CCUS IS NECESSARY TO REACH CLIMATE NEUTRALITY

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Introduction

The EU needs a timely and wide deployment of CCUS technologies to meet its Green Deal objectives[1]. However, whilst virtually all decarbonisation scenarios rely on large quantities of CCUS by 2050[2], the EU still lacks the political momentum and legal and policy framework necessary to kick-start investments and allow CCUS to live up its expectations.

The development of a CCS grid and storage will be an EU-wide and challenging endeavour, involving significant regulatory risk for investors that will need to commit billions of euros, technical innovation, the need for a new and robust regulatory and legal framework, and the commitment of very significant European funding from the ETS Innovation Fund and the CEF, and major funding from the Member States, notably from ETS revenues. Without action by the Commission in the next few years, CCS risks falling into a 'valley of death', as investments will not be able to be amortised in time, given that it is to a significant extent a 'transition technology'. Indeed, the Commission itself has recognized that CCUS technologies will not be available at competitive price before 2035 or 2040 if a conducive regulatory framework in is not put in place at EU level[3].

There are a number of reasons why the EU will need CCS to meet its decarbonisation goals:

1.1. CCUS is the only solution for sectors with hard-to-abate emissions

Meeting net zero objectives requires tackling emissions across all sectors, including those that are the most difficult to abate, such as energy intensive industry (which accounted for 20,5% of Europe CO2 emissions in 2019[4]). In these sectors, alternatives to fossil fuels are either prohibitively expensive (such as electricity to generate extreme heat), or even do not exist (in cement industry for instance).

Significant additional effort will be required to decarbonise the industrial sectors between 2030 and 2050, when EU's climate neutrality ambition will require industry to reduce its emissions to around 90-

[1] See European Commission (2018), In-depth analysis in support of the Communication COM(2018)773 "A Clean Planet for all - A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy" (available here), p. 61 ; IPCC (2018), Special Report on Global Warming of 1.5 degrees Celsius, available here ; IEA (2020), CCUS in Clean Energy Transitions, available here ; IRENA (2020), Reaching Zero with Renewables, available here.

[2] Tsiropoulos, I., Nijs, W., Tarvydas, D. and Ruiz Castello, P., Towards net-zero emissions in the EU energy system by 2050, EUR 29981 EN, Publications Office of the European Union, Luxembourg, 2020, available here. This JRC technical report provides a comparison of 8 scenarios achieving more than 50% reduction of GHG emissions by 2030, and 16 scenarios aiming at climate neutrality by 2050 similar with the ambitions of the "European Green Deal".

[3] European Commission (2018), *op.cit.*, section 9.4.2.7. The Commission specifies that: "*CCS for instance enters in significant numbers only by 2040 with carbon prices at that time of €200/tCO2 or more. Deployment of such solutions requires the necessary energy and CO2 infrastructure to be in place when the related technologies have been proved at scale. At the same time a supporting regulatory framework is necessary that will promote the deployment of such technologies, both on the production side, but also on the side of demand, creating for example lead markets for low carbon products*".

[4] IEA (2020), Energy Technology Perspectives 2020 Special Report on Carbon Capture, Utilisation and Storage, available here, p. 135.

95% compared to 1990 levels[5]. For most of these sectors, the deployment of affordable CCUS technologies is the only way to reasonably meet these objectives on time.

In practice, **some sectors will simply not be able to achieve net-zero emissions without CCUS**. Cement production is a prime example: two-thirds of the CO2 emissions of the cement industry are process emissions (i.e. they result from the manufacturing process, and are not associated with fossil fuel use), which means that even if the cement kilns could electrify their processes or be fuelled with bioenergy/zero-carbon hydrogen, these process emissions would persist. Therefore, with no demonstrated alternative way of producing cement, CCUS is effectively the only operation to decarbonise the sector[6].

Energy uses in energy intensive industries. There are limited alternatives to CCUS for reducing emissions from energy use in a number of energy intensive industries such as steel and chemicals in the medium and long-term. This results from both technical and economic considerations.

