Additionality of renewable electricity for green hydrogen production in the EU

Contents

Executive Summary

In sectors that are not easily electrified directly, hydrogen produced from renewable electricity could play a major role. As long as renewable electricity is scarce, choices will have to be made on where the next available renewable electricity capacity will be applied. In this context, ***the concept of additionality refers to the requirement that new electrolysers producing renewable hydrogen must be supplied by electricity from new, dedicated renewable sources.***

In this study we found that, in order to minimise CO_2 emissions during the energy transition, ***strict adherence to the additionality requirement is necessary.*** This is because:

1. In most EU Member States electricity is still produced from fossil fuels for significant periods of time, and producing hydrogen from fossil electricity generates far more CO_2 emissions than producing it directly from natural gas.
2. The application of hydrogen only leads to a limited decrease in emissions in end use.

We assessed the conditions for electricity to be counted as renewable as presented in the European Commission's draft Delegated Act on Additionality. ***The most important conditions are related to the option to conclude a Power Purchase Agreement (PPA) with a supplier of renewable electricity***, as this option will be used most in practice. The main conditions for this option are:

1. The renewable electricity used to produce hydrogen should be new to the system (<36 months).
2. There should be an hourly correlation between the production of the renewable electricity and the production of the hydrogen itself.
3. The production of the renewable electricity and the production of the hydrogen should take place in the same or in neighbouring bidding zones.

We concluded that these conditions by themselves are robust and would guarantee additionality as long as they are not being compromised. While the transitional phase proposed in the draft Delegated Act would temporarily suspend the additionality conditions, its impact on emissions would likely be limited. ***The grandfathering clause (Art. 8), however, would threaten the preservation of additionality*** more seriously as long as it is not bound by an end date.

Some proposals to amend the draft Delegated Act would undermine the additionality requirement as well and should be discouraged from a climate policy perspective. This applies for instance to suggestions to extend the relaxation of the temporal correlation (monthly or even quarterly instead of hourly), to relax the geographical correlation (e.g. country instead of bidding zone) or to relax the cut-off percentage for the definition of high renewable electricity penetration areas (>70% instead of >90%).

We placed our research in the context of the dual ambitions of the European Commission related to ***both large-scale deployment of renewable energy in general and a swift development of the production and use of renewable hydrogen in the EU***, with several concrete policy targets defined for 2030 and beyond. This led to the following additional findings:

- The Commission aims to have ***40 GW of electrolysers installed in 2030, and to produce 10 million tonnes of renewable hydrogen*** on European soil in the same year.
- Current concerns on energy security, fuelled by the war in Ukraine, led the Commission to further ***strenghten several of its 2030 targets*** in the RePowerEU Plan. For instance, the overall renewable energy target should increase to 45% (instead of 40%) and the renewable hydrogen target for transport to 5% (instead of 2.6%).
- In 2020, the total production from ***solar panels and wind turbines in the EU amounted to 537 TWh***, roughly equal to the electricity demand for the production of 10 million tonnes of hydrogen (the 2030 objective).
- The Commission's own ***projections for new renewable electricity capacity in 2030 are insufficient*** to fully decarbonise the power sector, cover newly emerging demand from electrification *and* produce the desired 10 million tonnes of renewable hydrogen.
- As long as renewable electricity is scarce, it should be applied to ***replace fossil electricity production rather than fossil hydrogen***, in order to minimise CO_2 emissions. This is because the displacement of fossil electricity production avoids multiple times as much emissions as the displacement of fossil hydrogen.
- Even though there may be a political desire to quickly develop a renewable hydrogen supply chain within the EU, this should not compromise ***the EU legislative framework directed at increasing the share of renewable energy, including renewable hydrogen***. The core of this framework is formed by the Renewable Energy Directive, including the Delegated Acts supplementing it.

1. Introduction

Electrification is key to achieve the energy transition. In sectors that are not easily electrified, such as some branches of industry and heavy transport, hydrogen produced from renewable electricity could play a major role as an energy carrier. The production of renewable hydrogen by electrolysers requires large amounts of renewable electricity, as this process is relatively inefficient. Thus, some competition might be expected between renewable electricity needed for hydrogen production and those for direct electrification of other sectors of the economy.

The question to what extent new electrolysers should be supplied with new, dedicated sources of renewable electricity is referred to as the issue of 'additionality' and is the main topic of this paper. On May 20th, 2022, the European Commission presented two draft Delegated Acts (DAs) supplementing the Renewable Energy Directive (REDII). The first draft DA — that we will refer to as the DA Additionality — presents rules on when electricity used to produce hydrogen can be counted as renewable (EC, 2022a). The second DA focuses on the rules to establish the greenhouse gas (GHG) emissions resulting from the use of renewable hydrogen[1] (EC, 2022b). We will refer to this DA as the DA GHG emissions savings.

At the request of Air Products, CE Delft has assessed the potential impact of the provisions of the draft DAs against the background of the EU's policy targets and the debate on additionality. The aim of this assessment has been to establish whether the conditions in the draft DAs are sufficient to preserve additionality in an EU energy system were both renewable electricity and electrolysis capacity are expanding.

In the first chapters of this report, we outline the context of the issue of additionality. Successively, we sketch the ambitions of the European Commission on the development of both renewable electricity in general and renewable hydrogen (*Chapter 2*), the actual provisions presented in the draft DAs (*Chapter 3*) and the first responses of stakeholders on the draft DAs (*Chapter 4*).

After these introductory chapters, we dive a little deeper into the matter, starting in *Chapter 5*, where we compare the EU's ambitions on renewable electricity and renewable hydrogen and assess whether they can actually be achieved at the same time. Based on the available projections, we present some headline figures on supply and demand of renewable electricity in 2030 and draw conclusions on its availability for decarbonisation of the electricity sector *and* direct electrification *and* the production of renewable hydrogen.

Next, we explain the need for a strict upholding of additionality in *Chapter 6*. We explain why the use of hydrogen produced by electrolysis will actually lead to higher CO_2 emissions if additionality is not preserved, and we draw conclusions on what this means — from a climate policy viewpoint — for both the application of hydrogen and for the EU's additionality rules.

Then we proceed to the core of our study: an assessment of the provisions of the draft DAs, including conditions for renewable electricity to be counted as renewable as well as derogations and exemptions, in *Chapter 7*. We explain the rationale behind the provisions and their practical implications. In our conclusion, we address the question to what extent these rules are sufficient to guarantee additionality.

Finally, in *Chapter 8*, we briefly discuss what options might be considered to reconcile the need for rapid electrification and the desire to develop a mature market for renewable hydrogen in the EU at the same time.

In the last section we summarise our main conclusions.

1 As well as for the use of so-called Recycled Carbon Fuels (RCFs), which are produced from waste and are not covered by our study.

2. EU's ambitions on renewable energy and green hydrogen

The EU has enshrined its targets on greenhouse gas (GHG) emission reduction for 2030 (at least 55% reduction compared to 1990 levels) and 2050 (climate neutrality) in the European Climate Law (EC, 2021a). The uptake of renewable energy is considered key to achieving these targets. In its revision of the REDII, a part of the so-called Fit for 55 package presented in July 2021, the Commission proposed to increase the overall target for renewable energy consumption from 32 to 40% in 2030 (EC, 2018), (EC, 2021b). Following the outbreak of war in Ukraine and growing concerns on energy security, the Commission presented the RePowerEU Plan (EC, 2022c) to make the EU independent of Russian fossil fuels, partly by accelerating the transition towards renewable energy. In the RePowerEU plan, the renewable energy target was proposed to be raised even further to 45% in 2030. It also includes a target of over 320 GW of solar photovoltaic newly installed in 2025, and almost 600 GW in 2030. Earlier, the Commission's Offshore Renewable Energy Strategy (EC, 2020a) introduced a target of 60 GW of offshore wind capacity installed in 2030, with a view to extend this to 300 GW in 2050.

