proportion of households for which solar PV is both cost-effective and desirable, given their underlying preferences.

The methodology is dependent on the assumption that cost-effectiveness of investment and consumer preferences are normally and independently distributed.

5.1.3 Total potential capacity

The technical potential for residential solar PV is calculated for each EU Member State (plus Iceland and Norway) by applying reduction factors to estimates of the total rooftop area across all residential dwellings. This approach is similar to that applied in Parsons Brinkerhoff (2015)[130], Wiginton et al. (2010)[131] and Lehman and Peter (2003)[132].

The total rooftop area of all residential dwellings is estimated based on Eurostat figures for the number of households[133] and the average size of dwellings[134]. A reduction factor is then applied to exclude the share of households for which solar PV installation would be unsuitable[135]. Based on estimates in Parsons Brinkerhoff (2015) and Eiffert (2003)[136], it is assumed that, of the dwellings deemed suitable for solar PV, 40% of the roof area would be un-obstructed with a southerly aspect, suitable for solar PV installations. It is assumed that 0.13kW solar PV capacity would be installed per 1m^2 of suitable roof space[137]. Based on these assumptions, the total potential residential solar PV capacity and total potential number of residential solar PV prosumers was derived for each Member State (as shown in Table 1).

Differences in total potential residential solar PV capacity among EU Member States are reflective of differences in the total number of residential dwellings. As such, France and the UK have the highest technical potential for residential solar PV (in each case, we estimate potential capacity of around 38GW and over 11 million potential prosumers). Despite having the largest population, and the highest rate of growth in residential solar PV over recent years, we estimate that the technical potential for solar PV in Germany is relatively low compared to that in similar-sized countries (with potential residential solar PV capacity estimated to be around 22GW and just under 6 million potential residential solar PV prosumers), as a high share of households in Germany are living in apartments and rented houses.

Table 1: Total potential capacity of residential solar PV (2016)

	Number of households (000s)	Estimated rooftop area of all residential dwellings	Proportion of homes suitable for solar PV (%)	Total potential residential solar PV capacity	Total potential number of residential solar PV prosumers

[130] Parsons Brinkerhoff (2015), 'Small-Scale Generation Costs Update'
[131] Wiginton, L.K. et al. (2010), 'Quantifying Rooftop Solar Photovoltaic Potential for Regional Renewable Energy Policy'. Available online at: http://solar.maps.umn.edu/assets/pdf/roof-libre.pdf
[132] Lehman and Peter (2003), 'Assessment of Roof & Façade Potentials for Solar use in Europe'. Available online at: http://susi-con.com/downloads/roofs.pdf
[133] Eurostat (2017), data code: lfst_hhnhtych
[134] Eurostat (2017), data code: ilc_hcmh01
[135] In this case, we assumed that rented houses and apartments would be unsuitable for investment.
Eiffert, P. (2003). 'Non-Technical Barriers to the Commercialization of PV Power Systems in the Built Environment';
IEA (2001). 'Potential for Building Integrated Photovoltaics'.
[137] Energy Saving Trust (2015), 'Solar Energy Calculator Sizing Guide'. The 'average detached house', with roof area of 29.5m2 would have space for 18 panels, with total capacity of 4kW; the 'average semi-detached house' with roof area of 20m2 would have space for 12 panels (and total capacity of 2.6kW).

		(km^2)		(GW)	(millions)
Belgium	4,699	365	58%	10.2	2.63
Bulgaria	2,940	134	49%	3.1	1.08
Czech Rep.	4,644	226	38%	4.1	1.32
Denmark	2,373	175	48%	4.1	0.86
Germany	40,258	2,373	20%	22.5	5.99
Estonia	572	24	29%	0.3	0.08
Ireland	1,712	86	66%	2.8	1.06
Greece	4,376	242	33%	3.8	1.07
Spain	18,376	1,138	25%	13.4	3.40
France	28,920	1,694	46%	37.6	11.61
Croatia	1,494	76	74%	2.7	0.67
Italy	25,789	1,509	35%	25.0	6.72
Cyprus	290	26	55%	0.7	0.12
Latvia	833	33	27%	0.4	0.17
Lithuania	1,332	53	39%	1.0	0.38
Luxembourg	229	19	47%	0.4	0.08
Hungary	4,152	196	61%	5.7	1.89
Malta	151	9	37%	0.2	0.04
Netherlands	7,622	508	53%	12.9	2.74
Austria	3,816	238	32%	3.7	1.20
Poland	14,113	663	46%	14.8	4.94
Portugal	4,083	271	41%	5.3	2.24
Romania	7,470	205	60%	5.9	3.36
Slovenia	883	44	55%	1.2	0.37
Slovakia	1,847	101	44%	2.1	0.61
Finland	2,623	145	50%	3.5	0.87
Sweden	5,100	329	42%	6.7	1.63
UK	28,219	1,340	59%	37.7	11.49
Iceland	119	10	41%	0.2	0.05
Norway	2,349	181	70%	6.1	1.74

Source: Own calculations, based on Eurostat data.
Notes: The proportion of homes suitable for solar PV includes privately-owned houses (i.e. excludes apartments and rented houses).
Estimates of total potential capacity were used to set an upper limit on solar PV investment in each Member State.

5.1.4 The cost-effectiveness of installing solar PV

To model the profitability of investment, the net present value (NPV) of investment under the market interest rate is calculated as the sum of discounted future revenues (electricity bill savings, plus benefits from Feed-in-Tariff and net-metering schemes) minus the sum of all costs (CAPEX costs, discounted OPEX costs, grid fees and tax). The net present value of investment in each year is then compared to the minimum net present value that is required by consumers to invest[138]. For the proportion of households where the net present value of investment is above their minimum requirement, we assume that they will invest with a given probability.

The NPV of solar PV is initially calculated for the mean household in each Member State and in each year over the period to 2030. The calculation for the NPV of investing in solar PV is defined in Annex 1 to this study. Key inputs to the calculation include assumptions for:

- the mean size of installations (in kWp)
- mean CAPEX and OPEX costs
- the policy support mechanism and available subsidies
- current and future expected electricity prices
- market interest rates
- load factors[139]

The assumptions applied are based on the most recent data available for each Member State. A literature review was used to assess the range of costs faced by different households, so as to derive the variance of the cost-effectiveness distribution.

The key policies that were included in the cost-effectiveness calculation are outlined in Table 2 below. A summary of the policies available, duration of availability, the value, eligibility and other important information can be found in Annex 2 to this study.

Table 2: Key policies modelled

Policy type	Description
Feed-in Tariffs	Prosumers are provided long-term contracts (usually of 10 to 25 years) by energy providers for electricity generated and exported to the grid. The Feed-in Tariff can be fixed, or designed to decrease as the technology matures. Prosumers pay the retail price for electricity they consume from the grid.
Feed-in Premiums	Feed-in premiums are long-term contracts that are designed to reduce short-term market exposure to elevated levels of grid-connected intermittent renewables. The payment for electricity exported to the grid is dependent on current wholesale market prices and so encourages electricity exports to the grid when it is needed, and self-consumption during periods of high electricity supply. The premium can be fixed or sliding (i.e. to reduce the gap between the wholesale price and the Feed-in Tariff).
Net-metering	Surplus electricity is fed back into the grid and prosumers are only charged for the net difference between electricity consumed from the

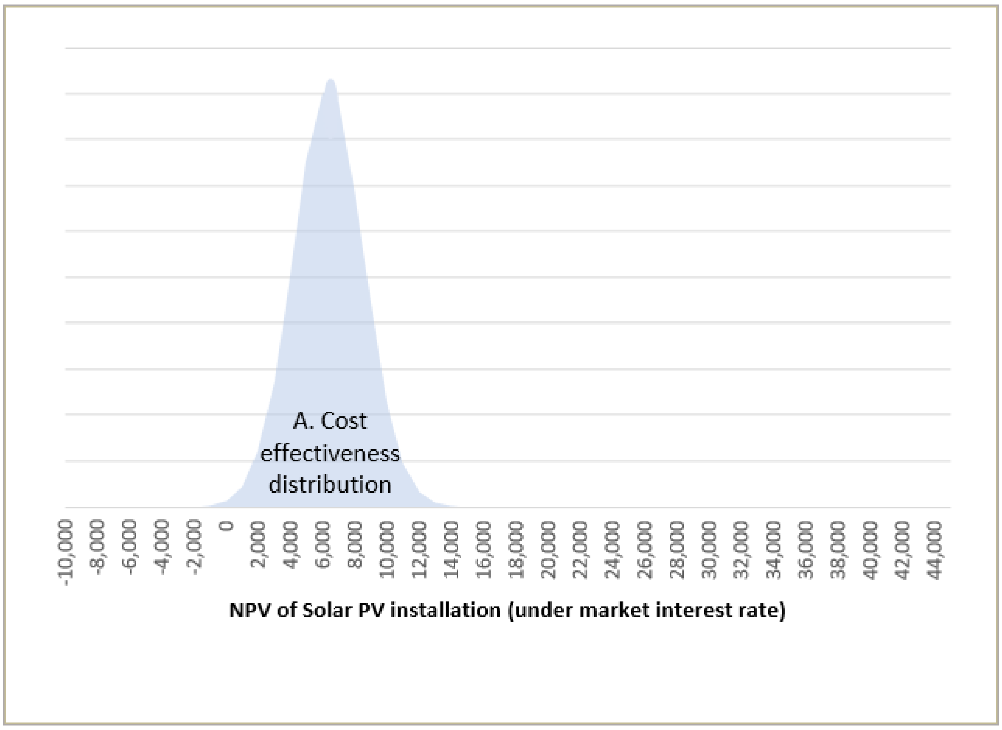
138 The minimum net present value required by consumers is calculated from information about the required rate of return on investment, based on consumer preferences.
139 Load factors (sometimes also referred to as capacity factors) measure the average quantity of electricity generated per hour relative to total potential generation (for a given level of capacity installed).

	grid and that fed back into the grid. The netting period (over which net bills are calculated) can be up to one year in length. Prosumers effectively use the grid for electricity storage and so there is no additional benefit of self-consumption versus exporting electricity to the grid, particularly if there is a long netting period.
Capital subsidies and loans	Subsidies or loans are provided to cover the costs of materials and/or installation. In some cases, prosumers are also eligible for reduced rates of VAT on solar PV equipment.

Figure 1 shows an example of the 'cost-effectiveness' distribution (expressed in net present value terms under market interest rates). The total area under the distribution is reflective of the technical potential for residential solar PV installations. In this example, the NPV of investing in solar PV is + €7,000 for the mean household. The right-hand tail of the distribution reflects the households where solar PV investment is most cost-effective i.e. households with large roof areas, facing low CAPEX and OPEX costs, living in regions with high levels of solar irradiation and, therefore, facing high load factors (for example, households located in the south of a specific Member State).

In this example, the NPV of solar PV installation is positive for almost all households. However, this is not to say that most households would install solar PV. In practice, most households are not aware of the financial benefit of investment. In addition, there are a number of non-financial barriers that reduce the attractiveness of investment.

Figure 1: Illustrative example of the distribution for the cost-effectiveness of installing solar PV

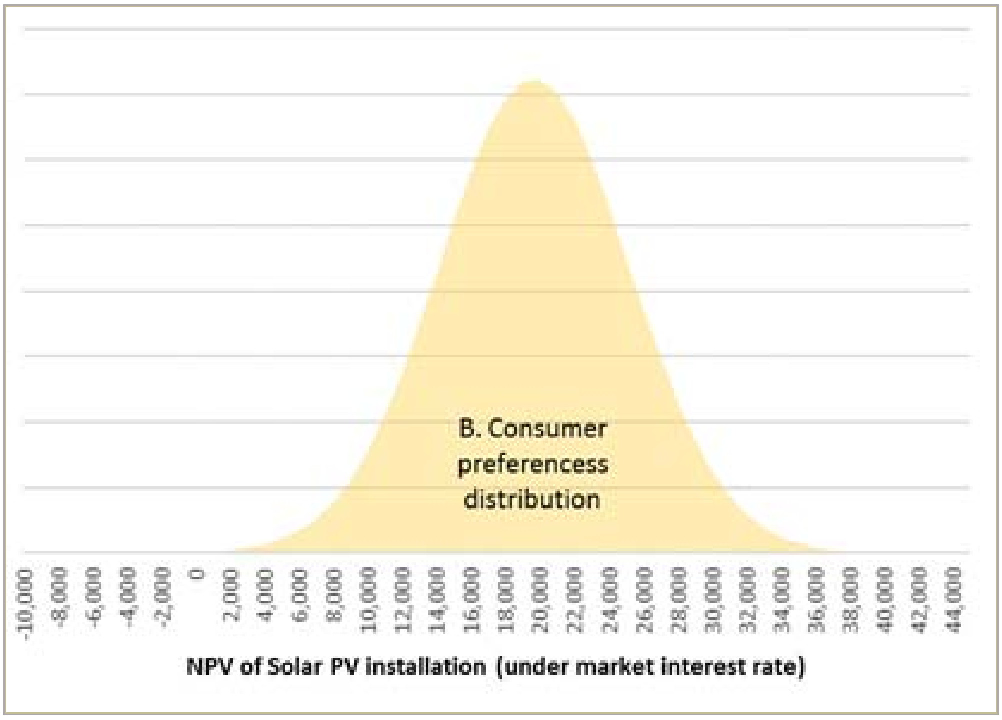


5.1.5 The distribution of consumer preferences

The 'consumer preferences' distribution is based on results from a review of literature on willingness to pay and the expected rate of return on solar PV investment. These factors vary among households depending on their own perceptions about solar PV and the barriers and non-financial costs and benefits associated with installation. Based on estimates in Parsons Brinkerhoff (2015) and NERA (2015), we assume that the mean household in the EU requires a 6.2% rate of return on investment to incentivise take-up of the technology[140]. This figure is then adjusted to account for the legal barriers identified in each EU Member State, as described in *'Key Modelling Assumptions'.*

Figure 2 shows an illustrative example of the distribution of consumer preferences in one EU Member State. In this example, the mean prosumer would require the NPV of a solar PV installation to be €20,000 (under market interest rates), equivalent to a 6.2% annual rate of return. Households in the right-hand tail of the distribution require a much higher rate of return to incentivise investment (for example, because they face higher non-financial barriers, do not like the aesthetics of solar PV or attribute a higher cost to the inconvenience and hassle of arranging for solar PV to be installed).

Figure 2. Illustrative example of the consumer preferences distribution



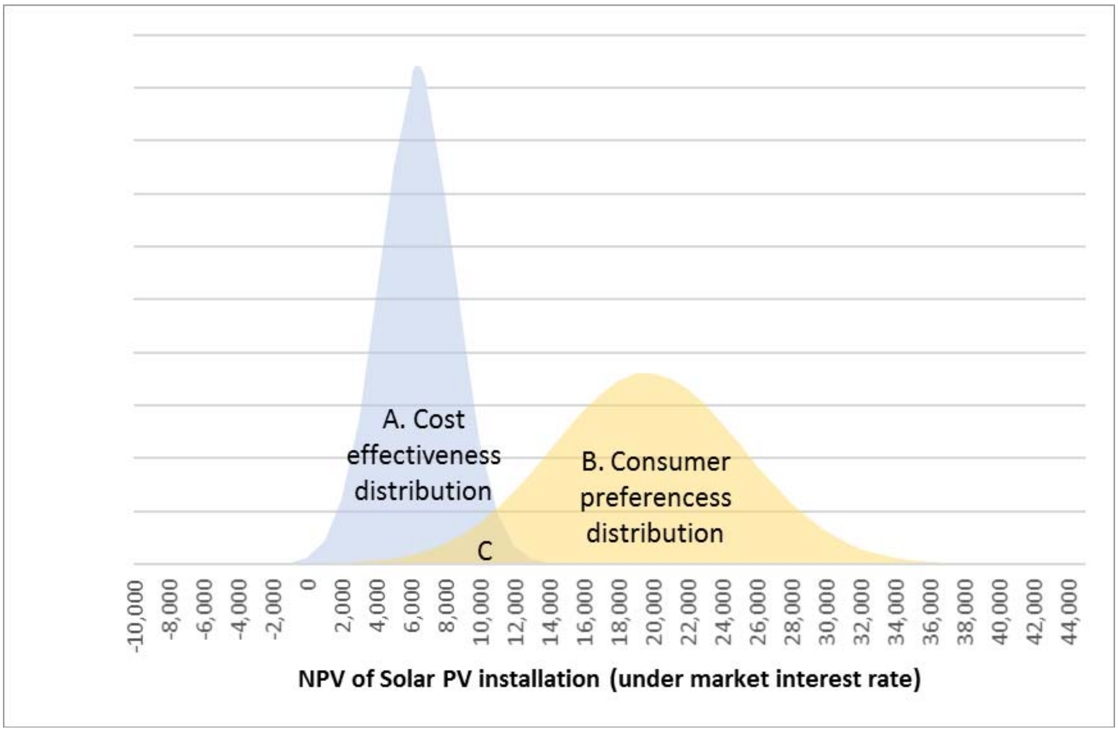
5.1.6 Combining information on cost-effectiveness and consumer preferences

After the distributions of cost-effectiveness and consumer preferences have been derived for each country, they are combined, as shown in Figure 3. The area, 'C', is the

[140] Parsons Brinkerhoff (2015), 'Small-Scale Generation Costs Update'; NERA (2015), 'Electricity Generation Costs and Hurdle Rates'.

overlapping area of the two distributions. A larger area C indicates that solar PV investment is an attractive option for a larger proportion of households. By combining the cost-effectiveness and consumer preference distributions, the proportion of households for which a solar PV investment is both cost-effective and desirable can be derived.

Figure 3. Combining the 'cost-effectiveness' and 'consumer preference' distributions



5.1.7 Calibration

The final stage involves calibrating the results, to correct for errors in our estimates due to factors that are not accounted for in the model.

The calibration factor is calculated as the share of investment that does take place (based on observed data) relative to the share that is considered attractive (based on model calculations). Calibration is used to account for factors that are not captured within the model, such as imperfect information and unobserved barriers to investment across households. The calibration factor is used to adjust the investment shares in all future years. The calibrated investment shares are then applied to estimates of total technical potential for solar PV in each Member State, to derive take-up in each year.

For most countries, the calibration factor was calculated based on new residential solar PV capacity in the most recent year of data available (2015) and the same calibration factor was then applied to every year in the projection period[141]. In some cases (e.g.

[141] By using a fixed calibration factor over the projection period, we implicitly assume that the likelihood that a seemingly attractive investment does take place, remains the same over time. It could be argued that the share of attractive investments that do take place would increase over time, as people become more familiar with the technology, which is part of the diffusion.

Czech Republic, Greece and Bulgaria), there was no change in installed capacity over 2014-2015, and so an earlier year of data was instead used to calibrate the model.

5.1.8 Key modelling assumptions

To project baseline take-up of solar PV over the period 2017-2030, several key modelling assumptions are made:

- Current policy measures, are assumed to remain unchanged over the projection period
- Financial and non-financial consumer preferences, proxied by expected return on investment, are assumed to remain unchanged over the projection period
- The cost of equipment and installation (CAPEX costs) is assumed to fall by 1.4% pa
- The cost of maintenance (OPEX costs) is assumed to fall by 0.2% pa
- Electricity prices for each EU Member State are set to grow in line with projections from the PRIMES reference scenario[142]
- A 0.1% pa degradation rate is assumed

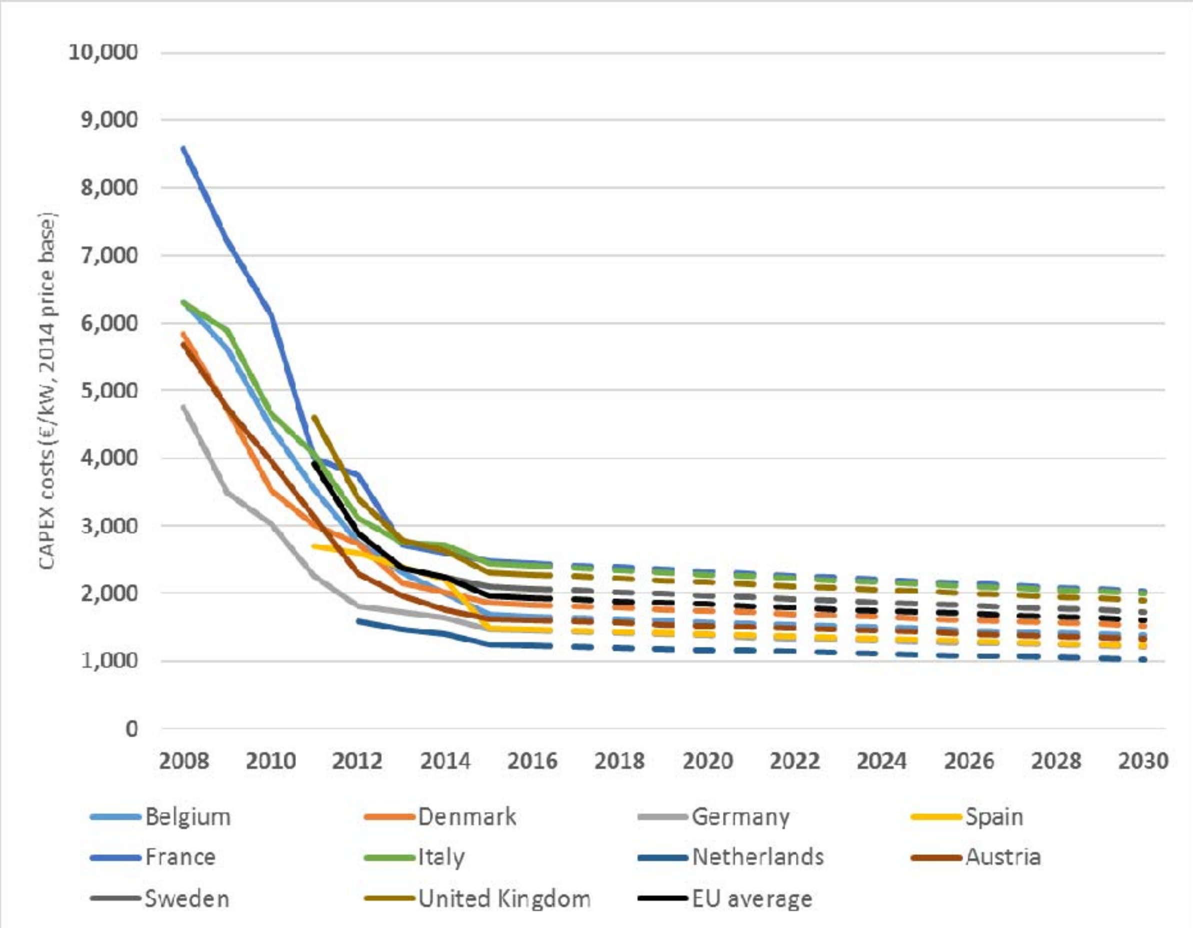
The assumed growth rates for CAPEX costs, OPEX costs and consumer preferences are set to be the same in each Member State. Electricity price inflation varies between Member States, as per the growth rates in the EU PRIMES reference scenario. Other data points, such as the average size of installation, interest rates, load factors and degradation rates are all assumed to remain unchanged over the projection period.

Figure 4 below shows the trend in CAPEX costs for selected Member States. The chart shows published CAPEX cost data (over the period 2007-2015) and our modelling assumptions (over the period 2016-2030). The baseline assumption for CAPEX costs is a conservative estimate, which assumes a considerably lower year-on-year reduction in CAPEX costs compared to that observed over 2007-2013. The impact of a more rapid fall in CAPEX costs is explored in the scenario analysis section, where it is assumed that EU anti-dumping legislation on Chinese solar panel imports is withdrawn.

Figure 4 shows some variability in CAPEX costs across EU Member States, with costs in France particularly high, due to legislation that provided Feed-in-Tariff bonuses for solar modules that were manufactured in the European Economic Area (IEA, 2014). In countries where historical CAPEX cost data were unavailable, an EU average CAPEX cost was assumed, based on the average of EU countries where data were available. The chart shows a huge reduction in capital costs of solar PV since 2007 due to economies of scale and efficiency improvements in the manufacturing process.

[142] 'EU Reference Scenario 2016: Energy, transport and GHG emissions Trends to 2050'. Available online at: https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_REF2016_v13.pdf

Figure 4: CAPEX costs data and projections over 2007-2030

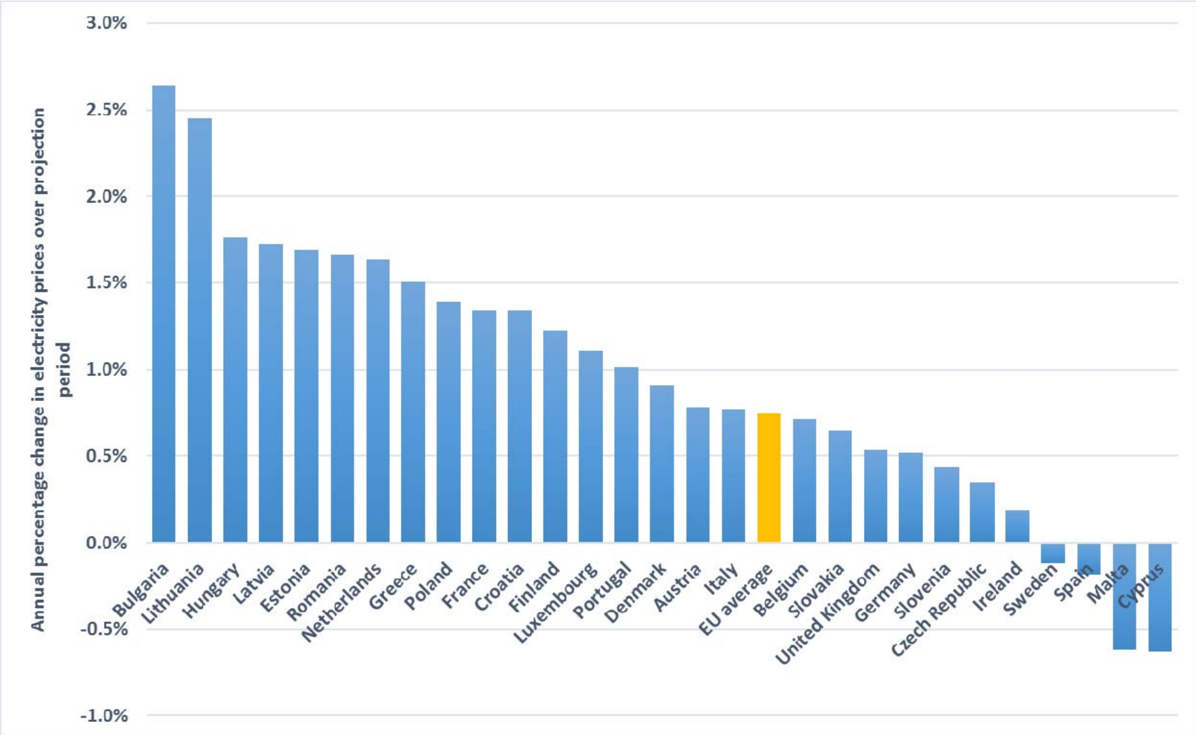


Historical OPEX costs are based on the assumption that the inverter will need to be replaced once every ten years. The cost of the inverter is assumed to be €1,000, based on figures in Parson Brinkerhoff (2015) and Fraunhofer ISE (2016)[143]. The OPEX cost is assumed to be the same in all Member States. OPEX costs are assumed to decline by 0.2% pa over the projection period, based on Parsons Brinkerhoff (2015).

Baseline electricity prices are assumed to grow in line with the *Average price of electricity in final demand sectors* from the EU PRIMES reference scenario. Figure 5 below shows the annual percentage change from 2015 to 2030, by Member State.

143 Fraunhofer ISE (2016) 'Photovoltaics Report'. Available at https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf

Figure 5: Annual percentage change in household electricity prices over 2015-2030, by country



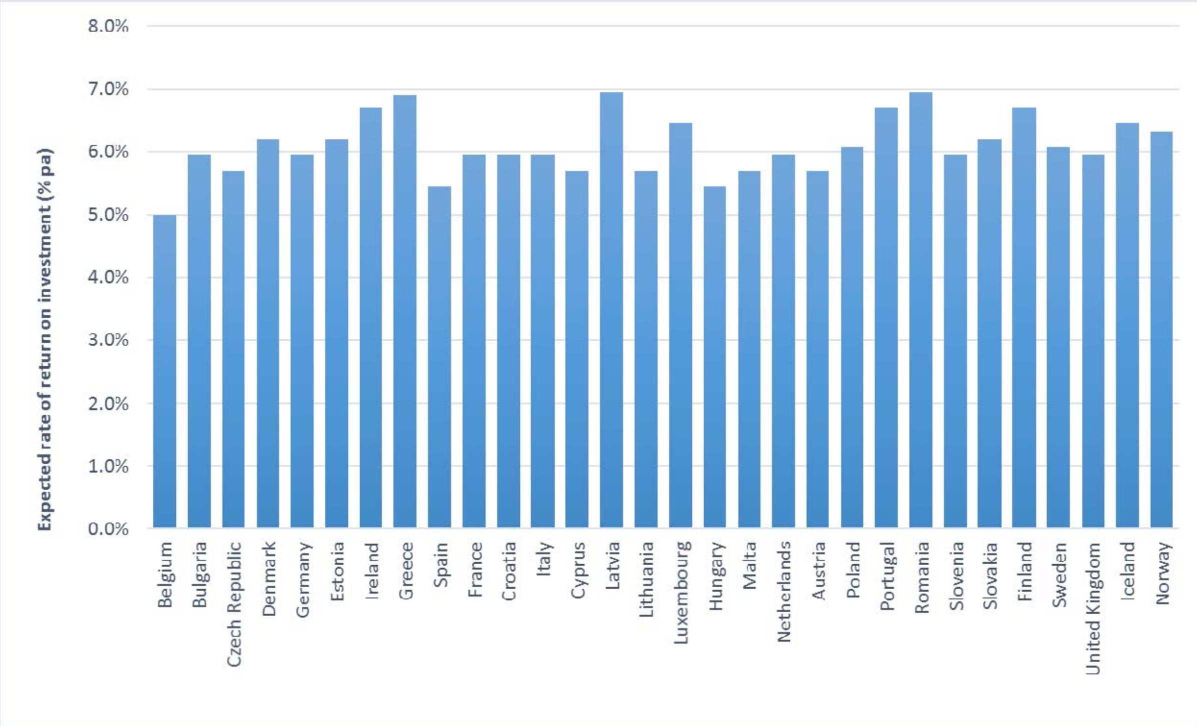
To take account of the range of consumer preferences with respect to solar PV required translating subjective information (i.e. consumers' perceptions about the aesthetics of solar PV and the hassle and administrative barriers of investment) into a metric that could be used for the quantitative modelling. A literature review was used to inform our assumption on the hurdle rate for investment in residential solar PV. The hurdle rate reflects consumers' willingness to invest, with lower hurdle rates indicating a perception of lower non-financial barriers (and therefore willingness to accept a lower rate of return on investment) and higher hurdle rates indicating a perception of higher non-financial barriers (and therefore a higher rate of return is required to incentivize investment).

Consumer preferences are proxied by the expected return of investment and are assumed to remain unchanged over the projection period. Our assumptions about the effect of non-financial barriers on the required rate of return of investment were informed by a literature review (see Annex 1). One of the studies by Parsons Brinckerhoff and[144] used a homeowner survey to calculate the required rate of return on investment, asking homeowners: "What is the maximum payback time you would be willing to accept for this installation (years)?". The results from the survey show that, on average, a 6.2% rate of return is required to incentivise take-up of the technology. This rate of return is broadly consistent with findings from the other studies and is used as our central assumption[145]. To take account of Member State specific non-financial barriers, this figure is then adjusted to account for legal barriers identified in each EU Member State (from Task 1). We used the high/medium/low ratings in relation to three key barriers: 'General description of the national regulatory framework'; 'Permitting requirements for each type

[144] Parsons Brinkerhoff (2015), 'Small-Scale Generation Costs Update'
[145] NERA (2015), 'Electricity Generation Costs and Hurdle Rates'

of residential prosumer'; and 'Rules applicable to the access to the grid'. Based on an assessment of best fit with the historical data, we assumed that if a legal barrier is given a score of 'High favourability for prosumers', then the expected rate of return on investment is reduced by 0.25 percentage points relative to a score of 'Medium favourability for prosumers'. Similarly, if a legal barrier is given a score of 'Low favourability for prosumers' then the expected rate of return on investment is increased by 0.25 percentage points relative to a score of 'Medium favourability for prosumers' The resulting consumer preference assumptions applied to each EU Member State (after taking account of existing legal barriers) are shown in the chart below.

Figure 6: Consumer preferences



Notes: Consumer preference assumptions for Belgium and Greece were adjusted to better align with observed data on installed capacity of residential solar PV.

For some indicators, a complete data set was not available for all Member States. To build the historical dataset other assumptions were used and the data were constructed. Estimates of average installation sizes, for example, were estimated for some countries using Eurostat (2012) data on dwelling size[146] and an estimate of the ratio of dwelling size to solar PV installation size (in kW), based on data for other EU Member States. At the EU level, we estimate that the average residential solar PV installation size is around 3.5kW.

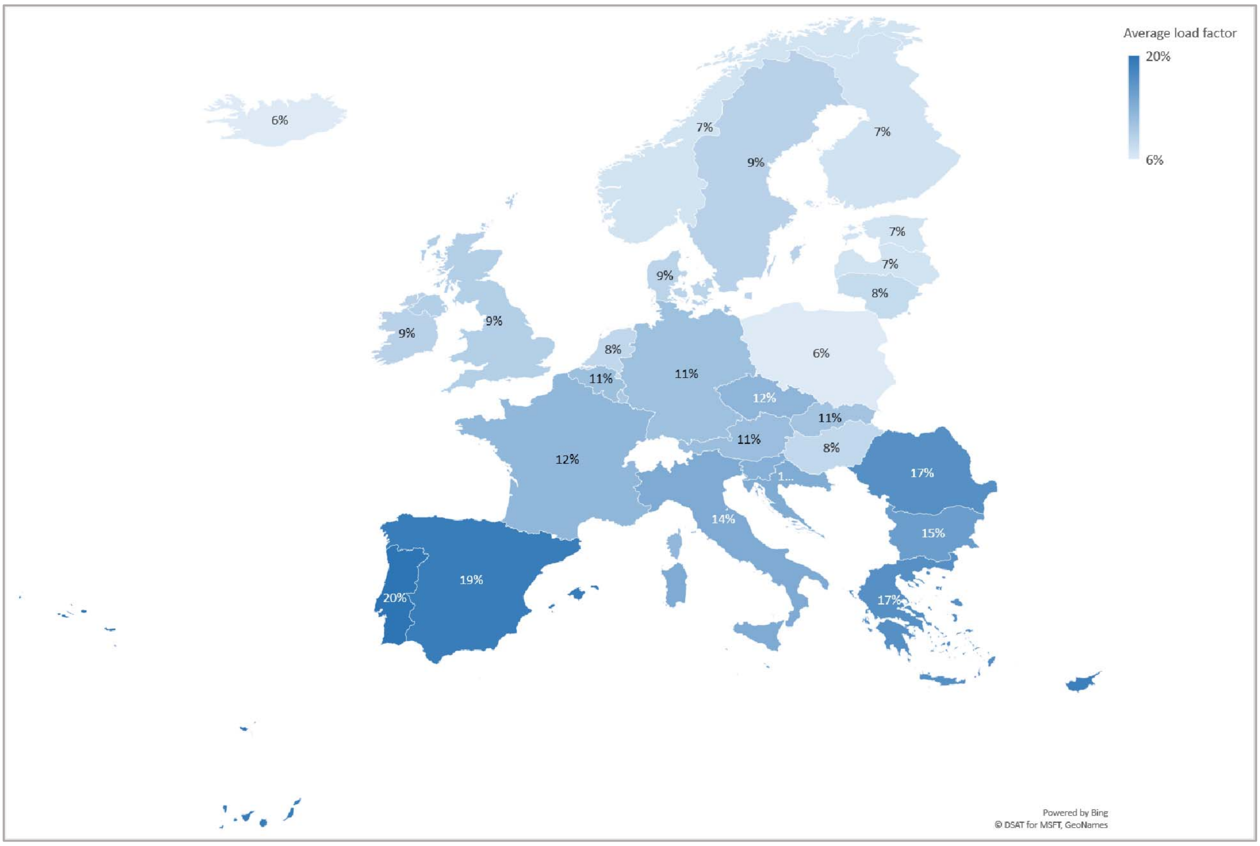
The interest rate used was the borrowing cost faced by households (for house purchases) from the European Central Bank[147]. This assumes that households could remortgage their house to finance their solar PV project. These data were only available for countries in the Eurozone. To calculate a similar interest rate for the other EU member states a euro differential was added to the money market 12-month interest rate from Eurostat[148]. The

[146] Eurostat (2012), data code: ilc_hcmh01
[147]Cost of borrowing for households for house purchase. Statistical Data Warehouse. ECB. Available here. Accessed on 07/04/2017
[148] Eurostat (2017), data code: irt_st_a

interest rate differential is the difference between the average borrowing cost faced by households (ECB) and the euro area money market 12-month interest rate.

The load factor represents the average quantity of electricity generated per hour relative to the maximum possible amount that could be generated for a given capacity. It is affected by the weather, air particulates and the efficiency of the solar modules. The load factor was calculated for each country using solar PV capacity and generation data from Eurostat[149]. Where data were unavailable for a specific Member State (or where installed solar PV capacity was particularly low), the load factor for a country at the same latitude was used. High load factors indicate high levels of solar insolation, high efficiency of the solar modules and, therefore, high electricity generation (for a fixed amount of capacity). Figure 7**Error! Reference source not found.** below shows the variation in load factors across the EU member states, Norway, and Iceland.

Figure 7: Load factors



The model assumes that the load factor is constant over the projection period as, when making their investment decision, it is likely that consumers would expect the weather to be relatively constant year-on-year.

Assumptions about the degradation rate of solar panels and expected lifetime were based on a study by Fraunhofer ISE (2015)[150]. The degradation rate (0.1% p.a.) is the average rate across 14 solar plants in Germany fitted with multicrystalline and monocrystalline

[149] Solar PV load factor = Solar PV generation (MWh) / (Solar PV capacity (MW) * 365*24) Eurostat (2017), Solar PV electricity generation, data code: nrg_107a; Eurostat (2017), Solar PV capacity, data code: nrg_113a
[150] Fraunhofer ISE (2015), 'Recent facts about Photovoltaics in Germany'

panels. In line with Fraunhofer ISE (2015), for all Member States, we assume that solar panels have a lifetime of 20 years.

There is considerable uncertainty in estimating precisely how much electricity prosumers are likely to consume and how much they will export under different policy regimes. Both are likely to be dependent on a number of factors such as the size of the house and ownership of technologies such as electric vehicles. For the analysis in Task 3, based on a review of recent literature[151], in all Member States we assume that 47% of electricity generated is self-consumed and the remaining 53% of electricity is exported to the grid.

[151] Parsons Brinkerhoff (2015), 'Small-Scale Generation Costs Update'; V. Bermudez (2017), 'Electricity storage supporting PV competitiveness in a reliable and sustainable electric network'.

5.2 Baseline Projections

5.2.1 Baseline take-up of residential solar PV

The chart below shows that, under baseline policies, take-up of residential solar PV in the EU28 is projected to nearly double over the period to 2030, increasing from an estimated 17GW in 2016 to 32GW in 2030. Under baseline policies, the long-term projected growth in residential solar PV broadly reflects a continuation of recent trends. The reason for this is that, whilst cost-effectiveness of investment improves over the period to 2030 (due to a fall in the costs of solar PV and an increase in electricity prices), there is a smaller pool of households that can invest (as those for which investment is most cost-effective and desirable, will have already installed solar PV). These two opposing effects lead to a steady rate of take-up in many countries.

Figure 8: Take up of residential solar PV: Baseline results

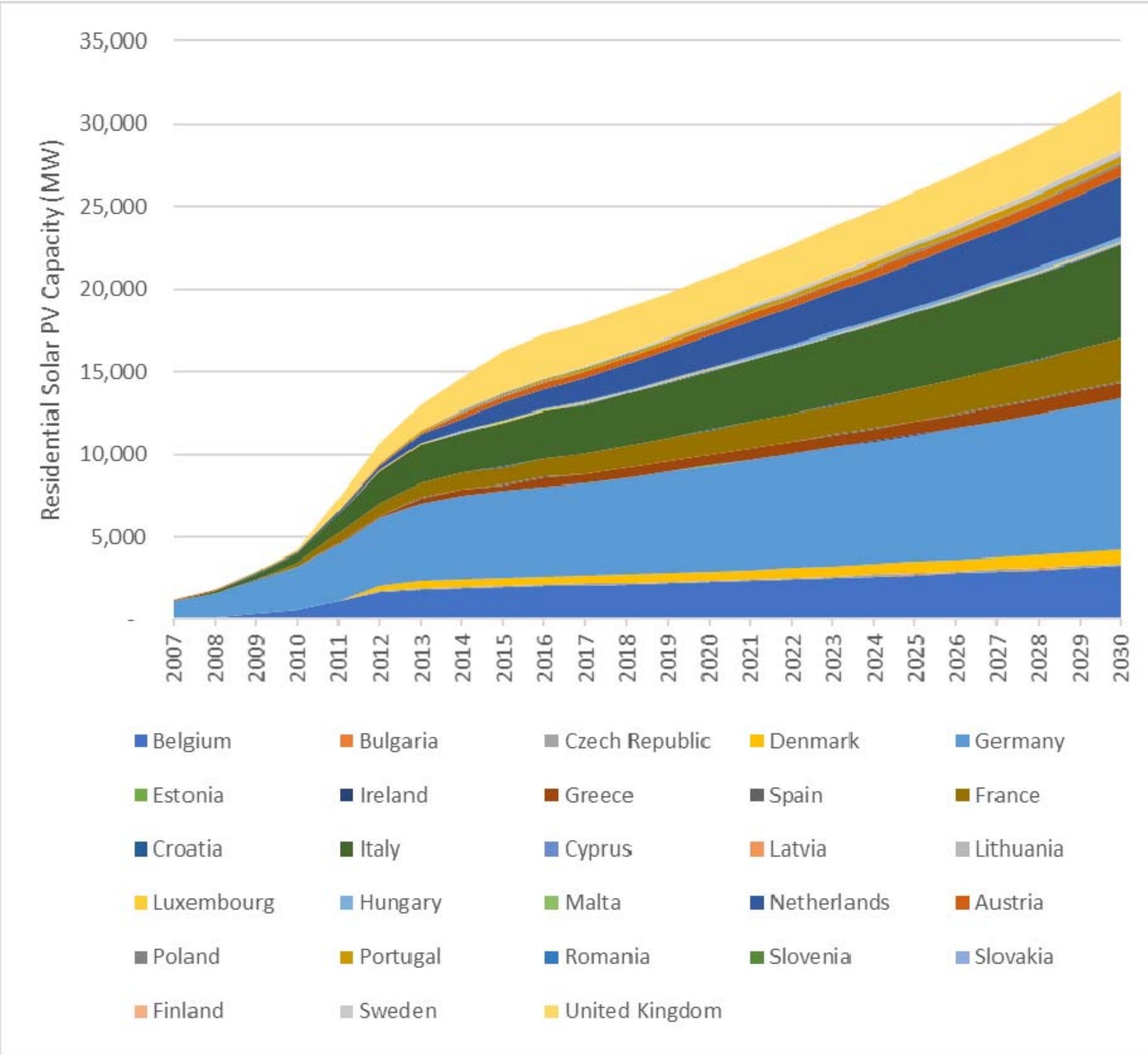


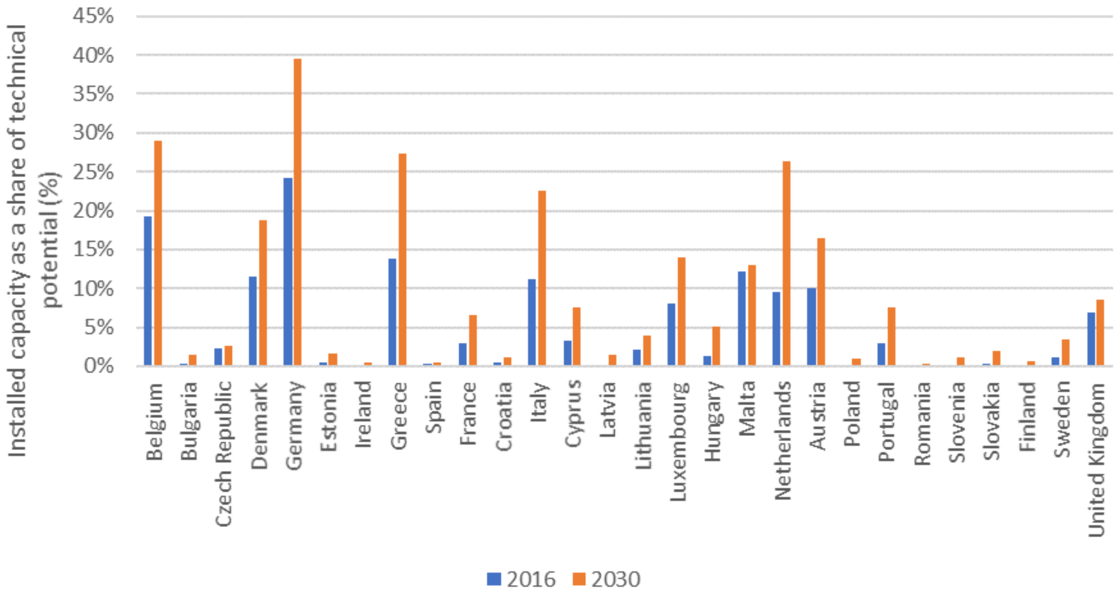
Figure 3 shows the full results by Member State and the change in take-up over 2016-2030 is shown in Figure 8.