In technical terms, for example, CCUS in the steel and chemicals sectors can be implemented quickly. Whilst, for example, the hydrogen-based direct reduced iron (DRI) route for making steel, which reduces emissions substantially, could emerge as a technically possible alternative to CCUS, this is not technologically mature and depends on the availability of large quantities of cheap clean hydrogen.

In economic terms, based on current estimates of the levelised costs of production for commercial-scale plants, producing one tonne of steel via CCUS-equipped DRI and innovative smelting reduction processes is typically 8-9% more expensive than today's main commercial production routes, but the hydrogen-based DRI route typically raises costs by around 35-70%[7]. The story is similar in the chemicals sector. Clean hydrogen as a feedstock for ammonia and methanol production could become an alternative to CCUS, but in most regions today, it is considerably more expensive than applying CCUS to existing or new plants. The cost of CCUS-equipped ammonia and methanol production is typically around 20-40% higher than is that of their unabated counterparts, while the cost of electrolytic hydrogen routes is 50-115% higher[8].

The pace of CCUS deployment in industry is currently very limited, emphasising the need to get the ball rolling as quickly as possible. According to the IEA in its Sustainable Development Scenario, by 2030, at global level, the cement industry alone will need one CCUS-equipped cement facility coming online per week between now and 2030, accelerating to almost 6 per month on average in the period 2030-50. Much of this capacity is retrofitted to existing plants or those currently under construction. To achieve this will require a massive expansion of CO2 transport and storage infrastructure[9]. The EU is leading the world on renewable energy and hydrogen, but falling behind on CCS.

Similar figures can be quoted for other energy intensive industry, which, as mentioned above, accounts for more than 20% of total EU emissions. ETS prices are highly unlikely to increase to the level needed to enable these industries to competitively invest in any alternative decarbonising solution to CCS before 2040 at best. Without a functioning CCUS system in the short-to medium term, they will simply not, therefore, be able to significantly decarbonise. The Commission's proposed reform of the ETS, combined with a CBAM, envisages that these sectors will become exposed to the ETS in a few years.

[5] European Commission (2018), *op.cit.*, section 9.4.2.7.
[6] IEA (2020), Energy Technology Perspectives 2020 Special Report on Carbon Capture, Utilisation and Storage, available here, p. 23.
[7] IEA (2020), *op. cit.* , p. 64.
[8] *Ibid*.
[9] *Ibid*., p. 67.

Without a functioning CCS option, they will have to pay for allowances, but have very few, if any realistic, concrete options to significantly decarbonise.

Power sector. Many of the plants responsible for CO2 emissions could be operating for decades to come. For instance, the average age of a European gas-based power plant is 17 years against an average technical lifetime of around 50 years. Those plants (and others under construction or planned) could potentially emit more than 25 Gt of CO2 between 2019 and 2070 unless they are retrofitted with CCUS or retired early[10]. These plants will progressively move to providing balancing rather than base-load power, as the level of renewable energy in the electricity mix increases. Zero-carbon alternatives to the use of natural gas combined with CCS exist, notably clean hydrogen. However, these are far more expensive alternatives than natural gas combined with CCS, will fail to use non-amortised existing assets, and would use valuable hydrogen in an end-use that fails to meet the 'energy efficiency first' principle (the scarce clean H2 should first be used to displace grey hydrogen, and for replacing fossil fuels in transport, for example).

In 2018, Germany paid more than €700 million in compensation for curtailed renewable electricity production, when it had a RES share of its electricity market of around 38%[11]. Its current (pre Green Deal) RES-E target for 2030 is 65%. It is rather self-evident that the EU will need a lot of low GHG balancing power moving towards 2050, and that existing gas OCGTs combined with CCS is by far the cheapest and most readily available option. Without a ready and cost-effective CCS network, this will not develop, and the EU will need to go straight to high-cost (hydrogen) solutions, and either the cost of balancing will be far higher than it need be, or low/zero GHG balancing power will be unavailable in the required quantity. Neither of these options are attractive.