REDII, a part of the so-called Fit for 55, target for renewable energy consumption:

32% to 40%

In the RePowerEU plan it was proposed to be raised even further:

45%

Table 1 — Overview of targets (legislated or proposed) for renewable energy and green hydrogen, as explained in main text

EU legislation or communication by the Commission	Date of issue	Renewable Energy	Green hydrogen
Renewable Energy Directive (REDII)	Nov 2018	Overall: 32% renewable energy in 2030.	70% emissions savings threshold for renewable hydrogen to be counted towards the REDII targets
Hydrogen Strategy	July 2020		2024: 6 GW renewable electrolysers, 1 million tons renewable hydrogen produced. 2030: 40 GW of renewable electrolysers, 10 million tons of renewable hydrogen produced.
Offshore Renewable Energy Strategy	Nov 2020	2030: 60 GW offshore wind capacity and 1 GW ocean energy (e.g. tidal). 2050: 300 GW offshore wind capacity and 40 GW ocean energy.	Offshore hydrogen infrastructure should be integrated in grid planning.
Revised Renewable Energy Directive (REDIII) (proposed)	July 2021	Overall: 40% renewable energy in 2030.	Industry: 50% of hydrogen renewable. Transport: 2.6% renewable hydrogen sub-target
ReFuel EU Aviation Initiative	July 2021	Sustainable aviation fuel (SAF) blending obligation increasing from 2% in 2025, over 5% in 2030 to 65% in 2050 (five year increasing targets).	Sub-target for RFNBOs increasing from 0.7% in 2030 to 28% in 2050 (five year increasing targets).
RePowerEU Plan	May 2022	Overall: 45% renewable energy in 2030. Solar: 320 GW of new PV in 2025; 600 GW in 2030.	Industry: 75% of hydrogen renewable. Transport: 5% renewable hydrogen sub-target. 10 million tons of renewable hydrogen produced in EU and 10 million tons imported.

At the same time as decarbonising the power sector and stimulating electrification of sectors such as mobility, the European Commission is strongly counting on the development of green hydrogen to realise the transition in hard-to-abate sectors. In July 2020, it issued a Hydrogen Strategy for a climate-neutral Europe (EC, 2020b). For the scale-up phase from 2020-2024, this strategy includes the objectives of at least 6 GW of installed renewable hydrogen electrolysers in the EU and the production of up to 1 million tons of renewable hydrogen.

In a second phase (2025-2030), renewable hydrogen should become an intrinsic part of the EU's energy system, leading to the installation of at least 40 GW of renewable hydrogen electrolysers by 2030 and a production of up to 10 million tons of renewable hydrogen in the same year. A third phase (2030-2050) should see renewable hydrogen technologies reaching maturity and being deployed at large scale. The Commission projects that by 2050 about a quarter of renewable electricity might be used to produce renewable hydrogen.

In the revision of the REDII (EC, 2021b), the Commission proposes provisions to support the use of renewable hydrogen in various sectors. For instance, a specific target for the use of renewable hydrogen[2] in the transport sector of 2.6% in 2030. Another example is a target of 50% of hydrogen used by industry to be renewable in 2030[3]. In the RePowerEU Plan (EC, 2022c), it is proposed to increase these targets to 5% and 75%, respectively. In the plan, the target of 10 million tons of renewable hydrogen produced in the EU in 2030 is retained, but it is extended to include 10 million tons of renewable hydrogen imported from outside the EU as well. The ReFuel EU Aviation Initiative (EC, 2021c) finally, proposes targets specifically for the aviation sector, with an RFNBO subtarget that increases from 0.7% in 2030 to 23% in 2050 (CE Delft, 2021).

2 Formally: Renewable Fuels of Non-Biological Origin (RFNBOs). In practice, this term includes mainly renewable hydrogen. Therefore in this paper the term renewable hydrogen is used.
3 For final energy and non-energy purposes (Art. 22a REDIII).

EU Hydrogen Strategy:
at least 40 GW renewable hydrogen electrolysers and production of 10 Mton of renewable hydrogen in 2030.

The Commission projects that by 2050 about a quarter of renewable electricity might be used to produce renewable hydrogen.

RePowerEU: *production target extended to include 10 Mton of renewable hydrogen imported from outside the EU.*

3. The EU's renewable hydrogen rules

3.1 Draft Delegated Act on Additionality

The EU's policy targets on renewable energy sources and the development of green hydrogen are strongly intertwined. As every kWh of renewable electricity produced can only be used once, there is an inevitable trade-off between the production of renewable hydrogen and direct electrification. This is where the concept of additionality comes in. It is not formally defined in the REDII or in the DA on Additionality, but it is described in their respective recitals, see *Textbox 1*. We may paraphrase it as the requirement that new electrolysing capacity is supplied by renewable electricity from new, dedicated sources.

Textbox 1 — References to the term additionality in the REDII and the DA on Additionality

> REDII, recital 90: "*[…] Furthermore, there should be an element of additionality, meaning that the fuel producer is adding to the renewable deployment or to the financing of renewable energy.*"
>
> DA Additionality, recital 2: *"In order to account hydrogen as fully renewable, the production of renewable hydrogen should therefore incentivise the deployment of new renewable electricity generation capacity (principle of additionality) or take place at times where the electrolysers support the integration of renewable power generation into the electricity system or in bidding zones where renewable electricity already represents the dominant share and adding additional renewable electricity generation capacity would not be necessary or possible."*

In terms of implementation, the requirement of additionality can take various forms. In the DA Additionality, it is translated into a set of rules stipulating, for various circumstances, when electricity used for the production of renewable hydrogen may count as renewable.

If there is a direct connection between the source of renewable electricity and the electrolyser, these rules come down to the requirement that the source should not have been around for a long time before the electrolyser is connected to it[4]. In case the electrolyser is supplied by electricity from the grid, other criteria apply for the electricity to be counted as renewable. This can be for instance through concluding a Power Purchase Agreement (PPA) with a provider of renewable electricity and/or by proving specific temporal and geographical correlations between the production of renewable hydrogen and the production of the renewable electricity.

Several assessments of the options laid out in the draft DA have been carried out (Allen & Overy, 2022) (Baker McKenzie, 2022) (Bird & Bird, 2022) (Freshfields Bruckhaus Deringer, 2022), leading to small variations in how many different options are defined. Partly based on these analyses, *Figure 1* shows a visual representation in

4 The question of how much time is allowed between the installation of the renewable electricity source and the installation of the electrolyser is actually part of the discussion around the draft DA Additionality. Of course, strict additionality would mean that the renewable electricity source would be completely dedicated to the electrolyser and would not supply electricity to the grid or otherwise before being connected to the electrolyser.

> *As every kWh of renewable electricity produced can only be used once, there is an* ***inevitable trade-off between the production of renewable hydrogen*** *and direct electrification.*

broad lines of the options and conditions presented in the draft DA Additionality (EC, 2022a). These will be treated in more detail in *Chapter 7*.

The draft DA Additionality also includes derogations with respect to the conditions shown in *Figure 1*, specifically applying to the PPA option:

The first condition (<36 months between start of operation of renewable electricity production and electrolyser) and second condition (no net financial support to renewable electricity installation) for this option do not enter into force before 1 January 2027. Also, these conditions do not apply (permanently) to electrolysers that come into operation before this date (grandfathering clause).