Table 3: Take-up of residential solar PV - baseline results

	Residential solar PV capacity in 2015 (MW)	Residential solar PV capacity in 2030 (MW)	Growth rate, 2017-2030 (% pa)	Share of total potential residential solar PV capacity (2030)	solar PV prosumers as a share of all households (2030)
Belgium	1,976.9	3,255	3.5%	29.0%	8.2%
Bulgaria	8.9	40.6	10.2%	1.4%	0.5%
Czech Rep.	95.0	106.3	0.8%	2.6%	0.7%
Denmark	454.1	838.1	4.2%	18.7%	6.8%
Germany	5,240.5	9,137.8	3.8%	39.5%	5.8%
Estonia	1.1	5.6	8.2%	1.7%	0.2%
Ireland	1.1	12.4	15.3%	0.4%	0.2%
Greece	350.0	950.2	4.4%	27.4%	6.7%
Spain	48.6	57.9	1.2%	0.4%	0.1%
France	1,049.0	2,622.7	6.3%	6.6%	2.6%
Croatia	12.1	30.3	6.3%	1.2%	0.5%
Italy	2,640.0	5,614.1	5.1%	22.6%	5.9%
Cyprus	20.6	55.7	6.7%	7.6%	3.1%
Latvia	0.4	5.6	14.9%	1.5%	0.3%
Lithuania	19.7	31.2	3.1%	3.9%	1.1%
Luxembourg	33.6	80.6	6.0%	14.1%	5.0%
Hungary	60.5	282.8	10.0%	5.0%	2.3%
Malta	19.7	23.6	1.3%	13.0%	3.6%
Netherlands	1,086.0	3,684.0	8.1%	26.4%	9.5%
Austria	377.5	684.2	4.3%	16.4%	5.1%
Poland	10.2	151.2	16.5%	1.0%	0.4%
Portugal	147.1	382.9	6.5%	7.5%	4.1%
Romania	13.3	18.7	2.3%	0.3%	0.2%
Slovenia	1.8	13	12.9%	1.1%	0.5%
Slovakia	5.9	40.4	12.5%	1.9%	0.6%
Finland	4.0	24.5	12%	0.7%	0.2%
Sweden	52.0	257.6	9.4%	3.4%	1.1%
UK	2,499.0	3,539.9	2.1%	13.1%	3.5%
Iceland	-	-	-	0.0%	0.0%
Norway	11.3	25.6	5.5%	0.4%	0.3%

Source: own calculations

Figure 9: Installed capacity as a share of technical potential in 2016 and 2030



Under the baseline projections, the share of solar PV installations relative to technical potential is highest in Germany (40%), Belgium (29%), Greece (27%), the Netherlands (26%) and Italy (23%). High rates of take-up by 2030 are explained by a combination of factors:

- A high starting point in terms of installed residential solar PV (e.g. in Germany and Belgium we estimate that, in 2016, around 20% of the technical potential for residential solar PV had already been installed)
- Favourable policies (e.g. by combining capital subsidies with Feed-in Tariffs, Feed-in Premiums or net-metering schemes)
- A relatively high investment ratio in the most recent years (as our model assumes current trends in investment are continued)
- High expected growth in electricity prices (e.g. in the Netherlands and Greece, electricity prices are assumed to grow by around 1.5% pa over the period to 2030, making solar PV investments more cost effective)

Countries with low rates of take-up relative to technical potential include Ireland, Spain, Romania, Slovenia, Finland, Iceland and Norway, where installed capacity in 2030 is projected to be less than 1% of the technical potential. The defining features of these countries are:

- Low solar insolation levels (and hence low potential electricity generation per year), particularly in Ireland and Finland
- Less favourable policy (e.g in Ireland there is no policy to promote take-up of solar PV and in Spain there is a tax on solar PV electricity generation)
- Low rates of take-up in recent years (reflecting high barriers to investment)

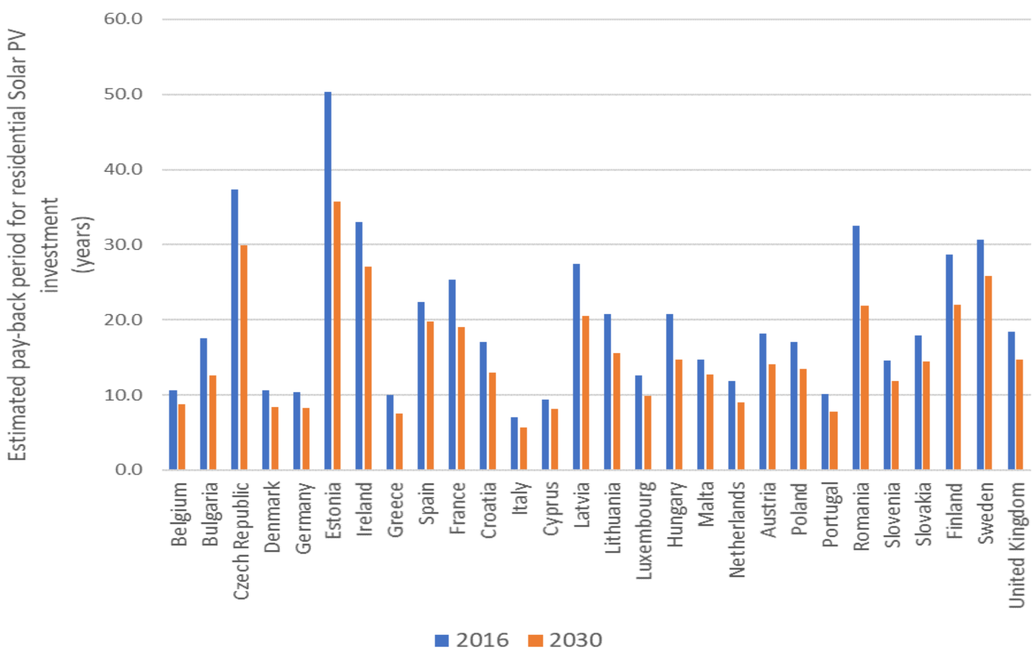
5.2.2 Payback periods

Figure 10**Error! Reference source not found.** shows payback periods for hypothetical residential solar PV investments in 2016 and 2030. The payback period shows the length of time (in years) that it would take to recover the initial cost of investment. Higher payback periods therefore imply that solar PV investment is less cost effective.

Payback periods vary considerably between countries, with particularly high payback periods in countries with low solar insolation (e.g. Iceland, Estonia, Latvia), high interest rates (e.g. Hungary, Iceland) and low electricity prices (e.g. Iceland, Hungary, Estonia, Ireland). Payback periods are lowest in Italy, Portugal and Germany, where residential electricity prices are relatively high, solar PV load factors are high and there is strong policy support for solar PV.

The model results show that, in all countries, payback periods fall over time as the cost-effectiveness of solar PV investment improves, primarily due to a reduction in CAPEX costs, but also, for most countries, due to an expected increase in real electricity prices over the period to 2030.

Figure 10: Estimated payback period for solar PV investments in 2016 and 2030



5.3 Scenario Results

5.3.1 Overview of scenarios

The take-up curves have been parameterised, to allow modelling of different cost and consumer preference scenarios. Three sets of scenarios were modelled, as outlined in the table below. The EV growth scenario is a technology driven scenario that affects consumer preferences in favour of solar PV. The other two scenarios both affect the cost-effectiveness of solar PV installation. The cost-effectiveness of investment in solar PV is reduced in the scenario involving a phase-out of existing policy support but the cost-effectiveness is increased in the scenario that assumes relaxation of EU anti-dumping legislation.

Table 4. Scenarios modelled

Scenario name	Description
Electric vehicle (or EV) growth	This scenario assumes a rapid increase in electric vehicles with smart charging and battery storage technologies so that, by 2030, the average self-consumption ratio for residential solar PV reaches 70%.
Subsidy phase-out	In this scenario, policy support including feed-in tariffs, net-metering schemes and capital subsidies are assumed to be phased out in all Member States over the period 2017-2020. Thus, new prosumers are only able to benefit from lower electricity bills due to self-consumption and they receive no compensation for surplus electricity fed into the grid.
Relaxation of anti-dumping legislation	The EU currently has in place anti-dumping legislation, which includes a 47.7% tariff on solar PV panels and cells imported from China[152]. This scenario assumes that these import duties are revoked and that, from 2017 onwards, all solar PV installations in the EU use Chinese panels, free from the 47.7% duties. This leads to an initial 15% fall in CAPEX costs (installation costs are not affected)[153]. CAPEX costs are then assumed to fall by 1.4% pa, in line with our baseline assumptions.

5.3.2 Scenario results

The scenario results highlight the considerable uncertainties in the baseline estimates of take-up of residential solar PV.

For all countries modelled, apart from Italy, the EV growth scenario has a positive impact on residential solar PV capacity installed. The effect is relatively small over the period to 2030, because take-up of EVs and battery storage technologies is very gradual and, in many countries, the proportion of 'attractive' investments that do take place, are very low. By 2030, cumulative installed capacity in the EV growth scenario with a positive impact is 5-40% higher than under baseline projections. The impact of the EV growth scenario is most positive in countries that receive little benefit from exporting electricity to the grid (as this scenario allows much higher levels of self-consumption to be reached). On the other hand, countries which receive a high benefit from exporting electricity to the grid are likely to be negatively affected by the EV growth scenario. This is apparent in Italy, where the impact on cumulative installed capacity of solar PV is 5% lower compared to the baseline scenario.

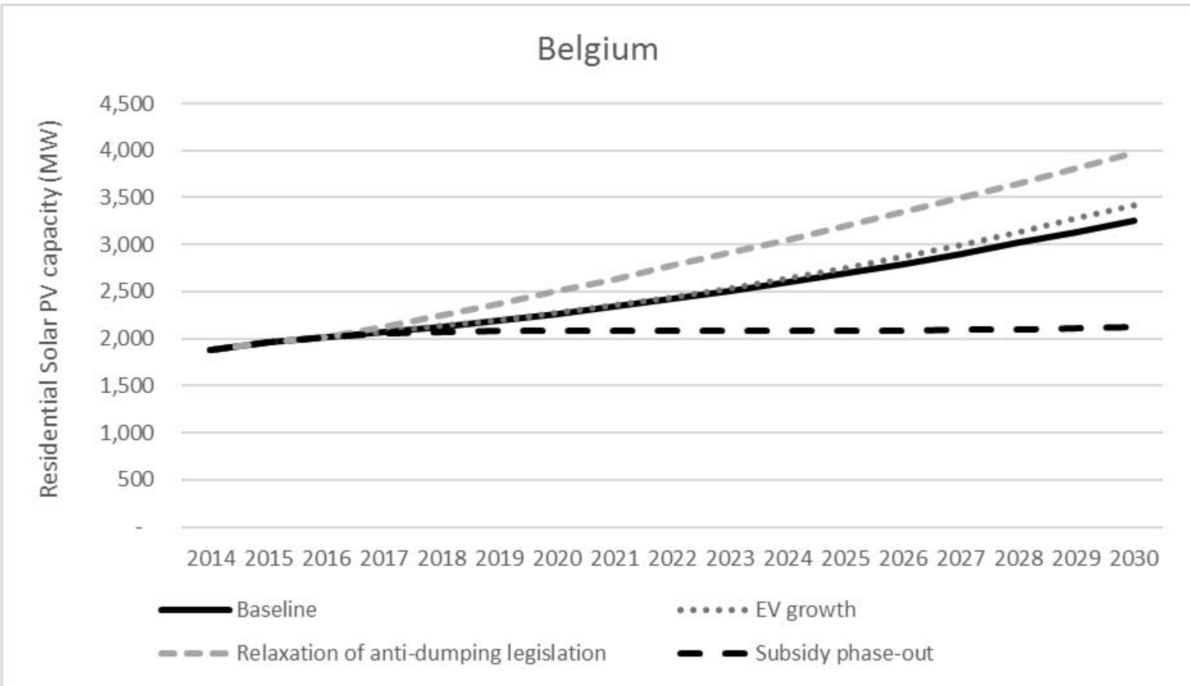
The subsidy phase-out scenario assumes that all policy support (including Feed-in tariffs, net metering schemes, feed-in premiums and capital subsidies) are phased out by 2020. In all cases, this scenario leads to a reduction in installed capacity relative to the baseline, except for in the Czech Republic and Spain, where there is already no policy

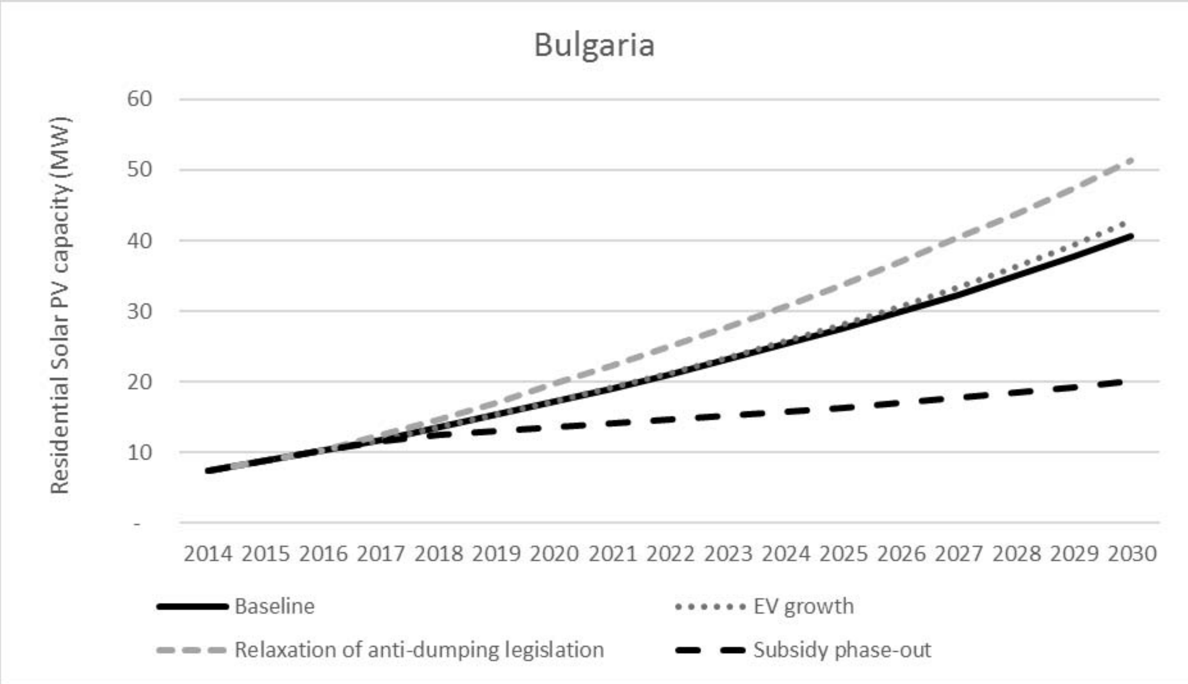
152 European Commission (2013) Press release, available at: http://europa.eu/rapid/press-release_IP-13-1190_en.htm
153 Based on Parsons Brinkerhoff (2015), 'Small-scale Generation Cost Update'

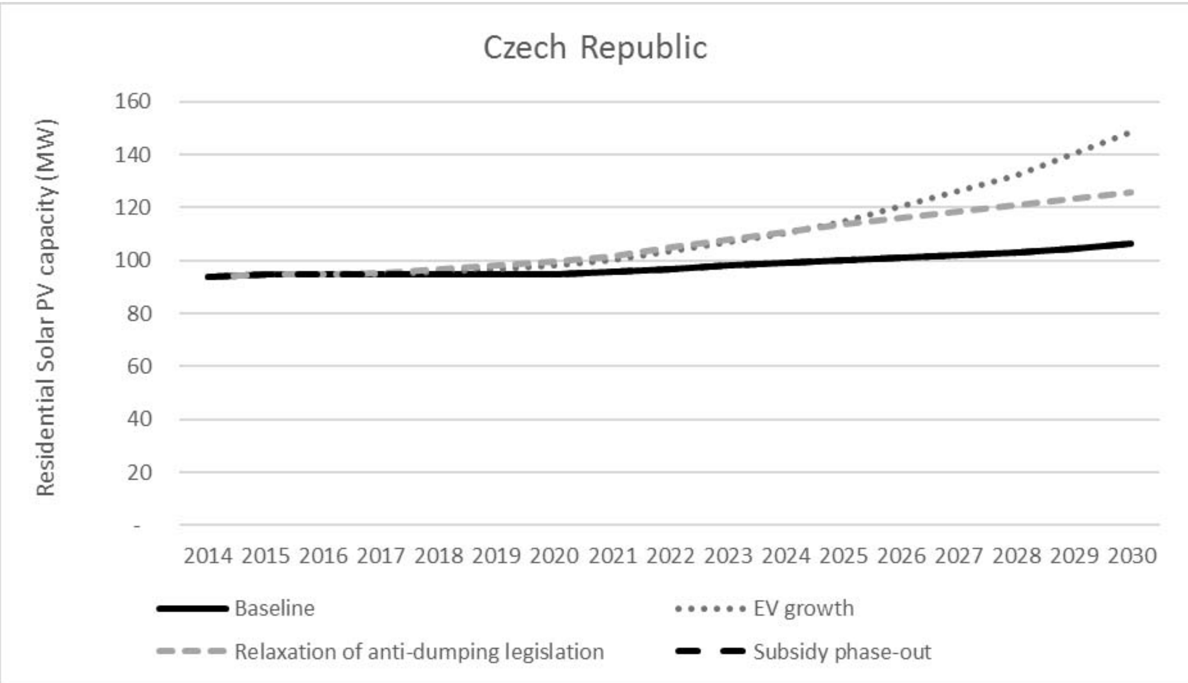
support or subsidies available to residential prosumers. In Spain the installed capacity relative to baseline increases by 44% because, prior to the phase out of policies, residential prosumers had to pay a tax on the electricity that they generated. The scale of the reduction in installed capacity varies considerably among countries. In Germany, France, the UK, Belgium, Italy and the Netherlands, this scenario leads to a very low installation rate in the short term, with total installed capacity hardly growing over the period to 2025. This low installation rate is because removal of policy support means that the cost-effectiveness is insufficient to incentivise investment for nearly all households. In some of these countries, there is a slight increase in growth post-2025, as falls in CAPEX costs and increases in electricity prices mean that investment becomes cost-effective again for a small share of households. In other countries, such as Bulgaria, Poland, Slovakia, Slovenia and Croatia, installed capacity continues to grow (albeit at a lower rate than in the baseline) over the short term, as electricity prices are sufficiently high and solar PV costs sufficiently low for investment to be still worthwhile for some households. By 2030, cumulative installed solar PV capacity is up to 63% lower than in the baseline for the countries that have existing policy support in place.

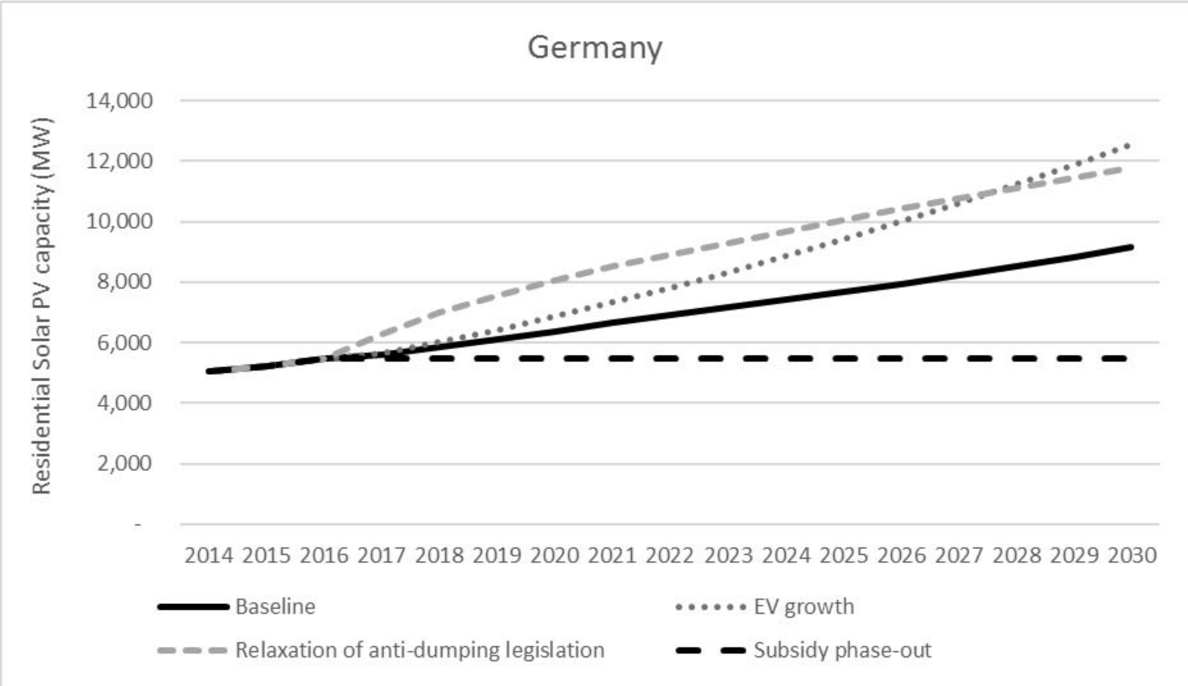
The final set of scenarios assessed the impact of relaxation of EU anti-dumping legislation. These scenarios lead to a reduction in CAPEX costs, creating an improvement in the cost-effectiveness of investment, and around a 20-30% increase in take-up in most countries (apart from Spain, which has a low take-up rate of 5%).

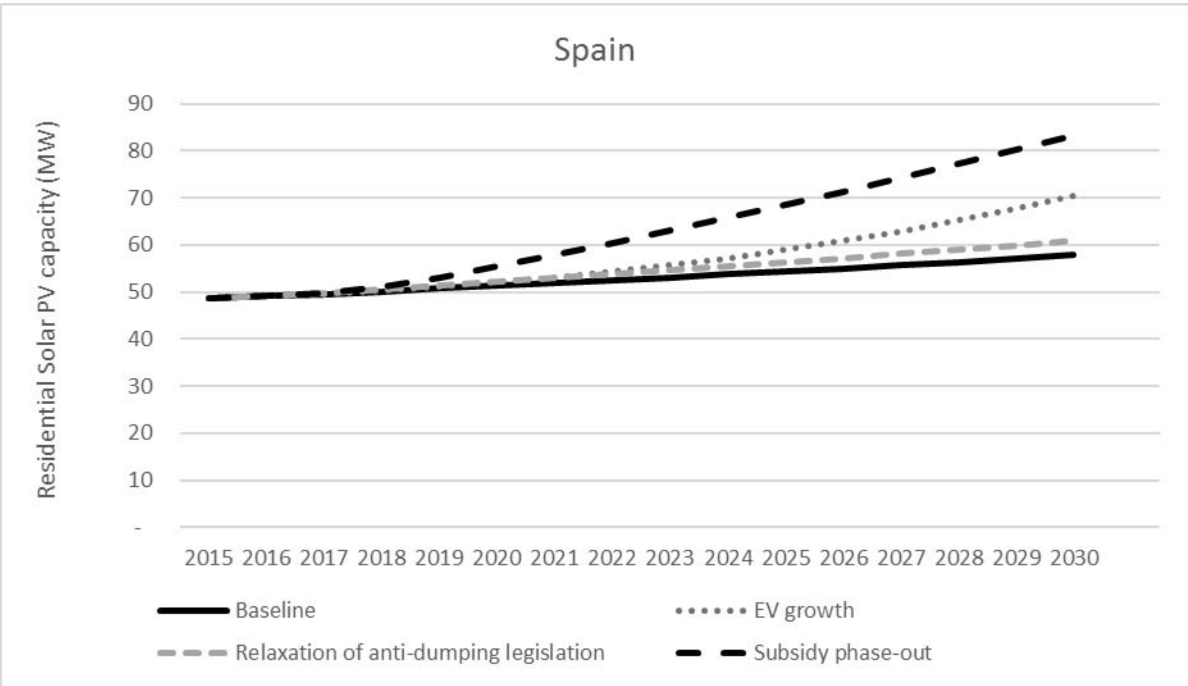
Figure 11. Scenario results for all countries

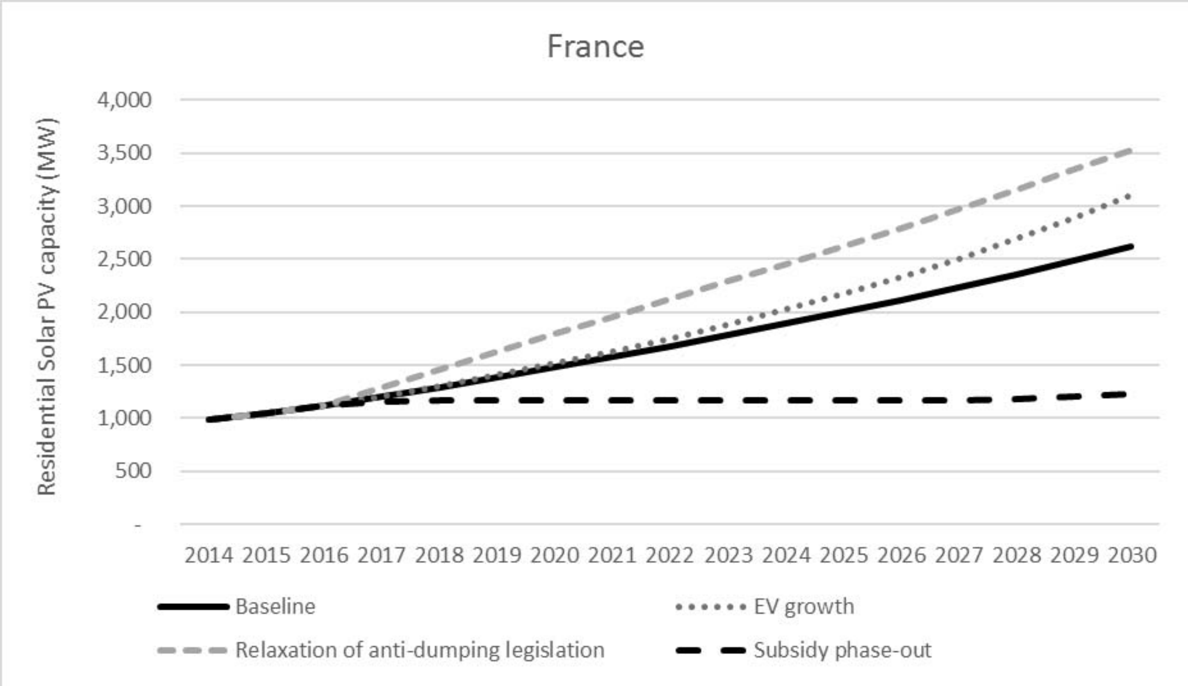


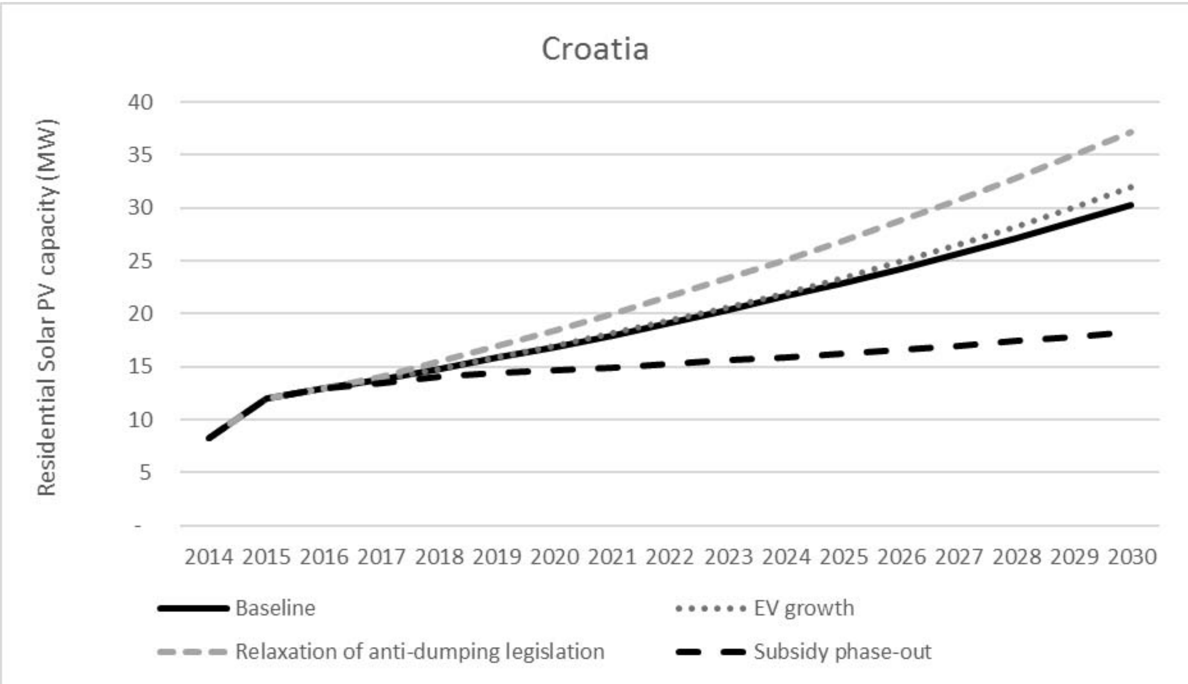

Bulgaria
Residential Solar PV capacity (MW)
60
50
40
30
20
10
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out

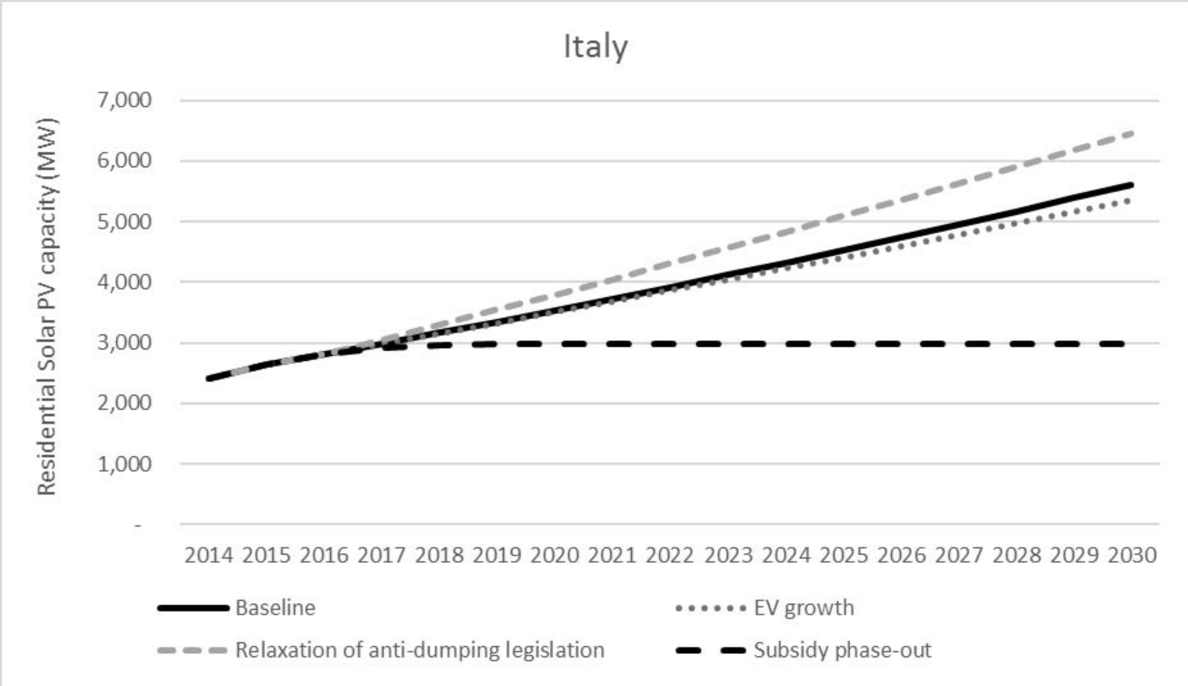

Czech Republic
Residential Solar PV capacity (MW)
160
140
120
100
80
60
40
20
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out

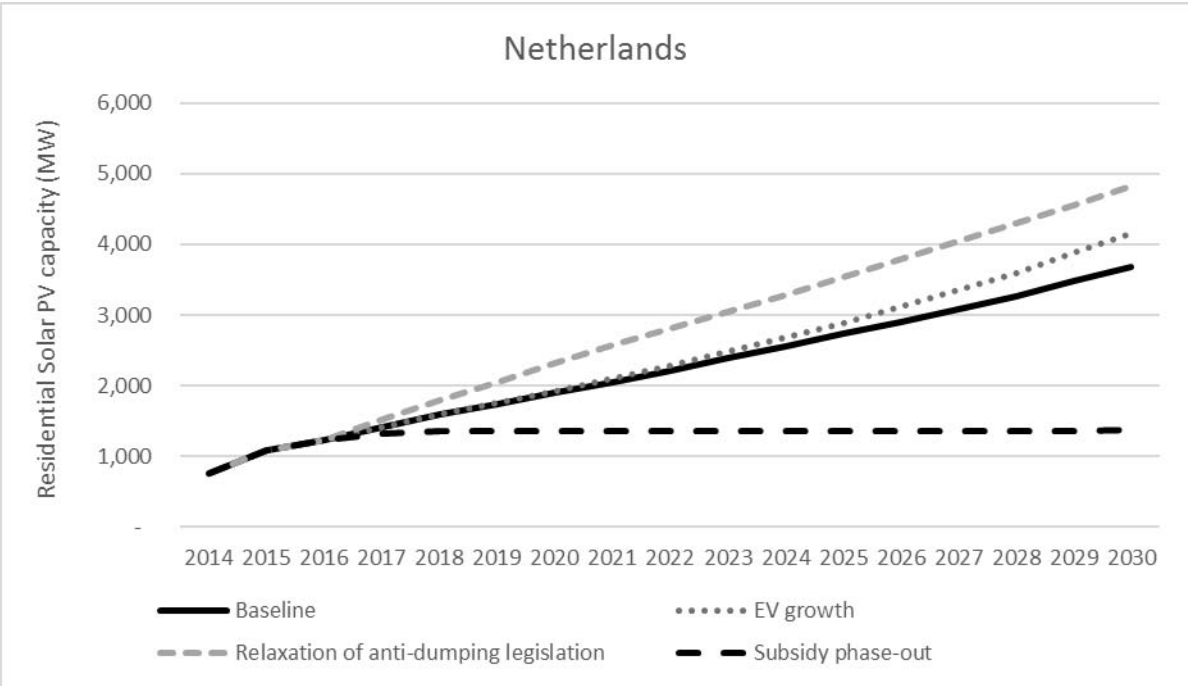

Germany
Residential Solar PV capacity (MW)
14,000
12,000
10,000
8,000
6,000
4,000
2,000
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out

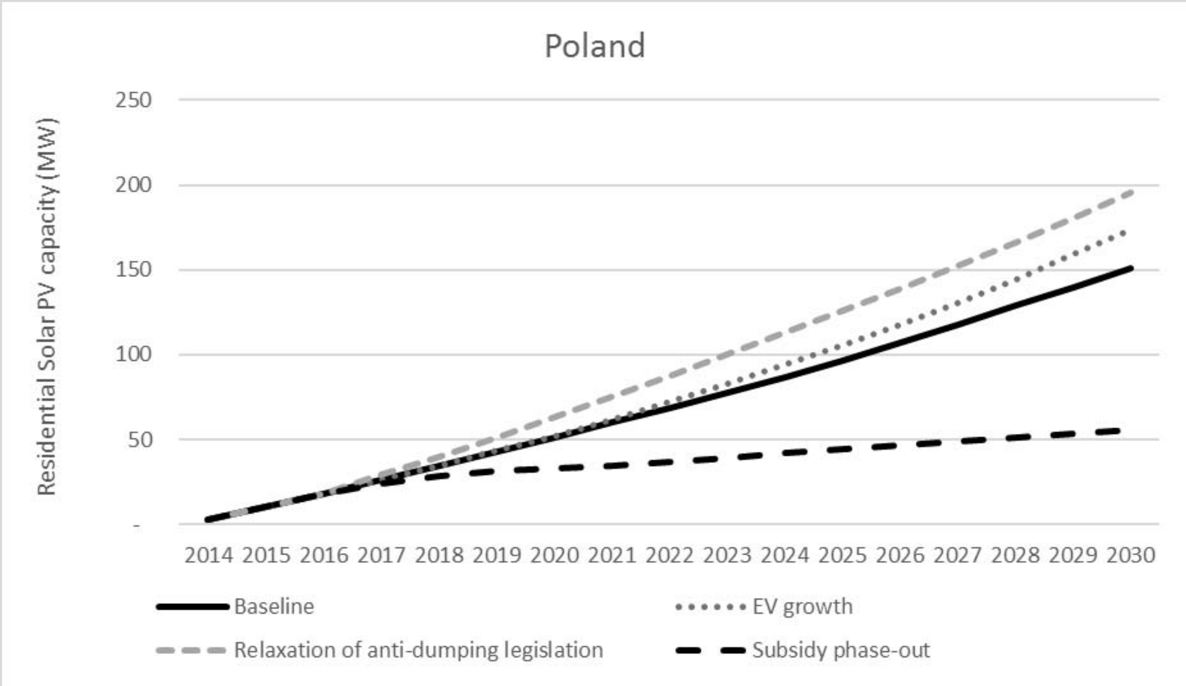

Spain
Residential Solar PV capacity (MW)
90
80
70
60
50
40
30
20
10
-
2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out

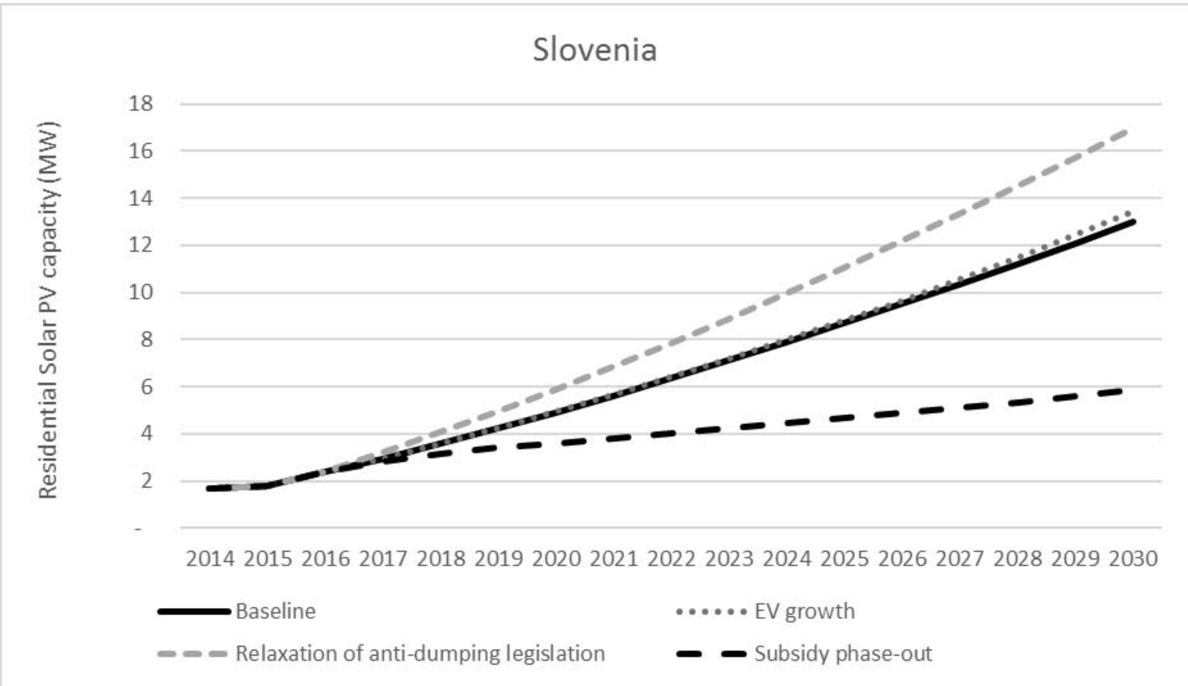

France
Residential Solar PV capacity (MW)
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out

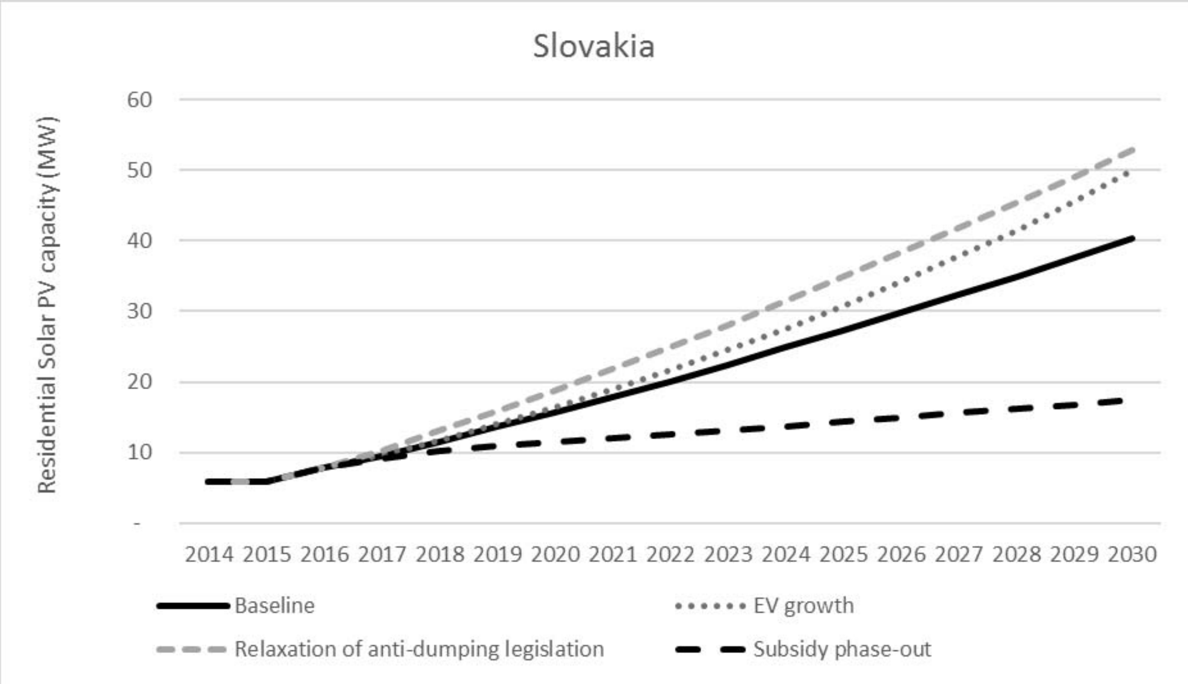

Croatia
Residential Solar PV capacity (MW)
40
35
30
25
20
15
10
5
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out

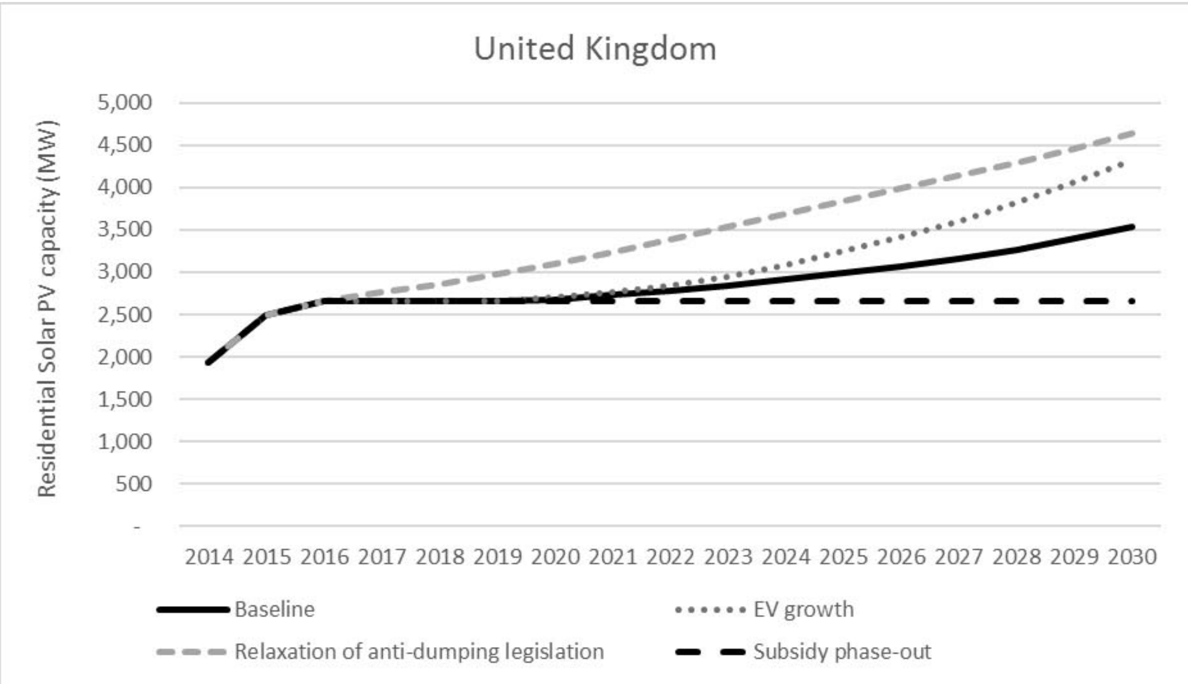

Italy
Residential Solar PV capacity (MW)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out


Netherlands
Residential Solar PV capacity (MW)
6,000
5,000
4,000
3,000
2,000
1,000
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out


Poland
Residential Solar PV capacity (MW)
250
200
150
100
50
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out


Slovenia
Residential Solar PV capacity (MW)
18
16
14
12
10
8
6
4
2
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out


Slovakia
Residential Solar PV capacity (MW)
60
50
40
30
20
10
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out


United Kingdom
Residential Solar PV capacity (MW)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
-
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030
Baseline
EV growth
Relaxation of anti-dumping legislation
Subsidy phase-out

5.4 Conclusions

In conclusion, the key messages emerging from the analysis in this chapter are summarised below:

- Under a baseline scenario that assumes a continuation of current policies, residential solar PV capacity in the EU28 is projected to nearly double (from 17GW estimated capacity in 2016 to 32GW estimated capacity in 2035).
- Following rapid growth in the period to 2012, growth in residential solar PV capacity has slowed slightly in recent years. Our baseline projections suggest a continuation of around 4% rate of growth per annum over the period to 2030, reflecting the balance of two offsetting effects: an improvement in the cost-effectiveness of solar PV investments over time (due to higher electricity prices and lower CAPEX costs) balanced against a smaller pool of potential investors (as those with most favourable preferences towards solar PV, for which investment is most cost effective, have already installed).
- There is considerable uncertainty in the baseline solar PV projections, which are dependent on key assumptions about the future development of CAPEX and OPEX costs, electricity prices, interest rates, self-consumption ratios and consumer preferences.
- The scenario results show that future rates of take-up are also highly affected by policy and the development of new complimentary technologies. An increase in the number of households with an EV will lead to a projected 5-40% increase in installed capacity by 2030, as the potential technology synergies would increase the attractiveness of solar PV investment and could increase self-consumption shares (e.g. in cases where EVs are charged at home during the day).
- A phase-out of existing support for residential solar PV by 2020 will limit growth of installed capacity across all counties. Our results show that in some cases, it would reduce the cost-effectiveness of solar PV to such an extent that it would stop any new investments in residential solar PV in the short term (until a point is reached in which CAPEX cost are sufficiently low, and electricity prices sufficiently high to incentivise some households to invest again).