There are other industries where CCS will also be important, for example natural gas processing. However, simply based on the two examples above, it becomes clear that without a functioning CCS network in the short-to-medium term, it will be very difficult to decarbonise these industries at scale during the next 20 years and beyond.

1.2. CCUS provides a cost-effective pathway for low-carbon hydrogen production

The European Commission adopted a Hydrogen Strategy in July 2020 which has been endorsed by Council and Parliament[12]. It sets out ambitious targets, with the aim of producing of up to 10 million tonnes of renewable hydrogen in the EU by 2030. Although no precise targets are set for 2050, it is commonly accepted that the EU will required at least 50 Mt of clean hydrogen by that date, and probably considerably more.

The Commission has adopted a 'renewable hydrogen first' approach in its policy and legislative proposals. Some Member States, notably Germany, have mirrored this approach, for example in its initial support scheme design. Others, such as the Netherlands, have adopted a more technology neutral approach. Whilst it remains to be seen how the market and technology will develop, a number of drivers indicate that notwithstanding this political preference, if the EU is to meet its hydrogen and Green Deal

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[10] *Ibid*., p. 136.

[11] Bundesnetzagentur, Monitoring Report 2019, 27 November 2019, available here, p. 161. See also IEA (2020), Germany 2020, available here, pp. 30-31.

[12] See the Commission's Communication "A hydrogen strategy for a climate-neutral Europe", published on 8 July 2020, available here. See Council of the EU's conclusions, "Towards a hydrogen market for Europe", published on 11 December 2020, available here. See European Parliament's resolution of 19 May 2021 on "A European Strategy for Hydrogen", available here.

objectives in a cost-effective, timely and affordable manner, we will need significant quantities of blue hydrogen produced from steam methane reforming combined with CCS.

Today, blue hydrogen is projected to be appreciably cheaper than green hydrogen, in the order of €1/kilo[13]. The competitiveness of green hydrogen depends on cheap electricity supplies. Competitiveness with blue hydrogen is often projected because of the low and falling costs of new RES capacity in excellent locations. However, hydrogen production will not pay low and falling costs of new RES capacity in excellent locations, but the overall forward electricity market price - , if one can produce cheap RES electricity, why sell it below market price for hydrogen production, if you can sell it more profitably for electricity supply? To subsidise just 10 Mt of green hydrogen at a €1/kilo price disadvantage compared to blue hydrogen, would require additional subsidies of €10 Bn per year, with limited GHG benefit. Given that Member States' 'green' budgets will be constrained post European Recovery Plan funding, they may well wish to use this €10 Bn for energy efficiency investments, if this price differential indeed emerges.

Furthermore, a convincing recent academic study argues that in reality there will not be enough incremental renewable capacity to meet all the needs of electrification (coal and nuclear closure), transport, buildings and industry over the coming decade and beyond, and still have enough for large scale green hydrogen production (which requires massive amounts of electricity)[14].

In this light, it is far from certain that green hydrogen will be able to meet the EU's low and zero-carbon needs for hydrogen in the medium term. Pyrolysis and electrolysis hydrogen may be the long-term answer, but blue hydrogen will certainly need to play an important role at least until 2050. Whilst, therefore, it makes absolute sense to use very significant R&D&I support to make sure electrolysis technology is mature when large quantities of cheap RES-E are available, the EU will almost certainly need blue hydrogen to meet its objectives. Without readily available and cost-effective CCS, the EU will deprive itself of this option.

1.3. Conclusions on the necessity of CCUS

It flows from the above that CCS will need to make up an important part of the EU's Green Deal delivery.

The EU needs a detailed plan how to get the CO2 grid built, the development of adequate storage, where this will be, when and how the grid will look like, how to finance it, and what should be the stable regulatory regime to finance it.