The one-hour period referred to in the third condition (temporal correlation, first and second sub-option) is considered to be a period of one calendar month before 1 January 2027.

3.2 Draft Delegated Act on GHG emission savings

While the DA Additionality focuses on the question under which criteria electricity can be considered renewable, the REDII also offers another approach to establish whether 'renewable hydrogen' can actually count towards the targets for renewable energy. This approach makes use of a greenhouse gas (GHG) emission savings threshold. The REDII stipulates that for renewable hydrogen this threshold should be 70%, meaning that emissions should be reduced by at least 70%[5] for the hydrogen to be counted towards the RED's renewable energy targets.

The draft DA GHG emissions savings presents detailed rules for calculating the emissions — and hence emissions savings — resulting from the use of renewable hydrogen. As renewable electricity (defined according to the DA Additionality) is assigned an emission value of zero g CO_2-eq./MJ by definition, the case of hydrogen produced by renewable electricity is trivial under the DA GHG emission savings. However, the latter DA offers another option for electricity to be assigned zero emissions, which is not included in the DA Additionality. If the number of full load hours the electrolyser is producing is equal or lower than the number of hours in which the marginal price of electricity was set by installations producing renewable electricity or nuclear power plants in the preceding calendar year, grid electricity used for the production of renewable hydrogen may be attributed a GHG emission value of zero g CO_2-eq./MJ (EC, 2022b), hence the hydrogen produced counts towards the renewable energy targets.

5 With respect to the fossil comparator, which is 94 g CO_2-eq./MJ (for use in transport).

3.3 Process towards adoption of the renewable hydrogen rules

As the consultation period for the two draft DAs has ended on June 17th, the Commission is expected to come up with the final texts for the DAs in due course. The European Parliament and the Council cannot amend the final DAs, they only have the option to block them with specified majorities.

At the same time, the revision of the REDII (aka REDIII), presented by the Commission in July 2021 (EC, 2021b), has recently been treated by the European Parliament. On September 14th, 2022, the plenary has voted on the EP's position in first reading, resulting in a number of elements from the DA Additionality to be referred to in the EP's proposal, albeit in less strict wording. Now the EP has established its position on the REDII revision, the negotiations with the Council and the Commission are expected to take at least several months before the new legislation will be adopted.

Figure 1 — Options for electricity used to produce hydrogen (H2) to be counted as renewable according to the DA Additionality

Direct line pathway (Art. 3)	Direct line	Conditions • Direct line between S and E, or S and E in the same installation • S came into operation less than 36 months before E • S not connected to the grid, *or* prove grid electricity was not used to produce H2
Grid pathway (Art. 4)	High renewable electricity penetration option	Conditions • S is located in a bidding zone with average proportion of renewable electricity of more than 90% in previous calendar year • Maximum number of hours of H_2 production (#hours per year * share of renewable electricity in bidding zone)
	Power Purchase Agreement option	Conditions • S came into operation less than 36 months prior to E • S has not received net support such as operating aid or investment aid • H_2 is produced: ◦ During the same hour-period as the electricity produced under the PPA; *or* ◦ From a storage asset that has been charged during the same hour-period; *or* ◦ During a one-hour period when the electricity clearing price is ≤ €20/MWh *or* lower than 0,36* ETS carbon price. • The location of the electrolyser fulfils at least one of the following criteria: ◦ S is in the same bidding zone as E ◦ S is in neighbouring bidding zone with electricity prices equal or higher ◦ S is in an offshore bidding zone adjacent to the bidding zone of E
	Imbalance settlement option	Conditions • Demonstrate that power generating facilities using renewable energy sources were downward redispatched and electricity used for producing renewable hydrogen reduces the need for redispatching by a corresponding amount

S = installation generating renewable electricity supplying the electrolyser; E = electrolyser producing renewable hydrogen. This figure does not reflect all exemptions and details of the provisions.

4. Stakeholder responses to the draft Delegated Acts

Since the publication of the draft DAs on May 20th, 2022, several stakeholders have presented their views on their contents and there has been some limited coverage in online media and fora (Euractiv, 2022) (EnergyPost.eu, 2022). In this section we present, without claiming to be exhaustive, some of the most common arguments brought forward by NGOs and industrial parties, respectively.

4.1 NGO responses

Several NGOs have expressed their concerns following the publication of the draft DAs (Bellona, 2022) (Bellona, Climate Action Network, Client Earth et al., 2022) (Clienth Earth, 2022) or already at an earlier stage, e.g. (Bellona, 2021). In their view, the rules presented are too lax to guarantee hydrogen will be a truly clean fuel and offer too many ways for industrial parties to continue producing hydrogen based on fossil electricity (Euractiv, 2022).

One of the main concerns presented by NGOs relates to the way additionality is enshrined in the DA Additionality. From their responses, two main arguments for the necessity of additionality stand out:

1. If new electrolysing capacity does not go hand in hand with new renewable electricity production, and the hydrogen is produced with electricity (partly) from fossil sources, total greenhouse gas emissions will actually rise. This is because the emission intensity of hydrogen produced from fossil-based electricity is substantially higher than the emission intensity of hydrogen produced from natural gas in conventional processes (EC, 2022a) (Bellona, 2021).
2. As we have seen above, apart from the general REDII-target on the share of renewable energy in final consumption, several sectoral targets exist or are proposed. If renewable electricity is not specifically dedicated to the production of green hydrogen, there is the risk of double counting by assigning the renewable electricity to the renewable hydrogen target and to the general RES target at the same time.

According to the NGOs, mainly the 'grandfathering clause' that suspends some of the criteria for the PPA option for electrolysers entering into force before 1 January 2027 undermines the concept of additionality (Bellona, 2022) (Bellona, Climate Action Network, Client Earth et al., 2022) (Clienth Earth, 2022). It would offer the possibility to install large capacities of electrolysers before that date, which would then not be bound to the rules laid down in the DA for the rest of their lifetime. Also, in the view of the NGOs, the fact that renewable hydrogen producers can choose from several alternative methodologies in both DAs to guarantee that the electricity used for hydrogen production is renewable, does not contribute to transparency and facilitates double counting of renewable electricity (Bellona, 2022) (Clienth Earth, 2022).

Furthermore, NGOs express concerns on the legal soundness of the DA Additionality. At the one hand, the wordings of the DA are considered flawed compared to the 'plain language' of Art. 27(3) of the REDII, even though the DA is meant to supplement the provisions in this Article (Clienth Earth, 2022). At the other hand, according to the NGOs the current draft of the DA Additionality is not in line with other pieces of EU legislation, such as the Climate Law (EC, 2021a) (Clienth Earth, 2022), or with objectives the Commission has defined itself, such as protecting citizens from high energy prices or reduce the EU's dependence on Russian natural gas (Bellona, 2022).

If new electrolysing capacity does not go hand in hand with new renewable electricity production, and the hydrogen is produced with electricity (partly) from fossil sources, total greenhouse gas emissions will actually rise.

Renewable electricity needs to be dedicated to green hydrogen production, or it risks to be counted twice under the EU renewable energy targets.

4.2 Industry responses

Stakeholders from the industry express their willingness to invest in facilities that produce and/or use green hydrogen. At the same time, they emphasise the need for the creating of a functioning market for renewable hydrogen. For this to happen, supply should sharply increase in order to initiate investments by the potential users of hydrogen. In that respect, some representatives of industry express concerns on the provisions in the DA Additionality.