Through its impact on reducing CAPEX costs, relaxation of EU anti-dumping legislation against imports of solar PV from China would have a positive impact on the investment rate, leading to around a 20-30% increase in installed solar PV capacity by 2030 (relative to the baseline scenario). Facing squeezed government budget following the EU debt crisis, this measure would be effective in incentivizing take-up, with limited costs to the state. However, exposure to increased competition from abroad could harm domestic solar PV manufacturers in the EU, as margins will be squeezed and less productive firms forced out of the market.

6 Residential prosumers experiences, understanding and decision-making process

As explained in the Background chapter, the purpose of the study is to compare the different types of residential prosumers across the EU28 plus Norway and Iceland, by gathering first-hand evidence and data on their experience, the financial and non-financial drivers affecting their self-generation decision-making process, the advantages and obstacles of being prosumer and the economic performance of self-generation over the lifecycle of investment.

This chapter therefore presents the results and conclusions of the analysis conducted under the two tasks of the project dedicated to primary data collection: the survey and the mystery shopping fieldwork (Main Task 2 and Main Task 4 respectively).

The primary data collection tasks contributed to shed light on the main advantages, difficulties, experiences and factors impacting the choice of those consumers seeking to make the transition, or already transitioned to residential self-generation.

In detail:

The analysis of the results of the in-depth survey of residential prosumers, i.e. targeting those who already made the transition, provided insight on their experience with self-generation (and often with feeding the self-generated electricity back into the grid). Besides, the analysis focused on the financial versus non-financial considerations affecting the choice to become prosumers. The survey analysis also provided comparable results split per country and per different types of self-generation technology, still with a focus on solar PV.

The mystery shopping described the experiences of consumers who seek to transition to self-consumption by installing solar PV technology on their rooftop, maintaining the connection to the grid (and feeding back or not into it) or disconnecting from the grid. The analysis focuses on consumers' experiences in the process of enquiring information to the energy providers about self-consumption. In detail:

- How easy it is for future prosumers to get in contact with the energy providers
- Which level of information about the procedure to become a prosumer is given
- Which level of information on costs, tariffs, taxes and incentives is given
- Which level of information on other advantages and difficulties is given

It should be noted that data gathered under the survey and the mystery shopping exercise, although very representative of consumers' experiences and opinions, should be read keeping in mind their overall subjectivity.

6.1 In-depth residential prosumer survey

As explained in the section of the Background chapter dedicated to the study's country scope, we planned to conduct the survey in the EU28 plus Norway and Iceland.

Concerning Iceland though, our efforts to build up a meaningful sample via online panel proved vain. We also were not able to develop the survey via the country's stakeholder organizations, as we received no or negative feedback from them. We received the following explanation from one of the stakeholder organization:

There are fairly few prosumers in this country (read: Iceland). In the early 20th century farmers in certain areas managed to construct small hydropower plants for their own farm, many of them were in isolated areas. Yet, when economies of scale became the rule, these small operators disappeared. One or two might still be functional. Then there may have been some farms or small communities which used diesel generators, but those are mostly gone now. Today, there are few wind mills being set up by farmers or small industries. These wind mills are probably producing cheaper energy than offered by the National Power Company. There are also ideas that small streams can be utilized for producing energy for small operators, who then can sell their overcapacity to the big company[154]*.*

The above feedback was confirmed by a recent IEA report, which pointed out that a high penetration of non-prosumer renewable energy generation may limit the potential of prosumer development. According to Iceland's Renewable Energy Action Plan, renewable resources already account for the country's 99.9% of electricity production and 99% of heating production respectively[155].

Our survey therefore in the end covered the EU28 plus Norway.

The fieldwork methodology was extensively explained in the Second Interim Report of the study. Here below we described again its main features, for clarity purpose, while this chapter focuses on the analysis of the survey's main results. The complete results gathered during the survey are provided in easy-to-read tables in annex to this report.

For the EU28 and Norway, we chose to collect responses via our online panels. This recruitment approach is a cost-effective manner to achieve additional survey responses from countries which have a relatively high incidence rate of prosumers. For countries with a lower incidence rate, such a method still allowed us to achieve a very good number of responses, making the entire exercise well representative of the situation across Europe.

As our general methodology, when recruiting samples from the panel we take a spread of region and urbanisation into account. We do not set quotas on region and urbanisation, due to a lack of quota target data for these two criteria and also to avoid too many potential respondents being screened out. However, our online panels have sufficient geographic spread to ensure that they are representative of each country.

The chosen method of surveying was Computer Assisted Web Interviewing (CAWI). We designed an online questionnaire of 15 minutes in length to conduct the survey and the Master in the English language was validated by the European Commission.

The questionnaire focused on the following issues:

- Details and difficulties of the process of becoming prosumer
- Level of satisfaction with the prosumer choice
- Compensation for feeding electricity back into the grid
- Drivers to self-generation

[154] Natturuvernd is an organization that provides consumer advice and awareness activities on eco-friendly and green lifestyle including in the energy sector
[155] The Icelandic National Renewable Energy Action Plan for the promotion of the use of energy from renewable sources in accordance, 2014 https://ec.europa.eu/energy/sites/ener/files/documents/dir_2009_0028_action_plan_iceland__nreap.pdf

- Prosumer attitudes towards technology and environment

6.1.1 Fieldwork result analysis

Based on the questionnaire, the data collected were broken down and examined by country, technology and main drivers for switching to self-generation. We chose these criteria in line with the analytical angle of the entire study that has been explained extensively in the introductory and background chapters.

The data included in the tables have been rounded to one decimal. Furthermore, in several occasions no respondents answered to one or more answer options. In order to keep the tables as comprehensible as possible these figures (i.e. 0,0%) are not presented.

At country level, a distinction was made between the more mature markets, for convenience referred to as "key countries", where the solar PV market is already more developed and a second group of countries where market has grown at a slower pace, in particular in Eastern Europe, so as to have a better understanding of the situation across all the European geographic regions.

The "key countries"/more mature solar PV markets include: Belgium, The Netherlands, France, Italy, Spain, Germany and the UK. We have then also focused on Portugal as well as a number of East European countries, looking more in detail at the prosumers' feedback there: Bulgaria, Croatia, Hungary, Poland, Slovenia and Slovakia.

Choice of self-generation technology

We asked prosumers which type(s) of technology were currently installed in their residence. These results are analysed by country and main drivers for switching to self-generation. In addition, respondents' willingness to recommend switching to self-generation is shortly discussed in this section.

Solar PV, heat pumps and wood pellet stoves qualified as the top three types of technology in both the key and second group of countries. Among the key countries, the presence of solar PV showed highest in Belgium and the UK, where respectively 60,9% and 57,4% of the respondents indicated having this technology installed.

The questionnaire focused on respondents who answered to be individual households (as opposed to a group of households) and to have installed self-generation technology after they purchased / started living in the residence. Within this subgroup, we examined:

- the main drivers for becoming a prosumer and
- the different steps consumers followed in the process of becoming self-generators.

We also looked more in detail at the following issues:

- whether or not, and to what extent, prosumers were still connected to the grid
- what compensations they were receiving for feeding electricity back into the grid and
- what was their feedback on switching electricity supplier when starting self-generation.

Drivers

In order to identify the main motivations for individual household self-generation, respondents were asked to indicate, among a selection of five factors, the one that eventually made them take the final decision. We analysed answers in a breakdown by country and by type of technology.

It emerged that saving money on energy bills was by far the most mentioned consideration for switching, both in the key and in the second group of countries. This result was especially dominant in the second group, with 89,8% of respondents indicating this in the Czech Republic, 82,8% in Croatia and 80% in Portugal. Within the key countries, the highest proportion mentioning this as most important was Spain with 68,9%.

Again in the analysis of all technologies by country, it was interesting that next to saving money on energy bills being the most indicated driver, government subsidies score high in all key countries, along with environmental impact considerations. Overall and by comparison having a positive impact on the environment was of lesser importance in the second group of countries compared to the key countries.

Table 9: Main drivers

	Government subsidies	Environment-al impact	Saving money on energy bills	Inspired by others' experiences	Other
Key countries					
BE – Belgium	18,2%	11,5%	63%	6,1%	1,2%
DE – Germany	12,8%	18%	66,9%	-	2,3%
ES – Spain	4,6%	18,5%	68,9%	6,6%	1,3%
FR – France	15,7%	27,1%	55,7%	1,4%	-
IT – Italy	16,2%	23,9%	53,8%	3%	3%
NL – The Netherlands	9,2%	19,6%	61,4%	3,9%	5,9%
UK – United Kingdom	17,4%	19,5%	57%	4%	2%
Second group of countries					
BG – Bulgaria	-	8,1%	73%	16,2%	2,7%
CZ – Czech Republic	2%	-	89,8%	4,1%	4,1%
HR – Croatia	-	1,7%	82,8%	10,3%	5,2%
HU – Hungary	13%	3,7%	79,6%	1,9%	1,9%
PL – Poland	21,7%	10%	65%	1,7%	1,7%
PT – Portugal	5%	15%	80%	-	-
SI – Slovenia	8,8%	8,8%	74,2%	2,5%	5,7%

SK – Slovakia	7,9%	10,5%	71,1%	10,5%	-

Focusing on solar PV technology, results are shown in the two figures here below.

Figure 16a: Main drivers for solar PV – Key Countries (Source: own development)

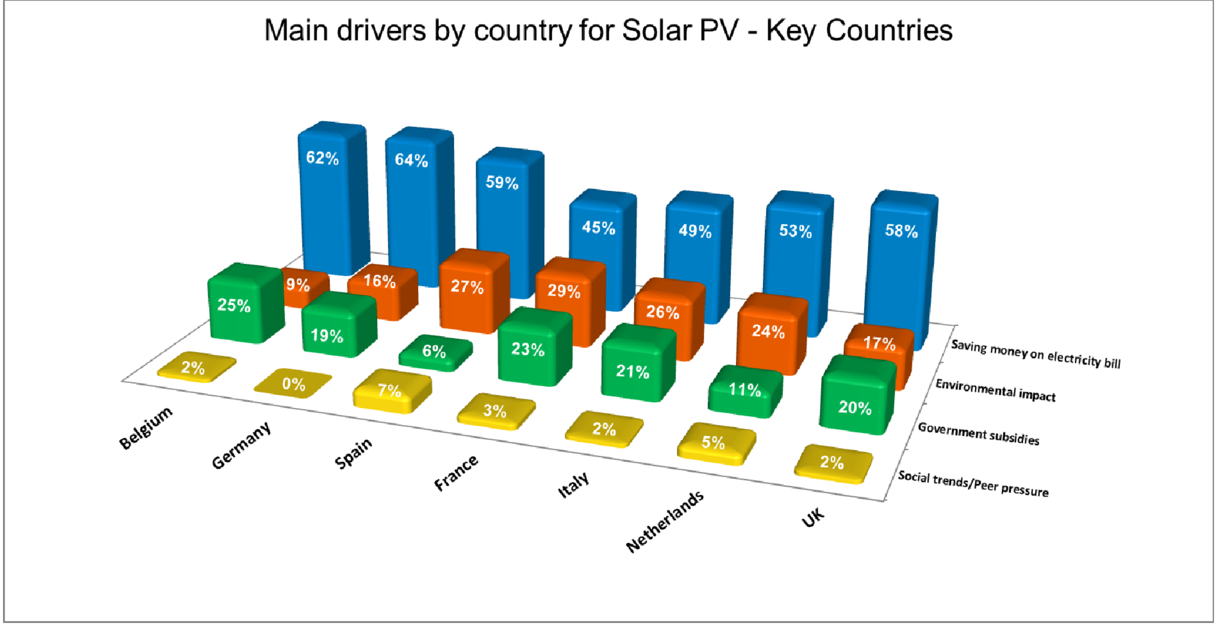
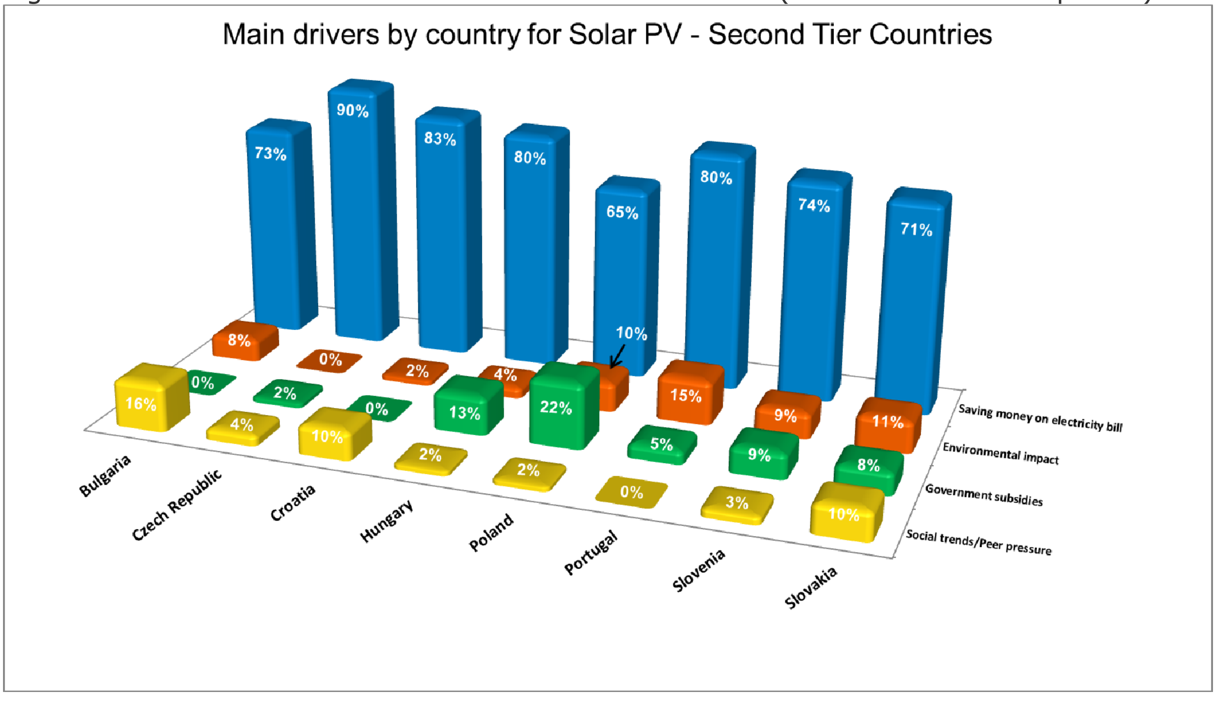


Figure 16b: Main drivers for solar PV – 2nd Tier Countries (Source: own development)



Switching to self-generation

Prosumers also received a question on the process of switching to self-generation. More specifically they had to indicate how easy or difficult it was to install the technology in general for each of all the steps in the transition process. The questionnaire also asked who they contacted for information or help regarding the process of becoming self-generator.

The majority of respondents from the key countries mentioned that it was very easy or easy to install the technology, ranging from 73,8% in the UK to 52,6% in Germany.

When asked which steps in the process of becoming self-generator were most easy/difficult, respectively 63,4% and 62,3% mentioned that "Obtaining information on the entire procedure" and "Finding someone to install the technology" were relatively easier steps, while benefiting from (19,7%) and obtaining information on available incentives (17,8%) were indicated as more difficult by less than 20% of all respondents.

Table 10: Steps in the process of becoming self-generator

	Very easy / easy	Neither easy nor difficult	Very difficult / difficult
Steps in the process of becoming a self-generator			
Obtaining information on the entire procedure	63,4%	27,2%	9,4%
Obtaining information on available incentives	48,8%	33,4%	17,8%
Obtaining information on the costs of becoming a self-generator	50,9%	34,6%	14,5%
Liaising with the electricity supplier	48,5%	37,4%	14,2%
Finding someone to install the technology	62,3%	28,3%	9,4%
Finding someone to maintain the technology	56,3%	31,3%	12,4%
Making changes to the billing scheme for electricity	44%	41,2%	14,8%
Benefiting from available incentives	42,5%	37,8%	19,7%
Other	37,2%	46,3%	16,5%

Self-generation technology installers were indicated as the preferred source of information in all countries and, although respondents could select multiple replies, they were the only source chosen by over half of respondents. Overall, consumer associations were the least indicated source, with some exceptions at country level (i.e. Spain (18,5%), Hungary and Poland (both 16,7%) and the UK (16,1%). Furthermore, 13,1% of all respondents indicated that they did not seek any help. This number again varies across different countries. Countries standing out in this case are Slovakia (34,2%) and Croatia (27,6%) – both second group countries.

Table 11: Source of information by country

	Energy supplier	Self-generation technology installer	Govern-ment agency	Consumer association	Other	Did not seek help
Overall	26,3%	60,1%	15,8%	9,8%	5,7%	13,1%
Key countries						
BE – Belgium	20%	69,7%	13,3%	4,8%	2,4%	14,5%
DE – Germany	39,8%	68,4%	26,3%	14,3%	2,3%	8,3%
ES – Spain	25,8%	64,2%	13,2%	18,5%	2,6%	7,3%
FR – France	28,6%	70%	25,7%	2,9%	1,4%	7,1%
IT – Italy	26,4%	67,5%	12,2%	8,6%	4,1%	9,6%
NL – The Netherlands	26,8%	51,6%	15%	11,8%	8,5%	11,8%
UK – United Kingdom	34,2%	56,4%	30,2%	16,1%	6,7%	10,7%
Second group of countries						
BG – Bulgaria	10,8%	62,2%	-	2,7%	18,9%	13,5%
CZ – Czech Republic	32,7%	59,2%	6,1%	4,1%	-	14,3%
HR – Croatia	12,1%	63,8%	8,6%	8,6%	6,9%	27,6%
HU – Hungary	18,5%	57,4%	9,3%	16,7%	7,4%	11,1%
PL – Poland	40%	68,3%	26,7%	16,7%	3,3%	-
PT – Portugal	35%	70%	12,5%	10%	-	7,5%
SI – Slovenia	14,5%	71,1%	7,5%	2,5%	10,1%	10,7%
SK – Slovakia	23,7%	28,9%	7,9%	5,3%	13,2%	34,2%

The survey also looked at the preferred sources of information by type of technology and by main driver for switching to self-generation.

Prosumers choosing solar PV technology were amongst the highest proportion of those contacting the technology installer (65,1%) but were also the group most likely to not have consulted one of the sources listed below for information (8,7%).

Table 12: Source of information by driver and technology

	Energy supplier	Self-generation technology installer	Govern-ment agency	Consumer association	Other	Did not seek help
Overall	26,3%	60,1%	15,8%	9,8%	5,7%	13,1%
Type of technology						
Solar photovoltaic	31,8%	65,1%	21,6%	12,2%	5,0%	8,7%
Heat-pumps	30,9%	61,8%	17,7%	10,4%	4,8%	11,5%

Solar thermal	32,9%	62,5%	25,7%	13,9%	4,4%	9,5%
Wood pellet stove	29,6%	59,9%	20,1%	11,7%	5,1%	14,0%
CHP	45,7%	62,4%	30,1%	23,7%	1,6%	4,3%
Micro wind turbine	47,5%	60,4%	31,7%	22,3%	2,2%	9,4%
Main driver for switching to self-generation						
Subsidies	33,2%	58,7%	28,3%	8,9%	5,3%	4,9%
Environment	31,6%	64,4%	28,5%	13,3%	2,5%	7,6%
Saving money	25,4%	60,8%	11,8%	9,4%	5,7%	13,9%
Others' experiences	22,0%	50,5%	10,1%	11,0%	10,1%	20,2%
Other reasons	5,7%	48,3%	8,0%	3,4%	14,9%	34,5%

In particular, when asked how easy or difficult were for them the main steps in the process of becoming self-generator, solar PV prosumers provided the following feedback:

Table 13: Steps in the process of becoming self-generator

	Very easy / easy	Neither easy nor difficult	Very difficult / difficult
Steps in the process of becoming self-generator			
Finding someone to install the technology	67,1%	24,8%	8,1%
Finding someone to maintain the technology	59,4%	29,7%	10,9%
Making changes to the billing scheme for electricity	51,9%	32,7%	15,4%
Benefiting from available incentives	52,3%	32%	15,7%

Finally, over 90% of self-generating consumers indicated that they would recommend switching to self-generation to others (e.g. friends and family). This trend was also better observed by examining the split by different technologies. In all cases, well over 90% of the respondents mentioned that they would recommend switching the self-generation. Especially in the case of solar PV, 94% of prosumers said they would recommend their choice to others.

Grid connection and compensation for feeding electricity into the grid

Another main aspect of the study addressed in the survey was grid connection and compensation for feeding electricity into it.

On grid connection, respondents were first asked to indicate whether or not they generated all their electricity by themselves or whether they were also still buying from the grid. Those who indicated producing all the electricity by themselves then were asked specific follow-up questions to ascertain whether they were still grid connected and whether they fed part of their electricity back into the grid. The overall results and their breakdown by country are presented in the table below.

Overall over 1 out of 4 respondents (27,7%) replied to be fully self-generating electricity and thus not buying from the grid anymore. Respondents in key countries were generally more likely to produce all electricity themselves compared to the second group of countries, with two exceptions: Hungary, where nearly half (49,1%) indicated producing all electricity themselves and Poland (over 1 out of three – 34,9%).

Of those who reported to self-generate all their electricity, a large majority (85,3%) indicated to be still connected to the grid. This proportion showed highest in Germany (96,3%) and Belgium (94,4%), and lowest in the UK (81,7%). For this question however, we obtained sample sizes in the second group of countries that were too small to allow a meaningful assessment.

Table 14: Connection to the grid

	Producing all electricity themselves		Still connected to the grid		Feed part back into the grid	
	Yes	No	Yes	No	Yes	No
Overall	27,7%	72,3	85,3%	14,7%	37,5%	62,5%
Key countries						
BE – Belgium	37,1%	62,9%	94,4%	5,6%	57,2%	42,8%
DE – Germany	34,6%	65,4%	96,3%	3,7%	46,2%	53,8%
ES – Spain	36%	64%	87,5%	12,5%	37%	63%
FR – France	33%	67%	84,4%	15,6%	45,4%	54,6%
IT – Italy	41,3%	58,7%	86,4%	13,6%	39,9%	60,1%
NL – The Netherlands	30,1%	69,9%	83,6%	16,4%	66,7%	33,3%
UK – United Kingdom	36,4%	63,6%	81,7%	18,3%	67,7%	32,3%
Second group of countries						
BG – Bulgaria	14,6%	85,4%	-	-	22,9%	77,1%
CZ – Czech Republic	6,8%	93,2%	-	-	20,3%	79,7%
HR – Croatia	16,9%	83,1%	-	-	21,5%	78,5%
HU – Hungary	49,1%	50,9%	-	-	65,5%	34,5%
PL – Poland	34,9%	65,1%	-	-	25,4%	74,6%
PT – Portugal	26,5%	73,5%	-	-	40,8%	59,2%
SI – Slovenia	10,3%	89,7%	-	-	19,9%	80,1%
SK – Slovakia	13,3%	86,7%	-	-	17,8%	82,2%

Targeting those respondents who answered that they were feeding part of the electricity back into the grid, a follow-up question was asked to ascertain whether they received compensation for doing so. The table below outlines the different types of compensation (multiple answers could be given) that prosumers in the key countries receive. Sample sizes for the second group of countries were too small for a meaningful analysis.

Table 15: Compensation for feeding electricity back into the grid

	Payment from the electricity supplier	Can store electricity	Other incentives	Do not receive compensation for feeding back into the grid
Overall	58,8%	34,2%	1,8%	14,1%
Key countries				
BE – Belgium	35,1%	47,7%	7,2%	24,3%
DE – Germany	77,8%	22,2%	-	5,6%
ES – Spain	37,8%	50%	-	16,2%
FR – France	84,1%	20,5%	-	9,1%
IT – Italy	67,1%	30,6%	4,7%	5,9%
NL – The Netherlands	60,7%	43,4%	1,6%	5,7%
UK – United Kingdom	77,3%	17,4%	0,8%	11,4%

Switching electricity provider to self-generate

The survey also asked respondents about their experience on switching provider. In the case of solar PV prosumers, only 12% chose to switch. The following tables illustrate their feedback:

Table 16: Switching provider easiness

	Very easy / easy	Neither easy nor difficult	Very difficult / difficult
Switching electricity provider			
How easy or difficult was switching electricity provider?	69,3%	21,3%	9,4%

Table 17: Switching provider timeframe

	3 weeks or less	3 weeks to 3 months	4 to 6 months	Over 6 months
Switching electricity provider				
Approximately how long did the entire process of switching take, from submitting the application to actually switching?	44%	44%	9,3%	2,7%

Attitudes towards technology

The final section of the questionnaire surveyed respondents about their affiliation with technology and electronics and about those ‘green’ activities that were already part of their lifestyle. Results were collected by country and revealed the following:

- When looking at prosumers' affiliation with technology and electronics, it emerged that not all prosumers are necessarily expert in this field. Still, around half mentioned to be passionate about technology (47,1%) and 43,9% believed that their family and friends relied on their advice on technology and electronics. On the other hand, 46,7% indicated to rely on others' advice.

- As for prosumers' "green" lifestyle, activities such as recycling waste, paying attention to energy consumption, buying energy-efficient household appliances and buying local products and food, score higher than avoiding using the car and opting for environment friendly alternatives. This partly reflected the different social/cultural and policy realities of Member States, e.g. in relation to transport and mobility: the existence of valid options and public policies encouraging commuting via greener means, consumers' attention to social status symbols etc.

- Replies provide a general picture on the experiences and attitudes of prosumers and can help better understand the non-financial drivers determining consumers' choice to self-generate.

We propose here below the results for the key countries only. For complete data covering all the EU28 and Norway, we refer to the annex to this report.

Table 18: Attitudes towards technology

	Knowledge & experience	Family & friends rely on my advice	First to try new technologies and appliances	Passionate about technology	Depending on other's advice	No time to think about it	Not interested
Overall	41,4%	43,9%	36,9%	47,1%	46,7%	25,8%	24,8%
Key countries							
BE – Belgium	31%	31,4%	24,7%	31,4%	48,3%	22,2%	26,1%
DE – Germany	45%	43%	36,5%	45,5%	49%	31%	36,5%
ES – Spain	47,1%	55,6%	49,3%	63,1%	61,8%	18,7%	12,5%
FR – France	39,8%	48,5%	40,8%	50,5%	64,1%	25,2%	23,3%
IT – Italy	61,5%	56,5%	50,6%	67,4%	36%	22,6%	22,6%
NL – The Netherlands	33,8%	40,3%	33,8%	36,8%	38,8%	25,4%	30,3%
UK – United Kingdom	45,5%	44,6%	42%	50,5%	41,1%	28,2%	25,7%

Table 19: Environment-friendly attitudes

	Recycling waste	Avoid using the car and using environment friendly alternatives	Paying attention to energy consump-tion	Buying energy-efficient household appliances	Buying local products and food	Other environ-mental friendly activities
Overall	66,8%	35,6%	70,4%	64,2%	58,4%	3,7%
Key countries						

BE – Belgium	78,7%	35,3%	80,7%	60,4%	47,3%	3,9%
DE – Germany	50,5%	42%	64,5%	72,5%	72%	2%
ES – Spain	75,6%	49,3%	85,3%	67,6%	51,6%	2,7%
FR – France	72,8%	44,7%	83,5%	74,8%	68%	2,9%
IT – Italy	71,5%	41%	81,6%	72,8%	55,6%	1,3%
NL – The Netherlands	74,1%	34,8%	76,6%	54,7%	39,8%	4,5%
UK – United Kingdom	74,8%	32,7%	68,8%	59,9%	55,4%	3%

6.1.2 Conclusions of the survey

After examining all results, the following issues were identified as most relevant to the study's overall integrated analysis:

- Solar PV was confirmed as top technology of choice both in more mature and in secondary markets, coupled with a high degree of satisfaction that prompted respondents to say they would also recommend self-generation to others;
- Respondents considered obtaining information on, and benefiting from, available incentives less easy than obtaining information on the procedure to become prosumers and related costs;
- Prosumers across the more mature markets receive compensation for feeding electricity into the grid, confirming this as a key factor of the rapid growth;
- Financial considerations such as sparing money on energy bills and benefiting from incentives are still top drivers of the self-generation choice in most of the mature markets. Incentives scored second to environmental concerns, but this could change if they ceased to be available.

6.2 Mystery shopping

The mystery shopping exercise aimed at investigating the experiences of consumers with becoming residential prosumers, or in other words with the transition to residential self-consumption and its different options: maintaining the connection to the grid (and feeding back or not the electricity into it) or disconnecting from the grid.

It allowed the assessment of consumers' experiences in the process of enquiring information to the energy providers about self-consumption. In detail, it gathered first-hand information on the following issues:

- How easy it is for future prosumers to get in contact with the energy providers
- Which level of information about the procedure to become a prosumer is given
- Which level of information on costs, tariffs, taxes and incentives is given
- Which level of information on other advantages and difficulties is given

Our selection of ten countries, based on ToR requirements, ensured a good balance in representation among more mature markets and less developed ones, and it also ensured the coverage of all the different geographic regions of Europe.

The evidence collection and analysis were developed on the basis of the questionnaire and assessment sheet. Another important step of fieldwork preparation was the training of mystery shoppers specifically on the objectives on this project exercise, so as to ensure the smooth implementation of "mystery calls". We chose to have the exercise conducted by phone rather than by visits in person as this appeared to be the more feasible way of approaching the energy suppliers.

Figure 17: Mystery shopping scenario

Pretend *not* to be a prosumer

☟

Call the electricity provider

☟

Ask about the procedure to become a prosumer:

✓ Timeframe, steps

✓ Electricity bill

✓ Costs, taxes and incentives

6.2.1 Fieldwork result analysis

In this section we focus on a number of key findings emerged from this primary data collection exercise, while the complete results are presented in detail in the form of easy-to-read tables in annex to this report.

Feedback on contacting the electricity provider

Consumers' feedback on this issue was overall positive. Around 2/3 of mystery shoppers reported that they did not have to make multiple attempts to be able to speak on the phone. Again around 2/3 of them reported that they did not have to get transferred to another agent to be able to complete the call.

Over half of the shoppers reported that their waiting time on the line was the shortest among the proposed answer options, i.e. less than 1 minute. Again over a half of them confirmed that they got very easily connected to the agent who handled their enquiry. This reported "easiness" could be interpreted as the combination of the positive impact on consumers of the short waiting time on the line, plus the attitude and competence of the operator answering their questions without any need of transferring the call.

Information on the procedure to become prosumer

Replies to this section of the assessment sheet were rather evenly split among the different options, with a prevalence of shoppers who reported that the information obtained was vague, over those who obtained a detailed feedback from the operator.

Especially on the solar panel-related questions, the feedback of the energy provider was judged as not informative at all by a high number of shoppers.

This could be partly explained with the fact that, as shown by other questions contained in the assessment sheet, the majority of energy providers would not offer solar panel installation services or information on technology suppliers. This lack of involvement of the electricity providers in the solar panel installation phase would also partly explain why 48% of shoppers reported that they could not obtain any information at all on the overall timeframe to become prosumer.

Finally, the majority of shoppers was also quite dissatisfied with the information obtained on the possible different options to become a prosumer (maintaining grid connection, selling back to the grid, disconnecting). One explanation can be that not all different options are available and/or in fact implemented in all countries.

Table 20: Could the agent give you information on the different options that you have to become a prosumer?

Answer option	Number of replies	Percentage
Yes, detailed information	95	26%
Only vague information	114	31%
No information at all	157	43%

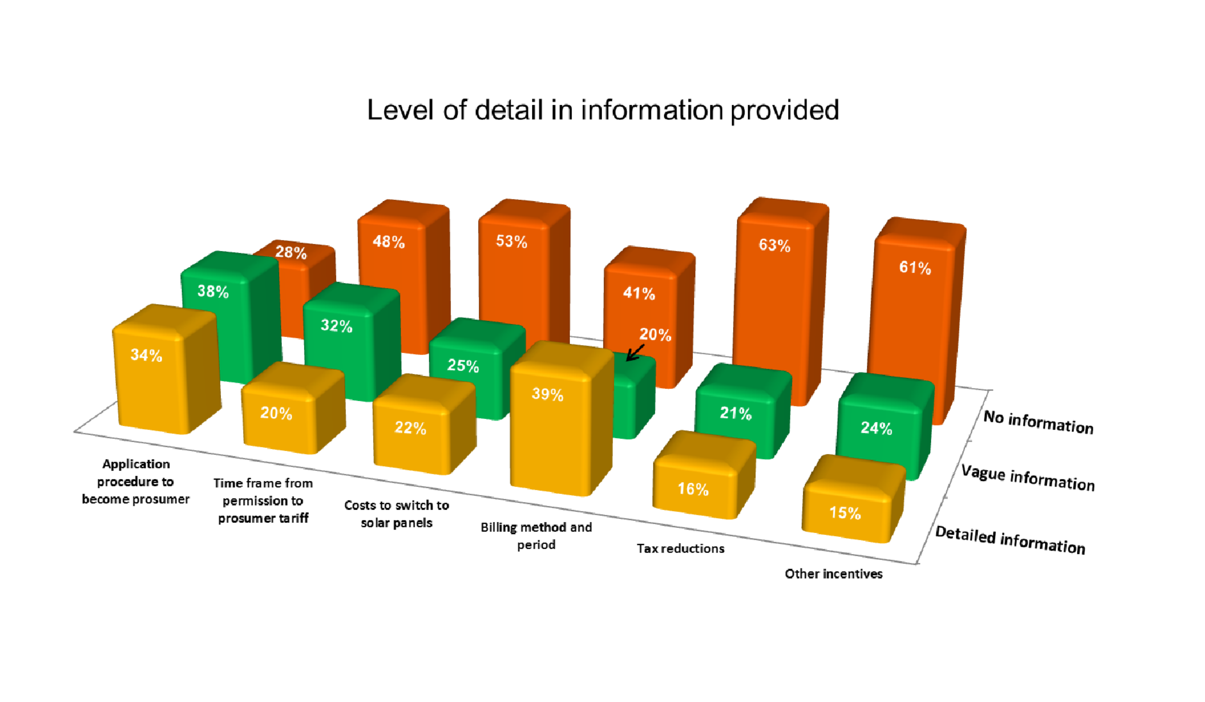
Information on tax and other incentives, as well as on other advantages and disadvantages

Most respondents here expressed their dissatisfaction with the information obtained. Over 60% of them replied that they did not get any information at all on tax reductions and other incentives available.

Only 45% of respondents reported that they were redirected to other sources in order to obtain the missing information.

The figure here below illustrates the feedback given by the mystery shoppers on the level of information obtained on the various main topics related to becoming prosumer.

Figure 18: Level of detail in information provided



The above responses are also further confirmed by the final low rating given by mystery shoppers in the evaluation of the knowledge of the electricity provider agents. The low rating suggests that there is a perceived need for more appropriate training of the electricity provider operators, so that they would offer better information service. As shoppers pointed out, based on the poor information received, if they were really interested in becoming prosumers, they would turn to another electricity provider. Or perhaps, if again facing unsatisfactory feedback, they might just drop the plan of becoming prosumers.

6.2.2 Conclusions on mystery shopping

After examining all results, the following issues were identified as most relevant to the study's overall integrated analysis:

- A high number of respondents were not satisfied with the information given by the electricity suppliers on issues such as procedural steps to become prosumer, length of the process, available incentives and tax reductions. These results are in line with those of the survey. Besides, electricity suppliers mostly did not redirect consumers to solar panel installers, who are seen as a relevant and reliable source of information by the survey respondents
- Consumers could not obtain from the electricity supplier comprehensive information on the advantages, apart from incentives, of the self-generation choice, this including key aspects such as electricity cost reduction, metering and technology options to best manage self-consumption. Answers with regard to these aspects showed that the information obtained was generally vague if not absent at all.

6.3 Conclusions

The different primary data collection tasks of the study were developed from different starting points, so that we could make the best possible use of their feedbacks and work on their complementarities, to build a final comprehensive analysis. In particular:

- While they all primarily focused on solar PV and covered extensively the more mature markets, they also allowed a comparison with other types of technologies (the survey results) and with less mature markets across the various European regions.

- While they all focused on residential prosumers, each examined them from a different angle in their process of choosing self-generation:
    - the decision-making phase, with various behavioural elements at play
    - the implementation phase, where prosumers could express their views on advantages and difficulties
    - the assessment phase, where prosumer assessed their experience, expressing or not their willingness to recommend it to others

This task combination allowed us to examine an extremely wide scope of consumer attitudes, impressions, experiences and feedbacks, again with the possibility to look at the overall European picture or to read results with a more specific country focus.

The cross-task analysis of financial and non-financial drivers affecting consumers' self-generation choices showed that considerations on the possibility to benefit from incentives still score high in the decision-making process, especially looking at more mature markets whose rapid growth was actually mainly prompted by financial supports in various forms.

Consumers overall were not very satisfied with the level of information received when enquiring about procedural steps and about the different financial advantages available.

The difficulty in gaining clarity itself could be considered as a non-financial driver discouraging their choice to self-generate, as particularly evidenced by the mystery shoppers' replies.

To a wide extent however, once their self-generation choice was made, consumers expressed satisfaction with it and willingness to recommend it to others, showing that in most cases the policies adopted so far have been generally perceived as advantageous. It remains to be seen how the feedback would change if incentives were broadly no longer available.

Environmental concerns also scored high, at the top of the non-financial drivers, only second to the top driver, i.e. the possibility to get reduced energy bills. It appeared therefore that policy fine-tuning allowing the deployment on a large scale of behind the meter, smart technologies would be a much needed development, possibly strong enough to further boost the prosumer market, even with the elimination of incentives. This is also confirmed by the fact that earning back the cost of electricity, benefitting from the advantages of smart metering, earning income by selling to the grid were all main considerations listed in the open-answer feedback of the mystery shopping exercise.

Besides, mixed financial considerations were shown concerning the real estate property: on the one hand, replies showed that consumers are aware of an increase in the value of their homes, thanks to the installation of green technologies, and also of the possibility to benefit from related financial support. On the other hand, consumers expressed some general concern about the extra costs related to the installation and maintenance of technology.

Besides environmental concerns, other non-financial drivers were not easy to measure in the survey and in the mystery shopping exercise. Consumers' interest in new technologies, their desire to be energy self-sufficient, to feel security of energy supply, to improve their "green lifestyle" or promote their personal social image all generally featured among their replies.

A more comprehensive assessment of drivers can be done via behavioural experiments, and our proposed approach on the design of such an experiment has been presented in the following, dedicated chapter of the study. Looking at the findings that emerged from the various tasks in the course of the project implementation, and in line with the analytical angle of the entire study, our proposed behavioural experiment design has the following aims:

- To assess the abilities and skills of traditional consumers to understand the offers for transitioning towards residential self-generation and storage.
- To gain insight into how traditional consumers can make the best choice regarding self-generation with solar PV panels.
- To gain insight into how easy or difficult it is for traditional consumers to find and assess information on self-generation and storage (and how much information can be digested).

7 Behavioural experiment

In this task, an experimental design focusing on solar PV is developed. The focus of our analysis is on consumers who are already interested in becoming prosumers – the "already green people". This consumer group has not made the transition yet but is searching the market.

The analysis focuses on the barriers that consumers face when deciding to purchase solar panels, including their understanding of the most important factors in this decision context. The study also focuses on how consumers may overcome barriers in their decision process. For example, research suggests that consumers are more likely to adopt solar panels when they (1) clearly see benefits and positive consequences, (2) when they feel enough social pressure, and (3) when they perceive less risk or feel they can overcome hassles associated with the adoption of solar panels.156 In line with previous research, we propose a model in which consumer choice is predicted by barriers in the decision process (as well as specific product characteristics), and show how consumers might overcome such barriers by certain drivers / beliefs (e.g., cost/benefit beliefs).

There are several phases in consumers' decision-making process: the intention phase, in which consumers form an intention to purchase solar panels; the orientation phase, in which consumers find and compare information on purchasing solar panels; and the action phase, in which solar panels are purchased.[157]

We focus on (barriers and beliefs in) the orientation phase, as consumers are already interested in purchasing solar panels. The study investigates whether, in the orientation phase, consumers have the motivation, ability, and opportunity to find, understand, and evaluate solar panel offers (e.g., do they represent a good investment?) in light of their energy consumption profile, financial situation, and so on. Moreover, the study investigates which barriers these consumers face and how they might overcome them.