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[13] IEA (2020), *op. cit.*, p. 24. The IEA indicates that "*Today, the cost of CCUS-equipped hydrogen production can be around half that of producing hydrogen through electrolysis powered by renewables-based electricity (which splits water into hydrogen and oxygen). The costs of electrolytic hydrogen will certainly decline over time, with cheaper electrolysers and renewable electricity, but CCUS-equipped hydrogen will most likely remain a competitive option in regions with low-cost fossil fuels and CO2 storage resources. CCUS also offers an opportunity to address emissions from existing hydrogen production that almost exclusively relies on natural gas and coal and is associated with more than 800 MtCO2 each year*". In addition to being more cost-efficient, IOGP argues that blue hydrogen is greener that hydrogen produced with electrolysers connected to the grid: "*In the EU, in 2016, average electricity emissions per MWh were 296 kg CO2. Production of hydrogen from electricity with such a CO2 intensity would result in an emission rate of 15 kg CO2 per kg of hydrogen. If the hydrogen was produced from natural gas with average European upstream and midstream CO2 emissions combined with CCS, the emission rate would be 2 kg of CO2 per kg produced hydrogen. CO2 emissions are therefore 7.5 times lower for hydrogen produced from natural gas with CCS. Outlooks from the European Commission's strategic long-term vision and IRENA's Outlook for Europe give a corresponding ratio in the range of 4.6 to 4.9. It can therefore be assumed that emissions from hydrogen production from grid average electricity will be above that from natural gas with CCS well beyond 2030*" (IOGP (2019), The potential for CCS and CCU in Europe available here, p. 7)

[14] R. BELMANS, P. CARLO DOS REIS, P. VINGERHOETS (2021), Electrification and sustainable fuels: Competing for wind and sun, available here.

The Commission in its 'Fit for 55' package and Communications, has focussed on 'end-game' technologies and long-term solutions. This is of course necessary - we need the technologies and infrastructure in place to meet the full decarbonisation in 2050 deadline.

However, CCUS must also be a vital part of the EU's decarbonisation strategy. It is largely a transition technology, and, unless it can succeed in capturing and permanently storing 100% of emissions from certain applications, has relatively little role to play post-2050. It will still have a role post-2050 - there is currently no solution to decarbonising cement than CCS for example, and technological innovation may enable 100% capture of CO2 - but current assumptions are that the CO2 grid will need to be largely amortised by 2050. This is one of the reasons why a sense of urgency is needed. The assumption is that the CCS grid and storage will need to be built and very largely amortised by 2050 - it can neither be a stranded asset nor an argument for grandfathering positive emission technologies post-2050.

The Commission therefore needs to take the same level of leadership, vision and determination regarding CCS as it has regarding hydrogen. In concrete terms we would suggest the following:

- **The adoption of a European Strategy for CCUS and legislative package.** This would take a form and level of ambition similar to the Hydrogen Strategy, announce clear targets and deadlines, commit to developing a CCUS Alliance (similar to the hydrogen, battery and microelectronics examples), and commit to new legislative proposals on CCUS. It would act as a catalyst for major action by industry, and mark a step-change in EU and Member State determination to deliver a cost-effective CCS network.

- **Encourage EU TSOs and their representatives (notably ENTSOG), to urgently propose an EU CO2 Backbone (**repurposed gas pipelines and possibly depleted gas fields would be an essential part of the future CO2 grid.

- **Upscaling support for CCUS. C**ommitting more for R&D&I from the Horizon and ETS Innovation funds, and committing to use the proposed possibility for contracts for difference in the increased ETS Innovation fund for green steel, cement and chemicals based on CCUS (or based on technology neutral tenders).

- **Under the upcoming hydrogen package, take a more positive and pro-active approach to blue hydrogen,** providing a secure regulatory framework (guarantees of origin, certification, standards…).

- **To support the developments of pyrolysis hydrogen.** Pyrolysis (or 'turquoise' hydrogen) is a CCU technology, producing zero or even negative-carbon hydrogen using renewable electricity as the energy source, with solid carbon as the by-product. The solid carbon can be used as an industrial feedstock (pigments, tyres, electronics), potentially as a soil improver (thus actually reducing and capturing CO2 and being an ideal 'circular economy' candidate), and as graphite in battery production (meeting EU goals for self-sufficiency in sensitive materials).