Three main issues raised by industry are related to Article 4 of the DA Additionality (outlining the grid pathway). These issues concern the cut-off percentage to count grid electricity as fully renewable, and the requirements on temporal and geographical correlation.

*Stakeholders from the industry emphasise **the need for the creating of a functioning market** for renewable hydrogen.*

1. 90-percent rule (Article 4.1)

- The 90% cut-off for bidding zones to be counted as fully renewable is considered too stringent by some representatives of industry. They propose to replace this cut-off value by a more relaxed 70% rule to encourage countries with increasing shares of renewables in their endeavours (Hydrogen Europe, 2022), (Cefic, 2022), (EU Industry, 2022). Others propose to include a provision that the current rule will be reviewed after three years (European Federation of Energy Traders, 2022).

2. Temporal correlation (Article 4.2.c)

- The temporal correlation requirement raises most opposition among representatives of industry. Stakeholders indicate that these requirements could thwart the business case for production of green hydrogen by limiting the number of hours that an electrolyser can operate and/or disturb the creation or operation of a healthy market. Some stakeholders prefer not to have any limiting criteria on the provenance of electricity (RWE, 2022), rather suggesting that Member States should expand national build-out targets for renewable power plants to increase the share of renewable electricity in the total mix (RWE, 2022), (Hydrogen Industry Cluster, 2022). Others propose to allow the use of electricity from the grid if equivalent quantities of guarantees of origin are cancelled, thus combining the instruments of power purchase agreements and guarantees of origin (Europex, 2022). Others yet advise to include a phase-in period supported by additional market-based instruments; to retain daily matching after 2027; to extend the monthly matching period until 2030; or to base the temporal correlation proof on monthly averages (Cefic, 2022), (EU Industry, 2022), (Hydrogen Industry Cluster, 2022), (Global Alliance Powerfuels, 2022).
- Stakeholders also raise concerns specifically with Article 4.2.c. (ii) on the requirements for storage assets. They indicate that location of storage should not matter (as long as they are within the same congestion zone), and that the use of commercial and collocated on-site storage should also be made possible (European Federation of Energy Traders, 2022), (RWE, 2022), (Europex, 2022).

3. Geographical correlation (Article 4.2.d (b))

- Industrial parties indicate that further clarity is needed on the neighbouring bidding zone rule: what is the logic of exporting power against the dominant flow, i.e., to a zone with a higher price (European Federation of Energy Traders, 2022). Others propose to extend the geographical correlation zone beyond bidding zones, provided there is sufficient interconnection between bidding zones. Stakeholders indicate that current bidding zones can change in the future, thus not providing sufficient certainty for investment (Cefic, 2022), (EU Industry, 2022), (Hydrogen Industry Cluster, 2022).

In addition to the issues above, some stakeholders raise some broader concerns and propose amendments, such as extending the grandfathering clause to 2030 (Hydrogen Industry Cluster, 2022), extending the transition period for capacity additions to at least 2032 (Europex, 2022) or allowing unsubsidised old renewable installations to be eligible within the DA, in order to keep them economically viable (Europex, 2022), (Global Alliance Powerfuels, 2022).

Finally, some representatives raise concerns on the time horizon for the validity of the DA, as growing shares of renewables might render it obsolete relatively fast (European Federation of Energy Traders, 2022).

5. EU's ambitions for RES and hydrogen compared

In *Chapter 2* we listed the EU's policy targets for both the development of renewable electricity capacity and the production of renewable hydrogen. In the reasoning of the European Commission, the development of renewable electricity for general electrification and for electrolysis can take place in parallel as long as additionality is preserved: in that case, renewable electricity for hydrogen does not come at the expense of renewable electricity for the electrification of economic sectors like mobility. Of course, for this reasoning to hold, additionality should be upheld strictly. This would not be a problem if renewable electricity would be widely available, but in practice, it will presumably be scarce for years to come (NLR, 2022). In this chapter we assess in broad lines whether the Commission's ambitions for renewable electricity and renewable hydrogen are mutually consistent and what would be needed to achieve them simultaneously.

5.1 Electricity demand for hydrogen

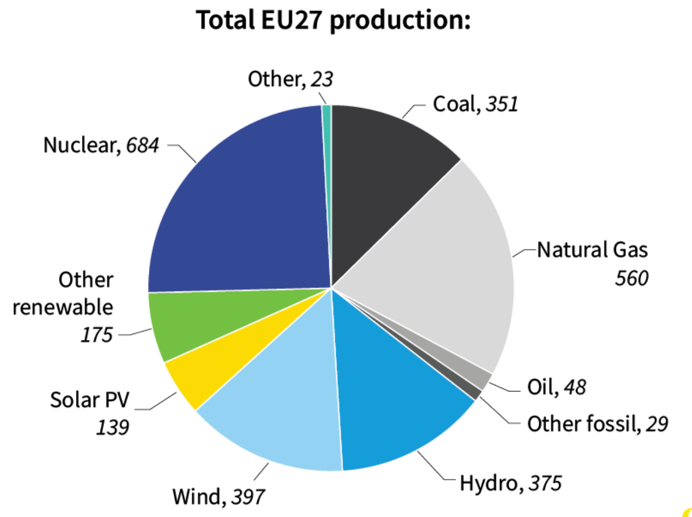
The EU aims to produce 10 Mton/y of hydrogen in 2030 (see *Chapter 2*). We estimate that in 2030 around 55 kWh/kg of electricity is required to realise this, based on (IRENA, 2020). The resulting electricity consumption is 550 TWh/y.

This requires an estimated 60-120 GW of electrolysers, much more than the EU target of 40 GW in 2030 (see *Table 1*). The lower bound of circa 60 GW translates to electrolysers running 24/7 at full load. The upper bound of 120 GW translates to electrolysers running 4,500 hours per year, roughly equal to the full load hours of an offshore wind farm. The upper bound is not a hard limit and could raise significantly if the electrolyser runs fewer hours, for example when directly coupled to a solar plant with only 1,000-2,000 full load hours per year.

5.2 Electricity demand for hydrogen equal to all EU electricity from solar and wind in 2020

To put the electricity demand from electrolysis in perspective, in 2020 the total electricity production of the EU27 countries was 2,781 TWh, see *Figure 2*. The total production from solar panels and wind turbines amounted to 537 TWh, roughly equal to the electricity demand for 10 Mton/y of hydrogen. Given the ambitions to electrify a large share of power production by 2030, this means that total solar and wind capacity in the EU should sharply increase to realise both this electrification and the target of 10 Mton of hydrogen production at the same time.

Figure 2 — EU27 electricity production (TWh/y) by source in 2020



Source: Eurostat.

*In 2020, total production from solar panels and wind turbines amounted to **537 TWh**, roughly equal to the electricity demand for **10 Mton/y** of hydrogen.*

5.3 Newly planned renewable electricity supply

How much new renewable capacity comes online?

The REPowerEU Plan (EC, 2022c) foresees installation of significant new renewable electricity generation capacity:

- REPowerEU mentions 600 GW of new solar by 2030, producing roughly 600 TWh/y of electricity[6]. This requires an area of 6,000 km2, an area over twice the size of Luxembourg.
- The EU Strategy on Offshore Energy (EC, 2020a) mentions at least 60 GW of offshore wind by 2030, compared to almost 15 GW at the end of 2020. 45 GW of new offshore wind by 2030 will produce around 200 TWh/y of electricity[7]. This is 30 times the size of Hollandse Kust Zuid, the world's largest wind park when it comes online in 2023[8]. Hollandse Kust Zuid has 140 turbines of 11 MW, for a total of 1.5 GW, covering an area of 236 km2.
- From the REPowerEU Annex, a total installed wind power capacity of around 500 GW can be distilled. Taking into account the current installed wind power and 45 GW of offshore wind growth, this results in around 280 GW of new onshore wind. This will produce around 580 TWh/y. This translates to 56,000 large turbines of 5 MW, more than five times the current onshore wind capacity in Germany[9].