Specifically, Main Task 5 has the following aims:

- To assess the abilities and skills of traditional consumers to understand the offers for transitioning towards residential self-generation and storage.

- To gain insight into how traditional consumers can make the best choice regarding self-generation with solar PV panels.

- To gain insight into how easy or difficult it is for traditional consumers to find and assess information on self-generation and storage (and how much information can be digested).

To answer these questions an experiment is designed which consists of two parts: an experimental part and a post-experiment survey. The experimental part focuses on how consumers choose solar panels and whether these choices are influenced by the way in which the information is presented (structured vs. unstructured). This already provides some insight into how easy or difficult the decision process is for consumers and

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[156] Ozaki, R. (2011). Adopting sustainable innovation: what makes consumers sign up to green electricity? Business Strategy and the Environment, 20(1), 1-17.
[157] See, for example, Van Putten, M., Van der Schors, A., Van Dijk, E., & Van Dijk, W. (2016). Consumenteninertie in de keuze van contracten van dienstenmarkten. Consumer inertia in the choices of contracts in service markets.

identifies which are the most relevant product characteristics for consumers. The post-experiment survey measures barriers and drivers in the decision process, including consumers' beliefs (e.g., cost/benefit beliefs). In this way, we can investigate which barriers and drivers predict consumers' intention to purchase solar panels, and identify the most important barriers and drivers.

The behavioural experiment aims to answer the following questions:

1) Which product characteristics and levels are most important to consumers when deciding whether to purchase solar panels? Which product characteristics more often result in no choice?

2) How easy or difficult is it for consumers to find, assess, and understand solar panel offers? How does the way in which information is presented (structured vs. unstructured) influence these things?

3) Which drivers and barriers do consumers experience in the decision process of purchasing solar panels? Which drivers may help consumers to overcome barriers?

First we provide background information based on a literature review and then we explain the study set-up. This chapter also contains the questionnaire and a data analysis plan.[158]

[158] As provided for in the ToR, Main Task 5 consisted of a study for which only materials had to be developed but no data collected; therefore this chapter does not include a results section

7.1 Literature review and hypotheses

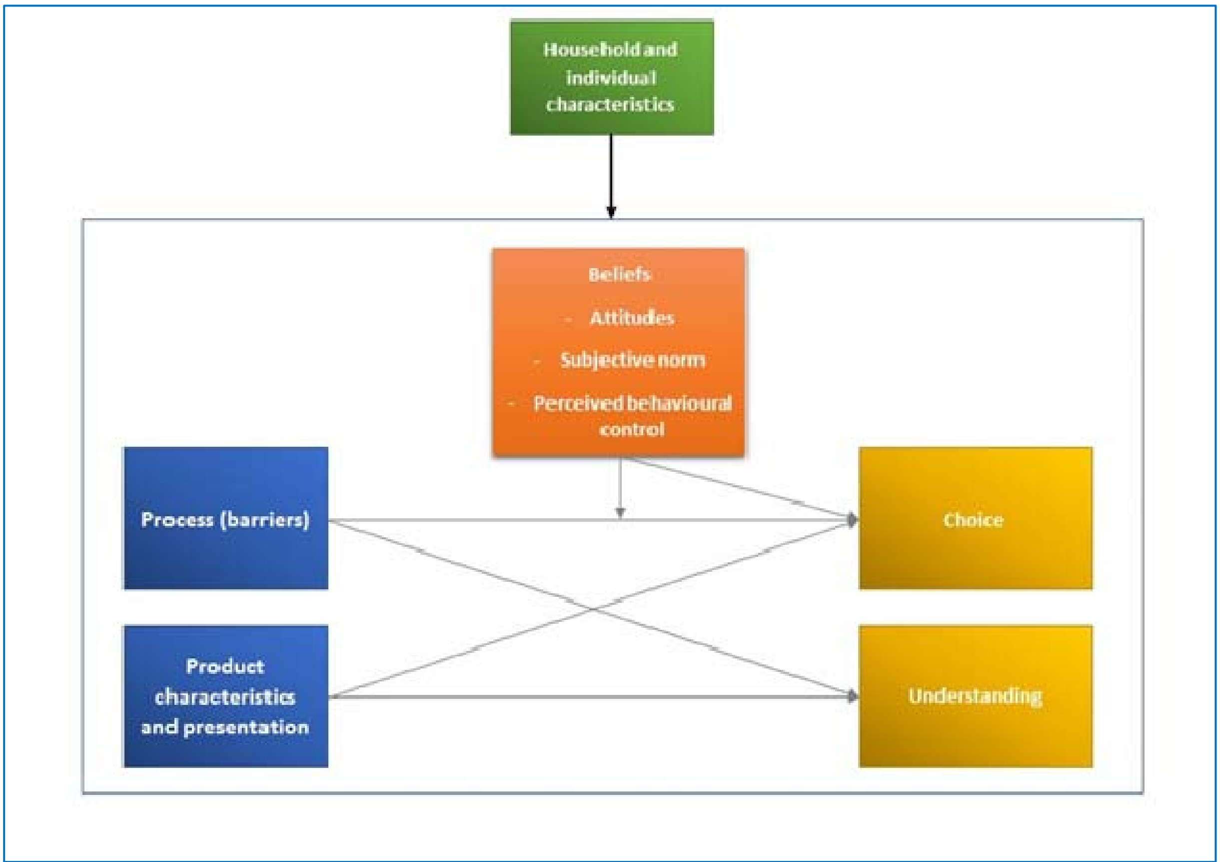
This chapter discusses relevant literature on consumers' decision process when purchasing solar PV panels. The chapter starts with the development of a conceptual model on consumer choice for solar panels and understanding of offers, which is tested in the study. The specific aspects of the model are explained in this chapter.

7.1.1 Conceptual model

Acceptance of solar PV panels is driven by market factors such as product composition of solar panels, costs, regulations and market structure.[159] At the same time, individual beliefs such as awareness, knowledge of technology, psychology of energy conservation, and household characteristics, influence the decision to purchase solar PV panels.

Figure 19 provides an overview of the conceptual model that we focus on. The model focuses on how decision making depends on (informational) aspects of offers towards solar PV panels (e.g. which product characteristics are most important in consumer choice) and relevant household and individual characteristics that determine the attractiveness of the offer, such as one's financial situation. The model also incorporates process barriers that consumers may face in the decision process as well as drivers/beliefs that may affect consumers' decision to purchase or not purchase solar panels.

Figure 19: Theoretical model



The remainder of this chapter explains each part of the conceptual model. All parts of the model are included in the study, so that all arrows (i.e. all expected effects) can be tested. However, some are incorporated in the experimental part of the study and some in the post-experiment survey. Together, the experimental part and post-experiment survey contain the full model.

7.1.2 Product characteristics (experimental part)

Solar panels are a technology for self-generation of energy. The composition of solar PV panels influences the decision to purchase solar panels. Typical considerations that consumers make in this process of deciding to purchase solar panels are related to price, aesthetics, and the payback period of solar PV panels.[160]

In this study, we investigate which product characteristics of solar PV panels are most important to consumers and which combinations of product characteristics they prefer. Such preferences can be determined with choice experiments, in which respondents choose among realistic solar PV panels.[161,162,163] As such, the study includes an experimental part in which consumers are provided with product sets with different solar panels in which certain product characteristics are systematically varied (see also 1.2.1). For instance, solar panels have different aesthetical value to the consumer. Solar panels can be divided in mono, poly, premium, coloured, and roof-integrated solar panels.[164] Consumers may perceive a roof-integrated solar panel to look better on a roof than a mono solar panel. Moreover, prices and efficiency levels of these solar panels differ. For instance, a coloured solar panel is often more expensive[165, 166]. Nonetheless consumers might be willing to pay more for such solar PV panels. In addition, there are several solar panel efficiency levels; most common are 250Wp, 270Wp and 290Wp. Other characteristics include the total investment costs, the (estimated) payback period, choice of inverter type (string inverter or micro-inverter that allows for monitoring the performance per panel and cancels out the negative impact of shading), lifetime, and maintenance costs. By systematically varying product characteristics it is possible to uncover which characteristics or combinations of characteristics are most important to consumers in their decision-making process. We investigate whether product characteristics and the way in which the product characteristics are presented influence consumer choice and understanding of solar panel offers.

When consumers start researching the market they can be overwhelmed by the many informational aspects, technical information, and the different characteristics that can be compared across solar panels. There are two typical ways in which information on solar

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[159] Islam, T. (2014). Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data. Energy Policy, 65, 340-350.
[160] Ozaki, R. (2011). Adopting sustainable innovation: What makes consumers sign up to green electricity?. Business Strategy and the Environment, 20(1), 1-17.
[161] Rossi, P. H. (1979). Vignette analysis: Uncovering the normative structure of complex judgments. In R. K. Merton, J. S. Coleman, & P. H. Rossi (Eds.), Qualitative and quantitative social research: Papers in honour of Paul F. Lazarsfeld (p. 176-186). New York: Free Press.
[162] Rossi, P. H., & Anderson, B. (1982). The factorial survey approach: An introduction. In P. Rossi & S. L. Nock (Eds.), Measuring social Judgements: the Factorial Survey Approach (p. 15-67). Beverly Hills: Sage.
[163] Sauer, C., Auspurg, K., Hinz, T., & Liebig, S. The application of factorial surveys in general population samples: The effect of respondent age and education on response times and response consistency. Survey Research Methods, 5(3), 89-102.
[164] Den Donker, M. Greveling, S., Vossen, F. &, Folkerts, W. (2016). De prijs van BIPV in Nederland.
[165] Den Donker, M. Greveling, S., Vossen, F. &, Folkerts, W. (2016). De prijs van BIPV in Nederland.
[166] https://www.solarguide.co.uk/coloured-solar-panels

panels is presented to the consumer. One way of presenting solar PV panels information is in a comparison format (structured), see for instance Figure 20.

Figure 20: Example of information on solar panels in a comparison format (structured) [167]

Compare solar panels

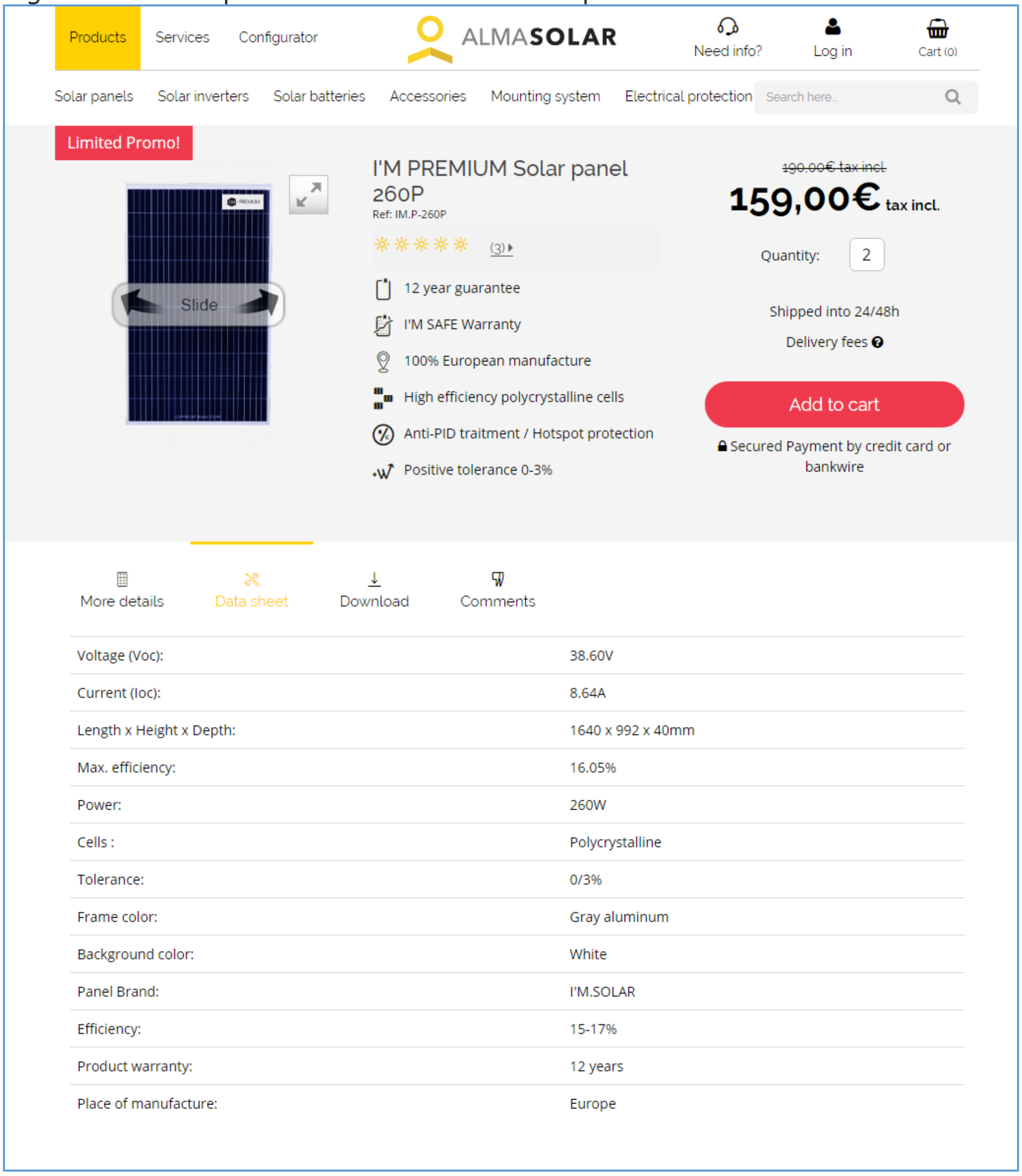
	AE300P6-72 (300W)	SPR-215-WHT (215W)	TSM-160PE040.07 (160W)
DC Electrical Characteristics			
STC Power Rating	300W	215W	160W
PTC Power Rating	277.46W[1]	196.3W[2]	140.7W[3]
STC Power per unit of area	14.4W/ft^2 (155.1W/m^2)	16.0W/ft^2 (172.5W/m^2)	9.0W/ft^2 (97.3W/m^2)
Peak Efficiency	15.51%	17.2%	9.72%
Power Tolerances	0%/+2%	-5%/+5%	0%/+3%
Number of Cells	72	72	40
Nominal Voltage	not applicable	not applicable	not applicable
Imp	7.91A	5.4A	8A
Vmp	37.94V	39.8V	20V
Isc	8.68A	5.8A	8.58A
Voc	45.43V	48.3V	24.9V
NOCT	45°C	45°C	44°C
Temp. Coefficient of Isc	0.06%/K		0.07%/K
Temp. Coefficient of Power	-0.36%/K	-0.38%/K	-0.41%/K
Temp. Coefficient of Voltage	-0.164V/K	-0.18V/K	-0.08V/K
Series Fuse Rating	15A	15A	15A
Maximum System Voltage	1000V	600V	1000V
Mechanical Characteristics			
Type	Polycrystalline Silicon	Monocrystalline Silicon	Polycrystalline Silicon
Output Terminal Type	Multicontact Connector Type 4	Multicontact Connector Type 4	Multicontact Connector Type 4
Output Cable Wire Gauge	12 AWG		12 AWG
Output Cable Wire Type	PV Wire	PV Wire	PV Wire
Output Cable Wire Length	900mm (35.4in)		400mm (15.7in)
Frame Color	Clear	Clear	data not available
Length	1,950mm (76.8in)	1,560.6mm (61.4in)	1,658mm (65.3in)
Width	992mm (39.1in)	798.6mm (31.4in)	992mm (39.1in)
Depth	50mm (2in)	46mm (1.8in)	25mm (1in)
Weight	23kg (50.7lb)	15kg (33lb)	23kg (50.7lb)
Installation Method	Rack-Mounted	Rack-Mounted	Rack-Mounted
Warranty and Certifications			
80% Power Output Warranty Period	30yrs	25yrs	30yrs
90% Power Output Warranty Period	12yrs	12yrs	10yrs
Workmanship Warranty Period	12yrs	10yrs	10yrs
UL 1703 Fire Classification	data not available	data not available	Type 13
Compliances	IEC 61215, IEC 61730, CEC, TUV	UL 1703	UL 1703, IEC 61215, IEC 61730, TUV
CSI Listed	No	No	Yes

1. PTC rating calculated using 45°C as the NOCT (Nominal Cell Operating Temperature)
2. California Solar Initiative (CSI) list of Eligible Modules
3. California Solar Initiative (CSI) list of Eligible Modules

[167] Information derived from Solar Design tool (worldwide): http://www.solardesigntool.com/compare-solar-panels-modules.html

Another way in which information on solar PV panels is presented to the consumer is by means of separate offers (unstructured). The consumer has to compare the different offers, which are structured in different formats. For an example offer see Figure 21.

Figure 21: Example of information on solar panels [168]



The way in which information is presented in offers of solar panels might help (or discourage) consumers to find and assess information and to buy the product that really matches their preferences. In a comparison format (structured) it will be easier for consumers to compare the information than when offers of several providers individually have to be assessed (unstructured). Research in other areas has shown that presenting difficult text in a clearer manner improves consumer understanding and choice[169, 170]. We

[168] Information derived from AlmaSolar (Dutch website): https://www.alma-solarshop.nl/zonnepanelen/961-i-m-premium-zonnepanelen-260p.html

[169] GfK Consortium. (2017). *Consumer Market Study to support the Fitness Check of EU consumer and marketing law.* Report for the European Commission.

[170] Elshout, M., Elsen, M., Leenheer, J., Loos, M., & Luzak, J. (2016). *Study on consumers' attitudes towards Terms and Conditions (T&Cs).* Report for the European Commission.

will investigate the impact of information presentation on consumer choice for and understanding of solar panels. We expect that consumers will be better able to find, assess, and understand information, and more often make a choice (instead of delaying or not making a choice at all), when the information is presented in a clearer manner.

7.1.3 Process barriers and beliefs (post-experiment survey)

In the post-experiment survey, we focus on barriers and drivers in the decision process to purchase solar panels. We first measure process barriers (e.g., the amount and complexity of information to go through). Next, we measure beliefs that may act as drivers and may even help consumers in overcoming process barriers (e.g., believing one is able to understand the technical aspects of solar panels or believing one can save money by purchasing solar panels).

Process barriers

Even though respondents are consumers who are already interested in becoming prosumers it could be the case that consumers opt out because they experience all kind of barriers in the decision process, which they are not able to overcome.[171] Several barriers are typically present in the orientation phase of the decision making process[172]:

- There may be too much information to consider.
- Consumers may find it difficult to compare the information of different options.
- Consumers may not have a clear view of what they are looking for.
- Consumers may deliberate too long, having difficulties making a final decision.

These barriers may all be relevant in the case of deciding whether to purchase solar panels. For example, consumers may feel overwhelmed by the amount and complexity of information that should be compared. It may seem quite costly to consumers to have to digest the (technical) information. Moreover, payback periods depend on a number of things (such as: investment costs, amount of solar panels, positioning of the rooftop, efficiency of the panels) and it can be difficult for an individual to make the calculations that estimate the payback period in their specific situation.

In the post-experiment survey, we measure these barriers to determine their (relative) impact on consumers' intention to purchase solar panels.

Beliefs

We follow the Theory of Planned Behaviour (TPB) to understand which beliefs may influence consumers' decision process. The Theory of Planned Behaviour[173] is a well-

[171] Note that we focus on barriers to consumers' purchasing behaviour (also called behavioural barriers). In the context of solar panels, there are other barriers as well, such as institutional and technical barriers, which affect the production and distribution sides. For an overview of such barriers, see Painuly, J. P. (2001). Barriers to renewable energy penetration: A framework for analysis. Renewable Energy, 24, 73-89. See also Martinot, E., & McDoom, O. (2000). Promoting energy efficiency and renewable energy: GEF climate change projects and impacts, http://www.martinot.info/Martinot_McDoom_GEF.pdf

[172] Van Putten, M., Van der Schors, A., Van Dijk, E., & Van Dijk, W. (2016). Consumenteninertie in de keuze van contracten van dienstenmarkten. Consumer inertia in the choices of contracts in service markets.

[173] Ajzen, I. (1991). The Theory of Planned Behavior. Organizational Behavior and Human Decision Processes, 50, 179-211.

known and validated model in behavioural economics and social psychology[174,] which is widely applied to decision making regarding energy-related products[175].

According to the TPB, consumers may have several beliefs that shape their attitudes, social norms, and perceived behavioural control. These in turn are likely to influence consumers' decisions to purchasing solar panels.

Attitudes

Cost/benefit beliefs[176] can influence people's attitudes towards purchasing solar panels. People's attitudes towards purchasing solar panels seem to be influenced by high initial costs and the long payback periods.[177, 178] The costs of solar panels are still high and even though having solar panels reduces the costs of energy each month, the payback period – when savings finally exceed the costs – is quite long, averaging between three and ten years[179,180,181,182] depending on several factors, such as the amount of clean energy that is generated (i.e., the amount of direct sunlight), the quality and costs of the installation, the price of grid electricity in the region and whether the solar panels are rented or owned.[183] If the payback period takes about ten years, there is, of course, no assurance of an eventual benefit, since the person's situation may have changed by that time (e.g., the person may have moved to a different house). (Lack of) funding and (lack of) awareness of funding by the government also influences costs and may be taken in consideration by consumers.

In addition to costs, there are several benefits that consumers may take into account. For example, if consumers think that solar panels are reliable and/or effective, they may form a positive attitude towards purchasing solar panels. Of course, consumers may form a negative attitude if they think that solar panels are not very reliable and/or effective, for example because not all light from the sun is absorbed.[184, 185] Consumers may also intentionally wait until solar systems will become more efficient.[186] Clearer benefits that consumers may expect is saving money by installing solar panels, and perhaps even earning money by delivering a surplus of energy back into the grid for relatively low

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[174] Armitage, C. J., & Connor, M. (2001). Efficacy of the Theory of Planned Behaviour: A meta-analytic review. British Journal of Social Psychology, 20, 471-499.

[175] Ecorys, CentERdata and GfK (2012). Study on the effects on consumer behaviour of online sustainability displays. For DG Connect.

[176] Also called behavioural beliefs; Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, 179–211.

[177] Painuly, J. P. (2001). Barriers to renewable energy penetration: A framework for analysis. Renewable Energy, 24, 73-89.

[178] https://thesolarsociety.wordpress.com/barrier-to-solar-photovoltaic-p2/

[179] https://www.choice.com.au/home-improvement/energy-saving/solar/articles/solar-panel-payback-times

[180] http://www.directenergysolar.com/blog/post/what-is-the-average-payback-period-of-a-solar-installation/

[181] http://energyinformative.org/solar-panels-cost/

[182] The present bias, in which consumers give stronger weight on the high initial cost on the short term and put less weight to the benefits in the long term, may result in a negative attitude and affect choice. For an explanation of the present bias see: O'Donoghue, T., & Rabin, M. (1999). Doing it now or later. American Economic Review, 89(1), 103-124.

[183] http://www.directenergysolar.com/blog/post/what-is-the-average-payback-period-of-a-solar-installation/

[184] http://www.conserve-energy-future.com/Disadvantages_SolarEnergy.php

[185] http://solarenergy.net/News/3-challenges-solar-energy-needs-overcome-continue-growth/

[186] Shih, L. H., & Chou, T. Y. (2011). Customer concerns about uncertainty and willingness to pay in leasing solar power systems. International Journal of Environmental Science & Technology, 8(3), 523-532.

Feed-in Tariffs. If consumers expect to save and perhaps even earn money, they may hold a positive attitude towards purchasing solar panels.

Consumers' attitudes may also depend on their perceptions of the aesthetics of solar panels. Consumers seem to worry about whether solar panels will look good on their rooftops, thinking that solar panels will look awkward, odd, or unappealing.[187,188] As a result, they may also be concerned about the resale value of their houses (whether justified or not).[189] We will measure whether consumers think solar panels on a roof do not look good and/or make the street look less attractive or whether they are not bothered by the look of solar panels.

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[187] Painuly, J. P. (2001). Barriers to renewable energy penetration: A framework for analysis. Renewable Energy, 24, 73-89.
[188] http://www.thesolarco.com/will-solar-panels-make-my-home-look-ugly/
[189] https://thesolarsociety.wordpress.com/barrier-to-solar-photovoltaic-p2/

Subjective norm

Normative beliefs are composed of people's belief or expectation that important others approve or disapprove of the behaviour.[190] Normative beliefs predict the perceived social norm (e.g. perceived social pressure to perform or not perform a certain behaviour). Research suggests that consumers are indeed influenced by (subjective) social norms for decisions regarding energy use.[191,192]

In the context of solar panels, consumers' decision to (not) buy a solar panel might be influenced by (1) people close in terms of physical proximity (neighbours), (2) people close in terms of emotional proximity (family / friends), (3) others they identify with. Consumers may have perceptions regarding which behaviour is typically performed by these important others (descriptive norm). For example, if many important others have solar panels, it appears that the typical behaviour among important others is to purchase solar panels. The consumer may perceive that it is the norm to purchase solar panels, thus increasing the consumer's intention to buy solar panels.

Moreover, injunctive norms (e.g. explicit approval or disapproval of purchasing solar panels by their peers) might also apply. This shows more directly whether purchasing solar panels is viewed as acceptable or unacceptable behaviour. Such norms may also be communicated by advertisements, the government and/or suppliers of solar panels. It is expected that consumers' perceptions regarding subjective norms are positively influenced by the number of friends, family members and neighbours who have installed solar panels and/or shown approval of purchasing solar panels as well as a high exposure to advertisements on purchasing solar panels.

Perceived behavioural control

Control beliefs predict people's perceived behavioural control (i.e., whether a person believes (s)he is able to perform the behaviour). These are beliefs regarding factors that may facilitate or impede behaviour. Such control beliefs may be based on past experiences or on second-hand information about the behaviour (including information on the experiences of close others). The more resources individuals possess and the fewer obstacles, the greater their perceived control should be.[193]

In the case of solar panels, having affinity with technology may result in a high perceived control to be able to process all the (technical) information, as may consumers' knowledge on how to save energy.[194,195] Conversely, perceiving the technology of solar panels as too complex ("although I would like to participate, it is all too technical for

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[190] Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, 179–211.
[191] Weber, L. (1997). Some reflections on barriers to the efficient use of energy. Energy Policy, 25, 833-835.
[192] Painuly, J. P. (2001). Barriers to renewable energy penetration: A framework for analysis. Renewable Energy, 24, 73-89.
[193] Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, 179–211.
[194] Leenheer, J., De Nooij, M., & Sheikh, O. (2011). Own power: Motives of having electricity without the energy company. Energy Policy, 39(9), 5621-5629.
[195] Islam, T. (2014). Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data. Energy Policy, 65, 340-350.

me")[196] or having a lack of knowledge, understanding or awareness regarding solar panels[197,198] may lower a person's perceived behavioural control.[199]

Consumers' perceived control may also be influenced by their perceived influence on the environment. For example, consumers may believe that their relatively small act of purchasing solar panels would hardly contribute to the fight against climate change. Moreover, consumers may place responsibility for a better environment with researchers and technicians, distancing themselves from being responsible. In addition, consumers' perceived control may be influenced by their perceived influence of solar panels in specific. Consumers might believe, for example, that solar panels would be useless in their situation because not enough sunlight is available in their area or not enough sunlight would reach the panels due to the house being covered by trees.[200,201]

<u>How do attitudes, the subjective norm, and perceived behavioural control impact purchase intentions?</u>

Specific beliefs may influence attitudes, norms, and consumers' perceived behavioural control, which in turn predict consumers' intention to purchase solar panels. The previous sections described the relationships between certain beliefs and attitudes, subjective norms, and perceived behavioural control. We measure all these beliefs in the post-experiment survey. We expect to find the following relationships with purchase intention:

- Attitudes: The more positive a consumer's attitude is towards solar panels, the higher the consumer's purchase intention. For example, if a consumer perceives low costs and high benefits from purchasing solar panels, the consumer is more likely to purchase them.

- Subjective norm: The more purchasing solar panels is perceived as the norm by a consumer, the higher the consumer's purchase intention. For example, if a consumer is encouraged by friends and family members to purchase solar panels, the consumer is more likely to purchase them.

- Perceived behavioural control: The higher a consumer's perceived behavioural control, the higher the consumer's purchase intention. For example, if a consumer believes (s)he is able to understand all the technical information provided about solar panels, the consumer is more likely to purchase them.

Apart from these direct effects on purchase intention, beliefs may also influence the relationships between barriers and purchase intention. Beliefs may even help consumers overcome certain barriers. We previously saw that the amount and complexity of information on solar panels may be an important barrier in the decision process. The expectation is that the more a consumer indicates that there is too much information and that the information is too complex, the lower the consumer's purchase intention will be. If, however, the consumer has a high perceived behavioural control – that is, the consumer considers that (s)he has the recourses to process and understand the information – this relationship may be weakened. It might even be the case that if a

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[196] Painuly, J. P. (2001). Barriers to renewable energy penetration: A framework for analysis. Renewable Energy, 24, 73-89.
[197] Painuly, J. P. (2001). Barriers to renewable energy penetration: A framework for analysis. Renewable Energy, 24, 73-89.
[198] https://thesolarsociety.wordpress.com/barrier-to-solar-photovoltaic-p2/
[199] Note that financial aspects may also lower a person's perceived behavioural control. Financial aspects are measured under household characteristics.
[200] http://www.conserve-energy-future.com/Disadvantages_SolarEnergy.php
[201] Ellis, R. C. inc. (2014). Solar solutions. Lulu Enterprises, inc.

consumer believes (s)he is well able to handle the situation (high perceived behavioural control), the amount and/or complexity of the information no longer predicts (low) purchase intention. It can be tested whether (some of) the beliefs are able to weaken the relationships between the barriers and purchase intention; in other words, whether they may help consumers overcome the barriers. It can also be tested whether consumers who often do not make a choice between the different solar panels experience lower perceived control.

7.1.4 Household and individual characteristics (post-experiment survey)

In the post-experiment survey, we also measure household and individual characteristics that may impact purchase intention. For example, consumers may care to behave in energy efficient ways (energy concern[202]) or see themselves as environmentally-friendly consumers (pro-environmental self-identity[203]), resulting in a higher likelihood that solar panels are purchased.[204]

A consumer's (perceived) financial situation may also impact purchase intention. Consumers may intend to generate their own energy but experience financial hurdles that withhold them from actually doing so.[205] Indeed, higher household income appears to be a dominant predictor for larger energy conservation investments.[206]

We also measure several (other) demographics that may influence purchase intention, specifically gender, age, education, and income. For example, older people seem to have lower intentions to generate their own energy[207], so they may be less likely to purchase solar panels than younger people.

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[202] Van Giesen, R. I., & Kieruj, N. (2016). START-2-ACT: Engaging European startups and young SMEs for action for sustainable energy. D2.1: Baseline assessment report. Report for the European Commission.

[203] Whitmarsh, L., & O'Neill, S. (2010). Green identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. Journal of Environmental Psychology, 30, 305-314.

[204] See also: http://cleantechnica.com/2013/10/08/advantages-disadvantages-solar-power/

[205] Leenheer, J., De Nooij, M., & Sheikh, O. (2011). Own power: Motives of having electricity without the energy company. Energy Policy, 39(9), 5621-5629.

[206] Islam, T. (2014). Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data. Energy Policy, 65, 340-350.

[207] Leenheer, J., De Nooij, M., & Sheikh, O. (2011). Own power: Motives of having electricity without the energy company. Energy Policy, 39(9), 5621-5629.

7.2 Methodology

The three main experimental methodologies are online surveys/experiments, laboratory studies and field experiments. Some of the main advantages and disadvantages of each option are summarised in Table 22 below, which is used to assist the choice of method.

The use of web-based surveys and experiments has been an important innovation within behavioural research. This approach combines high efficiency with access to a wider range of participant pools. By appropriate pre-screening, it is possible to target quite specific groups of people using web-based testing. In this case this allows to select possible prosumers, consumers who own a house, have not yet installed solar panels and are interested in and/or focusing on purchasing solar panels (more on these requirements will follow under "sample selection"). Furthermore, it is possible to sample substantial numbers of participants across Europe simultaneously, and cost-effectively, and hence to be able to help ensure that policy recommendations are targeted appropriately to individual European countries. For these reasons, an online survey will be used for this study.

Table 22: Advantages and disadvantages of experimental methods

Method	Advantages	Disadvantages
Online Experiments and Surveys	• Relatively quick and cheap to conduct studies with large sample sizes • Suitable to conduct multi-country, multi-language studies with a standardised method • Access to representative and/or very specific populations of participants	• Possible sample bias in countries with low internet penetration • Low level of control over the attention paid to the task by participants • Unsuitable for tasks with social interaction or where complex physical stimuli are used
Laboratory Experiment	• High level of control over the attention paid to the task by participants • Suitable for research tasks that involve social interaction or physical stimuli • Suitable for complex research or more time-consuming tasks than can be done online	• Relatively expensive and slow to conduct studies with large sample sizes • Challenging to standardise method across multiple laboratories and countries
Field Experiment	• Involve real decisions taken by the actual population of interest • Can be used to measure the impact of policy on longer-term choices or behaviours • High external validity means results more likely to generalize to real world • High internal validity and determination of cause and effect relationships	• Often expensive and must run over a long period of time to observe results • Logistical challenges of recruiting participants and avoiding spillover effects • Legal and ethical barriers to differentiating treatments between respondents

The study consists of an online experimental part followed by an online post-experiment survey. The experimental part takes approximately 10 minutes and focuses on consumers' choices among several products of solar panels, which vary in product characteristics. The subsequent survey takes approximately 10 minutes and investigates drivers and barriers of purchasing solar panels and measures relevant household and individual characteristics. In the survey we 1) measure parts of the model that are not included in the experimental part (e.g., consumers' beliefs) and 2) zoom in on different consumer profiles/segments that may moderate the results.

The advantage of online experiments is that they have high internal validity, the flipside is that it may come at the risk of low external validity. External validity is the degree to which the results also hold for other contexts or settings. A side effect of controlling external factors is that it can sometimes lead to overly artificial study settings. This increases the risk of observing behaviour that is not representative of more ecologically valid settings. The experimental part is developed in such a way that it mimics trade-offs that consumers make when purchasing solar panels. By creating an experimental setting that resembles real choices, the behaviour observed in the experiment is expected to generalise to the real world. This approach also precludes the need for performance-based incentives in the experimental part. The study setting is concrete rather than abstract and the experimental part is not designed to have a single "accurate" outcome. We do recommend to provide fixed incentives to respondents to avoid non-serious responses and thus increase data quality. Respondents are given a financial incentive for completing the survey.

7.2.1 Experimental part

The experimental part focuses on the market context. Two main experimental approaches can be taken to provide insights into these issues: an experiment in which the decision context is simulated (e.g. a simulated shopping experiment) and a (choice-based) conjoint experiment. As we are interested to learn which trade-offs consumers make and which product characteristics when purchasing solar panels, the experimental methodology that is typically used to reveal attribute trade-offs is a conjoint experiment. Choice-based conjoint experiments are particularly suitable for studying product choices and the trade-offs that consumers face when purchasing goods, because product information provided to consumers frequently consists of descriptions of the products' features.

Based on respondents' choices, we can provide insight into which product characteristics are most important to consumers (drive consumers' choice). For instance, is the payback period more important than aesthetical aspects? We investigate this by systematically varying product characteristics (e.g. high vs. low payback period, high vs. low attractiveness (BIPV vs. BAPV)) and calculating the relative importance of each product characteristic. We investigate whether consumers make a choice or make no choice (which is also an option) and if they make a choice, whether this choice is in line with consumers' financial situation and other preferences. We do this by linking the survey part to the experimental part.

While answering these questions respondents need some basic information. EU electricity consumption is around 3,800kWh per household and it seems reasonable to assume an average residential solar PV installation size of around 3.5kW (see previous tasks). We therefore develop a scenario in which we ask respondents to assume that they are an average household with a consumption of about 3,800 kWh of electricity per year.

The way in which the information is presented also varies across respondents. Respondents are randomly assigned to the information condition in which information is presented in an unstructured manner (information displayed per product), or to the information condition in which information is presented in a structured manner (a matrix with the product characteristics). Thus half of the respondents complete the structured information condition, and the other half of the respondents the unstructured information condition. Apart from choice, we measure whether consumers understand the information and whether they can easily find and compare the information they are looking for.

The experimental part ends with questions on purchase intention (i.e., whether respondents intend to buy solar systems). This enables us to investigate whether there are differences in preferred product characteristics between consumers who do and consumers who do not intend to actually buy solar panels.

Choice set

Efficient choice design

The main idea behind conjoint analysis is to investigate how consumers handle the available attribute information in order to arrive at an evaluation of alternative products. Conjoint analysis takes the trade-offs consumers make in their choices between products explicitly into account. The analysis reveals the relative importance of levels of product attributes on consumer preference. This allows investigating which characteristics of products are important to consumers, relative to others. Overall preferences for the products are decomposed into the utility associated with different attribute levels making up that product. As such, consumer needs are indirectly derived. The products in the product set are selected in such a way that these reflect difficult choices as these are most informative (e.g. otherwise respondents always opt for the cheapest product, see also the box below which explains utility balance) and closer to real-life situations. This is known as "utility balance" of alternatives within choice sets.[208] In practice, this means that, for instance, choice sets should not contain clearly dominating alternatives. We used SAS software to compute optimal product profiles and choice sets and to maximize statistical efficiency.

When creating product profiles the goal is to create an optimally efficient choice design. This typically involves a trade-off between statistical efficiency and response efficiency.[209] This means that the data provide a maximum amount of information given the sample size. Statistical efficiency is the precision with which the effects of interest can be measured.[210] Statistically efficient choice designs satisfy four criteria:[211]

- Level balance: levels of an attribute occur with equal frequency.
- Orthogonality: levels of any two attributes occur independently (in this way, the design allows for the estimation of the individual effect of each attributes).
- Minimal overlap: alternatives within a choice set do not share the same attribute levels.
- Utility balance: choice should represent (rather) difficult trade-offs, because these are most informative.

[208] Huber, J., & Zwerina, K. (1996). The importance of utility balance in efficient choice designs. Journal of Marketing research, 307-317.
[209] Louviere, J. J., Islam, T., Wasi, N., Street, D., & Burgess, L. (2008). Designing discrete choice experiments: Do optimal designs come at a price?. Journal of Consumer Research, 35(2), 360-375.
[210] Johnson, F. R., Lancsar, E., Marshall, D., Kilambi, V., Mühlbacher, A., Regier, D. A., ... & Bridges, J. F. (2013). Constructing experimental designs for discrete-choice experiments: report of the ISPOR conjoint analysis experimental design good research practices task force. Value in Health, 16(1), 3-13.
[211] Huber, J., & Zwerina, K. (1996). The importance of utility balance in efficient choice designs. Journal of Marketing research, 307-317.

Example utility balance:
Imagine having to choose between two products. Product A has a low price and a high quality, product B has a high price and high quality. This reflects utility imbalance: a rational respondent will choose product A, hence choices will be uninformative about respondents' preference for price vis-à-vis quality.
Now imagine having to choose between product A with a low price and a low quality and product B with a high price and a high quality. This reflects utility balance: the choice will be informative about respondents' preference for price vis-à-vis quality.

While high statistical efficiency designs are desirable, they may come at a price if they increase the cognitive burden for respondents.[212] Response efficiency refers to minimizing error resulting from respondents' inattention/fatigue or other unobserved, influences (e.g. different respondents may interpret the information differently). Response efficiency can be enhanced, for instance, by using a limited number of choice sets per respondent, by slightly relaxing the minimal overlap and utility balance criteria (while still avoiding obviously dominating alternatives within choice sets), and by excluding implausible combinations of attribute levels from the design (e.g. highest quality for the lowest price).

Optimal designs have a good balance between statistical efficiency and response efficiency. Practical designs thus may deviate from strict orthogonality because of restrictions placed on specific, implausible combinations of attribute levels, lack of balance, or repetition of particular attribute levels across alternatives in a choice set (overlap). In practice, designs that are nearly balanced and nearly orthogonal usually are still well identified.[213]

<u>Attributes and attribute levels</u>

Attributes that are of a major importance to consumers in the decision to buy solar panels were selected in consultation with experts and the European Commission. We propose to include the attributes and attribute levels listed in Table 23. For each attribute, we briefly discuss why it is important to include it.

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[212] Louviere, J. J., Street, D., Burgess, L., Wasi, N., Islam, T., & Marley, A. A. (2008). Modeling the choices of individual decision-makers by combining efficient choice experiment designs with extra preference information. Journal of choice modelling, 1(1), 128-164.
[213] Kuhfeld, W. F. (2005). Marketing research methods in SAS. Experimental Design, Choice, Conjoint, and Graphical Techniques. Cary, NC, SAS-Institute TS-722.

Table 23: Attributes and attribute levels

Features	Levels
Aesthetics (blue, black, black with line, terracotta, integrated in roof)	    
Cost per solar panel	€150 per panel, €200 per panel, €300 per panel
Inverter type	String inverter of €600, micro-inverter of €1225
Installation	Do it yourself, installation by installer (€1050)
Total investment	€XX (Will be calculated based on costs per solar panel, inverter type, installation costs)
Efficiency	250, 270, 290 Wp per panel
Payback period	XX years (Will be calculated based on total investment and savings)
Lifetime and maintenance costs	• Lifetime of 15 years with maintenance costs of €1500 over 15 years • Lifetime of 15 years with maintenance costs of €2250 over 15 years • Lifetime of 20 years with maintenance costs of €1000 over 20 years • Lifetime of 20 years with maintenance costs of €1500 over 20 years • Lifetime of 25 years with maintenance costs of €2500 over 25 years • Lifetime of 25 years with maintenance costs of €3750 over 25 years

Aesthetics plays an important role in the decision process of consumers to buy solar panels. Previous research has shown that if product alternatives are comparable in terms of functionality and price, aesthetical value plays a major role.[214] Moreover, research has shown that aesthetic design increases acceptance of (new) products and that acceptance of solar panels is lower if consumers think solar panels negatively affect the visual landscape.[215,216] So, aesthetics can be seen as one of the barriers in the decision process of consumers to buy solar panels.[217] We define aesthetics in the product set by showing pictures to the respondent of different solar panels. The solar panels are divided into polycrystalline solar panels (aesthetics explained to the respondent as "blue" solar-panels), monocrystalline solar panels (aesthetics explained to the respondent as "all back solar-panels"), PERC solar panels (aesthetics explained to the respondent as "black solar panels with a white border"), terracotta solar panels and roof-integrated solar panels.[218,219,220,221] In addition, pictures of the solar PV panel on an orange roof top will be shown to respondents so that the consumer understands how the solar PV panel looks on an actual roof top. It is recommended to pre-test the pictures presented in Table 23 to make sure that the solar panels in the last picture are perceived as roof-integrated solar panels and to check if the roof-integrated solar panels and the terracotta solar panels are (as intended) considered as higher in aesthetical value (e.g. "more beautiful", "better liked") than the other solar panels.

Many studies have shown that price considerations are important to the consumer, also in the context of solar panels.[222] Price is displayed as total investment cost which in turn depends on the costs per solar panel, the inverter type and the installation costs.223 The costs per solar panel in the product sets reflect low – medium – high costs, operationalized as €150, €200, and €300 per panel.[224,225,226,227] The costs of solar panels have decreased quickly; therefore, by the time the study is conducted we advise to check if the prices still reflect the current market situation. The inverter type is either a string inverter or a micro-inverter which allows for monitoring the performance per panel and cancels out the negative impact of shading. The costs of the different inverter types are also displayed, namely €600 for a string inverter and €1225 for a micro-inverter.[228,229,230]

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214 Creusen, M. E., & Schoormans, J. P. (2005). The different roles of product appearance in consumer choice. Journal of product innovation management, 22(1), 63-81.

215 Yamamoto, M., & Lambert, D. R. (1994). The impact of product aesthetics on the evaluation of industrial products. Journal of Product Innovation Management, 11(4), 309-324.

216 Faiers, A., & Neame, C. (2006). Consumer attitudes towards domestic solar power systems. Energy Policy, 34(14), 1797-1806.

217 Sidiras, D. K., & Koukios, E. G. (2004). Solar systems diffusion in local markets. Energy Policy, 32(18), 2007-2018.

218 http://energyinformative.org/best-solar-panel-monocrystalline-polycrystalline-thin-film/

219 http://sinovoltaics.com/solar-cells/perc-solar-cell-technology-will-perc-dominate-silicon-cell-technology/

220 http://oilfiredup.com/first-terracotta-solar-roof-tiles-installed-in-south-shields-28268

221 http://www.solarsolutions.nl/site/wp-content/uploads/2015/04/WS2-12.45-13.15-mini-symposium-SEAC.pdf

222 Karakaya, E., & Sriwannawit, P. (2015). Barriers to the adoption of photovoltaic systems: The state of the art. Renewable and Sustainable Energy Reviews, 49, 60-66.

223 Zhang, X., Shen, L., & Chan, S. Y. (2012). The diffusion of solar energy use in HK: What are the barriers?. Energy Policy, 41, 241-249.

224 https://www.seac.cc/wp-content/uploads/2016/12/BIPV-prijsstudie-2016.pdf

225 https://www.seac.cc/wp-content/uploads/2016/11/SEAC_-_BIPV_Pricing_in_The_Netherlands_2014.pdf

226 https://setis.ec.europa.eu/system/files/ETRI_2014.pdf (page 21)

227 https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf (page 39)

228 https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf (page 36)

229 https://setis.ec.europa.eu/sites/default/files/reports/PV-status-report-2014.pdf (page 26)

The installation costs are either nothing, in a do-it-yourself situation (so that consumers can save costs), or €300 per kW. So, in the case of 3.5 kW the installation costs are €1050.231

Consumers consider energy efficiency an important attribute.[232] At the same time, consumers have concerns that the efficiency improves quickly. There are several solar panel efficiency levels, most common are 250Wp, 270Wp and 290Wp.[233] With smaller rooftops solar panels with a higher efficiency level are recommended. In the questionnaire the energy efficiency levels and how to interpret these are explained to the consumer.

The payback period is an economic measure indicating the number of years an investment takes to pay for itself. The payback period is an important barrier that consumers take into account in the decision process to purchase solar PV panels. [234,235,236,237] The payback period will be calculated based on total investment costs and savings on energy that result from owning solar PV panels. Note that the payback period indicates when the investment pays off for itself, but that socio-economic factors also play a role, such as the financial status of the household. Therefore, at the end of the study also household and personal characteristics will be measured.

Next to aesthetical and financial aspects the lifetime and maintenance costs are important to the consumer.[238] In agreement with the European Commission it was decided that lifetime and maintenance costs are related and are therefore treated as a "super-attribute". A super attribute combines two attributes. It is then not possible to disentangle the effect of each underlying attribute. The lifetime of solar PV panels are estimated up to 30 years and solar PV panels typically come with a range of 10 to 20 year warranties.[239] Therefore, a range of 15-25 years is chosen in the study. The maintenance costs mainly reflect replacement of the inverter, taking into account that inverters will become cheaper over time (€1000) or replacement of the inverter plus additional cleaning costs (€1500). We assume that the inverter is replaced every 10 years. This results in the following super-attribute:

- Lifetime of 15 years with maintenance costs of €1000 over 15 years

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[230] Fraunhofer (2016) suggests 11c/W – 19c/W, which would imply €385-€665 for a string inverter. For the micro inverter, the costs estimated by Fraunhofer (2016) are 35c/W, which would imply a total cost of €1225.
[231] https://setis.ec.europa.eu/sites/default/files/reports/PV-status-report-2014.pdf (page 26)
[232] Shih, L. H., & Chou, T. Y. (2011). Customer concerns about uncertainty and willingness to pay in leasing solar power systems. International Journal of Environmental Science & Technology, 8(3), 523-532.
[233] https://www.seac.cc/wp-content/uploads/2016/12/BIPV-prijsstudie-2016.pdf
[234] Watson, J., Sauter, R., Bahaj, A. S., James, P. A. B., Myers, L. E., & Wing, R. (2006). Unlocking the Power House: Policy and system change for domestic micro-generation in the UK.
[235] Zhang, X., Shen, L., & Chan, S. Y. (2012). The diffusion of solar energy use in HK: What are the barriers?. Energy Policy, 41, 241-249.
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[239]http://www.engineering.com/ElectronicsDesign/ElectronicsDesignArticles/ArticleID/7475/What-Is-the-Lifespan-of-a-Solar-Panel.aspx

- Lifetime of 15 years with maintenance costs of €1500 over 15 years
- Lifetime of 20 years with maintenance costs of €1000 over 20 years
- Lifetime of 20 years with maintenance costs of €1500 over 20 years
- Lifetime of 25 years with maintenance costs of €2000 over 25 years
- Lifetime of 25 years with maintenance costs of €3000 over 25 years

The attributes presented in Table 23 are all to a more or lesser extent related and dependent. However, in order to estimate the independent attribute effects (e.g. to what extent plays aesthetics a role in the trade-offs consumers make? etc.) we will treat some attributes as independent to be able to disentangle the individual effect of each attribute in the decision (thus, although aesthetics is related to price we still treat this as independent attribute).

The following attributes will be treated as independent in the study:

- Aesthetics
- Cost per solar panel
- Inverter type
- Installation costs
- Efficiency

The following attributes are treated as dependent:

- Total investment costs reflect the sum of costs for 3800 kWh household energy usage (so approximately 4500 Wp is needed). The total costs reflect:
  - Cost per solar panel (€150, €200, €300)
  - Efficiency per panel / number of panels (250 Wp = 18 panels, 270 Wp = 17 panels, 290 Wp = 16 panels)
  - Inverter type (€600, €1225)
  - Installation costs (€0, €1050)

The total investment cost in the choice experiment is computed as follows:

Total investment = (number of solar panels * costs per panel) + inverter type + installation. The price range of the different solar panels in the choice sets is between €3150 and €7375.

- Payback period reflects:
  - Savings, computed as: energy generated per year (3800 kWh) * energy tariff €0,206 per kWh = €782.80. Note that the energy tariff is a European average.[240]
  - Total investment costs

The payback period in the choice experiment is computed as follows:

Payback period = total investment / savings. The payback period of the different solar panels in the choice sets is between 4 years and 9.4 years.[241]

Determining the number of profiles

Based on the attributes and the attribute levels there are too many possible combinations for one respondent to evaluate. A full-factorial design requires 1080 profiles (namely 5*3*2*2*3*6 = 1080). Therefore in the next step, hypothetical product profiles that are combinations of different attribute levels are generated using specialized software. The software computes how many product alternatives are needed to be able to properly assess the relative importance of each individual product attribute, based on the input in Table 24. The software tries to find a solution in which perfect balance and orthogonality can occur, or at least sizes in which violations of orthogonality and balance are minimized.

Table 24: Attributes and attribute levels input for the software

X1 = aesthetics (5 levels)
X2 = costs per panel (3 levels)
X3 = inverter type (2 levels)
X4 = installation (2 levels)
X5 = efficiency (3 levels)

[240] http://ec.europa.eu/eurostat/statistics-explained/images/4/4f/Half-yearly_electricity_and_gas_prices_%28EUR%29.png

[241] Often quoted ranges are between 5 to 8 years. See: http://solar-power-now.com/the-typical-solar-panel-payback-period/ Fraunhofer indicates payback times of the PV system in Nothern Europe of 2.5 year and in the South of 1.5 years, of course depending on the technology used. https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf (page 7).

X6 = lifetime & maintenance (6 levels)

Note. Total investments costs and payback period are provided as totals and are dependent on the specific combinations.

Based on the number of product attributes and levels as in Table 23 a 100% efficient design requires 180 profiles. 180 profiles are still too many profiles for one respondent to judge as this will place a high burden on the respondent. The next most optimal design option is to include 60 profiles (see Table 25). We do however use the 180 profiles as larger "candidate set" to allow for flexibility in the choice set stage when combining profiles together into choice sets. We thus have a larger candidate set of 180 profiles from which we create 60 profiles. This has the advantage that poor choice set candidates can be rejected at the initial stage (e.g. when the attributes of one or more alternatives are dominated or where a particular combination of attributes cannot exist).

Table 25: Optimal number of profiles

```
Saturated      = 16
                 Full Factorial = 1,080

                 Some Reasonable                      Cannot Be
                    Design Sizes       Violations     Divided By

                             180 *              0
                              60                3     9 18
                              90                3     4 12
                             120                3     9 18
                              30                6     4  9 12 18
                              36                6     5 10 15 30
                              72                6     5 10 15 30
                             108                6     5 10 15 30
                             144                6     5 10 15 30
                             150                6     4  9 12 18
                              16 S             18     3  5  6  9 10 12 15 18
30

                    * - 100% Efficient design can be made with the MktEx macro.
```

<u>Creating candidate set</u>

We then create a "candidate set", which also takes the restrictions into account listed in Table 26.

Table 26: Restrictions

- Unrealistic product combinations are:
- Low price and terracotta solar panel
- Low price and BIPV solar panel
- High price and low efficiency (250 Wp)
- Low price and high efficiency (290 Wp).

We use the D-efficiency, which is the most commonly used metric in design construction to evaluate the design. D-efficiency is high, namely 99.99, which indicates an efficient design. The correlations between the factors are low, as desired (see Table 27). This shows that the factors are uncorrelated and orthogonal (independent). Table 28 shows that all attributes are in the profiles an equal number of times, which shows level balance. There are some duplicate product profiles in this design (n-way), though there is still minimal overlap as there are only a few duplicates (14). As we use a larger candidate set this is not a problem when we start creating choice sets and the duplicates will not appear in the final selection.

Table 27: Correlations between the factors

	x1	x2	x3	x4	x5	x6
x1	1	0	0	0	0	0
x2	0	1	0.03	0	0	0
x3	0	0.03	1	0	0.03	0
x4	0	0	0	1	0	0
x5	0	0	0.03	0	1	0
x6	0	0	0	0	0	1

Table 28: Frequencies

x1	36 36 36 36 36
x2	60 60 60
x3	90 90
x4	90 90
x5	60 60 60
x6	30 30 30 30 30 30
x1 x2	12 12 12 12 12 12 12 12 12 12 12 12 12
	12 12
x1 x3	18 18 18 18 18 18 18 18 18 18
x1 x4	18 18 18 18 18 18 18 18 18 18
x1 x5	12 12 12 12 12 12 12 12 12 12 12 12 12
	12 12
x1 x6	6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6 6
	6 6 6 6 6 6 6 6 6 6 6
x2 x3	29 31 30 30 31 29
x2 x4	30 30 30 30 30 30
x2 x5	20 20 20 20 20 20 20 20 20
x2 x6	10 10 10 10 10 10 10 10 10 10 10 10 10
	10 10 10 10 10
x3 x4	45 45 45 45
x3 x5	31 30 29 29 30 31
x3 x6	15 15 15 15 15 15 15 15 15 15 15 15
x4 x5	30 30 30 30 30 30
x4 x6	15 15 15 15 15 15 15 15 15 15 15 15
x5 x6	10 10 10 10 10 10 10 10 10 10 10 10 10
	10 10 10 10 10
N-Way	1 1 1 1 1 1 1 1 1 2 1 1 1 2 1 1 1 1 1
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 2 1
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1 1 1
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 1
	1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 2 1 2 1
	1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 1 1 2 1
	1 1 2 1 2 2 1 1 1 1 1 1 1 2 1 1 1 1 1
	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
	1 1 1 1 1 1 1 1 1 1 2 1

Creating choice sets

In the next step we create choice sets. In each choice set there will be 3 choice alternatives and a no-choice option. The no-choice option is added to each choice set, and hence there is no need to incorporate this in the design process.

Utility balance can be improved by using informative priors. This enhances statistical efficiency of the choice design. For instance, it can be expected that cheaper options are more favourable or that roof-integrated solar panels are more attractive. For aesthetics

(X1) we can a priori expect that terracotta and roof-integrated solar panels are considered to be more attractive. For X2 (costs per panel) we can a priori expect that lower prices are more favourable. For X3 (inverter type) we can a priori expect that a cheaper inverter is more attractive. For X4 (installation) it is more difficult to expect what is more attractive, so we treat these as equally attractive. For X5 (efficiency) we expect that more efficient panels are considered more attractive. For X6 (lifetime and maintenance) the most attractive option is to have a long lifetime with low maintenance costs (€1000 over 20 years). Imposing non-zero part-worth assumptions produces choice sets with alternatives that are more equal in terms of attractiveness (assuming that our predictions are accurate). We take this into account by changing the assumed beta weights such that we take into account that lower costs and more efficient solar PV panels are more favourable and roof-integrated and terracotta solar PV panels are more favourable (see Table 29, assumed beta).

However, utility balance is not the only requirement of optimal design. Sometimes less utility balanced choice sets are needed in order to improve the design in terms of orthogonality or level balance, which also contribute to higher statistical efficiency. Thus, not all choice sets will have alternatives with exactly equal expected probabilities (33%-33%-33%). Rather, most choice sets will have alternatives with expected choice probabilities in the range of 10%-50%, representing difficult, but not too difficult trade-offs (which in turn improves response efficiency).

Based on the choice design procedure we defined 20 choice sets with 3 choice alternatives, reflecting the 60 profiles. The correlations between the factors are low, reflecting an uncorrelated and orthogonal design (see Table 30).

Table 29: Model parameters

n	Variable Name	Label	Variance	Assumed Beta	DF	Standard Error	Wald	Prob > Squared Wald
1	x11	x1 1	1.07124	-1.0	1	1.03501	-0.96618	0.3340
2	x12	x1 2	0.94846	-1.0	1	0.97389	-1.02681	0.3045
3	x13	x1 3	1.08076	-1.0	1	1.03960	-0.96191	0.3361
4	x14	x1 4	0.59151	0.0	1	0.76910	0.00000	1.0000
5	x21	x2 1	0.65150	1.0	1	0.80716	1.23892	0.2154
6	x22	x2 2	0.43573	0.5	1	0.66010	0.75746	0.4488
7	x31	x3 1	0.53447	1.0	1	0.73107	1.36786	0.1714
8	x41	x4 1	0.22126	0.0	1	0.47038	0.00000	1.0000
9	x51	x5 1	0.65863	-1.0	1	0.81156	-1.23219	0.2179
10	x52	x5 2	0.43055	-0.5	1	0.65616	-0.76200	0.4461
11	x61	x6 1	0.83720	0.0	1	0.91499	0.00000	1.0000
12	x62	x6 2	0.84273	0.0	1	0.91800	0.00000	1.0000
13	x63	x6 3	1.21913	1.0	1	1.10414	0.90568	0.3651
14	x64	x6 4	1.24931	1.0	1	1.11773	0.89467	0.3710
15	x65	x6 5	0.76054	0.0	1	0.87209	0.00000	1.0000

Table 30. Correlations

	x1	x2	x3	x4	x5	x6
x1	1.0000					
x2	0.1893	1.0000				
x3	0.0254	-0.1637	1.0000			
x4	0.0024	-0.0410	-0.0403	1.0000		
x5	-0.0999	0.0725	0.1423	0.1051	1.0000	
x6	0.0554	-0.0468	0.0740	-0.0326	-0.0825	1.0000

As it will be too high a burden for the respondent to judge 20 choice sets, we blocked the design into versions that show a limited number of choice questions to each respondent, presenting status-quo alternatives. This means that we created two blocks of 10 choice sets, which are comparable to one other.

Each attribute and attribute level is explained to the respondent. All product sets can be found in appendix A. Figure 22 presents a few example choice sets.

Figure 22: Example choice sets

Example A, block 1, choice set 1 (choice alternatives with expected probabilities of 45% - 45% - 10%)

Characteristic	Alternative 1	Alternative 2	Alternative 3	No-choice
Type				
Cost per solar panel	€150	€300	€300	
Inverter type	String inverter of €600	Micro-inverter of €1225	Micro-inverter of €1225	
Installation	Installation by installer €1050	Do it yourself (€0)	Do it yourself (€0)	
Total investment	€4350	€6025	€6325	
Efficiency	250 Wp	290 Wp	270 Wp	
Payback period	5.56 years	7.7 years	8.08 years	
Lifetime and maintenance costs	€3750 over 25 years	€1000 over 20 years	€1500 over 15 years	
choice	☐	☐	☐	☐

Example B, block 1, choice set 3 (choice alternatives with expected probabilities of 33% - 33% - 33%)

Characteristic	Alternative 1	Alternative 2	Alternative 3	No-choice
Type				
Cost per solar panel	€200	€300	€150	
Inverter type	Micro-inverter of €1225	String inverter of €600	String inverter of €600	
Installation	Installation by installer €1050	Do it yourself (€0)	Do it yourself (€0)	
Total investment	€5675	€5400	€3300	
Efficiency	270 Wp	290 Wp	250 Wp	
Payback period	5.56 years	7.7 years	8.08 years	
Lifetime and maintenance costs	€2250 over 15 years	€1500 over 15 years	€3750 over 25 years	
choice	☐	☐	☐	☐

Example C, block 2, choice set 10 (choice alternatives with expected probabilities of 45% - 27% - 27%)

Characteristic	Alternative 1	Alternative 2	Alternative 3	No-choice
Type				
Cost per solar panel	€300	€150	€200	
Inverter type	String inverter of €600	String inverter of €600	Micro-inverter of €1225	
Installation	Installation by installer €1050	Do it yourself (€0)	Do it yourself (€0)	
Total investment	€7050	€3150	€4425	
Efficiency	250 Wp	270 Wp	290 Wp	
Payback period	9.01 years	4.02 years	5.65 years	
Lifetime and maintenance costs	€1500 over 20 years	€1500 over 15 years	€3750 over 25 years	
choice	☐	☐	☐	☐

Information variation

We also vary the way in which the choice sets are presented to the respondent, by varying the way in which the information is presented between respondents. In the structured variant the information is displayed as on comparison websites (see Figure 22). In the unstructured variant the information is displayed per product (see Figure 23). This represents the way in which consumers receive information from different providers. Half of the respondents receives the information in a structured manner and half of the respondents receives the information in an unstructured manner. As a result, 20 structured and 20 unstructured (40 choice sets in total) are created, with each choice set consisting of three products.

Figure 23: Unstructured information presentation

Alternative 1

Cost per solar panel	€200
Inverter type	Micro-inverter of €1225
Installation	Installation by installer €1050
Total investment	€5675
Efficiency	270 Wp
Payback period	5.56 years
Lifetime and maintenance costs	€2250 over 15 years

☐

Alternative 2

Efficiency	290 Wp per panel
Payback period	7.7 years
Lifetime and maintenance costs	€1500 over 15 years
Cost per solar panel	€300
Inverter type	String inverter of €600
Installation	Do it yourself (€0)
Total investment	€5400

☐

Alternative 3

Total investment	€3300
Payback period	8.08 years
Cost per solar panel	€150
Inverter type	Do it yourself (€0)
Installation	installation by installer €600
Lifetime and maintenance costs	€3750 over 25 years

No-choice

Efficiency 250 Wp	
☐	☐

Measures

Choice

Choice is measured by asking respondents which of the solar panels presented they would most likely choose. Respondents can also select the option to make no choice. If the respondent indicated multiple times to not make a choice a follow-up question will be presented (after all choice sets are presented) to find out why the respondent did not want to make a choice. We will investigate the relative importance of the different attributes, and whether choices differ across consumer segments.

We recommend conducting a pilot test in order to test if many respondents choose the no-choice alternative. In case many respondents opt for the no-choice alternative, the choices might be too difficult for the respondent and some adjustment in the design are needed.

Understanding information (find, assess, digest)

After respondents made choices for solar panels they will be asked questions on how easy it was to find, understand, and compare the information of the different solar panels and whether they could handle the large amount of information. Moreover, questions will be asked on the clarity and relevance of the information presented. In addition, understanding is assessed per attribute (e.g., payback period, inverter type).

Purchase intention

The experimental part ends with questions on intention to buy solar panels and how many years from now respondents would be interested to buy solar panels. Socio-economic factors, such as the household's financial situation may also play a role. Therefore, at the end of the survey household and personal characteristics are measured (see "survey"). Separate analyses on purchase intention can be conducted for households with a low versus high income.

Note that respondents are not asked to actually buy solar panels in the experimental part.

7.2.2 Survey

The context of the survey is broader and focuses on drivers and barriers that consumers experience in the decision process, which may influence consumers' purchase intention. The survey also measures (other) household characteristics that may influence the relationships in our model, such as one's financial situation.

Barriers

We measure the process barriers that were described before, specifically:

- Barriers in terms of need assessment: Are respondents (un)able to determine what type of solar panels would fit their situation?
- Barriers in terms of the amount of information: Do respondents think that there is too much information to consider?
- Barriers in terms of comparability of information: Are respondents (un)able to compare information from different offers and/or sellers?
- Barriers in terms of deliberation: Do respondents think too long about which solar panels they should purchase?

Attitudes

We measure the following beliefs regarding attitudes:

- Costs: perceptions on high initial costs, long payback periods, lack of funding.
- Benefits: perceptions on the reliability and effectiveness of solar panels, expectations on saving and earning money.
- Aesthetics: perceptions on the visual attractiveness of solar panels and acceptance of visually unattractive solar panels.

Subjective norms

We measure the following beliefs regarding subjective norms:

- Descriptive and injunctive norms set by close others: whether many neighbours, friends and family have solar panels and encourage the respondent to also purchase solar panels.
- Exposure to advertisements: the extent to which respondents are exposed to advertisements on solar panels by governments or suppliers.

Perceived behavioural control

We measure the following beliefs regarding respondents' perceived behavioural control:

- Affinity with technology: the extent to which respondents perceive they possess knowledge of and like technology.
- (Self-reported) knowledge on saving energy: the extent to which respondents think they know much about saving energy and closely monitor their energy consumption. Moreover, to measure knowledge more objectively, a short quiz follows on common misconceptions regarding solar panels. The statements such as "solar panels work when it is cloudy" can be answered with "true" or "false".
- Perceived influence: the extent to which respondents think their actions can contribute to a better environment and the extent to which they think their own situation is suitable for placing solar panels.

Household and individual characteristics

Household and individual characteristics that are measured are energy concern (in terms of attitudes and the actions that a respondent takes to conserve energy), pro-environmental self-identity (whether the respondents see themselves as environmentally-friendly), perceived financial situation, and demographics (gender, age, education, income). Household and individual characteristics are measured at the end of the survey. When measuring pro-environmental self-identity and energy concern at the start of the study this could already put respondents in a certain mindset to make energy efficient choices. It could be the case that respondents report to have a higher likelihood to buy solar panels than they actually have.

7.2.3 Sample selection

The sample should consist of respondents who:

- own a house,
- do not have solar panels yet,
- are interested in and/or focusing on purchasing solar panels.

Respondents will be selected to participate in this study based on selection questions that will be asked prior to fielding the study, see the box below.

Do you own a house? Yes / no Do you have solar panels installed on your roof top? Yes / no Are you interested in and / or focusing on purchasing solar panels? Yes / No

The contractor should contact online panellists that own a house, have not installed solar panels, and are interested in and/or focusing on purchasing solar panels shall be recruited to take part in the study. Respondents are sent an email inviting them to take part in the survey and they are given a financial incentive for completing the survey. The incentive provided is not dependent on answers given by the respondent – i.e. it is not reward-based – but rather each completed survey receives the same incentive.

Questionnaires will be made available to respondents in the national languages of all countries surveyed in order to maximise respondent engagement and understanding. The questionnaire will be finalised in English, and then translated into the other survey languages. The translation process will be launched after the final master questionnaire has been approved by the Client.

Each respondent is randomly assigned to one of the information conditions (structured or unstructured). Next, respondents shall be presented with the choice sets.[242] As we blocked the design, per block a minimum of 200 respondents is recommended to be sampled (per country).[243] Thus, a total of 2 blocks (of 10 choice sets) x 2 information conditions (structured or unstructured) x 200 respondents is needed, resulting in a total of 800 respondents per country (see Table 31). In case extensive segmentation analyses are conducted it is recommended to increase the sample size. For instance, in case four segments are expected it would be wise to include, at a minimum, 800 per group (1600 per block), leading to a total of 3200 respondents per country.[244]

Table 31: Number of respondents (per country)

Block	Information condition: structured	Information condition: Unstructured	Total N
1	200	200	400
2	200	200	400
Total N	400	400	800
Note. Respondents see 10 choice sets, each block represents 10 choice sets.			

7.2.4 Country selection

Here we describe the methodology for selecting the countries to be included in the study. We also propose a country selection on the basis of the selection criteria.

The countries should be selected in such a way that they together constitute a representative sample of the EU28 plus Norway and Iceland on relevant factors. The country selection should include population coverage (i.e. big and small countries), regional spread, and a mix of EU15 and EU13 countries. Moreover, we propose to include several other factors that may have an impact on the intention to purchase solar panels. Market potential can be estimated by comparing data on:

[242] Preferably all options are randomly selected and shown to a respondent.
[243] The number of respondents to be sampled choice experiments is higher than in other experimental designs. See: Orme, B. K. (2010). Getting started with conjoint analysis: strategies for product design and pricing research. Research Publishers. Chapter 7.
[244] Orme, B. K. (2010). Getting started with conjoint analysis: strategies for product design and pricing research. Research Publishers. Page 65.

- Household installations available (low vs. high)
- Concern about the environmental impact of purchases
- Attractiveness for consumers to purchase solar PV panels
- GPD per capita and AIC per capita

We also referred to the chapter on the comparative legal analysis and to the baseline and projection chapter, for more details on the obstacles and incentives for prosumers.

Household installations available

An important aspect to take into account is differences in household installations available. Table 32 shows the average solar PV installation size available in different countries. It is important to include in the selection low and high installation size. Belgium, Germany, France, Italy and The Netherlands have a high average installation size.

Table 32: Average installation size in kW (residential solar PV)

Country	2015 data / estimate	Source
Belgium	3.87	VREG (2016) data on number of residential prosumers and installed capacity
Bulgaria	2.91	Constructed data*
Czech Republic	3.10	Constructed data*
Denmark	4.70	Constructed data*
Germany	3.75	Constructed data*
Estonia	4.00	CE Delft (2016) data on number of residential prosumers and installed capacity
Ireland	2.61	SEAI (2016) data on number of residential prosumers and installed capacity
Greece	3.53	Constructed data*
Spain	3.94	Constructed data*
France	3.24	French government data (2016) on number of residential prosumers and installed capacity
Croatia	3.98	CE Delft (2015) data on number of residential prosumers and installed capacity
Italy	3.73	Constructed data*
Cyprus	5.63	Constructed data*
Latvia	2.49	Constructed data*
Lithuania	2.52	Constructed data*
Luxembourg	5.22	Constructed data*
Hungary	3.01	Constructed data*
Malta	3.82	Constructed data*
Netherlands	4.25	Constructed data*

Austria	3.97	Constructed data*
Poland	2.99	Constructed data*
Portugal	2.39	Portugese gov (2016) data on number of residential prosumers and installed capacity
Romania	1.75	Constructed data*
Slovenia	3.20	Constructed data*
Slovakia	3.48	Constructed data*
Finland	4.04	CE Delft (2016) data on number of residential prosumers and installed capacity
Sweden	4.11	Constructed data*
United Kingdom	3.31	Ofgem (2016), data on installations by size
* Data has been constructed by Cambridge Econometrics using Eurostat (2012) data on dwelling size and an estimate of the ratio of dwelling size to Solar PV installation size (in kW), based on data from other EU Member States		

Concern about the environmental impact of purchases

In the Eurobarometer survey[245] consumers were surveyed regarding their attitudes towards the environmental impact of their purchases. Specifically, consumers indicated whether the environmental impact of the goods or services they purchased influenced their choice. In 2014, the survey indicates that on average in the EU just over half of consumers were concerned about the environmental impact of their purchases (55%) which indicates a significant change in European attitudes since 2011 when less than a third (29%) said yes. This might be a relevant factor to take into account when selecting the countries that will participate in a study on purchasing solar panels.

Attractiveness for consumers to purchase solar panels

Of importance in the acceptance of renewable energy is also the socio-political, community, and market perspective in the country. The degree of social and market acceptance for renewable electricity is based on strong institutional capacity, political commitment, favourable legal and regulatory frameworks, competitive installation / product costs, mechanisms for information and feedback, access to financing, individual ownership and use, participatory project sitting, and recognition of externalities (positive public image).[246] It is relevant to take into account in which countries subsidies are available for solar PV panels.

GDP and AIC per capita

Differences in income level may result in differences in purchase intentions across countries. That is, in low income countries consumers face stronger budget constraints and energy-related products constitute a larger share of an average consumer budget than in high-income countries. It is likely that the trade-off between price and energy

[245] Flash Eurobarometer 397 http://ec.europa.eu/COMMFrontOffice/PublicOpinion/index.cfm/Survey/getSurveyDetail/instruments/FLASH/surveyKy/2031

[246] Sovacool, B. K., & Ratan, P. L. (2012). Conceptualizing the acceptance of wind and solar electricity. Renewable and Sustainable Energy Reviews, 16(7), 5268-5279.

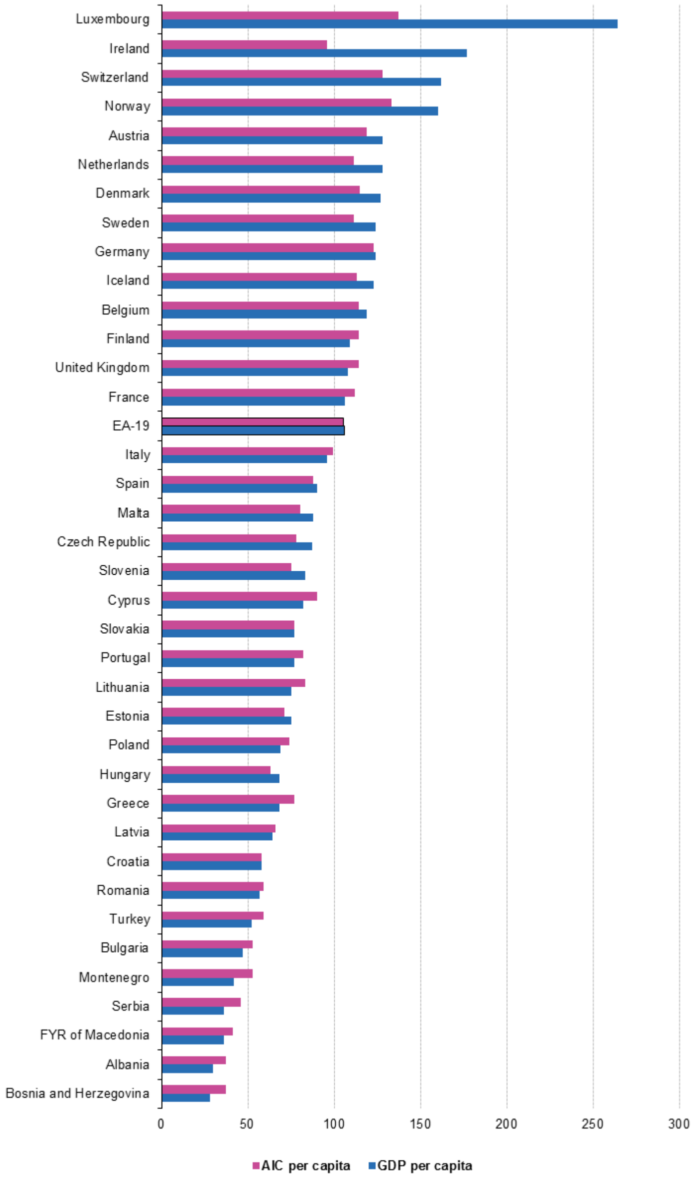
efficiency is different in high than in low-income countries. Therefore, the country sample should contain low, high and middle-income countries. Comparisons of standards of living between countries are frequently based on gross domestic product (GDP) per capita, which presents in monetary terms how rich one country is compared with another. However, this headline indicator says very little about the distribution of income within a country and also fails to provide information in relation to non-monetary factors that may play a significant role in determining the quality of life of a particular population. On the one hand, inequalities in income distribution may create incentives for people to improve their situation through work, innovation or acquiring new skills. On the other hand, such income inequalities are often viewed as being linked to crime, poverty and social exclusion.[247]

Although GDP per capita is an important and widely used indicator of countries' level of economic welfare, consumption per capita may be more useful for comparing the relative welfare of consumers across various countries. Actual individual consumption, abbreviated as AIC, refers to all goods and services actually consumed by households. It encompasses consumer goods and services purchased directly by households, as well as services provided by non-profit institutions and the government for individual consumption (e.g., health and education services). In international comparisons, the term is usually preferred over the narrower concept of household consumption, because the latter is influenced by the extent to which non-profit institutions and general government act as service providers. AIC per capita is usually highly correlated with GDP per capita, because AIC is, in practice, by far the biggest expenditure component of GDP.

As an indicator, GDP/capita (with 100 being the average EU-level) is used. In the EU28, there are 9 countries with a high income level (GDP/capita>115), 8 countries with a medium high income level (75≤GDP/capita≤115) and 11 low-income countries (GDP/capita<75). See Figure 24.

Figure 24: GDP and AIC per capita (Source: Eurostat, December 2016[248])

[247] http://ec.europa.eu/eurostat/statistics-explained/index.php/Income_distribution_statistics
[248] http://ec.europa.eu/eurostat/statistics-explained/index.php/GDP_per_capita,_consumption_per_capita_and_price_level_indices



Proposed countries
In line with the entire study, we propose to focus on the more mature solar PV markets, including Belgium, France, The Netherlands, Germany, Italy, Spain and the UK. In addition, a second group of markets where solar PV has expanded at a relatively lower pace, but that would be interesting to examine. These include Portugal and especially Eastern Europe's countries such as Hungary, Poland, Croatia, Slovenia, Czech Republic, Bulgaria and Slovakia.

7.3 Questionnaire

The sample should consist of consumers who have bought (not rented) a house and who do not yet have solar panels. The sample should also consist of consumers who are interested in purchasing solar panels (see also sample selection).

7.3.1 Part 1: experiment (±10 min.)

Respondents receive multiple product sets with three different solar panels and a no-choice option. Each solar panel is based on specific product characteristics which will be varied according to Table 33. Moreover the choice sets are varied, so the solar panel that the respondent selected in the previous choice set will not be displayed in the next choice set.

Table 33: Attributes and attribute levels

Features	Levels
Aesthetics (blue, black, black with line, terracotta, integrated in roof)	    
Cost per solar panel	€150 per panel, €200 per panel, €300 per panel
Inverter type	String inverter of €600, micro-inverter of €1225
Installation	Do it yourself, installation by installer (€1050)
Total investment	€XX (Will be calculated based on costs per solar panel, inverter type, installation costs)
Efficiency	250, 270, 290 Wp per panel
Payback period	XX years (Will be calculated based on total investment, efficiency
Lifetime and maintenance costs	• Lifetime of 15 years with maintenance costs of €1500 over 15 years • Lifetime of 15 years with maintenance costs of €2250 over 15 years • Lifetime of 20 years with maintenance costs of €1000 over 20 years • Lifetime of 20 years with maintenance costs of €1500 over 20 years • Lifetime of 25 years with maintenance costs of €2500 over 25 years

	• Lifetime of 25 years with maintenance costs of €3750 over 25 years

[Product set and manipulations]

[Introduction]

This study focuses on solar panels. You are invited to participate because you have earlier indicated that you are interested in and/or focusing on purchasing solar panels. In the first part of this study you will see different solar panels that vary on several characteristics. You are asked to make a choice among these solar panels, based on the characteristics that are most important to you. In total you will make 10 choices. It is also possible to make no choice among the options. Each time you will see three new solar panels. When answering the questions please assume that it is possible to place solar panels on your roof top. In the second part of the questionnaire we ask about beliefs and drivers you might have when purchasing solar panels.

[Screen 2]

We would like to ask you to imagine that your household is an average household of two adults and two kids. You live in a house of around 95m2. For such a household, the electricity consumption is around 3,800 kWh of electricity per year. The solar panels in the product sets are based on a consumption of 3,800 kWh of electricity per year. Sometimes, it is possible to receive a financial reward for generating additional electricity that you do not use yourself. We have not taken this into account in the product sets.

[screen 3,4,5]

First you receive some background information about the characteristics that are varied across solar panels.

Aesthetics

Solar panels come in different flavours. In the choice set we distinguish five types of solar panels:

		
Blue solar-panels	All black solar-panels	Black solar-panels with a white border
		
Terracotta solar panels	Roof-integrated solar panels	

Costs per solar panel

The costs of solar panels are displayed per panel. With an average consumption of 3,800 kWh of electricity per year one solar panel will not suffice. You therefore have to take into account that you have to buy multiple solar panels (16-19). The solar panels are in a price range of €150 to €300.

Inverter type[249]
Inverters are an important part of any solar installation. An inverter is needed to convert power produced by the solar panels into usable power. Inverters enable monitoring so that one can see how a system is performing. The solar panels in the choice set either use a string inverter or micro-inverters.

String inverters usually have a cost around €600 and you need one per house. The energy generated by solar panels is dependent on the least productive panel, if one or more of the solar panels is shaded during any part of the day.

For micro-inverters you need one per panel, the total cost for a system is around €1225 (for 16-19 panels). Micro-inverters are installed on each individual panel in a solar energy system. Micro-inverters cancel out the negative impact of partial or complete shading. Micro-inverters also allow you to monitor the performance of individual solar panels.

Installation
Installation can either be done by yourself (€0) or by an installer (€1050).

Total investment
The total investment price is based on the costs of the solar panels, the inverter type, and installation costs.

Efficiency
The efficiency of a solar panel reflects the portion of energy in the form of sunlight that can be converted into electrics. The efficiency is displayed in Wp. The more Wp the more efficient the solar panel. The efficiency of the solar panels varies between 250 Wp per panel and 290 Wp per panel.

Payback period
The payback period is calculated based on the total investment costs divided by the savings you will have on your energy costs by having an own solar PV installation.

Lifetime
The lifetime and maintenance cost of the solar panels varies as follows:

- Lifetime of 15 years with maintenance costs of €1500 over 15 years
- Lifetime of 15 years with maintenance costs of €2250 over 15 years
- Lifetime of 20 years with maintenance costs of €1000 over 20 years
- Lifetime of 20 years with maintenance costs of €1500 over 20 years
- Lifetime of 25 years with maintenance costs of €2500 over 20 years
- Lifetime of 25 years with maintenance costs of €3750 over 20 years

[Choice]
[10 times a choice set will be displayed with 3 solar panels and a no choice option, see appendix A]

[249] https://www.energysage.com/solar/101/string-inverters-microinverters-power-optimizers/

*Example choice set in the structured conditions (*Example A, block 1, choice set 1)*:*

Characteristic	Alternative 1	Alternative 2
Type		
Cost per solar panel	€150	€300
Inverter type	String inverter of €600	Micro-inverter of €1225
Installation	Installation by installer €1050	Do it yourself (€0)
Total investment	€4350	€6025
Efficiency	250 Wp	290 Wp
Payback period	5.56 years	7.7 years
Lifetime and maintenance costs	€3750 over 25 years	€1000 over 20 years
choice	☐	☐

Characteristic	Alternative 3	No-choice
Type		
Cost per solar panel	€300	
Inverter type	Micro-inverter of €1225	
Installation	Do it yourself (€0)	
Total investment	€6325	
Efficiency	270 Wp	
Payback period	8.08 years	
Lifetime and maintenance costs	€1500 over 15 years	
choice	☐	☐

Q1A - J. Which of the three options would you MOST likely choose? If you would choose none of the options, please select “I do not make a choice”

[after all product sets are displayed and if "no choice" was selected at least once]

Q2. You have indicated at least once that you do not want to make a choice among the products. Please select your reason for this. Multiple answers are possible.

1. I found it difficult to make a choice.
2. I did not think any of the products were attractive.
3. I am not interested in purchasing solar panels.
4. Other reason, namely______.

[after all product sets are displayed and if "no choice" was selected at least once]

Q2a. Would you change your mind and consider a purchase if your municipality subsidized part of the installation cost?

1. Yes
2. No

If q2a is yes:

Q2a_1. An average household needs about 17 solar panels to cover the electricity consumption of around 3,800 kWh of electricity per year. The exact amount of solar panels depends on a number of things, such as the efficiency and looks of the solar panels. Now imagine that you want to buy a solar PV installation with 17 solar PV panels, in a price range of €5000 and €7500. What should the minimum subsidy be for you to seriously consider the purchase of solar PV panels? Please indicate your answer in [currency, e.g., euros].
[Open textbox]

[after all product sets are displayed and if "no choice" was selected at least once]

Q2b. Now imagine that you also have the possibility to lease solar panels. You then pay a fixed amount per month for leasing the solar panels. By leasing solar panels your energy costs per month decrease as you generate your own electricity. The earnings from generating your own energy are higher than the costs for leasing the solar panels. Would you change your mind and consider solar panels if you would have the option to lease solar PV panels and therefore, do not have to make the investment yourself?

1. Yes
2. No

[Finding and digesting information]
You just made a number of product choices in solar panels. Please indicate to what extent you agree with the following statements.

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q3_1. In general, I thought it was easy to make a choice.	1	2	3	4	5	6	7
Q3_2. It was easy to find information that was useful for me.	1	2	3	4	5	6	7
Q3_3. It was difficult to compare information from different products.	1	2	3	4	5	6	7
Q3_4. There was too much information.	1	2	3	4	5	6	7
Q3_5. I felt as if I lost my way in all the information that was provided.	1	2	3	4	5	6	7
Q3_6. I felt as if I had all information that is needed to make a good choice.	1	2	3	4	5	6	7
Q3_7. I think some important information was still missing.	1	2	3	4	5	6	7

[Assessing information: perceived clarity, (subjective) understanding, perceived relevance]
You just made a number of product choices in solar panels. Please indicate to what extent you agree with the following statements.

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q4_1. The information was displayed in a clear manner.	1	2	3	4	5	6	7
Q4_2. The information provided was well organised.	1	2	3	4	5	6	7
Q4_3. It was difficult to understand the information.	1	2	3	4	5	6	7
Q4_4. I understood the information that was provided.	1	2	3	4	5	6	7
Q4_5. The information was relevant.	1	2	3	4	5	6	7
Q4_6. The information was useful.	1	2	3	4	5	6	7

[Understanding product characteristics]

Q5. You just saw a number of products with different characteristics. Did you understand the information that was provided for each characteristic? Please indicate per characteristic whether you understood all of the information (yes) or not (no).

	Yes, I understood all of the information	No, I did not understand all of the information
Type of solar panel		
Cost per solar panel		
Inverter type		
Installation (DIY or installation by installer)		
Total investment costs		
Lifetime and maintenance costs		
Efficiency		
Payback period		

[Intention to buy]

Q6_1. To what extent do you intend to actually purchase solar panels in reality?

Definitely not	Unlikely	Probably not	Possibly	Probably	Very likely	Definitely
1	2	3	4	5	6	7

If Q6_1 =1:

Q6_2 Do you intend to lease solar panels?

1. No, I do not intend to lease solar panels
2. Yes, I intend to lease solar panels

*If Q6_1 >1 OR if Q6_2 =*2*:*

Q6_3. You indicated that you might [*if Q6_1 >1*, "purchase", *if Q6_2 = 2*, "lease"] solar panels in reality. Please estimate how many years from now you will [*if Q6_1 >1*, "purchase", *if Q6_2 = 2*, "lease"] solar panels.

1. 1 year from now
2. 2 years from now
3. 3 years from now
4. 4 years from now
5. 5 years from now
6. 6 years from now
7. 7 years from now
8. 8 years from now
9. 9 years from now
10. 10 or more years from now (or maybe never)

7.3.2 Part II: survey (10 min.)

The survey part measures the beliefs and barriers that consumers have and experience in the decision-making process of buying solar panels. The survey part takes about 10 minutes, this is based on our previous experience with designing questionnaires. A pilot-study can confirm if this estimation is correct and if the questionnaire is deemed too long, some questions can be deleted from this part.

[Process (barriers)]

[Need assessment]
In the second part of the survey, you will read statements on purchasing solar panels. Please indicate for each statement to what extent you agree. In a previous survey[250] you indicated that you are interested in buying solar panels, so take this in mind when answering the questions. If you are not currently focusing on purchasing solar panels, please provide your expectations.

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q7_1. I find it difficult to determine which type of solar panels is suitable for me.	1	2	3	4	5	6	7
Q7_2. I have a clear view on which solar panels fit with my situation.	1	2	3	4	5	6	7
Q7_3. I know which things I need to take into account to determine which solar panels I should choose.	1	2	3	4	5	6	7

[Amount of information]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q8_1. I have no idea where I should start with choosing/comparing solar panels.	1	2	3	4	5	6	7
Q8_2. I know where I can find information on government funding/grants for purchasing solar panels.	1	2	3	4	5	6	7
Q8_3. I think that there are too	1	2	3	4	5	6	7

[250] The selection questions

many different types of solar panels to compare when choosing solar panels.							
Q8_4. I think there are too many characteristics to compare when choosing solar panels.	1	2	3	4	5	6	7
Q8_5. There is too much information to go through when comparing solar panels.	1	2	3	4	5	6	7

[Comparability of information]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q9_1. It is easy to distinguish among different solar panels.	1	2	3	4	5	6	7
Q9_2. For me, it does not take much effort to discover how solar panels differ from each other.	1	2	3	4	5	6	7
Q9_3. I would easily lose the overview when comparing solar panels.	1	2	3	4	5	6	7
Q9_4. I understand the information when I compare solar panels.	1	2	3	4	5	6	7
Q9_5. When comparing solar panels, the information is explained in a way I can understand.	1	2	3	4	5	6	7
Q9_6. I do not understand the meaning of all characteristics of solar panels.	1	2	3	4	5	6	7
Q9_7. The computations that you have to make to understand *which* solar panels you need are too complicated.	1	2	3	4	5	6	7
Q9_8. The computations that you have to make to understand *how many* solar panels you need are too complicated.	1	2	3	4	5	6	7
Q9_9. It is difficult to compute how expensive the solar panels that you need are.	1	2	3	4	5	6	7
Q9_10. It is difficult to compute how long it takes to earn back the costs of solar	1	2	3	4	5	6	7

panels.							