Summing up, the total planned new renewable electricity according to the EU's projections will amount to around 1,380 TWh/y. We will now explore how this new generation capacity compares to the extra demand that will arise in the coming years.

Where to use the new electricity?

Any new renewable electricity enters the electricity market and is not earmarked for a specific goal. Instead, the electricity is required for multiple (decarbonisation) goals:

- To replace fossil electricity generation. In 2020, 989 TWh was generated from fossil fuels.
- To replace nuclear energy, since construction of new nuclear power plants is insufficient to replace the closure of ageing plants. From the RePowerEU Impact Assessment, we expect a shortfall of at least 40 TWh, although this number is quite uncertain.
- To cover new demand from direct electrification of vehicles and heating. The REPowerEU plans include a strong push for the use of electricity for electric vehicles and heat pumps. From the Impact Assessment we expect around 230 TWh of additional demand.
- To produce 10 Mton/y of renewable hydrogen by 2030. As mentioned earlier in this text, an estimated 550 TWh/y is required for hydrogen production.

To cover all these goals, at least some 1,800 TWh/y is required.

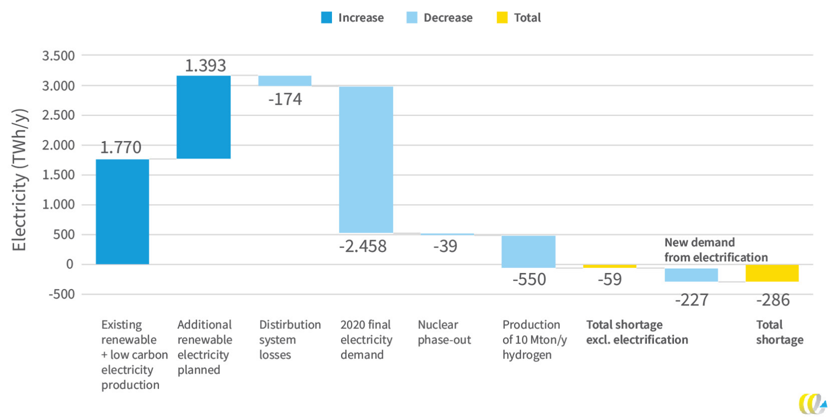
5.4 Supply and demand compared

Not enough renewable electricity to reach all goals simultaneously

The projected new renewable electricity generation and the newly emerging demand are displayed together in *Figure 3*.

From this figure, it is clear that the planned new renewable generation is not enough to fully decarbonise the power sector and produce 10 Mton/y of renewable hydrogen within the EU and cover new electricity demand for electrification. Either even more new renewable generation is required, or the decarbonisation goals cannot yet be fully achieved by 2030.

Figure 3 — Projected renewable generation compared to decarbonisation challenges (TWh/y)

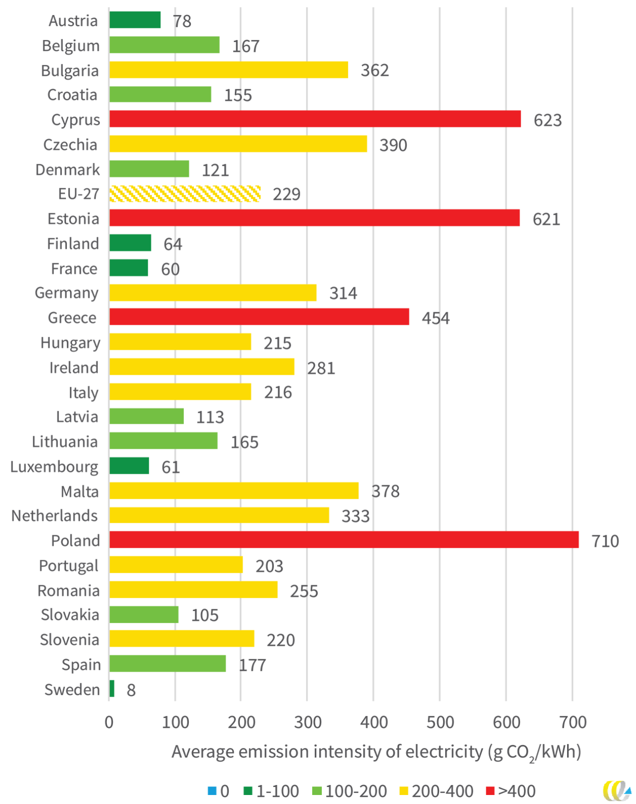


6 Capacity factor based on 2020 production and installated capacity data from Eurostat.
7 Assuming 4.500 full load hours.
8 www.nl.wikipedia.org/wiki/Windpark_Hollandse_Kust_Zuid
9 www.statista.com/statistics/868463/onshore-wind-energy-capacity-in-germany/

Desirability of renewable hydrogen production varies per member state

In the previous paragraphs we have discussed the developments at the EU level. However, the situation is more complex at Member State level. To illustrate this, *Figure 4* lists the average emission intensity of electricity production per member state in 2020.

Figure 4 — Average emission intensity of electricity production in g CO_2/kWh per member state in 2020



The differences in emission intensity are significant: while Sweden's average emissions were only 8 g CO_2/kWh due to abundant hydropower, Poland's emissions were more than 700 g CO_2/kWh due to its strong reliance on coal.

In countries with emission-intensive electricity production, it is even more pressing to first clean up the power sector before generating large amounts of hydrogen from electricity. On the other hand, in countries where electricity production is already relatively clean, there is more room to accommodate large scale electrolysis plants. Even in those countries, care has to be taken that electrolysers are only activated at the moment when additional electricity supply does not lead to the activation of a fossil power plant.

5.5 Conclusion

The projected capacities for additional renewable generation according to the RE-PowerEU Plan (and previous EU strategy documents) are insufficient to fully decarbonise the power sector, cover additional demand from direct electrification *and* produce 10 Mton/y of renewable hydrogen in the EU. The feasibility of an even faster deployment of renewables is questionable, since the current targets are already highly ambitious with regard to permitting, limited availability of skilled labour and materials, and manufacturing capacities.

The most likely way out of this conundrum is that renewables will be scaled up at maximum speed and that in most countries some fossil electricity production will remain in 2030 to cover peak demand. Only in countries with already high shares of low carbon power supply will electricity be fully renewable at almost every moment in 2030. In most countries however, it will still not be a given that electricity is renewable, which is why additionality is required. We will expand on this further in the next chapter.

The projected capacities for additional renewable generation are insufficient to fully decarbonise the power sector, cover additional demand from direct electrification and produce 10 Mton/y of renewable hydrogen in the EU.

6. The need for additionality

The concept of additionality guarantees that any hydrogen that is produced from electricity is produced from *additional renewable* electricity, i.e. from newly built renewable power generation capacity such as solar or wind, which would not have existed if not for the production of hydrogen.