[Deliberation (vs. action focus)]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q10_1. I have the tendency to think too long about which choice in solar panels I should make.	1	2	3	4	5	6	7
Q10_2. Once I have received all information on solar panels, I would find it difficult to make a decision.	1	2	3	4	5	6	7
Q10_3. I am well able to make a choice among all the different solar panels.	1	2	3	4	5	6	7

[Beliefs: attitudes, norms, perceived control]

[Attitudes]

[Costs: high initial costs, long payback period, lack of funding]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q11_1. Looking at what you receive, the costs of solar panels are acceptable.	1	2	3	4	5	6	7
Q11_2. The costs of solar panels discourage me.	1	2	3	4	5	6	7
Q11_3. It takes too long before you have earned back the costs of solar panels.	1	2	3	4	5	6	7
Q11_4. The time you need to earn back the costs of solar panels is acceptable.	1	2	3	4	5	6	7
Q11_5. There is not enough government funding/grants for purchasing solar panels.	1	2	3	4	5	6	7
Q11_6. I think I could easily receive government funding/grants for purchasing solar panels.	1	2	3	4	5	6	7

[Benefits: reliability, effectiveness, saving money, earning money/Feed-in Tariff]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q12_1. I can rely on solar panels to provide me with enough energy.	1	2	3	4	5	6	7
Q12_2. I expect quite some technical problems with solar panels.	1	2	3	4	5	6	7
Q12_3. The current solar panels absorb enough sunlight.	1	2	3	4	5	6	7
Q12_4. Solar panels currently do not produce enough energy.	1	2	3	4	5	6	7
Q12_5. From a long-term perspective, solar panels save me money.	1	2	3	4	5	6	7
Q12_6. Solar panels currently do not bring in enough money.	1	2	3	4	5	6	7
Q12_7. I think I can earn money by exporting energy back to the electricity grid.	1	2	3	4	5	6	7
Q12_8. I cannot predict what I can earn in the future by exporting energy back to the electricity grid.	1	2	3	4	5	6	7
Q12_9. I can earn more money by investing in solar panels than by having my money on a bank account.	1	2	3	4	5	6	7
Q12_10. I can save on network costs, if I consume my own electricity.	1	2	3	4	5	6	7

[Aesthetics: (un)attractiveness, (not) accepting]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q13_1. Solar panels on a roof do not look good.	1	2	3	4	5	6	7
Q13_2. The street looks less attractive when there are houses with solar panels on their roofs.	1	2	3	4	5	6	7
Q13_3. The look of solar panels on a roof does not bother me.	1	2	3	4	5	6	7
Q13_4. The look of solar panels on a roof is not that important to me.	1	2	3	4	5	6	7
Q13_5. I have no objections to different types of solar panels on my roof (e.g. a combination of black and blue solar panels).	1	2	3	4	5	6	7
Q13_6. I am willing to pay more for solar panels that look better (e.g. roof-integrated panels, which are less noticeable).	1	2	3	4	5	6	7
Q13_7. It would not matter to me if the houses in my neighbourhood all had different types of solar panels (e.g. one house with black solar panels, one house with blue solar panels, etc.).	1	2	3	4	5	6	7
Q13_8. Solar panels on my roof decrease the value of my house.	1	2	3	4	5	6	7

[Norms]

[Descriptive and injunctive norms set by neighbours, friends, family]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q14_1. Many people in my street have solar panels.	1	2	3	4	5	6	7
Q14_2. I have many friends / family members with solar panels.	1	2	3	4	5	6	7

Q14_3. My friends / family would encourage me to buy solar panels.	1	2	3	4	5	6	7

[Exposure to advertisements by the government and sellers]

Q15_1. The government is actively committed to encourage the use of solar panels.	1	2	3	4	5	6	7
Q15_2. The government advertises the use of solar panels.	1	2	3	4	5	6	7
Q15_3. I often see advertisements on solar panels from the government.	1	2	3	4	5	6	7
Q15_4. I often see advertisements on solar panels from sellers of solar panels.	1	2	3	4	5	6	7

[Perceived control]

[Affinity with technology]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q16_1. I have a more than average knowledge of technology.	1	2	3	4	5	6	7
Q16_2. I like to make home improvements by myself.	1	2	3	4	5	6	7
Q16_3. I am capable in the area of technical home improvements.	1	2	3	4	5	6	7
Q16_4. I am interested in technological issues.	1	2	3	4	5	6	7

[(Self-reported) knowledge on how to save energy]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q17_1. I know whether an electric appliance uses much or little energy.	1	2	3	4	5	6	7
Q17_2. I am paying close attention to my energy usage.	1	2	3	4	5	6	7

Q17_3. I am well informed on how to save energy.	1	2	3	4	5	6	7

[Perceived influence (general)]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q18_1. I can really contribute to a better environment by taking solar panels.	1	2	3	4	5	6	7
Q18_2. The use of solar panels only affects the environment if many people would use them.	1	2	3	4	5	6	7
Q18_3. I believe that firms and researchers will find solutions for a better environment.	1	2	3	4	5	6	7
Q18_4. I believe that if many people use solar panels the electricity grid will crash.	1	2	3	4	5	6	7

[Perceived influence (specific)]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q19_1. I am afraid that there is too little sunlight near my house to receive enough energy from solar panels.	1	2	3	4	5	6	7
Q19_2. I am afraid that there is too much shadow on my roof to receive enough energy from solar panels.	1	2	3	4	5	6	7
Q19_3. I am afraid that my roof is too small to place enough solar panels.	1	2	3	4	5	6	7
Q19_4. I am afraid that my roof is not suitable for placing solar panels.	1	2	3	4	5	6	7
Q19_5. I am afraid that the panels will be hard to keep clean.	1	2	3	4	5	6	7

[Quiz]

	True	False
Q20_1. Solar panels work when it is cloudy.	X	

Q20_2. Solar panels can only be used in warmer climates.		X
Q20_3. Solar panels cannot be installed on small roofs.		X
Q20_4. Solar panels do not require expensive maintenance.	X	
Q20_5. The technology of solar systems is unstable.		X
Q20_6. Solar panels work better when they are clean.	X	

[Household and personal characteristics]

[Energy concern (attitudes and actions)]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q21_1. I like trying to save on energy usage	1	2	3	4	5	6	7
Q21_2. I consider it important to conserve energy.	1	2	3	4	5	6	7
Q21_3. It is worth paying a little more for a more energy efficient product.	1	2	3	4	5	6	7
Q21_4. When I have finished using my computer at home, I turn it off.	1	2	3	4	5	6	7
Q21_5. When I leave a room at home that is unoccupied, I turn off the lights.	1	2	3	4	5	6	7

[Pro-environmental self-identity]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q22_1. I think of myself as an environmentally-friendly consumer.	1	2	3	4	5	6	7
Q22_2. I think of myself as someone who is very concerned with environmental issues.	1	2	3	4	5	6	7
Q22_3. I would be embarrassed to be seen as having an environmentally-friendly lifestyle.	1	2	3	4	5	6	7
Q22_4. I would not want my family or friends to think of me as someone who is concerned about environmental issues.	1	2	3	4	5	6	7

[Financial situation]

	Strongly disagree	Disagree	Somewhat disagree	Neither agree or disagree	Somewhat agree	Agree	Strongly agree
Q23_1. I often have a shortage of money.	1	2	3	4	5	6	7
Q23_2. I often wonder whether I have enough money.	1	2	3	4	5	6	7
Q23_3. I often worry about money.	1	2	3	4	5	6	7
Q23_4. I only focus on what I have to pay now.	1	2	3	4	5	6	7
Q23_5. I feel as if I have too little control over my financial situation.	1	2	3	4	5	6	7

[Aesthetics versus financial aspects]

Q24A. Please indicate what is more important to you: the looks of solar panels or the costs of solar panels.

1. The looks of solar panels.
2. The costs of solar panels.

Q24B. Please make a choice. Would you pay more for better looking solar panels (such as roof-integrated solar panels)?

1. I prefer to buy cheaper solar panels, which look less good on my roof.
2. I prefer to buy more expensive solar panels, which look better on my roof.

If Q24B = 1, Q24B_2:
Q24B_2. Would you opt for more expensive but better looking solar panels if you could lease them?

1. No.
2. Yes.

[Demographics, may not have to be measured if already available[251]]

Q25. What is your gender?
1 Man
2 Woman

Q26. What is your age?

Q27. At what stage did you complete your full-time studies?
1 Elementary (primary) school or less
2 Some high (secondary) school

[251] This information is often already available in panels. If this is the case, it does not need to be included in the questionnaire.

3 Graduation from high (secondary) school
4 Graduation from college, university or other third-level institute
5 Post-graduate degree (Masters, PhD) beyond your initial college degree
6 Still studying full-time
7 Other qualification
8 Refusal

Q28. Which of these best describe your current work status?
1 Self-employed
2 Manager
3 Other white collar
4 Blue collar
5 Student
6 House-person and other not in employment
7 Seeking a job
8 Retired

7.4 Data analysis

The data analysis plan describes the steps that should be taken in order to analyse the results from the experimental and survey parts.

7.4.1 Sample characteristics

First of all, the sample characteristics should be described. Including the following information:

- Time when data was collected
- Total sample size and sample size per country
- Socio-demographic make-up of the total sample based on gender, age, education level. This information will be provided in a table.

If desired the socio-demographic make-up per country can also be provided in a table.

7.4.2 Data checks

Histograms and frequencies should be checked for all variables to check if there are any strange values occurring in the dataset. Moreover, response patterns should be checked to see if there are any response tendencies such as persons who answer on all questions a "7" even though there are also reversed-coded items. In terms of consistency respondents should answer "1" instead of "7" on reversed-coded items. For respondents who seem to have a response tendency, the individual responses on all other variables and the completion time should be checked. For each individual case a decision needs to be made whether the respondent is a person who provides extreme answers or was not serious. Respondents who have extreme answers can remain in the dataset, non-serious respondents cannot.

Based on the data checks things that are interesting to investigate further, such as specific relationships between variables, or analyses not included in this data analysis plan should be listed. For instance, it could be that respondents are quite pro-environmental. Does this correlate with education level? Or is this because of social desirability (skewed distributions)?

7.4.3 Experimental part

Central research questions in the experimental part are:

- RQ1: Which product characteristics (attributes) are most important in consumer choice for solar panels?
- RQ2: Which attribute levels per attribute are most important in consumer choice for solar panels?
- RQ3: Which attributes and attribute levels more often lead to no choice?
- RQ4: How does the way in which information is presented (structured vs. unstructured) influence consumer choice?
- RQ5: How easy or difficult is it for consumers to find, assess, and understand solar panel offers?
- RQ6: How does the way in which information is presented influence assessment and understanding of solar panel offers?

Most important product characteristics and levels (RQ1 – 3)

To answer research questions 1 to 3 a conjoint analysis should be conducted, more specific a no-choice multinomial logit model should be estimated. The data file contains choice sets with the different profiles and the preference scores of those profiles collected from the respondents. The solar panel characteristics are assumed to only have additive contributions (main-effects only). Regression weights give contributions of characteristics. These contributions are called part-worths (or part utilities) and are obtained by decomposition of overall preferences, and thus show trade-offs that consumers make among attribute levels.

When analysing the data there are two relevant statistics[252:]

- Average importance values: relative importance of each attribute;
- Utility values: also called part-worth scores, these indicate a valuation of a level within an attribute, compared to other levels within that same attribute, in making a choice.

Utilities thus give the direction of the preference. Utility values are scaled to sum to zero within each attribute (therefore also negative utilities occur). It is also possible to use dummy coding to set the part-worth of one level within each attribute to zero and estimate the remaining levels as contrasts with respect to zero.

The average importance values provide insight into which product characteristics are most important in consumer choice (RQ1). A table should be provided with the importance of each attribute from which can be derived whether price, aesthetics, efficiency or any of the other attributes is most important to the consumer in the decision process. The utility values provide insight into which attribute levels are most important in consumer choice (RQ2). A table should be provided with the utility values for each attribute level per attribute. Together the importance values and utility values provide insight into which attributes and attribute level combinations more often lead to no choice (RQ3).

We also included a no-choice alternative in the choice experiment as in real life consumers also do not necessarily make a choice; they can decide to not purchase these specific solar panels (or to purchase solar panels at all). We assume that respondents determine the utility for each option and choose the no-choice option if none of the alternatives offers sufficient utility. A No-choice Multinomial Logit model should be estimated.[253,254] The basic idea is that the model takes into account that respondents first decide whether or not to choose (if the alternatives are not interesting enough to choose from) and only when they decide to choose they select one of the choice alternatives. The utility of the no-choice option is compared to the sum of part-worth utilities across the other attributes. If the total utility exceeds the utility of the no-choice alternative, it is likely that a choice is made.[255] There are also some follow-up questions in the experimental part if a respondent selected the no

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[252] Leijten, F. R., Bolderdijk, J. W., Keizer, K., Gorsira, M., van der Werff, E., & Steg, L. (2014). Factors that influence consumers' acceptance of future energy systems: the effects of adjustment type, production level, and price. Energy Efficiency, 7(6), 973-985.

[253] Haaijer, R., Kamakura, W. A., & Wedel, M. (2001). The'no-choice'alternative in conjoint choice experiments.

[254] Vermeulen, B., Goos, P., & Vandebroek, M. (2008). Models and optimal designs for conjoint choice experiments including a no-choice option. International Journal of Research in Marketing, 25(2), 94-103.

[255] See for example Haaijer, Kamakura, and Wedel (2001) "The 'no-choice' alternative in conjoint choice experiments," International Journal of Market Research, 43 (1), 93-106.

choice option once or more. The follow-up questions help in determining the reasons why people often did not choose one of the solar PV panel alternatives. Furthermore, it is possible to estimate the Willingness To Pay for any alternative (WTP). Differences in any pair of attribute levels are used and multiplied with the price coefficient.256 This provides answers on which attributes and attribute levels more often lead to no choice.

In the experimental part we also measure purchase intention, the extent to which consumers are actually willing to purchase solar panels and how many years from now. We will estimate a model in which differences in the choices that consumers make are further investigated for consumers who do have the intention to actually buy solar PV panels and consumers who do not.

Information presentation (RQ4)

In order to test whether information presentation affects the choices that consumers make it should be tested whether information presentation has an effect on the mean part-worth estimates that were obtained for the different attribute levels using ANOVA tests. The mean part-worth estimates for the structured and unstructured conditions need to be compared. A table with the utilities for the structured and unstructured information condition should be provided with significance levels. This provides insights into whether the way in which information is presented influences consumer choice (RQ4).

Finding and digesting information (RQ5, RQ6)

It should be tested whether the ease with which respondents found the information, could understand the information on solar PV panels and could compare the different choice alternatives influences the decision to make a choice or no choice. First it should be investigated how easy or difficult it was for respondents to find, assess, and understand solar panel offers (RQ5). A table with descriptives should be provided. Next, it should be tested whether information presentation has an effect on understanding, and how consumers assess information. This allows to investigate questions like: Is understanding higher when information is presented in a structured way? Finally, the part-worths should be compared for consumers who find it easy to understand and digest information with respondents who find this difficult. A table with results should be provided. This shows how information presentations influences choice.

Also understanding per attribute should be assessed and a table with the percentage of respondents that understood the information per attribute should be provided. This provides insights into where information on solar PV panels could be further clarified to the consumer. Together this will provide insights into how information presentation influences assessment and understanding of solar panel offers (RQ6).

7.4.4 Post-experiment survey

Based on the constructs measured in the post-experiment survey relationships among barriers and drivers and purchase intention should be tested.
Central research questions in the post-experiment part are:

[256] For an example see: Shih, L. H., & Chou, T. Y. (2011). Customer concerns about uncertainty and willingness to pay in leasing solar power systems. International Journal of Environmental Science & Technology, 8(3), 523-532.

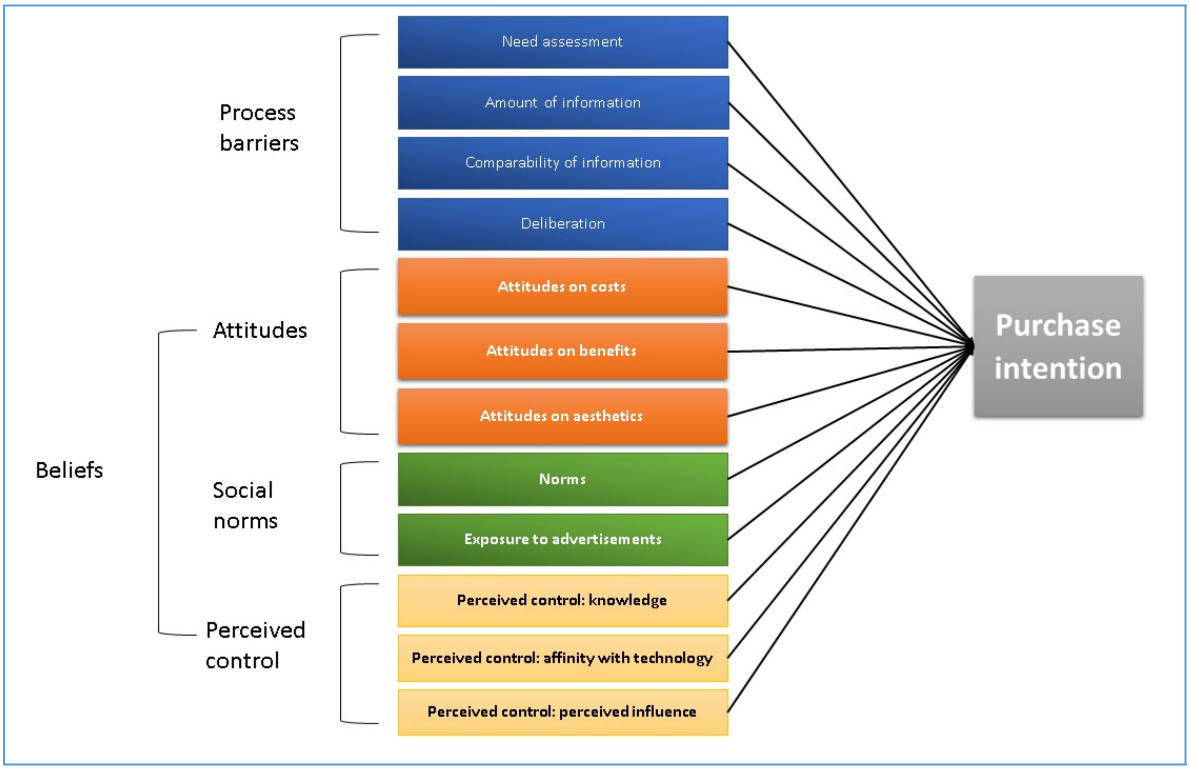
- RQ8: Which drivers and barriers do consumers experience in the decision process of purchasing solar panels?
- RQ9: Which drivers may help consumers to overcome barriers?

First, the data should be prepared for data analysis by recoding negatively phrased items and averaging items. Whether the items form reliable constructs should be checked via a reliability analysis and Cronbach's alphas for each construct should be reported. In addition, a table with descriptive statistics (e.g. mean, standard deviation) per construct should be provided.

Process barriers related to low understanding are measured as need assessment, amount of information, comparability of information, and deliberation. Beliefs are measured as attitudes on costs (high initial costs, long payback period, lack of funding), attitudes on benefits (reliability, effectiveness, saving money, earning money), attitudes on aesthetics ((un)attractiveness and (not) accepting), norms (descriptive and injunctive norms by neighbours, friends and family), exposure to advertisements, perceived control related to affinity with technology, perceived control related to knowledge and perceived control related to perceived influence.

A multilevel regression model with purchase intention as dependent variable and the process barriers and beliefs as predictors should be estimated (see Figure 25). Multilevel models improve over standard ANOVAs and single-level regression models in that they properly take into account the multilevel structure of the data, that is, the fact that responses are "nested" within individuals, which are "nested" within countries. It should be tested whether experienced barriers lead to lower purchase intention. Moreover, it should be tested whether (positive) attitudes, if many neighbours, friends and family have solar PV panels (the social norm to have solar PV panels) and whether higher perceived control is associated with higher purchase intention of solar PV panels. It should be tested for each predictor whether there is a significant impact on purchase intention and the direction of the effect (positive or negative) should be reported. We define statistical significance at the .05 level. For instance, if there is a significant effect of attitudes on costs on purchase intention and the direction is negative this indicates that the more the respondent expects that solar PV panels are expensive the less likely the purchase intention. Also effect sizes in addition to statistical significance should be examined. It could be that differences are (statistically) significant, but small in absolute sense. The results should be reported in a table or figure.

Figure 25: Estimated multilevel regression model purchase intention

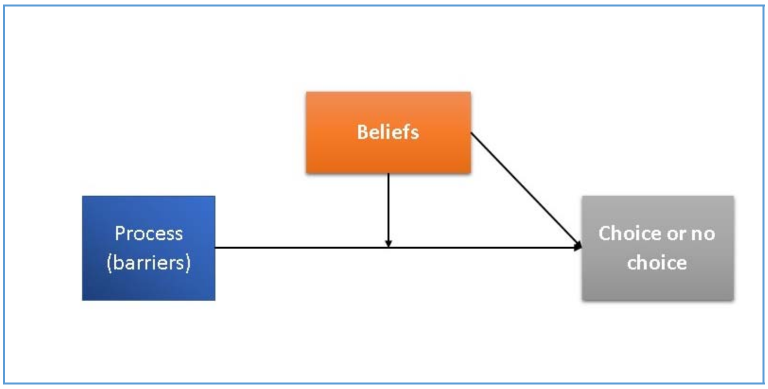


In addition, a multilevel logistic regression model with choice versus no choice as the dependent variable and the process barriers and beliefs as predictors could be estimated to see which barriers and beliefs increase or decrease the likelihood to make no choice. For instance, if many barriers are experienced this will increase the likelihood that respondents make no choice at all. The results should be reported in a table or figure.

Together the multilevel regression model for purchase intention and the multilevel logistic regression model for choice vs. no choice provide insights into which drivers and barriers consumers experience in the decision process and how this influences purchase intention and choice (RQ8). This provides insights into which barriers need to be taken away for consumers before they actually will start purchasing solar PV panels. In follow-up studies possible intervention strategies can further be tested.

It can be the case that if a consumer perceives that there is too much information or if the information is perceived as too complex his/her purchase intention is low. However, if the consumer perceives much control and thinks he/she is able to digest the amount and complexity of information the amount and complexity of information may no longer predict low purchase intention. Therefore, a multilevel logistic regression model should be estimated in which the direct effects of the experienced barriers and beliefs on choice versus no choice are tested and the moderating effect of beliefs is taken into account (see Figure 26). This provides answers to which drivers help consumers to overcome barriers (RQ9).

Figure 26: Estimated multilevel logistic regression model choice



7.4.5 Possible follow-up analysis

In the survey we asked whether the respondent was currently focusing on purchasing solar panels and whether the respondent searched for information or previously received offers on solar PV panels. It might be that consumers with more experience (those who actually searched for information or received offers) find it easier to compare and assess information and hence more often make a choice instead of no choice. A separate model can be estimated in which previous experience is taken into account.

Moreover, in the survey we also asked for energy concern and pro-environmental self-identity. It can be expected that respondents with high energy concern and who perceive themselves as pro-environmental have higher purchase intentions and less often opt for the no-choice option. Separate models can be estimated in which energy concern and pro-environmental self-identity are taken into account.

Segmentation analysis can be conducted to understand what the socio-demographic make-up of the consumers is who opt for different type of solar panels. Note that the more extensive the segmentation analysis is, the larger sample size is needed. We propose to base the segmentation on gender, income level and financial situation, and education. This helps identifying what the optimal choice is for different consumer groups and helps answering questions such as: What is the socio-demographic make-up of the group of consumers that prefers cheap solar panels? What is the socio-demographic make-up of the group of consumers that prefers more aesthetic panels (roof-integrated solar PV panels)? Are woman more concerned about aesthetics when purchasing solar PV panels and are men more concerned about the price when purchasing solar PV panels? Next to demographics, preferences from the survey part can be linked to the choices made in the conjoint experiment. Particularly whether consumers' preferences in the trade-off between aesthetics versus price match with the choices made in the conjoint experiment.

7.5 Conclusions and recommendations

This section summarizes the main issues discussed above and draws conclusions, providing recommendations for running the study.

The aims of the behavioural task are (i) to assess the abilities and skills of traditional consumers to understand the offers for transitioning towards residential self-generation and storage, (ii) to gain insight into how traditional consumers can make the best choice regarding self-generation with solar PV panels and (iii) to gain insight into how easy or difficult it is for traditional consumers to find and assess information on self-generation and storage (and how much information can be digested).

In order to study these questions, we have recommended to carry out an experimental part as well as a post-experiment survey.

Experimental part

The experimental part focuses on how consumers choose solar panels and whether these choices are influenced by the way in which the information is presented (structured vs. unstructured). A choice experiment is designed in which statistical efficiency and respondent efficiency are maximised. Based on a literature review and discussion with experts, the following product characteristics were selected: 1) aesthetics, 2) costs per solar panel, 3) inverter type, 4) installation, 5) efficiency, 6) lifetime and maintenance costs, 7) total investment costs, 8) payback period.

We also recommended studying the way in which information is presented in the experimental part. Consumers can find information and offers on solar PV panels in different ways. One way of searching, comparing and assessing the information in the solar PV panel context is by means of comparison websites. Another way in which consumers can find and compare information is by comparing individual offers from different websites or providers. The latter makes it more difficult to compare information as the information is presented in a different set-up and lay-out, so the consumer has to put in more effort to compare the different options. This was taken into account by including a structured way of presenting the choice alternatives (comparable to comparisons websites) and an unstructured way of presenting the choice alternative (comparable to when individual offers are provided to the consumer by different providers).

A procedure was followed to determine the optimal number of choice sets and optimal combinations of choice alternatives in the choice set. This led to a choice design in which there are 2 blocks of 10 choice sets, each consisting of three choice alternatives and a no-choice option.[257] It is recommended to conduct a pilot study for several reasons, such as to check if the no-choice option is not most often chosen by respondents and to test the length of the second part. If the no choice option is often chose the choice sets are probably too difficult to judge for the respondent and some adaptations are necessary. Moreover, we recommended to include at least 200 respondents per cell, leading to a minimum total of 800 respondents per country, and to conduct the study with countries that differentiate in market potential as indicated by number of household installations available, concern about the environment, attractiveness for consumers to purchase solar PV panels, CGP and AIC per capita.

[257] Note that in the experimental part consumers are not asked to actually buy the solar panels

The experimental part provides insights into which product characteristics and which specific features are most attractive to the consumer. Moreover, the experimental part provides insight into how easy or difficult the decision-making process is for consumers.

Post-experiment survey

The post-experiment survey measures barriers and drivers in the decision process, including consumers' beliefs (e.g., cost/benefit beliefs). The survey provides insight into which barriers and drivers predict consumers' intention to purchase solar panels and identifies the most important barriers and drivers. With the survey we can identify the barriers that need to be overcome before consumers will actually start purchasing solar PV panels. Based on these results, intervention strategies can further be developed and tested. The study reveals what the most important considerations are when deciding between different solar panels and which barriers consumers experience in the decision process. This helps in further promoting self-generation systems to consumers.

Country selection

We recommended also selecting countries in such a way that they together constitute a representative sample of the EU28, Norway and Iceland on relevant factors. The country selection should include population coverage (i.e. big and small countries), regional spread, and a mix of EU15 and EU13 countries. Moreover, we propose to include several other factors that may impact the intention to purchase solar panels. Market potential can be estimated by comparing data on:

- Household installations available (low vs. high)
- Concern about the environmental impact of purchases
- Attractiveness for consumers to purchase solar PV panels
- GPD per capita and AIC per capita

Data collection and analysis

The following are our recommendations for the final steps, respectively the data collection and data analysis:

- Data should be collected by a data collection agency that can set out the study in the proposed countries or can select a representative sample of countries, based on the market potential selection criteria, indicated by household installations available, concern about the environmental impact of purchases, attractiveness for consumers to purchase solar PV panels, GPD and AIC per capita.

- Designing and analysing choice experiments in a multilevel context and combining the results thereof with survey data requires expertise and experience with such designs. The data should be analysed by a research agency that has ample experience with experimental research, and analysing complex choice-based designs. This requires extensive experience of no-choice multinomial logit models, multilevel (logistic) regression models and moderated regression models.

8 Overall conclusions and recommendations

As illustrated in the Background chapter, the European Commission has identified a number of priority areas for its policy and regulatory action, to enable all consumers to generate, store and/or sell their own electricity based on retail market conditions while also taking into account the costs and benefits for the system as a whole.

This study, focusing on residential prosumers, aimed at putting forward conclusions and recommendations that could be part of a more comprehensive analysis assessing the costs and benefits for all the other players involved in the energy market.

By using the analytical tools available under the different project tasks, this study aimed at shedding light on the following issues:

-Is it possible to have a widespread development across Europe of residential self-generation through solar PV technology? Can this development occur without incentives currently available such as Feed-in Tariffs, premiums, green certificates, loans and other investment supports, or tax reductions?

-Can the widespread development of solar PV self-generation at residential level take place based only on market-driven factors including solar PV technology investment cost (buy, maintain and repair), extra technology investment cost (storage, aggregator) and availability of smart solutions such as smart metering?

-What are the main drivers of consumers' self-generation choice? Are financial considerations mainly affecting consumers' choice to become residential prosumers? Is electricity price the main consideration? Or the possibility to benefit from incentives? Or the assessment of the investment payback period? What about other financial considerations, such as the increased real estate property value?

-Are environment protection, social considerations such as status, visibility, reputation, important drivers affecting the prosumer choice? Or individual interests in new technologies, therefore showing that European consumers are not mainly considering financial factors when choosing self-generation? And to what extent these drivers can be encouraged, can be factored in, by the upcoming policy-making initiatives?

Non-incentivised development of solar PV residential self-generation

The comparative analysis of the legal frameworks of all countries in the scope of this study showed that in the majority of them, despite broad differences, various types of incentives are still available.

The comparative legal analysis further showed that in some countries, where markets have developed fast over the past years, incentivising measures were adjusted.

Although adjustments did not lead to the complete cancellation of favourable conditions, which played a major role in stimulating the rapid market growth, still a number of petitions on *policy risk in support systems* were filed to the Policy

Department on Citizens' Rights and Constitutional Affairs of the European Parliament, expressing concern for the changes in the policy environment. Countries where retroactive changes are implemented and where frequent changes to support schemes occur can experience a reduced growth rate of solar PV[258]. This already suggests that a phasing-out of incentivising policies on a large scale is not very welcome.

In addition to the comparative legal analysis, the primary data collection tasks, the survey of residential prosumers and the mystery shopping, also examined the issue of incentives, concluding that they are a top driver of consumers' self-generation choice.

Besides, the chapter dedicated to baseline and projection scenarios also concluded that incentivising measures are a key factor to ensure further expansion of residential self-generation. In particular:

Under a baseline scenario that assumes a continuation of current policies, residential solar PV capacity in the EU28 is projected to double (from 17GW estimated capacity in 2016 to 32GW estimated capacity in 2035).

A phase-out of existing support for residential solar PV by 2020, will limit growth of installed capacity across all counties. Our results show that in some cases, it would reduce the cost-effectiveness of solar PV to such an extent that it would stop any new investments in residential solar PV in the short term (until a point is reached in which CAPEX cost are sufficiently low, and electricity prices sufficiently high to incentivise some households to invest again).

Widespread development of solar PV self-generation at residential level based only on market-driven factors

The conclusions drawn in the chapter dedicated to the baseline and projection scenarios show that:

Following rapid growth in the period to 2012, growth in residential solar PV capacity has slowed slightly in recent years.

The baseline projections suggest a continuation of around 4% rate of growth per annum over the period to 2030, reflecting the balance of two offsetting effects: an improvement in the cost-effectiveness of solar PV investments over time (due to higher electricity prices and lower CAPEX costs) balanced against a smaller pool of potential investors (as those with most favourable preferences towards solar PV, for which investment is most cost effective, have already installed).

There is considerable uncertainty in the baseline solar PV projections, which are dependent on key assumptions about the future development of CAPEX and OPEX costs, electricity prices, interest rates, self-consumption ratios and consumer preferences.

The scenario results show that future rates of take-up are also highly affected by policy and the development of new complimentary technologies. An increase in the number of households with an EV will lead to a projected 5-40% increase in installed capacity by 2030, as the potential technology synergies would increase the attractiveness of solar PV investment and could increase self-consumption shares (e.g. in cases where EVs were charged at home during the day).

[258] http://www.europarl.europa.eu/supporting-analyses

Through its impact on reducing CAPEX costs, relaxation of EU anti-dumping legislation against imports of solar PV from China would have a positive impact on the investment rate, leading to around a 20-30% increase in installed solar PV capacity by 2030 (relative to the baseline scenario). Facing squeezed government budget following the EU debt crisis, this measure would be effective in incentivizing take-up, with limited costs to the state. However, exposure to increased competition from abroad could harm domestic solar PV manufactures in the EU, as margins will be squeezed and less productive firms forced out of the market.

Main drivers of the prosumer choice

We developed our analysis of the main financial and non-financial drivers looking at the different phases of consumers' self-generation choice:

- the decision-making phase, where consumers make their choice with various behavioural factors at play
- the implementation phase, where prosumers look at the advantages and difficulties of self-generation
- the assessment phase, where prosumer assess their experience, expressing or not their willingness to recommend it to others

Consumers expressed satisfaction with it and willingness to recommend it to others, showing that in most cases the policy and regulatory environment so far has been broadly perceived as advantageous. It remains to be seen how the picture would change if incentives were broadly no longer available.

Financial considerations were top drivers also in those countries were the market is already more developed thanks to the incentivising policies put in place over the years. Environmental concerns also scored high, as the main non-financial driver.

Policy fine-tuning allowing the deployment on a large scale of behind the meter, smart technologies would be a welcome development, and could possibly become a strong driver to further boost the prosumer market, even with the elimination of incentives. Earning back the cost of electricity, benefitting from the advantages of smart metering, earning income by selling to the grid were all main considerations listed in the open-answer feedback of the mystery shopping exercise.

Mixed financial considerations were shown concerning the real estate property: on the one hand, consumers expressed awareness of the increased value of their homes, thanks to the installation of green technologies, and also of the possibility to benefit from related financial support. On the other hand, consumers expressed some general concern about the extra costs related to the installation and maintenance of technology.

Besides environmental concerns, other non-financial drivers were not easy to measure in the survey and in the mystery shopping exercise. Consumers' interest in new technologies, their desire to be energy self-sufficient, to feel security of energy supply, to improve their "green lifestyle" or promote their personal social image all generally featured among their replies. A more comprehensive assessment of drivers can be done via behavioural experiments, and our proposed approach on the design of such an experiment has been presented in the dedicated chapter of this study.

Recommendations

Electricity generation from solar PV represents a growing component of the EU energy mix[259].

In the short-term, continued roll-out of solar PV faces challenges, as increasing the share of intermittent renewables on the grid could lead to increasingly peaky electricity supply, causing grid congestion and stability issues. In many Member States, policies and regulatory measures (illustrated in detail in the chapter dedicated to the comparative legal analysis) have been designed to reduce this risk by compensating for electricity offloaded to the grid at variable, time-dependent rates to better match electricity supply and demand (e.g. through Feed-in Premiums). However, the effect of these measures is constrained by consumers' limited control over time-of-day electricity consumption.

Despite these short-term challenges, it is envisaged that, in the medium term, improvements in demand response and roll-out of smart meters, battery and grid storage technologies, as well as increases in electricity demand and synergies with technologies such as electric vehicles, will create opportunities for solar PV capacity to further increase. To achieve this, surely a comprehensive policy and regulatory framework has to be put in place at the EU level.

Our analysis shows that, despite considerable reductions in CAPEX costs over recent years, continued policy support is crucial to achieve further growth in residential solar PV capacity in the EU. The range of different policy options that could be pursued[260] to incentivise take-up of solar PV can be grouped into four key channels, as summarised below.

➢ Increase the cost-effectiveness of solar PV for residential prosumers

- Ensure policies are in place to compensate for electricity exported to the grid e.g. Feed-in Tariffs, Feed-in Premiums, net-metering schemes
- Introduce capital subsidies or reductions to VAT charged on solar PV modules
- Offer exemptions to electricity taxes and grid costs for prosumers' self-consumed electricity and in cases where these costs are artificially inflated and are not reflective of the prosumers' own grid usage[261]
- Remove trade restrictions and import tariffs on solar PV modules

➢ Increase consumer acceptance

- Remove non-financial barriers such as restrictive administrative procedures and planning legislation that inhibit investment

[259] In addition to requirements of 20% of energy from renewables by 2020, the EU has targets to cut greenhouse gas emissions by 20% in 2020, 40% in 2030 and by 80% in 2050 (compared to 1990 levels).
260 The study has not examined the impact of the different incentives on market integration, grid congestion and grid stability. It is noted that certain types of incentive could raise more issues for market integration, grid congestion or grid stability than others.
261 Without prejudice to the obligation of prosumers to pay for the costs they are causing to the network.

- Put in place policy guarantees, to increase acceptance among risk-averse consumers
- Support growth and development of complementary technologies (such as EVs and battery storage technologies)

➢ Increase take-up for households where investment is most beneficial

- Organize information campaigns, so that households are more aware of the potential benefits of investment in Solar PV
- Assist with access to finance e.g. via easily obtainable loans at low fixed interest rates

➢ Increase the technical potential for residential solar PV

- Introduce low-carbon building regulations (so that energy efficiency measures, solar PV and/or other renewable micro-generation technologies are a requirement for new houses and apartments)
- Allow tenants living in apartments to benefit from self-generation, by establishing collective rights to self-generation and self-consumption[262]

➢ Legislative and regulatory initiatives

- A common, comprehensive definition of “residential prosumers” could be a catalyser for the development of a clear and strong EU policy and regulatory framework supporting consumers’ self-generation while respecting the subsidiary principle described under Article 194(2) TFEU and the Member States’ right to determine their choice of energy sources and the general structure of their energy mix.
- An EU-level framework could focus on the establishment of portfolio of carefully designed incentives, tailored to the different situations and the consequences of the different measures applied overtime, such as the increase of energy cost for traditional energy consumers if the uptake of prosumers increases.
- In addition to the financial incentives, the energy savings or the environmental considerations are behind the consumers’ behaviour and should be taken into account when developing the appropriate regulatory framework.
- The measures designed should aim at supporting the development of new technologies take-up, with an environmental objective but whose development has proved to be slow due to the combination of financial factors (high costs) and national energy policy choices following Article 194 TFEU.

[262] BEUC (2017), ‘Tenants’ Access to Solar Self-Consumption’. Available at: http://www.beuc.eu/publications/beuc-x-2017-020_jmu_iut_tenants_access_to_solar.pdf

9 Annex 1: The cost-effectiveness of investing in solar PV

The net benefit (i.e. cost-effectiveness) of solar PV investment is calculated for a mean household in each year and for each Member State. The calculation is also performed at the 5th and 95th percentiles, to derive the variance of the cost-effectiveness distribution. The calculations below show the net benefit of investing in solar PV under (1) a Feed-in Tariff policy and (2) a net metering scheme.

1. Under a Feed-in Tariff policy

The net benefit of investing in solar PV in each region and in each year, is calculated on a net present value (NPV) basis. In this NPV calculation, the upfront investment cost and longer-term maintenance costs of solar PV are subtracted from the financial benefits over the lifetime of the solar panel (i.e. taking account of the future savings on electricity bills and additional compensation or remuneration for electricity exported to the grid over the duration of the Feed-in Tariff scheme). Future costs and benefits (in terms of fuel bill savings, Feed-in Tariff payments and maintenance costs) are discounted, so that a lower value is attributed to future financial costs and benefits than to those experienced today. The discount rate used is the market interest rate at which households can borrow money against their mortgage (to reflect the probable decision environment when households choose whether to purchase a solar panel). Note that although this calculation purely reflects the financial costs and benefits, a separate calculation is made to model consumer preferences (reflecting potential non-financial barriers and consumers time preferences when making investment decisions). The NPV of Solar PV is broken down into four components:

- NPV Export Income, plus the
- NPV Electricity Bill Savings, plus the
- NPV Other Subsidies, minus the
- NPV Costs

In the equation below, the summation operator (sigma) shows that cash flows are calculated for each year over the policy horizon, future years are discounted and then all years are summed to derive the NPV. In the first year that a solar panel is installed, t is equal to 0. Therefore, the denominator is 1 and the export payment is not discounted. In the second-period, t is equal to 1 and the value of costs or income in that year is reduced, based on the interest rate faced by householders. As t increases (up to T), the discount factor (1+r) increases, and these payments are further discounted. Note that, for export payments, T is the length of time that households are eligible for the Feed-in Tariff scheme; for all other components of the calculation, T refers to the lifetime of the solar panels.

The first component, NPV Export Income, is the quantity of electricity exported to the grid multiplied by the Feed-in tariff rate. The export payment for each year is calculated like this and summed over the Feed-in Tariff policy horizon to give the NPV Export Income.

NPV Electricity Bill Savings, is the amount of self-generated electrical energy that is consumed, multiplied by the electricity price (what they would have paid if they had consumed from the grid). The same process of summation of each period is applied here.

The NPV Other Subsidies, is a simpler calculation because, in most cases, a lump sum payment is made in the first period (i.e. a subsidy on CAPEX and installation costs) and there are no future payments to discount.

The NPV Costs is the capital expenditure (CAPEX cost) plus the cost of installation plus the discounted operating costs (OPEX cost).

$$Net\ benefit = NPV\ Export\ Income + NPV\ Electricity\ Bill\ Savings + NPV\ Other\ Subsidies - NPV\ Costs$$

Where:

$$NPV\ Export\ Income = \sum_{t=0}^{T} \frac{Generation_t \times Percentage\ exported_t \times FiT\ rate_t}{(1+r)^t}$$

$$NPV\ Electricity\ Bill\ Savings = \sum_{t=0}^{T} \frac{Generation_t \times Percentage\ consumed_t \times Electricity\ price_t}{(1+r)^t}$$

$$NPV\ Costs = CAPEX\ cost + Installation\ cost + \sum_{t=0}^{T} \frac{OPEX\ costs_t}{(1+r)^t}$$

r = market interest rate
T = lifetime of Solar PV (i.e. 20 yrs)
In the context of the NPV Export Income term,
T = the policy horizon (which may be lower than the assumed Solar PV lifetime)

2. Under a net metering scheme

In the case of a net metering scheme, the value of electricity exported to the grid is offset against future electricity bills.

The net benefit of a net metering scheme is broken down into two components:

- NPV Electricity Bill Savings, minus the
- NPV Costs

The NPV Electricity Bill Savings is the total generation multiplied by the electricity price discounted for future periods. The NPV Costs is calculated using the same method described above.

$$Net\ benefit = NPV\ Electricity\ Bill\ Savings - NPV\ Costs$$

Where:

$$NPV\ Electricity\ Bill\ Savings = \sum_{t=0}^{T} \frac{Generation_t \times Electricity\ price_t}{(1+r)^t}$$

$$NPV\ Costs = CAPEX\ cost + Installation\ cost + \sum_{t=0}^{T} \frac{OPEX\ costs_t}{(1+r)^t}$$

r = market interest rate
T = lifetime of Solar PV (i.e. 20 yrs)

Note, for simplification, the net-metering calculation is not adjusted to account for differences in length of the netting period. It is implicitly assumed that household electricity consumption is high enough to re-coup all the net bill savings.

Consumer preferences and willingness to pay for solar PV

The table below shows summary results from a literature review to assess households' willingness to pay for solar PV (after accounting for perceptions of non-financial aspects such as aesthetics, risk and other barriers)

Source	Scope of Study	Countries covered	Key results or findings
Gährs et al. (2016), 'Acceptance of Ancillary Services and Willingness to Invest in PV-storage-systems'.	A face-to-face interview of 500 private Solar PV owners in Germany about their willingness to invest in battery storage systems.	Germany	Mean expected rate of return for PV storage: 7.4% (self-consumption optimising); 8.2% (grid relieving operational mode)
Claudy, M., O'Driscoll, A. Duffy, A. (2010), 'Home Owners' Attitudes, Perceptions and Willingness to Pay for Microgeneration Technologies'.	Used a survey of 1012 Irish homeowners to evaluate awareness of, attitudes to and perceptions of microgeneration technologies (incl Solar PV). It assesses home owners willingness to pay for Solar PV and other microgeneration technologies.	Ireland	Mean willingness to pay for Solar Panels = €4,254 (8.5yr payback period)
NERA (2015), 'Electricity Generation Costs and Hurdle Rates Lot 1: Hurdle Rates update for Generation Technologies'	To evaluate investor hurdle rates (the minimum rate of return for investment) for a range of generating technologies (including Solar PV >5MW).	UK	Hurdle Rate for Solar PV >5MW in 2015 (real, pre-tax): 6.5%-9.4%
Oxera (2011), 'Discount rates for low-carbon and renewable generation technologies'	Identified the main drivers of discount rates for low-carbon electricity generating technologies, taking into account both technological and market risks.	UK	Discount rate for Solar PV (real, pre-tax): 6%-9%
Parsons Brinkerhoff, Ricardo AEA (2015), 'Small-scale generation costs update'	Used a homeowner survey to calculate the required rate of return on investment, asking homeowners: "What is the maximum payback time you would be willing to accept for this installation (years)?".	UK	6.2% expected rate of return on investment

The impact of solar panels on the price and saleability of domestic properties in Oxford'	Used a survey to assess how Solar PV affected peoples' home-purchasing decisions	Oxford, UK	The study found that for around half of the prospective buyers surveyed, the presence of solar panels would not affect their purchase decision. The study hypothesises that this ambivalence partially stems from a lack of information about the potential energy bill savings.
Wissink, T.P. 'Home buyers appreciation of installed photovoltaic systems: A discrete choice experiment'	A survey to assess the behaviour of home buyers regarding installed Solar PV systems	Netherlands	Willingness to pay for Solar PV: €5000-€7000. 22% of respondents attributed zero value to the Solar PV system.
Hoen, B. (2016), 'Residential Solar Energy, Property Values and Real Estate: Vote Solar Webinar'	Impacts of residential solar energy on property values	US	Average US house price premium = $3,780/kW Solar PV (based on 2012 sales data)

10 Annex 2: Baseline take-up of residential solar PV

Belgium (Flanders)

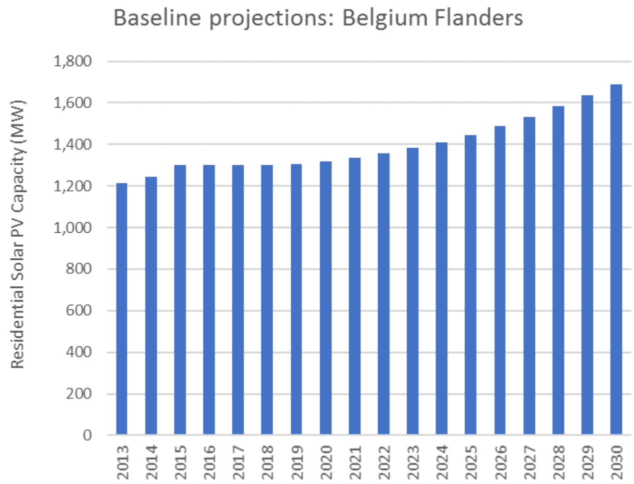
KEY POLICIES – BELGIUM (FLANDERS)[263]

Type of scheme: Net metering
Start/end: 2010 - current
Eligibility: Installations with a maximum capacity of 10 kW are eligible
Other information: There is no direct financial compensation for the injected electricity, but the financial equivalent of the injected kW is deducted from the overall electricity bill. However, if an installation feeds more electricity into the grid than it has taken from the grid during a billing period, this amount is not financially reimbursed.

Type of scheme: Prosumer tariff
Value: It depends on the electricity distributor - from 105.92 €/kVA/year (Gaselwest) to 80.98 €/kVA/year (Imea)
Start/end: July 2015 - current
Eligibility: All installations with a maximum capacity of 10 kVA connected to a low-tension energy grid and benefiting from net metering

ASSUMPTIONS – BELGIUM (FLANDERS), 2030

Technical potential for residential solar PV (MW):	7,327
Capex cost (€14/kW):	1,364
Load factor:	0.11
Size of average residential solar PV installations (kW):	3.87
Interest rate (%):	2.0%
Required real rate of return on investment (%):	5.0%
Electricity price (€14/MWh):	0.27



	2015	2020	2025	2030
Residential solar PV capacity (MW)	1,301	1,319	1,447	1,691
Share of technical potential for residential solar PV	19.4%	19.1%	20.3%	23.1%
Number of residential solar PV prosumers (000s)	336	340	373	436

263 Source: Res Legal (2017) and Eandis (2016)

Share of households that invest in residential solar PV	7.1%	7.0%	7.5%	8.5%
Mean payback period for residential solar PV (years)	14.7	14.9	14.1	13.4

Belgium (Wallonia)

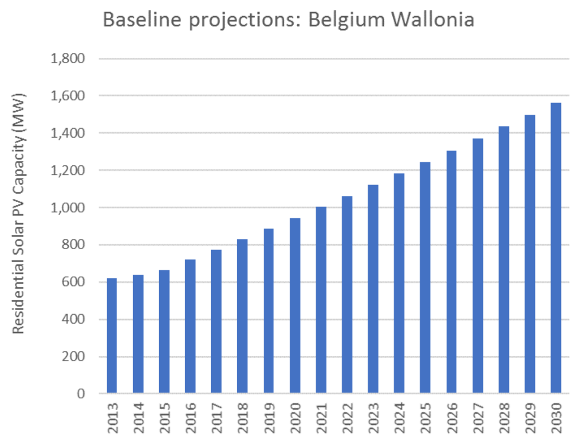
KEY POLICIES – BELGIUM (WALLONIA)[264]

Type of scheme: Net metering (Mécanisme de compensation)
Value: N/A
Start/end: 2001 - current
Eligibility: Prosumers producing through a renewable energy plant with a capacity <= 10 kVA and connected to the distribution grid.
Other information: The prosumer benefits from the compensation mechanism for the period between two meter-readings. The compensation mechanism remains valid only during the technical life span of the installation.

Type of scheme: Subsidy (Qualiwatt)
Value: between € 164.73 and € 202.30 per kWp from 1 January 2017 to 30 June 2017.
Start/end: 2014 - current
Eligibility: Solar PV installations less than or equal to 10 kW are eligible.
Other information: The amount of the subsidy is calculated in order to allow the PV producer to achieve a return on investment after 8 years, along with a return rate of 5% over the lifetime of the PV installation (6.5% for clients and self-producers with precarious income). The subsidy is calculated on the basis of the average cost per kWp of an installation of 3 kWp. In general, the amount of the bonus granted to the producer of photovoltaic electricity remains the same during the 5 years in which it is granted.

ASSUMPTIONS – BELGIUM (WALLONIA), 2030

Technical potential for residential solar PV (MW):	3,753
Capex cost (€14/kW):	1,364
Load factor:	0.11
Size of average residential solar PV installations (kW):	3.87
Interest rate (%):	2.0%
Required real rate of return on investment (%):	5.0%
Electricity price (€14/MWh):	0.27



	2015	2020	2025	2030
Residential solar PV capacity (MW)	666	944	1,244	1,564
Share of technical potential for residential solar PV	19.4%	26.6%	34.1%	41.7%
Number of residential solar PV prosumers (000s)	172	244	321	404

[264] Source: Res Legal (2017) and Milieu country report

Share of households that invest in residential solar PV	3.7%	5.0%	6.4%	7.9%
Mean payback period for residential solar PV (years)	6.9	5.2	4.6	4.0

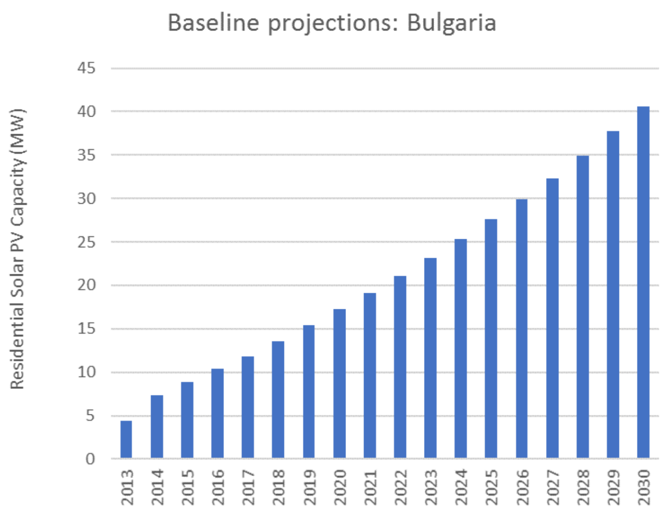
Bulgaria

KEY POLICIES - BULGARIA[265]

Type of scheme: Feed-in-Tariff
Value: €0.1306/kWh (excl. tax) (≤5kW)
Start/end: 2011 - current
Eligibility: A higher FiT rate is available for installations of ≤5kW and a lower rate for installations >5kW

ASSUMPTIONS – BULGARIA, 2030

Technical potential for residential solar PV (MW):	2,800
Capex cost (€14/kW):	1,591
Load factor:	0.15
Size of average residential solar PV installations (kW):	2.91
Interest rate (%):	3.9%
Required real rate of return on investment (%):	6.0%
Electricity price (€14/MWh):	0.13



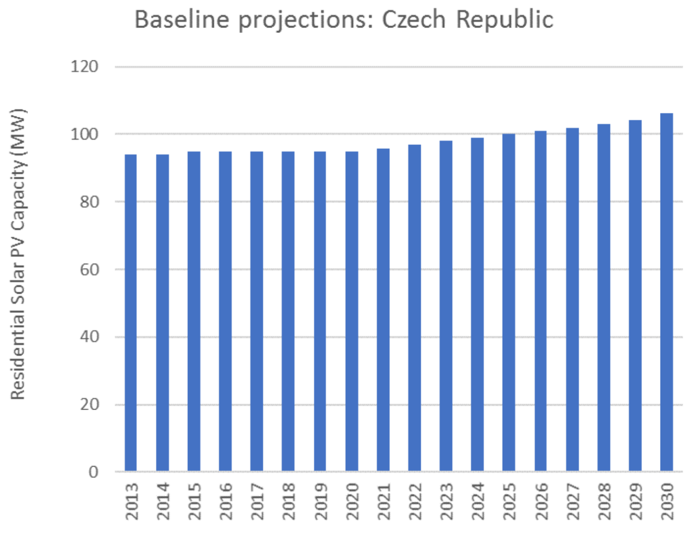
	2015	2020	2025	2030
Residential solar PV capacity (MW)	9	17	28	41
Share of technical potential for residential solar PV	0.3%	0.6%	0.9%	1.4%
Number of residential solar PV prosumers (000s)	3	6	10	14
Share of households that invest in residential solar PV	0.1%	0.2%	0.3%	0.5%

265 Source: Res Legal (2017)

Mean payback period for residential solar PV (years)	17.6	16.0	14.2	12.5

Czech Republic

KEY POLICIES – CZECH REPUBLIC[266]	ASSUMPTIONS – CZECH REPUBLIC, 2030	
Type of scheme: Feed-in-Tariff Value: CZK 2,632 (€ 97) per MWh in 2013 Q2 Start/end: 2010-2013 Eligibility: Capacity of up to 30 kW in case of rooftop or façade PV installation. Other information: Guaranteed for 20 years. Type of scheme: Premium Tariff: Green Bonus Value: CZK 1,932 (€ 72) per MWh in 2013 Q2 Start/end: 2010-2013 Other information: Guaranteed for 20 years. Subject to a tax of 11% (except for building-integrated installations with a capacity of up to 30 kW)	Technical potential for residential solar PV (MW):	4,167
	Capex cost (€14/kW):	1,591
	Load factor:	0.12
	Size of average residential solar PV installations (kW):	3.10
	Interest rate (%):	1.9%
	Required real rate of return on investment (%):	5.7%
	Electricity price (€14/MWh):	0.15



	2015	2020	2025	2030
Residential solar PV capacity (MW)	95	95	100	106
Share of technical potential for residential solar PV	2.3%	2.3%	2.4%	2.6%
Number of residential solar PV prosumers (000s)	31	31	32	34
Share of households that invest in residential solar PV	0.7%	0.7%	0.7%	0.7%
Mean payback period for residential solar PV (years)	38.2	35.0	32.3	29.9

[266] Source: Res Legal (2017)

Denmark

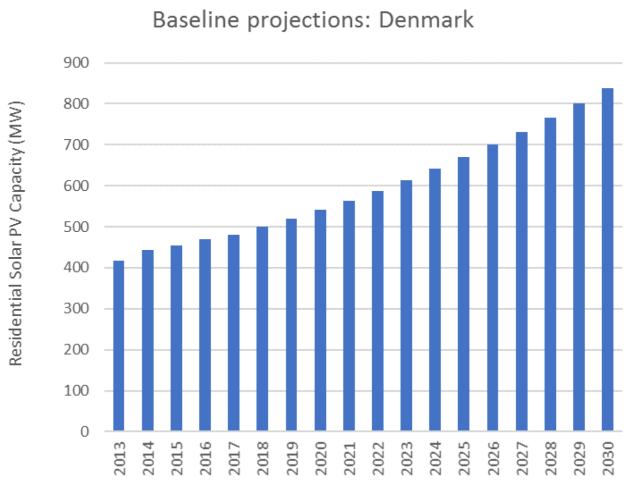
KEY POLICIES - DENMARK[267]

Type of scheme: Net-metering
Value: Retail price (hourly netting period)
Start/end: current
Eligibility: Solar energy installations up to 50 kW and connected to a private supply system
Other information: Participation in a net metering scheme authorises exemptions to paying a Public Service Obligation (PSO). Solar energy installations ≤50kW are exempt from paying the whole PSO tariff if the installation is 100% owned by the property owner.

Type of scheme: Premium Tariff
Value: Dependent on market price and statutorily maximum. For Solar PV capacity installed before 2014, the maximum subsidy (bonus plus market price) is 1.30 DKK (approx. €0.17) per kWh, applicable for 10 years after connection. For Solar PV connected from 2014, the bonus is reduced annually by 0.14 DKK (€0.02). The maximum subsidy for installations in 2016 is 0.88 DKK/kWh (approx. €0.12) and in 2017 0.74 DKK/kWh (approx. €0.10)
Start/end: current
Eligibility: Non-commercial RES systems <6 kW
Other information: A bonus on top of the market price. The sum of the bonus and the market price should not exceed a statutory maximum.

ASSUMPTIONS – DENMARK, 2030

Technical potential for residential solar PV (MW):	4,474
Capex cost (€14/kW):	1,506
Load factor:	0.09
Size of average residential solar PV installations (kW):	4.70
Interest rate (%):	2.1%
Required real rate of return on investment (%):	6.2%
Electricity price (€14/MWh):	0.35



	2015	2020	2025	2030
Residential solar PV capacity (MW)	454	541	670	838
Share of technical potential for residential solar PV	11.3%	12.9%	15.4%	18.7%
Number of residential solar PV prosumers (000s)	97	115	142	178
Share of households that invest in residential solar PV	4.1%	4.7%	5.6%	6.8%
Mean payback period for residential solar PV (years)	10.8	9.9	9.1	8.3

[267] Source: Res Legal (2017)

Germany

KEY POLICIES - GERMANY[268]

Type of scheme: Feed-in Tariff or FiT (Renewable Energy Act (EEG))
Value: €0.123/kWh (annual average rate for 2016)
Start/end: 2000 - current
Eligibility: Small RES-E plants ≤ 100kW, different Feed-in Tariff depending on the size of installation.
Other information: Producers are guaranteed a Feed-in Tariff rate for 20 years (from first day of solar PV installation), paid out on all electricity produced by residential prosumer. Electricity capacity of the grid became overloaded and in 2009, a "self-consumption bonus" was introduced, this allowed producers of solar power to receive an additional payment from the support scheme - a reduced FiT rate for the self-consumed power they did not feed into the grid. The self-consumption bonus was ineffective due to the high cost of battery storage, the maximum self-consumption a household could achieve was only 20%. This meant that in 2012 the additional "self-consumption bonus" was phased out. Instead, in 2012, the FiT rate was supplemented by the introduction of a floating Feed-in-Premium (or FiP). Plant operators could switch monthly between FiT and the FiP or may benefit proportionately from both. The FIP is linked to the market price of solar energy.

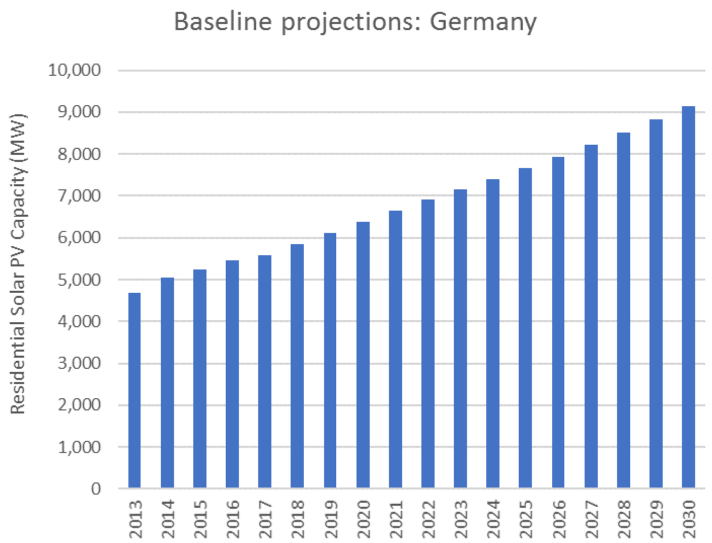
Type of scheme: Tax exemption (on EEG surcharge)
Value: €0.0635/kWh (annual rate in 2016)
Start/end: current
Eligibility: Solar PV installations up to 10kWp are exempt from general EEG surcharge and the EEG self-consumption surcharge
Other information: Solar PV installations up to 10kWp are exempt from the EEG surcharge on the self-consumed electricity.
Other information: The EEG surcharge is an additional fee attached to the price of electricity. It was put in place to pay for the FiT and premiums paid out to producers of solar energy (and other renewable energy sources). In 2014 concerns for welfare meant the EEG surcharge was extended to self-consumed electricity. As of August 2014 consumers had to pay the EEG-surcharge not only on electricity consumed from the grid but also on self-generated electricity. However, it was later decided that residential prosumers with an installed capacity up to 10kW were exempt from the EEG-surcharge on the self-generated electricity (for a maximum of 10 megawatt hours of self-consumed electricity per calendar year). This decision was informed by a commissioned study that found it was not cost effective if prosumers had to pay the EEG-surcharge on self-generated electricity, thus they were made exempt from the policy. Solar PV systems greater than 10kWp normally received only partial exemption (60% exemption). They remained, however, fully exempted under some specific conditions.

ASSUMPTIONS – GERMANY, 2030

Technical potential for residential solar PV (MW):	23,150
Capex cost (€14/kW):	1,189
Load factor:	0.11
Size of average residential solar PV installations (kW):	3.75
Interest rate (%):	1.8%
Required real rate of return on investment (%):	6.0%
Electricity price (€14/MWh):	0.31

[268] Source: Res Legal (2017), Milieu country report and IEA-RETD (2014)

KEY POLICIES – GERMANY (CONT.) [269]
Type of scheme: 100,000 roof programme Value: Interest rate of 4.5 percent below market conditions Start/end: 1999 - 2003 Eligibility: Installations larger than 1kWp Capacity cap: Government plans to discontinue FIT when a total of 52 GW of installed capacity is reached. Currently a cap of 2.5GW is in place which triggers a monthly reduction in the FIT rate.

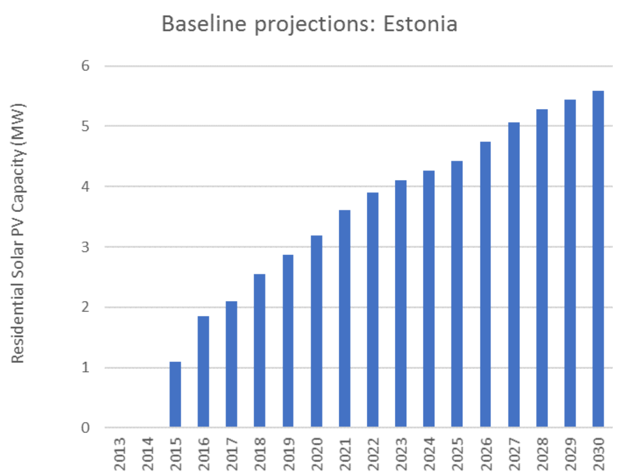


	2015	2020	2025	2030
Residential solar PV capacity (MW)	5,240	6,383	7,669	9,138
Share of technical potential for residential solar PV	23.6%	27.9%	33.2%	39.5%
Number of residential solar PV prosumers (000s)	1,396	1,701	2,043	2,435
Share of households that invest in residential solar PV	3.5%	4.1%	4.9%	5.8%
Mean payback period for residential solar PV (years)	10.3	9.7	8.9	8.2

[269] Source: Res Legal (2017), Milieu country report and IEA-RETD (2014)

Estonia

KEY POLICIES - ESTONIA[270]	ASSUMPTIONS – ESTONIA, 2030	
Type of scheme: Feed-in Tariff Value: 0.0537 €/kWh Start/end: 2007 - current (amended in 2012) Eligibility: Applies to renewable installations with capacity <100MW. Only electricity supplied to the network qualifies for the support (own consumption is not subsidised). The support is paid for a period of 12 years from the date of commission. Other information: The prosumer pays a one-time charge for connecting to the grid but, for residential prosumers, this usually includes only the cost of a meter and its installation.	Technical potential for residential solar PV (MW):	328
	Capex cost (€14/kW):	1,591
	Load factor:	0.07
	Size of average residential solar PV installations (kW):	4.00
	Interest rate (%):	2.2%
	Required real rate of return on investment (%):	6.2%
	Electricity price (€14/MWh):	0.15



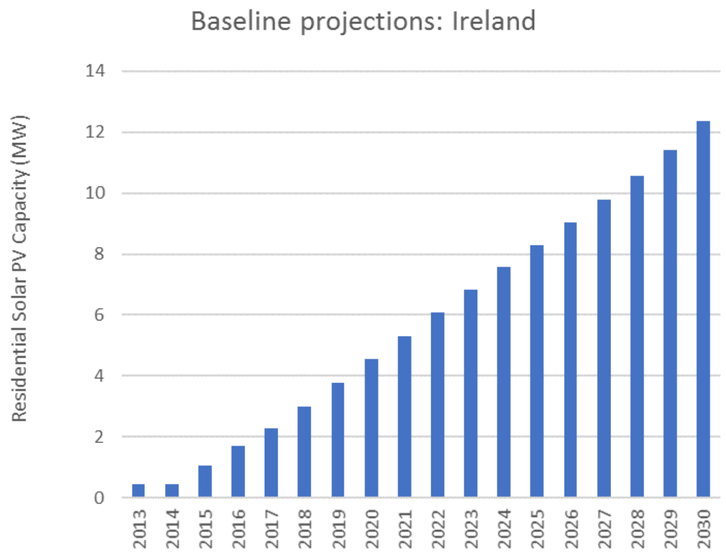
	2015	2020	2025	2030
Residential solar PV capacity (MW)	1	3	4	6
Share of technical potential for residential solar PV	0.3%	1.0%	1.3%	1.7%
Number of residential solar PV prosumers (000s)	0	1	1	1
Share of households that invest in residential solar PV	0.0%	0.1%	0.2%	0.2%
Mean payback period for residential solar PV (years)	47.7	45.7	40.5	35.8

[270] Source: IEA (2017) and Milieu country report

Ireland

KEY POLICIES - IRELAND[271]
No schemes currently in place to incentivise residential self-generation of Solar PV. Other information: No payment or benefits are received for surplus electricity that is unloaded to the grid. There is no charge to connect a micro-generator to the ESB network but the current installation fee for an import/export meter is €340 (incl. VAT).

ASSUMPTIONS – IRELAND, 2030	
Technical potential for residential Solar PV (MW):	3,045
Capex cost (€14/kW):	1,591
Load factor:	0.09
Size of average residential Solar PV installations (kW):	2.61
Interest rate (%):	3.2%
Required real rate of return on investment (%):	6.7%
Electricity price (€14/MWh):	0.23



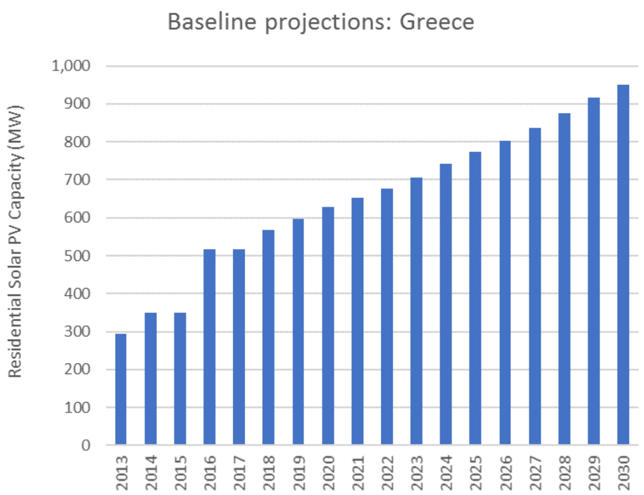
	2015	2020	2025	2030
Residential Solar PV capacity (MW)	1	5	8	12
Share of technical potential for residential Solar PV	0.0%	0.2%	0.3%	0.4%
Number of residential Solar PV prosumers (000s)	0	2	3	5
Share of households that invest in residential Solar PV	0.0%	0.1%	0.2%	0.2%
Mean payback period for residential Solar PV (years)	32.1	31.2	29.0	27.0

[271] Source: Milieu country report

Greece

KEY POLICIES - GREECE[272]
Type of scheme: Net metering Value: Retail price (annual netting period) Start/end: 2014- current Eligibility: PV plants <20kW for the interconnected system and <10kW for non-interconnected islands connected to low voltage distribution network are eligible. Type of scheme: Feed-in Tariff Value: 0.105 €/kWh for surplus electricity sold to the grid (net of the total consumed each year). Planned to be gradually reduced each year, reaching 0.08.0 €/kWh by Aug. 2019. Start/end: 2010 - current Eligibility: Applies if electricity exported to the grid exceeds total electricity consumption. Tariff is paid for 25 years from installation date. Roof-mounted PV installations of up to 10 kWp on the mainland and rooftop off-grid installations of up to 5 kWp.

ASSUMPTIONS – GREECE, 2030	
Technical potential for residential Solar PV (MW):	3,467
Capex cost (€14/kW):	1,591
Load factor:	0.17
Size of average residential Solar PV installations (kW):	3.53
Interest rate (%):	2.7%
Required real rate of return on investment (%):	6.9%
Electricity price (€14/MWh):	0.22



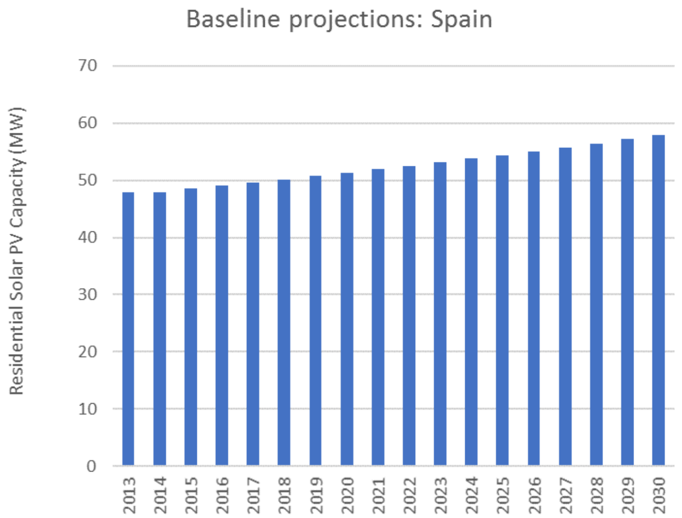
	2015	2020	2025	2030
Residential Solar PV capacity (MW)	350	629	773	950
Share of technical potential for residential Solar PV	9.2%	17.1%	21.6%	27.4%
Number of residential Solar PV prosumers (000s)	99	178	219	269
Share of households that invest in residential Solar PV	2.3%	4.2%	5.3%	6.7%
Mean payback period for residential Solar PV (years)	10.1	9.3	8.4	7.6

[272] Source: Res Legal (2017)

Spain

KEY POLICIES - SPAIN[273]
Type of scheme: Economic retribution (compensación económica) for electricity discharged back to the grid. Value: N/A Eligibility: Type 1 prosumers (i.e. residential prosumers with installed capacity <100kW and not directly connected to a wholesaler or intermediary) are ineligible for the retribution. Type 1 prosumers can discharge energy back to the grid but will not receive any kind of economic retribution for it. Type 2 prosumers (i.e. prosumers that can directly sell electricity to the wholesale market or via an intermediary) will be retributed at the market price at the time (hour) that it is discharged to the grid. Type of scheme: Feed-in-Tariff: Régimen Especial Value: 0.274 €/kWh in 2011Q3 Start/end: 2008-2011 Eligibility: A higher rate for installations of <20kW and a lower rate for installations >20kW Other information: Guaranteed for 30 years.

ASSUMPTIONS – SPAIN, 2030	
Technical potential for residential Solar PV (MW):	13,620
Capex cost (€14/kW):	1,208
Load factor:	0.19
Size of average residential Solar PV installations (kW):	3.94
Interest rate (%):	1.9%
Required real rate of return on investment (%):	5.5%
Electricity price (€14/MWh):	0.21



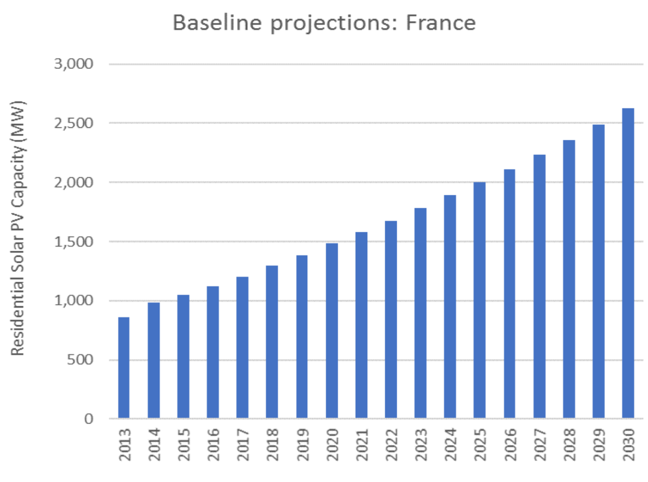
	2015	2020	2025	2030
Residential Solar PV capacity (MW)	49	51	54	58
Share of technical potential for residential Solar PV	0.4%	0.4%	0.4%	0.4%
Number of residential Solar PV prosumers (000s)	12	13	14	15
Share of households that invest in residential Solar PV	0.1%	0.1%	0.1%	0.1%
Mean payback period for residential Solar PV (years)	19.6	21.6	20.7	19.8

[273] Source: Milieu country report

France

KEY POLICIES - FRANCE[274]
Type of scheme: Feed-in Tariffs (contrat pour l'achat de l'électricité) Value: For simple integrated systems <=36 kWp, annual average FiT in 2016 was 13.08 c/kWh Start/end: 2005 - current Eligibility: Different FiT rates apply to fully integrated and simple integrated systems. Other information: Feed in Tariffs are paid for 20 years; income from Feed-in-Tariffs is exempt from income tax; every quarter digression coefficients are adjusted to the number of grid connection requests adopted in the previous quarter but the reduction in tariff rates is never more than 20% per year
Type of scheme: Tax exemption Value: Exemption from CSPE Eligibility: Only prosumers that consume all the electricity they produce
Type of scheme: Reduced rate of VAT Value: 10% VAT charged on Solar PV systems and installation Eligibility: Only valid for Solar PV installations <3kWp

ASSUMPTIONS – FRANCE, 2030	
Technical potential for residential Solar PV (MW):	39,810
Capex cost (€14/kW):	2,762
Load factor:	0.12
Size of average residential Solar PV installations (kW):	3.24
Interest rate (%):	1.5%
Required real rate of return on investment (%):	6.0%
Electricity price (€14/MWh):	0.20



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	1,049	1,484	2,000	2,623
Share of technical potential for residential Solar PV	2.8%	3.9%	5.1%	6.6%
Number of residential Solar PV prosumers (000s)	324	458	617	809
Share of households that invest in residential Solar PV	1.1%	1.6%	2.0%	2.6%
Mean payback period for residential Solar PV (years)	25.1	23.4	21.1	19.0

[274] Source: Res Legal (2017), Milieu country report, photovoltaique.info and les-energies-renouvelables.eu

Croatia

KEY POLICIES - CROATIA[275]

Type of scheme: Loan (The Environmental Protection and Energy Efficiency Fund)[276]
Value: Interest-free loans, subsidies, financial assistance and donations to renewable energy projects, exact amount is defined in contract
Start/end: 2004-current
Eligibility: Tendering process

Type of scheme: Premium tariff (TPi)[277]
Value: Calculated yearly based on formula (see below)
Start/end: 2016-current
Eligibility: To qualify for premium tariffs, prosumers must meet a number of conditions. They must have a connection to the grid and a meter enabling calculation of net electricity fed to the grid
Other information: The premium is the additional amount paid out to producers as well as the revenue from the sale of electricity if the Croatian Energy Market Operator (HROTE) has selected them as lowest bidder in a public tender. The premium is calculated via the formula: Tpi = RV - Tci
Where RV is the reference value of electric energy (in the accounting period) and Tci is the reference market price.

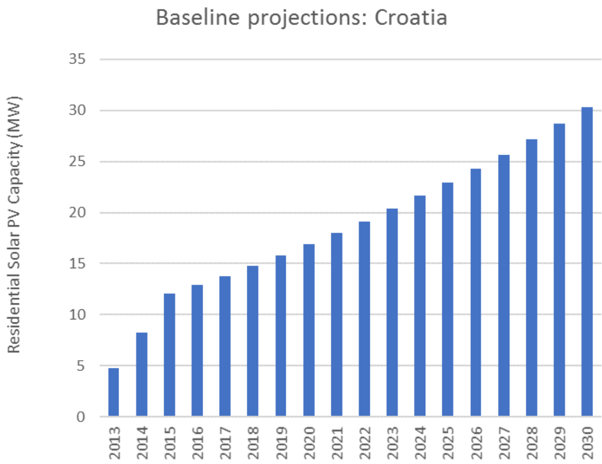
Type of scheme: Guaranteed purchase price
Value: Guaranteed price
Start/end: 2012 - current
Eligibility: PV installations ≤ 30kW and selected as the lowest bidder in a public tender.
Other information: The plant operator (successful in winning the bid) agree upon a price with the Croatian Energy Regulatory Agency (HERA), this price is fixed for the length of the contract.

Type of scheme: Feed-in Tariff (FiT)
Value: 1.10 HRK/kWh (0.145€/kWh)
Start/end: 2013 - 2015
Eligibility: PV installations ≤ 1MW
Other information: 14 year payment term

ASSUMPTIONS – CROATIA, 2030

Technical potential for residential Solar PV (MW):	2,524
Capex cost (€14/kW):	1,591
Load factor:	0.14
Size of average residential Solar PV installations (kW):	3.98
Interest rate (%):	3.2%
Required real rate of return on investment (%):	6.0%
Electricity price (€14/MWh):	0.16

[275] Source: Res Legal (2017) and Milieu country report
[276] Not modelled due to insufficient data
[277] Not modelled due to insufficient data



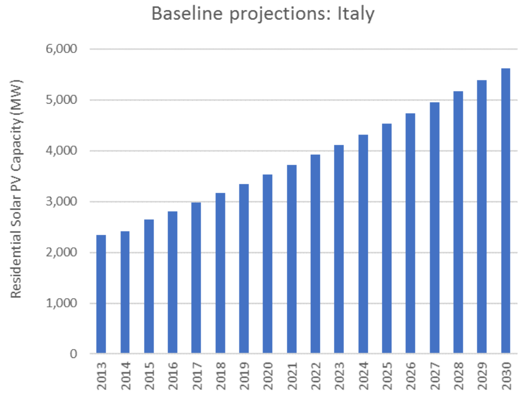
	2015	2020	2025	2030
Residential Solar PV capacity (MW)	12	17	23	30
Share of technical potential for residential Solar PV	0.4%	0.6%	0.9%	1.2%
Number of residential Solar PV prosumers (000s)	3	4	6	8
Share of households that invest in residential Solar PV	0.2%	0.3%	0.4%	0.5%
Mean payback period for residential Solar PV (years)	8.2	15.8	14.3	12.9

Italy

KEY POLICIES - ITALY[278]
Type of scheme: Feed-in Tariff (Ritiro Dedicato) Value: Average export tariff of 0.431c/kWh across regions in 2016 during F1 time slots (i.e. Monday - Friday at 8:00-18:00) Start/end: 2008 - current Eligibility: Solar PV installations <100kWp Other information: Prosumers with Solar PV capacity >3kWp, must pay the Manager of Electricity Services GSE a fee to cover the costs of management of the scheme. The cost changes each year and is dependent on installation size. For Solar PV with capacity between 1 and 20 kW, the cost is 0.7 €/kW.
Type of scheme: Net metering (Scambio sul Posto) Start/end: 2006 - current Eligibility: For installations between 20-200kW (if commissioned in 2008 or later). Installations <20kW are eligible (if commissioned in 2007 or earlier). Other information: remuneration based on time-of-use prices
Type of scheme: Reduced rate of VAT Value: 10% VAT charged on Solar PV systems
Type of scheme: Income tax credits Value: 50% deduction to the installation of Solar PV up to 20 kW for residential applications and self-consumption
Type of scheme: Building regulations Value: There are 979 municipalities (out of 7,987) that have introduced within the Municipal Building Regulations a mandatory installation of Solar PV.

ASSUMPTIONS – ITALY, 2030	
Technical potential for residential Solar PV (MW):	24,869
Capex cost (€14/kW):	1,974
Load factor:	0.14
Size of average residential Solar PV installations (kW):	3.73
Interest rate (%):	2.1%
Required real rate of return on investment (%):	6.0%
Electricity price (€14/MWh):	0.26

278 Source: IEA (2014), GSE (2017) and Milieu country report



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	2,640	3,532	4,526	5,614
Share of technical potential for residential Solar PV	10.5%	14.1%	18.1%	22.6%
Number of residential Solar PV prosumers (000s)	709	948	1,215	1,507
Share of households that invest in residential Solar PV	2.7%	3.7%	4.7%	5.9%
Mean payback period for residential Solar PV (years)	6.0	6.6	6.1	5.6

Cyprus

KEY POLICIES - CYPRUS [279]

Type of scheme: Net metering
Value: N/A
Start/end: 2013 - current
Eligibility: Residential consumers connected to the grid with Solar PV capacity <3kWp (or 5kWp). Scheme last 10 years.
Other information: cost of €250 + VAT to submit application to the scheme, grid charges of 47.23 €/kWp/year

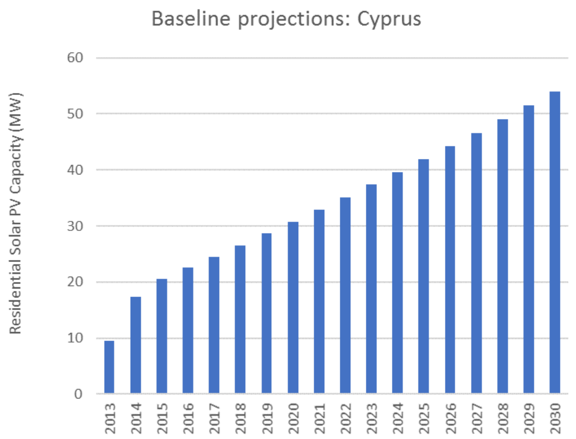
Type of scheme: Subsidy
Value: €900 per kW (max of €2,700 per installation)
Start/end: 2013 - current
Eligibility: Vulnerable households with Solar PV capacity <3kWp
Other information: 1.2MW of Solar PV installations can be subsidised in aggregate

Capacity cap: 5MW annual cap for installations <500kWp

ASSUMPTIONS – CYPRUS, 2030

Technical potential for residential Solar PV (MW):	732
Capex cost (€14/kW):	1,591
Load factor:	0.19
Size of average residential Solar PV installations (kW):	5.63
Interest rate (%):	3.0%
Required real rate of return on investment (%):	5.7%
Electricity price (€14/MWh):	0.14

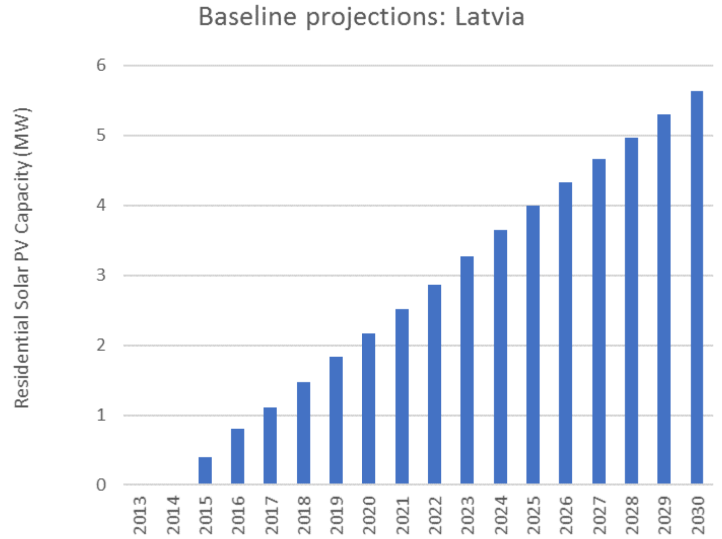
[279] Source: Milieu country report; Kontos (2015), 'Net metering Policy and Electricity Market in Cyprus', available online at: http://www.raee.org/fileadmin/user_upload/mediatheque/raee/Documents/Publications/Recueil_interventions/2015/PVNET_MARS2015/2_CYPRUS_DSO_06_March_2015.pdf



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	21	31	43	56
Share of technical potential for residential Solar PV	3.1%	4.5%	6.0%	7.6%
Number of residential Solar PV prosumers (000s)	4	6	8	10
Share of households that invest in residential Solar PV	1.3%	1.8%	2.5%	3.1%
Mean payback period for residential Solar PV (years)	7.5	9.0	8.6	8.1

Latvia

KEY POLICIES - LATVIA[280]	ASSUMPTIONS – LATVIA, 2030	
Type of scheme: Net metering Value: Electricity compensation at retail price (annual netting period) Start/end: 2005 - current Eligibility: Household Solar PV installations <11kWp, with installation <400V and grid connection size ≤3x16A Other information: To receive permission to install Solar PV, prosumers must pay for an assessment by Sadales tīkls that costs €59.00 (incl. VAT 21%) Type of scheme: Income tax Value: 10% for renewable energy sources Start/end: N/A Eligibility: Income from electricity generated	Technical potential for residential Solar PV (MW):	368
	Capex cost (€14/kW):	1,591
	Load factor:	0.07
	Size of average residential Solar PV installations (kW):	2.49
	Interest rate (%):	2.7%
	Required real rate of return on investment (%):	7.0%
	Electricity price (€14/MWh):	0.20



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	0	2	4	6
Share of technical potential for residential Solar PV	0.1%	0.5%	1.0%	1.5%
Number of residential Solar PV prosumers (000s)	0	1	2	2
Share of households that invest in residential Solar PV	0.0%	0.1%	0.2%	0.3%
Mean payback period for residential Solar PV (years)	27.4	25.3	22.8	20.5

[280] Source: Res Legal (2017), European Commission (2015) and Milieu country report

Lithuania

KEY POLICIES - LITHUANIA[281]

Type of scheme: Sliding Feed-in Premium (FiP)
Value: €0.136/kWh (installations not integrated in buildings) is value of guaranteed Feed-in-Tariff for first half of 2017
Start/end: 2011-2017
Eligibility: PV installations ≤ 10kW are eligible, installations not integrated in buildings receive a small FIT rate (see above), installations integrated with buildings receive slightly higher FiT (€0.169/kWh)
Other information: The sliding FiP ensures the prosumer receives the best available price. The guaranteed FiT is decided once a quarter (see value above), if the sale of electricity is greater than the FiT a premium is paid out (equal to the difference), and if the sale of electricity is less than the FiT the prosumer is remunerated by the value of the FiT. The sliding FiP is available for 12 years from the moment of signing an agreement for the connection to the grid with the grid operator. Remuneration is only paid out on a maximum of 50% of electricity generated.