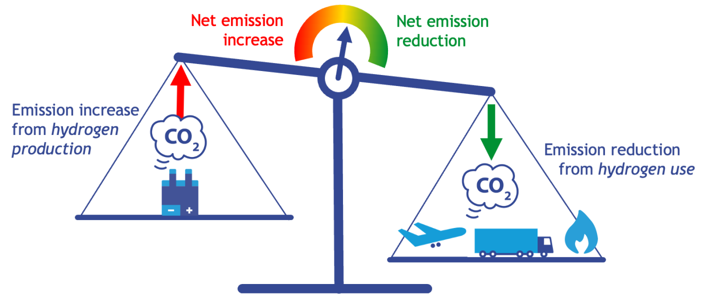
The RED requires an overall emission reduction of at least 70% in order for Renewable Fuels of Non-Biological Origin (RFNBOs) to be classified as renewable. For hydrogen, most of the emissions stem from the use of electricity to produce the hydrogen by electrolysis. The Delegated Act on Additionality lists several conditions under which this electricity can be *administratively* counted as emitting zero CO_2 emissions. We will explore these conditions in more detail in *Chapter 7*. In this chapter, we will first explain what *physically* happens in the electricity system when hydrogen is produced and under which conditions the additional emissions are actually zero *in practice*.

We will look under which conditions the production and use of hydrogen can result in real-world emission reductions. In more detail, the overall emissions effect of the application of hydrogen is the balance of the additional emissions created by producing hydrogen and the emission reduction from replacing fossil fuels by using hydrogen, see *Figure 5*. We will show that only hydrogen from additional renewable sources results in an overall decrease of real-world emissions.

The need for hydrogen

The production and use of hydrogen is a key element in the EU decarbonisation strategy, and for good reason. The production of hydrogen by electrolysis can help integrate more renewable electricity supply if electrolysers are purposively activated only during moments of abundant supply from variable renewable sources. The use of renewable hydrogen is essential to decarbonise existing hydrogen demand (produced from fossil fuels), to produce renewable fuels for long distance shipping and aviation and to act as long-term energy storage in the electricity system. These are essential functions with few alternatives. The positive climate effect of hydrogen does however strongly depend on the specifics of the production and use.

Figure 5 — The net emissions effect of hydrogen is the balance of production and use



6.1 Emissions from the production of hydrogen

Activation of electrolysers increases electricity demand

Electrolysers use electricity to split water into hydrogen and oxygen as a by-product. There is currently no meaningful installed capacity of electrolysis plants in Europe. The use of hydrogen will generally not lead to a decrease in electricity demand, since hydrogen replaces fossil fuels and not electricity. The installation of electrolysers will thus lead to an increase in electricity demand, on top of the already existing demand.

Electricity market basics — Additional electricity demand means fossil power plants ramp up

The electricity system differs from most other energy systems in that supply and demand have to be in absolute balance at every moment in time. Even slight instabilities can result in a rapid shutdown of the system, leading to blackouts.

For each day, supply and demand are matched for each hour in the day-ahead auction. Electricity consumers that are willing to pay a high electricity price are served before consumers that only want to use electricity when it is cheap. Conversely, power plants that can make a profit at low power prices are activated before power plants that need high prices to be profitable. In this auction, any additional demand will be served by the cheapest supplier that is not yet activated: the marginal generator.

The order of activation of electricity generators means that zero marginal cost generators such as solar, wind, hydropower and nuclear are activated first, even at very low prices. Besides having no or very low marginal costs, these plants also have zero marginal CO_2 emissions. These sources are sometimes sufficient to serve all electricity demand, usually if generation is high due to good weather conditions (sunny and windy), or if demand is very low (e.g. Sunday afternoon). This situation is still very rare in most European countries, although it will be increasingly common as more renewable capacity comes online.

Fossil plants are activated if demand is higher than the level that can be met by zero marginal cost generators. Inflexible but cheap sources like lignite and coal power plants are usually activated first. These plants generally have low costs but produce very high CO_2 emissions. At yet higher prices, more flexible natural gas power plants are activated. The more efficient combined cycle power plants are activated first, the inefficient but very flexible peaker plants are only activated when prices are very high[10].

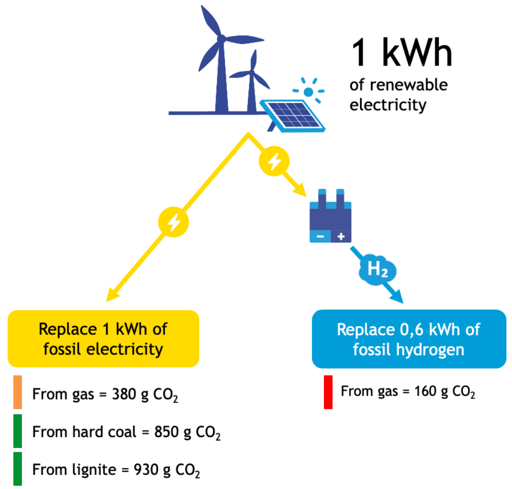
Across Europe, the marginal generator is usually a gas plant, which means that additional demand is served by gas plants until there is enough renewable capacity that the marginal generator is a renewable producer. Exceptions do of course exist. In some countries that rely extensively on coal (e.g. Poland), heavily emitting coal plants may be the marginal generator. Conversely, some countries generate large quantities of low-carbon electricity from hydropower (e.g. Norway, Sweden), or nuclear (France), leading to those sources being the marginal generator for some periods, instead of gas plants.

Decarbonise electricity production first, then hydrogen production

Hydrogen is currently mostly produced directly from natural gas by reforming gas at high temperatures into hydrogen. The efficiency of this steam methane reforming (SMR) process is around 75%. This is far more efficient than first converting natural gas into electricity at an average efficiency of 54% and then using the electricity to produce hydrogen at around 60% efficiency. The combined efficiency of the gas plant and the electrolyser is only around 34%, less than half of the efficiency of the SMR.

Figure 6 shows the avoided emissions from using a kilowatt-hour of renewable electricity to either replace fossil electricity or to replace hydrogen production from fossil gas. From this figure, it is clear that the displacement of fossil electricity production avoids multiple times as much emissions as the displacement of fossil hydrogen. Therefore, from an emission reduction perspective, as long as renewable electricity is scarce, it should be applied to replace fossil electricity production rather than fossil hydrogen.

Figure 6 — Avoided emissions from using an additional kWh of renewable electricity to replace either fossil electricity or fossil hydrogen production



The EU hydrogen ambition of 10 Mton/y renewable hydrogen production in 2030 could lead to 210-510 Mton/y of additional CO_2 emissions in the power sector if the electrolysers are not powered by additional renewable power, depending on wheth-

10 Peaker plants use a gas turbine to generate electricity with an efficiency of around 40 45%. Combined cycle plants use the waste heat from the gas turbine to produce steam and generate extra electricity with a steam turbine, raising efficiency to 55-64%.

er the electricity is produced from natural gas or coal. By comparison, total CO_2 emissions in the EU were 3,700 Mtons in 2020[11].

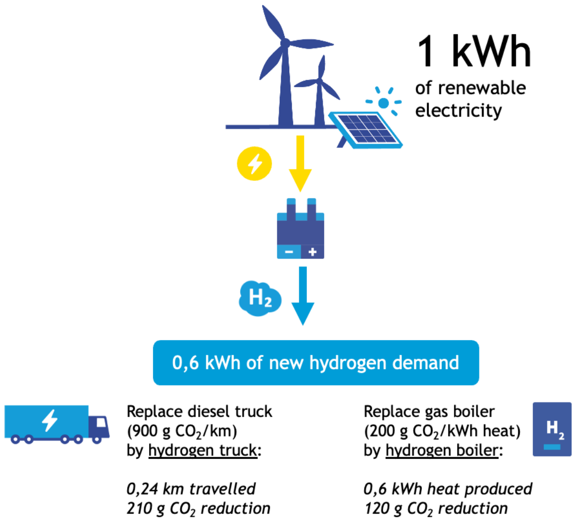
6.2 Emission reduction from the use of hydrogen

Hydrogen avoids relatively little emissions in end applications

The overall net effect on CO_2 emissions is the sum of the additional emissions in the power sector and the emission savings by reducing fossil fuel demand in end applications.