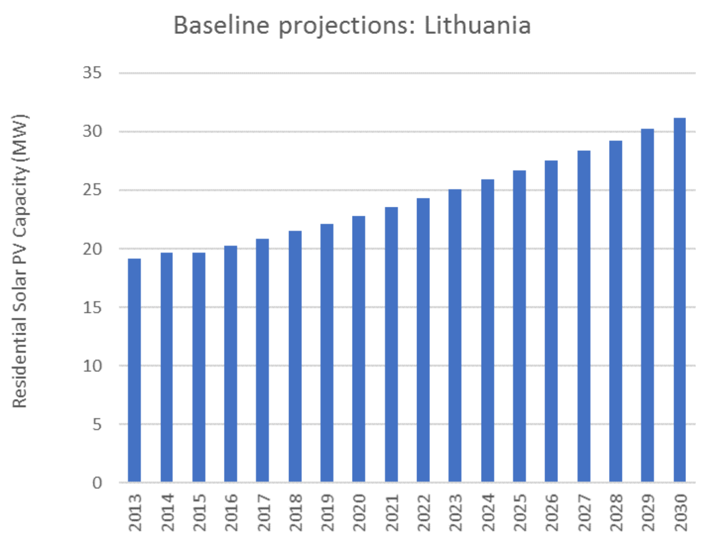
Type of scheme: Net-metering
Eligibility: Residential Solar PV installations ≤ 10kW
Other information: After each year, if the quantity of electricity consumed by the prosumer is greater than the quantity supplied by the prosumer to the electrical grid, then the prosumer pays for the difference at a rate set in the contract between the customer and the electricity supplier. If the quantity supplied to the grid exceeds what the prosumer consumes then this amount is not carried forward into the next year and the prosumer is not paid for the excess. The residential prosumer is obliged to cover up to 20% of the expenses for connection to the grid, and up to 10% of operator expenses (necessary improvements needed to allow residential prosumer access to the grid). The residential prosumer must also pay a usage fee.

Type of scheme: Subsidy (Climate Change Special Programme)
Value: Max level of funding for small-scale projects is €14,500, amount of subsidy should not exceed 80% of the entire eligible expenses for a project.
Start/end: 2009-current
Eligibility: Non-economic or commercial investment projects

Type of scheme: Exemption on excise tax on electricity
Value: €1.01 per MWh
Start/end: 2002-current
Eligibility: Non-economic or commercial investment projects

[281] Source: Res Legal (2017) and Milieu country report

ASSUMPTIONS – LITHUANIA, 2030	
Technical potential for residential Solar PV (MW):	805
Capex cost (€14/kW):	1,591
Load factor:	0.08
Size of average residential Solar PV installations (kW):	2.52
Interest rate (%):	2.0%
Required real rate of return on investment (%):	5.7%
Electricity price (€14/MWh):	0.17



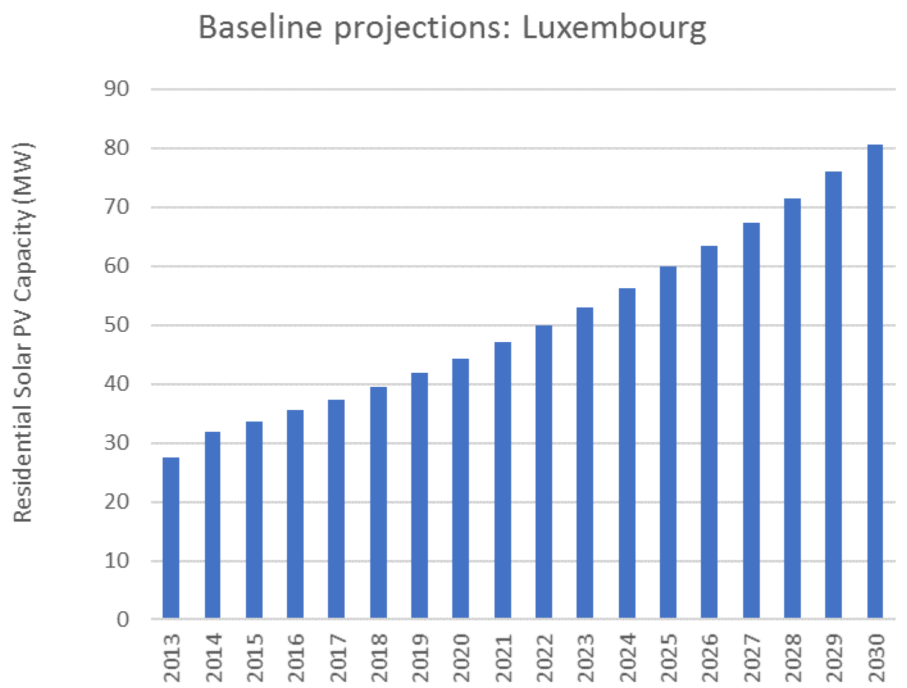
	2015	2020	2025	2030
Residential Solar PV capacity (MW)	20	23	27	31
Share of technical potential for residential solar PV	2.0%	2.5%	3.1%	3.9%
Number of residential solar PV prosumers (000s)	8	9	11	12
Share of households that invest in residential Solar PV	0.6%	0.7%	0.9%	1.1%
Mean payback period for residential Solar PV (years)	20.5	19.1	17.3	15.6

Luxembourg

KEY POLICIES - LUXEMBOURG[282]
Type of scheme: Feed-in Tariff (FiT) Value: 0.264€/kWh (2014) Start/end: 2008-current (amended in 2013,) Eligibility: PV installation capacity ≤ 30kW Other information: Tariff rate between 2008 and 2012 was 0.42€/kWh. Remuneration is guaranteed for a period of 15 years, starting on the day of the first unit of electricity exported. After August 1 2014 Grand-Ducal Regulation (GDR) increased the tariff rates for all technologies.
Type of scheme: Premium tariff (Prime de marché) Value: Market premium (PM) Start/end: 2014-current Eligibility: PV installation capacity ≤ 30kW Other information: Prosumers can receive a variable market premium (PM) on top of the market price. The amount of PM results from the sum of the direct sales premium (PVD) and the difference between a technology-specific reference remuneration (PRR) and the monthly market price (PMM): PM = PRR – PMM + PVD. Value of PRR is €0.1694/kWh. Guaranteed for a period of 15 years, starting on the day of the first unit of electricity exported.
Type of scheme: Subsidy I Value: 20% of eligible costs, max of €500/kWp Start/end: 2012-current Eligibility: PV installation capacity ≤ 30kW Other information: Expenses that are eligible: PV modules, mounting system, wiring, inverter, electrical protection devices, meter and installation costs.

ASSUMPTIONS – LUXEMBOURG, 2030	
Technical potential for residential Solar PV (MW):	574
Capex cost (€14/kW):	1,591
Load factor:	0.10
Size of average residential Solar PV installations (kW):	5.22
Interest rate (%):	1.7%
Required real rate of return on investment (%):	6.5%
Electricity price (€14/MWh):	0.20

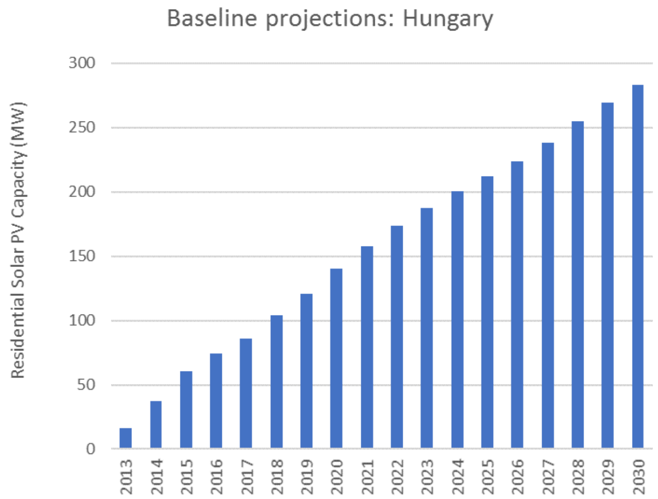
[282] Source: Res Legal (2017) and Milieu country report



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	34	44	60	81
Share of technical potential for residential Solar PV	7.9%	9.3%	11.4%	14.1%
Number of residential Solar PV prosumers (000s)	6	9	11	15
Share of households that invest in residential Solar PV	2.8%	3.3%	4.1%	5.0%
Mean payback period for residential Solar PV (years)	12.6	11.7	10.7	9.8

Hungary

KEY POLICIES - HUNGARY[283]	ASSUMPTIONS – HUNGARY, 2030	
Type of scheme: Net metering Value: Retail price (monthly, bi-annual or annual netting period dependent on agreement with grid operator) Start/end: 2007-current Eligibility: Households with a maximum capacity of 50 kVA are eligible. Other information: The electricity surplus discharged to the grid is remunerated by the electricity supplier with the electricity retail price. Households do not pay a fee to connect to the grid, but pay a network charge that is dependent on the amount of electricity consumed and the amount discharged to the grid. Type of scheme: Subsidy - Otthon melege program - a családi házak energetikai korszerűsítése Value: Up to €8,000 depending on the specific project, the financial support usually covers between 40-55% of the total costs of the investment Start/end: 2016- current Eligibility: Prosumers whose house was built before 1996, provided that the total habitable surface does not exceed 135 m2	Technical potential for residential Solar PV (MW):	5,605
	Capex cost (€14/kW):	1,591
	Load factor:	0.08
	Size of average residential Solar PV installations (kW):	3.01
	Interest rate (%):	4.8%
	Required real rate of return on investment (%):	5.5%
	Electricity price (€14/MWh):	0.14



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	61	140	212	283
Share of technical potential for residential Solar PV	1.1%	2.5%	3.8%	5.0%
Number of residential Solar PV prosumers (000s)	20	47	70	94
Share of households that invest in residential Solar PV	0.5%	1.1%	1.7%	2.3%
Mean payback period for residential Solar PV (years)	21.6	19.8	17.1	14.7

[283] Source: Res Legal (2017) and Milieu country report

Malta

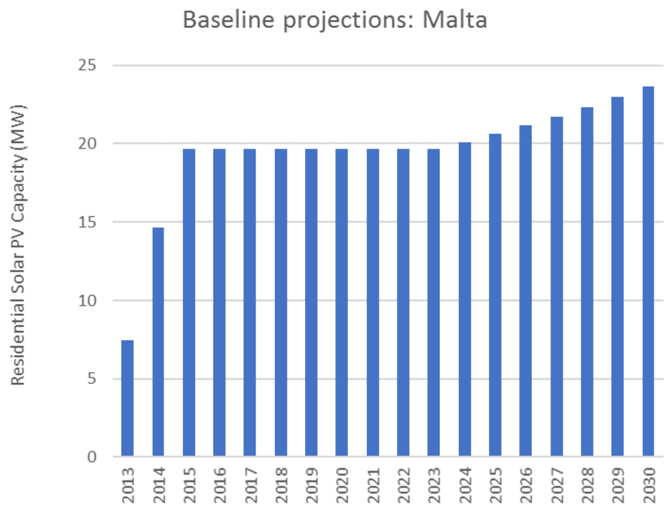
KEY POLICIES - MALTA[284]

Type of scheme: Feed-in Tariff
Value: €0.155 per kWh
Start/end: 2010-2016
Eligibility: <40kWp
Other information: Feed-in Tariffs are paid for 20 years
Capacity Cap: 8MWp per annum, for installations with capacity between 1 and 40 kWp. This was reached on 11 May 2016.

Type of scheme: Subsidy (PV grant)
Value: 50% of eligible costs of PV installation
Start/end: 2016-2017
Eligibility: Grid connected PV installations with capacity greater than 0.5kW
Other information: Max grant is €2300 per installation and € 757 per kWp minus eligible cost

ASSUMPTIONS – MALTA, 2030

Technical potential for residential Solar PV (MW):	181
Capex cost (€14/kW):	1,591
Load factor:	0.14
Size of average residential Solar PV installations (kW):	3.82
Interest rate (%):	2.9%
Required real rate of return on investment (%):	5.7%
Electricity price (€14/MWh):	0.11



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	20	20	21	24
Share of technical potential for residential Solar PV	12.4%	11.7%	11.8%	13.0%
Number of residential Solar PV prosumers (000s)	5	5	5	6
Share of households that invest in residential Solar PV	3.4%	3.2%	3.2%	3.6%
Mean payback period for residential Solar PV (years)	14.7	14.1	13.4	12.7

[284] Res Legal (2017) and Milieu country report

Netherlands

KEY POLICIES - NETHERLANDS[285]

Type of scheme: Loan
Value: Reduction in the interest rate of 1%, maximum project costs are €25,000
Start/end: 2016 - current
Eligibility: PV solar panels (Gelderland, NL province)
Other information: A tax benefit exists for consumers who invest or put their savings in a green fund. Banks offer loans at lower interest rates to 'green' projects. Each project can apply for the loan on the basis of the Regulation Green Projects 2016. In general, projects which positively affect the environment are eligible. The declaration is valid for 10 or 15 years depending on the application.

Type of scheme: Net metering and reduction of environment protection tax
Value: Electricity compensation at retail price (annual netting period). Consumer is exempt from paying tax on self-generated electricity.
Start/end: current
Eligibility: Net metering requires a connection size <3x80A
Other information: Tax is only to be paid on electricity that the prosumer has not generated. The tax payable by households per 12-month period is €ct 10.13 per kWh.

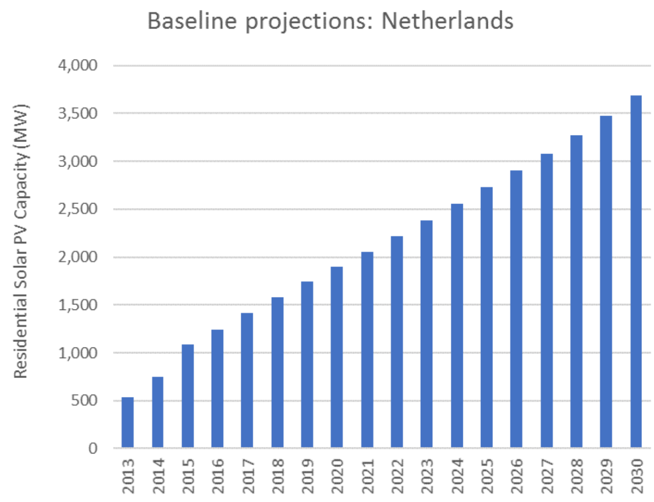
Type of scheme: Refundable VAT on solar panel purchase and installation
Value: VAT rate in NL (21%)
Start/end: 2012-current
Eligibility: Prosumer must be connected to the grid and earning income from generation, therefore the law regards the prosumers 'activity' as an 'economic activity' which makes the prosumer eligible for VAT exemption.

Type of scheme: Feed-in Tariff (FiT)
Start/end: Eligibility for residential prosumers ended in 2011
Eligibility: SDE was superseded in 2011 by the SDE+ Feed-in Tariff scheme. Residential prosumers invested in solar panels are not eligible for the new scheme.

ASSUMPTIONS – NETHERLANDS, 2030

Technical potential for residential Solar PV (MW):	13,945
Capex cost (€14/kW):	1,010
Load factor:	0.08
Size of average residential Solar PV installations (kW):	4.69
Interest rate (%):	1.4%
Required real rate of return on investment (%):	6.0%
Electricity price (€14/MWh):	0.20

[285] Source: Res Legal (2017) and Milieu country report

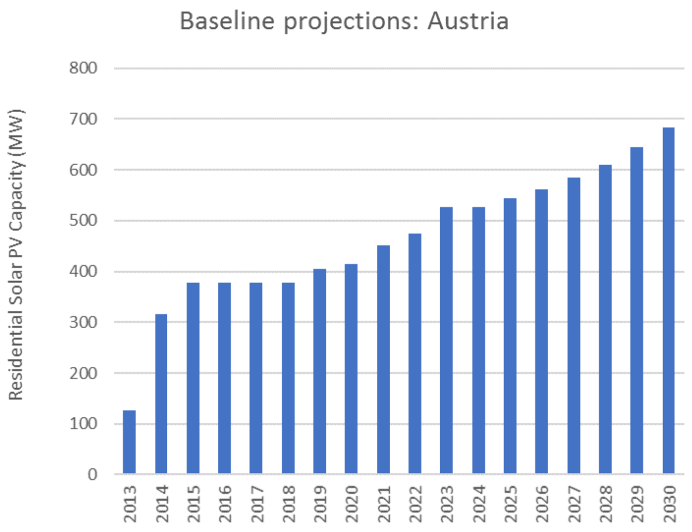


	2015	2020	2025	2030
Residential Solar PV capacity (MW)	1,086	1,899	2,731	3,684
Share of technical potential for residential Solar PV	8.5%	14.4%	20.1%	26.4%
Number of residential Solar PV prosumers (000s)	232	405	582	785
Share of households that invest in residential Solar PV	3.0%	5.2%	7.2%	9.5%
Mean payback period for residential Solar PV (years)	9.7	11.0	9.9	8.9

Austria

KEY POLICIES - AUSTRIA[286]
Type of scheme: Subsidy Value: 275 €/kW installed capacity is granted to private households that install a roof-top or ground mounted solar PV system (375 € for building integrated installations) Start/end: 2006 - current Eligibility: Maximum installed capacity of 5kW Other information: Households can apply more than once, if applicant aims to build another unit at a different site.
Type of scheme: Feed-in-Tariff Value: 0.125 €/kWh in 2014 and 0.0791 €/kWh in 2016 (5kW to 200kW); predetermined tariff/wholesale market price (≤5kW) Start/end: 2012 - current Eligibility: up to 200kW (increased to 350kW in 2014) Other information: Prosumers can sell electricity back to the grid and are eligible for a Feed-in Tariff for 13-15 years from the date of first operation. For installations, less than 5kWp, excess electricity can be sold back to OeMAG at the predetermined tariff/wholesale market price (2.859 cents/kWh in Q1 2017) for a guaranteed period of time, annual adjustments to the predetermined tariff are made for new plants. There are 15 other energy suppliers that will purchase the excess energy at higher prices, but deals with these other suppliers will depend on whether the prosumer is already a client.
Capacity cap: annual budget is €8 million (for solar energy) reduced by €160,000 every year for the first 10 years.

ASSUMPTIONS – AUSTRIA, 2030	
Technical potential for residential Solar PV (MW):	4,164
Capex cost (€14/kW):	1,317
Load factor:	0.11
Size of average residential Solar PV installations (kW):	3.13
Interest rate (%):	1.9%
Required real rate of return on investment (%):	5.7%
Electricity price (€14/MWh):	0.22



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	377	414	543	684
Share of technical potential for residential Solar PV	10.2%	10.7%	13.5%	16.4%

[286] Source: Res Legal (2017), BEUC (2016) and pvaustria.at

Number of residential Solar PV prosumers (000s)	121	132	174	219
Share of households that invest in residential Solar PV	3.2%	3.3%	4.2%	5.1%
Mean payback period for residential Solar PV (years)	17.9	16.9	15.4	14.1

Poland

KEY POLICIES - POLAND[287]

Type of scheme: Subsidy (National Fund for Environmental Protection and Water Management - Prosumer)
Value: The value of a loan plus subsidy together can cover up to 100% of the eligible costs and must be over PLN 200,000 (€ 45,530). The subsidy covers up to 30% of the cost of Solar PV (up to 20% of costs in 2015-2016). Maximum eligible investment costs are PLN 100,000 (€ 22,765) for private individuals who invest in only one form of self-generation.
Start/end: 2015-2022
Eligibility: PV installations with a capacity of up to 40 kWp.
Other information: The maximum duration of the loan is 15 years and the interest rate on the loan is 1%.

Type of scheme: Feed-in Tariffs
Value: €0.18 per kWh (for installations <3kWp); €0.11 per kWh (for projects <10kWp)
Start/end: ended 2016
Eligibility: PV installations with a capacity of up to 40 kWp , valid for a period of 15 years

Type of scheme: Net metering
Start/end: 2016-current
Eligibility: PV installations with a capacity of up to 40 kWp
Other information: Net metering scheme was introduced as a replacement to the Feed-in-tariff

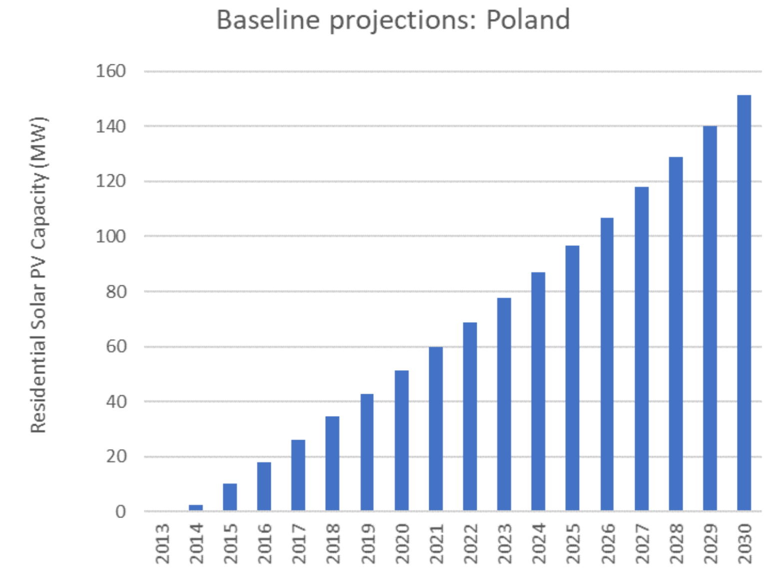
Type of scheme: VAT exemption
Start/end: 2015-current
Eligibility: PV installations with a capacity of up to 40kWp
Other information: Start-year (2015) proxied by start-year of other schemes in PL

Capacity cap: 300 MW cap for systems <3kW; 500 MW cap for systems <10 kW

ASSUMPTIONS – POLAND, 2030

Technical potential for residential Solar PV (MW):	14,479
Capex cost (€14/kW):	1,591
Load factor:	0.06
Size of average residential Solar PV installations (kW):	2.99
Interest rate (%):	4.0%
Required real rate of return on investment (%):	6.1%
Electricity price (€14/MWh):	0.16

287 Source: Res Legal (2017), sunwindenergy.com, European Commission (2015) and Milieu country report



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	10	51	97	151
Share of technical potential for residential Solar PV	0.1%	0.3%	0.7%	1.0%
Number of residential Solar PV prosumers (000s)	3	17	32	51
Share of households that invest in residential Solar PV	0.0%	0.1%	0.2%	0.4%
Mean payback period for residential Solar PV (years)	16.8	15.9	14.7	13.5

Portugal

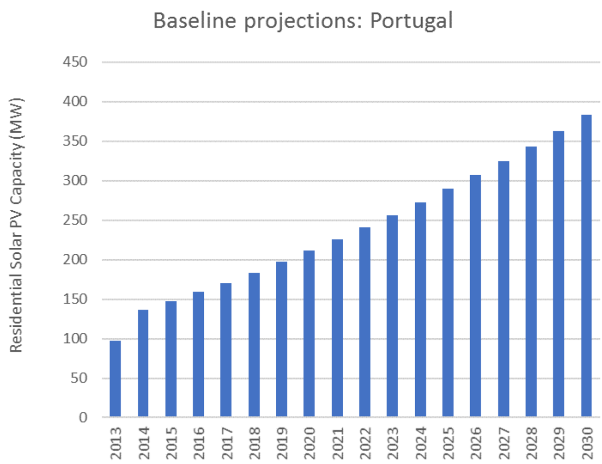
KEY POLICIES - PORTUGAL[288]

Type of scheme: Feed-in-Tariff for Small Production Units (UPP)
Value: Reference tariff is €0.095 per kWh (2017) under new regime for UPP
Start/end: 2010-current, new regime for UPP introduced in 2015
Eligibility: ≤ 250kW
Other information: Existing technologies (commissioned before Jan 2015) receive remuneration of €0.257 per kWh. Remuneration is received for a period of 15 years. After 2015, the remuneration that prosumers receive per month in euros due to the electricity provided to the grid corresponds to the energy provided in that month in Kwh multiplied by the value resulting from the simple arithmetic average of the prices of closure of the Operator of the Iberian Energy Market (OMIE) for Portugal in that month in euros by kw, multiplied by 0.9.

Type of scheme: Tax exemption
Value: 30% off the acquisition of new equipment of renewable energies and production of electricity (max 803 euros)
Start/end: N/A-2010
Other information: Tax exemption was repealed in 2010

ASSUMPTIONS – PORTUGAL, 2030

Technical potential for residential Solar PV (MW):	5,102
Capex cost (€14/kW):	1,591
Load factor:	0.20
Size of average residential Solar PV installations (kW):	2.39
Interest rate (%):	1.8%
Required real rate of return on investment (%):	6.7%
Electricity price (€14/MWh):	0.26



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	147	211	290	383
Share of technical potential for residential Solar PV	2.7%	4.0%	5.6%	7.5%
Number of residential Solar PV prosumers (000s)	62	88	121	160
Share of households that invest in residential Solar PV	1.5%	2.2%	3.1%	4.1%

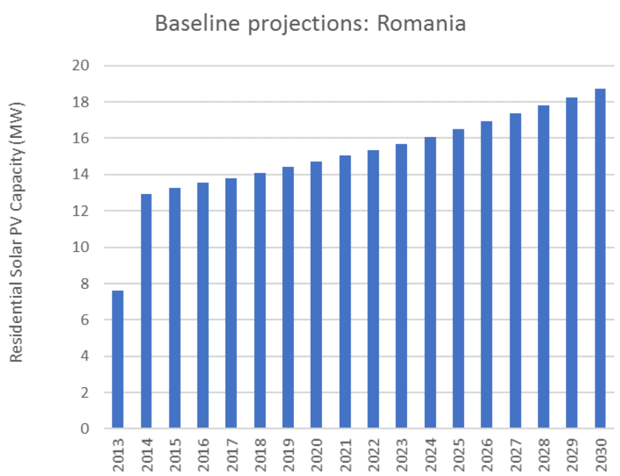
[288] Source: Res Legal (2017) and Milieu country report

Mean payback period for residential Solar PV (years)	10.3	9.4	8.6	7.8

Romania

KEY POLICIES - ROMANIA[289]
Type of scheme: Draft Feed-in-Tariff Value: Proposed feed-in-tariff between €0.0694 per kWh and €0.167 per kWh depending on the type of technology Start/end: Not yet enforced Eligibility: ≤ 1MW

ASSUMPTIONS – ROMANIA, 2030	
Technical potential for residential Solar PV (MW):	5,354
Capex cost (€14/kW):	1,591
Load factor:	0.17
Size of average residential Solar PV installations (kW):	1.75
Interest rate (%):	3.9%
Required real rate of return on investment (%):	7.0%
Electricity price (€14/MWh):	0.15



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	13	15	17	19
Share of technical potential for residential Solar PV	0.2%	0.3%	0.3%	0.3%
Number of residential Solar PV prosumers (000s)	8	8	9	11
Share of households that invest in residential Solar PV	0.1%	0.1%	0.1%	0.2%
Mean payback period for residential Solar PV (years)	31.1	29.1	25.2	21.9

[289] Source: Res Legal (2017) and Milieu country report

Slovenia

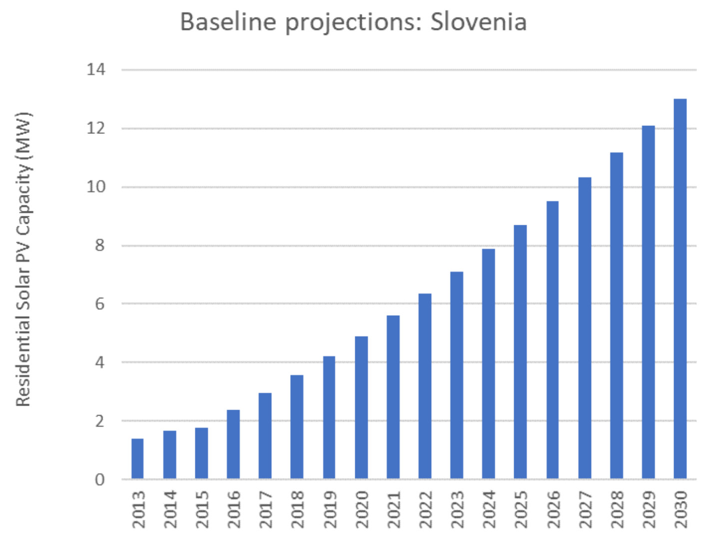
KEY POLICIES - SLOVENIA[290]

Type of scheme: Net metering
Start/end: 2016 - current
Eligibility: Households and small businesses with installations of <=11kVa
Other information: Prosumers and utility companies exchange electricity: if prosumers produced more than they consume, they do not get paid for their excess production but are not charged for their electricity consumption from the grid if electricity produced is greater than electricity drawn. Prosumers do not pay network charges and other charges for electricity that they produce themselves.

Type of scheme: Subsidy (Climate Change Fund Plan)
Value: 20% of investment
Start/end: 2016-current
Eligibility: Investment in self-consumption projects.

ASSUMPTIONS – SLOVENIA, 2030

Technical potential for residential Solar PV (MW):	1,182
Capex cost (€14/kW):	1,591
Load factor:	0.13
Size of average residential Solar PV installations (kW):	3.20
Interest rate (%):	2.2%
Required real rate of return on investment (%):	6.0%
Electricity price (€14/MWh):	0.17



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	2	5	9	13
Share of technical potential for residential Solar PV	0.2%	0.4%	0.6%	0.9%
Number of residential Solar PV prosumers (000s)	1	1	2	4
Share of households that invest in residential Solar PV	0.1%	0.2%	0.3%	0.5%
Mean payback period for residential Solar PV (years)	31.6	13.7	12.7	11.8

[290] Source: IEA (2016), uradni-list.si and Milieu country report

Slovakia

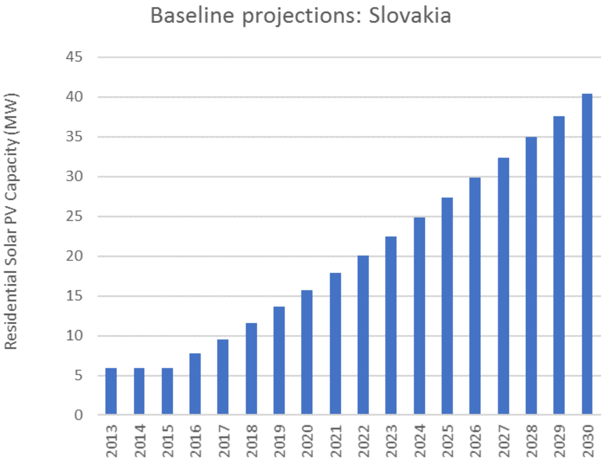
KEY POLICIES - SLOVAKIA [291]

Type of scheme: Feed in tariff
Value: 84.98 €/MWh from 1 January 2017
Start/end: 2016 - current
Eligibility: Only PV installations on rooftops or facades with an installed capacity of no more than 30 kW are eligible
Other information: The obligation period for all eligible technologies is limited to 15 years and starts in the year in which a plant is put into operation or in the year of reconstruction or upgrade. The FiT is made up of two components the "price to cover losses" and an additional surcharge.

Type of scheme: Subsidy (Zelena domacnostiam)
Value: 30-50% funding support covering the cost of the RES installation
Start/end: 2014 - 2020
Eligibility: RES technologies
Other information: For small RES and in houses and apartments buildings, budget of 45 million euro. The total amount allocated is 115 million euro for the period 2014-2020.

ASSUMPTIONS – SLOVAKIA, 2030

Technical potential for residential Solar PV (MW):	2,125
Capex cost (€14/kW):	1,591
Load factor:	0.11
Size of average residential Solar PV installations (kW):	3.48
Interest rate (%):	1.9%
Required real rate of return on investment (%):	6.2%
Electricity price (€14/MWh):	0.16



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	6	16	27	40
Share of technical potential for residential Solar PV	0.3%	0.7%	1.3%	1.9%
Number of residential Solar PV prosumers (000s)	2	5	8	12
Share of households that invest in residential Solar PV	0.1%	0.2%	0.4%	0.6%
Mean payback period for residential Solar PV (years)	38.9	16.9	15.6	14.5

291 Source: Res Legal (2017) and Milieu country report

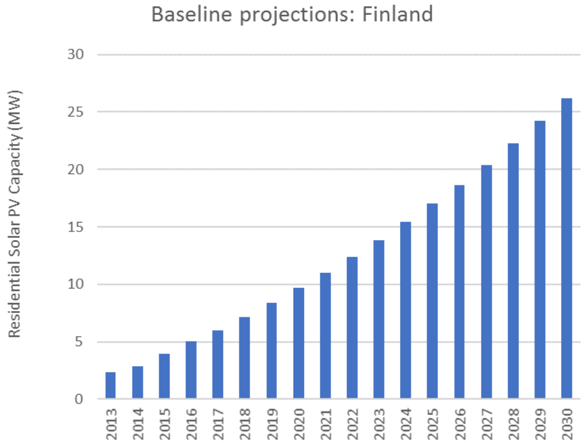
Finland

KEY POLICIES - FINLAND [292]

Type of scheme: Net metering
Start/end: 2009 - current
Eligibility: Installation capacity of up to 100kVA
Other information: consumers that purchase some electricity from the grid can offset part of their power bill by feeding self-generated electicity back to the grid. Pricing and billing arrangements are freely determined by the distributors, so long as they comply with general principles of the Electricity Market Act. If installed capacity is less than 100kVA, the prosumer does not need to purchase a separate metering device.

Type of scheme: Exemption from the Act on Excise Duty on Electricity and Clean Fuels (1260/1996)
Start/end: 1996 - current
Eligibility: Plants with output ≤ 100kWh are exempt from electricity tax.

ASSUMPTIONS – FINLAND, 2030	
Technical potential for residential Solar PV (MW):	3,641
Capex cost (€14/kW):	1,591
Load factor:	0.07
Size of average residential Solar PV installations (kW):	4.04
Interest rate (%):	1.1%
Required real rate of return on investment (%):	6.7%
Electricity price (€14/MWh):	0.18



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	4	10	16	25
Share of technical potential for residential Solar PV	0.1%	0.3%	0.5%	0.7%
Number of residential Solar PV prosumers (000s)	1	2	4	6
Share of households that invest in residential Solar PV	0.0%	0.1%	0.2%	0.2%
Mean payback period for residential Solar PV (years)	28.6	26.2	24.2	22.1

[292] Source: Res Legal (2017) and Milieu country report

Sweden

KEY POLICIES - SWEDEN [293]

Type of scheme: Subsidy (grants for the installation of Solar PV installations
Value: 20% of the eligible costs for private individuals and municipalities. Eligible costs include labour costs, cost of materials and planning costs. The maximum grant per installation is SEK 1.2 million, and the total eligible costs must not exceed SEK 37,000 (plus VAT) per kW of installed maximum capacity.

Start/end: 2009 - 2019
Eligibility: Grants are available for the installation of PV installations only (connected to either internal of external grid)
Other information: The costs arising from the grant scheme are borne by the State. The budget for the scheme from 2017 to 2019 is SEK 390 million (€ 41 million) annually.

Type of scheme: Tax reduction for micro production of renewable electricity
Value: Tax credit of 0.60 SEK/kWh of renewable electricity fed into the grid at the access point during the calendar year.

Start/end: 1999 - current
Eligibility: Electricity produced from solar, wind, wave, tidal, hydro, geothermal or biomass plants is eligible for tax reduction.
Other information: The tax reduction may not exceed 30,000 kWh or the amount of electricity withdrawn from the electricity grid at the access point during the same year per natural person / legal entity or per connection point. The PV system owner shall not have a fuse that exceeds 100 amperes at the connection point and shall notify the grid owner that renewable electricity is produced at the connection point.

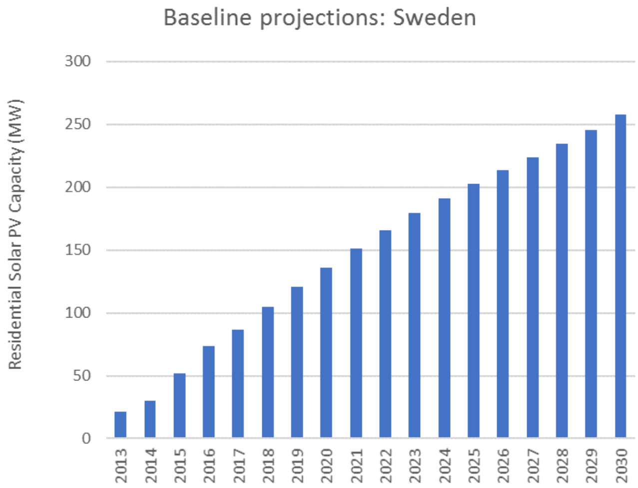
Type of scheme: Energy Tax exemption

Start/end: 2017 - current
Eligibility: Electricity produced from solar energy in electricity generators with a capacity lower than 255 kW is not taxable.

Other information: The State bears the costs arising from the tax privileges.

[293] Source: Res Legal (2017) and Milieu country report

ASSUMPTIONS – SWEDEN, 2030	
Technical potential for residential Solar PV (MW):	7,637
Capex cost (€14/kW):	1,705
Load factor:	0.09
Size of average residential Solar PV installations (kW):	4.11
Interest rate (%):	2.9%
Required real rate of return on investment (%):	6.1%
Electricity price (€14/MWh):	0.18



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	52	136	203	258
Share of technical potential for residential Solar PV	0.8%	1.9%	2.8%	3.4%
Number of residential Solar PV prosumers (000s)	13	33	49	63
Share of households that invest in residential Solar PV	0.2%	0.6%	0.9%	1.1%
Mean payback period for residential Solar PV (years)	31.1	29.2	27.5	25.8

United Kingdom

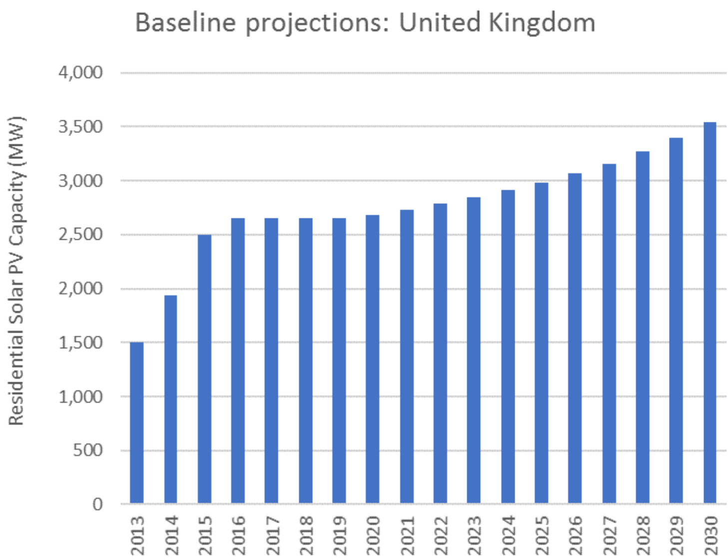
KEY POLICIES – UNITED KINGDOM[294]

Type of scheme: Feed-in Tariffs + Export tariff
Value: For installations ≤ 10 kWp, 4.28 p/kWh and export tariff of 5.03 p/kWh (2016)
Start/end: 2010-current
Eligibility: Higher rate applies to prosumers with EPC of level D or above with less than 25 installations. Export tariff applied for up to 50% of excess power fed into the grid.
Other information: Feed in Tariffs are paid for 20 years; income from Feed-in-Tariffs is exempt from income tax; tariff rates are adjusted annually in line with the retail price index (RPI).

Type of scheme: Reduced rate of VAT
Value: 5% VAT charged on Solar PV systems
Start/end: 1994-current (under the VAT Act 1994)

ASSUMPTIONS – UNITED KINGDOM, 2030

Technical potential for residential Solar PV (MW):	41,636
Capex cost (€14/kW):	1,872
Load factor:	0.09
Size of average residential Solar PV installations (kW):	3.25
Interest rate (%):	2.5%
Required real rate of return on investment (%):	6.0%
Electricity price (€14/MWh):	0.21



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	2,499	2,681	2,983	3,540
Share of technical potential for residential Solar PV	6.6%	6.9%	7.4%	8.5%
Number of residential Solar PV prosumers (000s)	755	825	918	1,089
Share of households that invest in residential Solar PV	2.7%	2.8%	3.0%	3.5%
Mean payback period for residential Solar PV (years)	11.4	17.3	16.0	14.8

[294] Source: Ofgem (2017) and Milieu country report

Iceland

KEY POLICIES – ICELAND[295]	ASSUMPTIONS – ICELAND, 2030	
No schemes currently in place to incentivise residential self-generation of Solar PV. Other information: Electricity produced for self-consumption is not taxed. The tariff for the electricity that residential prosumers draw from the grid is the same as for other small consumers. Residential prosumers get a discount of the distribution tariff based on how economically efficient their power plant is: 100kW or lower entitles owner to at least 50% and up to 100% of distribution tariff.	Technical potential for residential Solar PV (MW):	210
	Capex cost (€14/kW):	1,591
	Load factor:	0.06
	Size of average residential Solar PV installations (kW):	3.25
	Interest rate (%):	6.8%
	Required real rate of return on investment (%):	6.5%
	Electricity price (€14/MWh):	0.13

	2015	2020	2025	2030
Residential Solar PV capacity (MW)	0	0	0	0
Share of technical potential for residential Solar PV	0.0%	0.0%	0.0%	0.0%
Number of residential Solar PV prosumers (000s)	0	0	0	0
Share of households that invest in residential Solar PV	0.0%	0.0%	0.0%	0.0%
Mean payback period for residential Solar PV (years)	94.3	79.9	72.0	64.9

[295] Source: Milieu country report

Norway

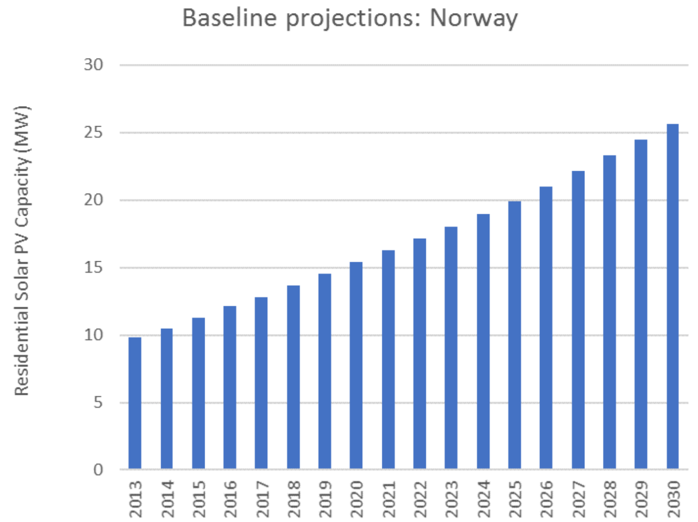
KEY POLICIES – NORWAY[296]

Type of scheme: Feed-in-tariff (Plusskundeordningen)
Value: 30 øre/kWh electricity sold to the grid (0.03-0.04 €/kWh)
Start/end: 2015 - current
Eligibility: <100kW capacity
Other information: NOK 15 000 registration fee for prosumers (<100 kW). These schemes differ depending on the energy provider.

Type of scheme: Subsidy (Enova)
Value: Support is limited to 10,000 NOK plus 1,250 NOK/kWp, up to a maximal capacity of 15 kWp. This is equivalent to 10-30% of the system cost.
Start/end: 2015- current

ASSUMPTIONS – NORWAY, 2030

Technical potential for residential Solar PV (MW):	6,915
Capex cost (€14/kW):	1,591
Load factor:	0.08
Size of average residential Solar PV installations (kW):	3.25
Interest rate (%):	2.6%
Required real rate of return on investment (%):	6.3%
Electricity price (€14/MWh):	0.15



	2015	2020	2025	2030
Residential Solar PV capacity (MW)	11	15	20	26
Share of technical potential for residential Solar PV	0.2%	0.2%	0.3%	0.4%
Number of residential Solar PV prosumers (000s)	3	5	6	8
Share of households that invest in residential Solar PV	0.1%	0.2%	0.2%	0.3%
Mean payback period for residential Solar PV (years)	46.1	46.0	44.0	42.2

[296] Source: IEA (2015) and solenergi.no

11 Annex 3: List of sources

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