Hydrogen can be used in many applications. We highlight the use of hydrogen in a fuel cell electric truck and in a hydrogen fired boiler. *Figure 7* shows that the avoided emissions from the use of hydrogen in these two applications are 210 g per kWh of electricity used and 120 g per kWh respectively.

Figure 7 — Avoided emissions from hydrogen applications



11 www.eea.europa.eu/publications/annual-european-union-greenhouse-gas-1

6.3 The net emission effect of hydrogen

Hydrogen only results in net emission savings if produced from additional renewable electricity

Comparing the emissions from the production of hydrogen in *Figure 6* and the emission reductions resulting from its use in *Figure 7*, it is clear that it is hard to reduce CO_2 emissions by using hydrogen from reforming natural gas. Moreover, it is practically impossible to reduce overall CO_2 emissions produced from electrolysis with fossil electricity. Significant emission reductions are only possible if the hydrogen is produced from additional renewable electricity.

Additionality is a must for renewable hydrogen

As we have shown, hydrogen can only be rightly called renewable if it is produced from additional renewable electricity. If this is not the case, total CO_2 emissions will increase as a result of the application of hydrogen. We have shown that this is not a given and a too fast ramp-up of electrolyser capacity will result in additional emissions. Of course, hydrogen suppliers are free to produce hydrogen in this way, but they should not be able to market that hydrogen as renewable and it should not count as renewable for the EU policy targets. Therefore, it is crucial that the EU's rules on additionality, which we assess in more detail in Chapter 7, guarantee that renewable hydrogen is produced from renewable electricity that is truly additional to the system.

Hydrogen can only be rightly called renewable if it is produced from additional renewable electricity.

7. Additionality criteria assessed

In this chapter we follow the structure of the DA Additionality as shown in *Figure 1* and analyse, for the various options to count electricity as renewable, the meaning and impact of each of the criteria. In doing so, we explain the rationale behind the provisions of the DA and assess their significance in terms of guaranteeing additionality. We also analyse the impact of the derogations, as they amount to temporally scrapping some of the criteria, and pay attention to the DA GHG emissions savings as well. Finally, we draw conclusions on the extent to which the current draft rules preserve the requirement of additionality, and the possible changes that would endanger it the most.

7.1 Only new renewable generation capacity eligible

Both the direct line option and the grid (PPA) option contain a clause that states that the electrolyser shall come into operation no later than three years after the renewable electricity generator(s). The three year term would give operators room to handle delays in the realisation of the renewable electricity generating installation, often caused by permitting. In that light, the three year period is a reasonable time.

This clause prevents the use of already existing renewable generation capacity for the production of hydrogen. If that were allowed, renewable electricity would in practice be 'taken away' from the power sector and rerouted to hydrogen production. The hydrogen would be branded as renewable, while it in fact leads to the direct replacement of renewable electricity by fossil electricity, hence leading to additional emissions. Since the production of hydrogen in such case leads to large additional emissions, it is obviously not just to call it renewable hydrogen. Therefore, renewable hydrogen can only be produced from newly built, additional renewable electricity.

The capacity of the electrolyser can be expanded within two years (direct line) or three years (grid PPA) while still being considered part of the original installation.

Draft Delegated Act: *The electrolyser shall come into operation no later than three years after the renewable electricity generator(s).*

7.2 Direct line (art. 3)

How does it work?

The direct line is defined[12] as meaning "*either an electricity line linking an isolated generation site with an isolated customer or an electricity line linking a producer and an electricity supply undertaking to supply directly their own premises, subsidiaries and customers*". In Layman's terms this means that a renewable generator is connected directly to the electrolysis installation, i.e. without either being connected to the grid. For instance: an offshore wind turbine with an integrated electrolyser or an off-grid solar installation with an electrolyser.

The direct line is the most straightforward way to ensure that only renewable energy is consumed for the production of hydrogen, since there is simply no way for non-renewable power to reach the electrolyser.

The direct line is not commonly employed, since the possibility for price arbitrage is eliminated. With a grid connection, the operator can choose between selling electricity to the grid when the price is high, converting it to hydrogen, and buying electricity from the grid for the production of hydrogen when the operator's own asset does not generate much power but market prices are low. The direct line only allows to convert electricity into hydrogen, which lowers the potential profitability. For example: an electrolyser that is directly connected to an offshore wind farm cannot profit from low market prices in summer caused by an overabundance of solar energy.

Only new generation capacity is eligible for direct line

The electrolyser shall come into operation no later than three years after the renewable electricity generator(s). The capacity of the electrolyser can be expanded within two years while still being considered part of the original installation.

12 In Directive 2019/944 on the common rules for the internal electricity market in the EU.

7.3 Grid: High RE penetration (art. 4.1)

How does it work?

Under the proposed DA Additionality, hydrogen can also be considered renewable if the electrolyser is located in a bidding zone where more than 90% of the electricity is produced from renewable sources on an annual basis. Note that a bidding zone is not always the same as a country (see Textbox). If a bidding zone has >90% renewable electricity, the amount of full load hours of the electrolyser is restricted to the proportion of renewable electricity on the grid, e.g. for a grid with 95% renewable electricity, the electrolyser is allowed to make at most 95% x 24 h/d x 365 d/y = 8,322 full load hours per year.

Although it is likely that additional electricity demand in such regions would mostly be covered by renewable sources, this is not guaranteed. As renewable sources are generally intermittent, an excess of power is often generated and exported when weather conditions are favourable. When weather conditions are less favourable, electricity is generated from fossil sources or imported. So even when the *average* share of renewable electricity is high, this does not translate to an equal share of hours where additional demand does not lead to additional emissions. For example the Netherlands Environmental Planning Agency estimates that by 2030 around 70% of the electricity in the Netherlands is produced from renewable sources (PBL, 2021b), but renewable energy will be the marginal generator for only 3,000 hours per year (34% of annual hours) (PBL, 2021a).

The DA does not contain a clause under Art. 4.1 to limit electrolyser operation in these bidding zones to hours where the marginal generator actually is a renewable installation. This means that, even when 90% of electricity in the bidding zone is renewable on an annual basis, under this rule the electrolyser will probably still run on fossil electricity for a certain amount of hours per year.

Countries with high shares of renewable electricity

In 2020, no EU country had a renewable electricity penetration factor of over 90%[13]. Non-EU Member States Norway, Iceland and Albania did reach the threshold, however.

13 www.ec.europa.eu/eurostat/databrowser/view/sdg_07_40/default/table?lang=en

Bidding zones vs. country borders

A bidding zone is a geographical region that has the same electricity price throughout. This can be an entire country, but some countries (Norway, Sweden, Denmark and Italy) have multiple bidding zones. In these countries, there are large differences in the locations where electricity is generated and where it is consumed, and insufficient grid capacity between these zones.

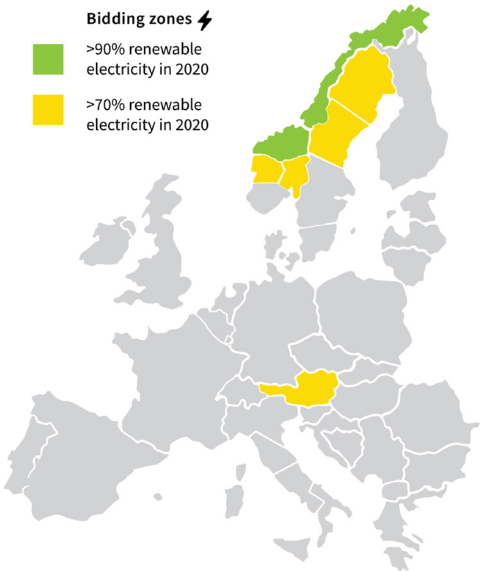
For example, both Norway and Sweden have a surplus of generation in the north, caused by abundant hydropower. The south of both countries houses major population and industrial areas with high demand. Multiple bidding zones means multiple electricity prices in one country. For Norway and Sweden, this means cheap electricity in the north and more expensive electricity in the south. This gives an incentive for extra generation in the south, extra demand in the north and more interconnection in between. A relaxation of Art. 4.1 from bidding zones to countries would be counterproductive in this light.

In the future, Germany, France and the Netherlands may also be split in multiple bidding zones. Alternative configurations are considered for Italy and Sweden (ACER, 2022).

Hydrogen can also be considered renewable if the electrolyser is located in a bidding zone where more than 90% of the electricity is produced from renewable sources on an annual basis.

By 2030 around 70% of the electricity in the Netherlands is produced from renewable sources (PBL, 2021b), but renewable energy will be the marginal generator for only 3,000 hours per year (34% of annual hours).

Figure 8 — Electricity bidding zones in the EU in September 2020 with share of renewables estimated by CE Delft based on country averages



Bidding zones in green have >90% renewable electricity in 2020, bidding zones in yellow have >70% renewable electricity. Source: www.fsr.eui.eu/electricity-markets-in-the-eu/.

Push for 70% renewable share

Some parties have argued that a 70% share of renewable electricity would be more apt, as they feel it would also stimulate hydrogen production in countries with rapidly growing shares of renewable electricity (see Chapter 4).

In this case, Austria and Sweden would fall under this rule as they have renewable electricity shares in excess of 70%. As discussed above, however, the share of annual hours when the marginal generator is renewable could be much less than 70% in this case. This would mean that the electricity used for the production of hydrogen would actually not be renewable for a significant share of the electrolyser's full load hours.

7.4 Grid: PPA (art. 4.2)

Electricity can also be procured from the grid, so without a direct, identifiable connection between a certain producer and consumer of electricity. This option is the most common one, as most electrolysers will be connected to the grid and will not dispose of their own, dedicated renewable electricity production capacity.

A Power Purchase Agreement (PPA) is a contract between a supplier (the renewable electricity generator) and a user (the electrolyser) to trade a predetermined amount of electricity. Under Art. 4.2 the hydrogen can be considered renewable if a PPA is procured that supplies enough renewable electricity to cover the total demand for the entire electrolysis plant, or more.

The same as for the direct line, the PPA for the electrolyser shall start not later than three years after the start of operation of the renewable electricity generation. Furthermore, conditions on subsidies, temporal correlation and geographical correlation should be met at the same time.

Subsidies (Art. 4.2b)

Only installations for the generation of renewable electricity that have not received net support in the form of investment aid or operating aid are eligible to supply PPAs if the electricity is to count as renewable.

Temporal correlation (Art. 4.2c)

The DA sets additional requirements on the match between the time of generation and consumption of the electricity. If renewable electricity is generated at the same time as it is consumed, no fossil back-up is required and hence no additional carbon emissions are generated. The Act stipulates three options:

1. Hourly matching

Electricity should be used within the same hour as it is generated. It is critical that this period is hourly at the longest; it should not be extended to weekly, monthly, quarterly or even yearly, as some parties propose.

The output of variable renewable sources such as solar panels and wind turbines varies strongly throughout the day. The most intuitive example is that solar panels cannot generate electricity at night. Longer matching periods than hourly allow electrolysers to operate at a constant level during the matching period, regardless of the actual hourly production of the renewable energy source. Viewed on a monthly, quarterly or yearly basis, a combination of solar and wind provides a near constant output, while the hourly production fluctuates strongly.

In countries with higher shares of renewable electricity, longer matching periods than hourly will lead to additional CO_2 emissions. When renewable sources generate electricity in these countries, there is an increasing chance that they contribute to a surplus of renewable electricity, where some renewable electricity has to be curtailed ('thrown away') to balance the grid. This curtailed renewable electricity cannot replace fossil electricity, while fossil plants are still used during hours when renewable sources do not generate electricity. This leads to a net increase of CO_2 emissions.

In countries with little renewable energy, longer matching periods hardly lead to additional emissions. The amount of avoided emissions from a temporary surplus of renewable electricity is roughly equal to the additional emissions generated by fossil plants to cover a temporary shortfall in renewable electricity. As we have shown in Chapter 6 however, these countries should use any renewable electricity to displace fossil electricity rather than to produce hydrogen.

An even shorter period than hourly, for example fifteen minutes, would strongly increase administrative demands, while not contributing to additional emission reductions.

2. Storage

Electricity can also be supplied by storage capacity located at the same location as the electrolyser. The storage should be charged during the same hour as the renewable electricity is generated. **Storage causes higher energy losses than direct use, but it does not lead to any additional carbon emissions since any losses are covered by the renewable PPA.**

3. Low clearing price

Electricity can be used during periods of low prices on the day-ahead market. **Low prices correlate well with high renewables output and/or low demand**. The Act mentions an electricity price lower than 20 €/MWh *or* lower than 0.36 times the price of an EU ETS emission allowance. In Annex A we explain the rationale behind these price limits and show that these prices are insufficient for fossil power plants to make a profit. This means that such prices will only arise when there is a surplus of electricity and the marginal generator is a renewable source. Any remaining fossil electricity generation will come from non-flexible plants forced to sell at a loss. Since there is a strong economic incentive to avoid this situation, it will not jeopardise additionality on any meaningful scale.

Geographical correlation (Art. 4.2d)

The DA also sets rules for the location of the renewable electricity source and the electrolyser. The generator of renewable electricity should be located:

- in the same bidding zone as the electrolyser; or
- in a neighbouring bidding zone with electricity price equal or higher; or
- in an adjacent offshore bidding zone.

The geographical correlation rules are a second necessary condition to prevent additional emissions from fossil power plants. The temporal correlation rules dictate that the electrolyser is activated during the same period as the renewable electricity is generated, so no emissions from fossil fuelled power plants occur. When the electrolyser is in a different bidding zone, this is no longer guaranteed, as different power plants are activated in different bidding zones and interconnection capacity between bidding zones is inherently limited. In fact, limits in grid capacity are the very reason different bidding zones exist at all. For example: there can be a surplus of renewable electricity in Spain, while there are still gas plants running in Portugal because of limited interconnection capacity between the countries. Activating an electrolyser in Portugal on Spanish electricity would in this situation lead to additional emissions in Portugal. Using the same reasoning, a relaxation of the geographical correlation from bidding zones to countries could also result in additional emissions.

Geographical correlation also prevents that new electrolysers aggravate grid congestion issues by transporting electricity over long distances between generation and electrolyser. The unnecessary use of the grid by electrolysers prevents other applications from using electricity, slowing down the energy transition and causing more emissions. Infrastructure for the transport of electricity (HV lines) is far more costly than pipelines for hydrogen. It would make sense to locate the electrolyser as closely to the electricity source as possible and transport the energy with a cheap pipeline to the location of hydrogen demand, instead of requiring costly grid upgrades to transport the electricity to an electrolyser close to the location of hydrogen demand.

Electrolysers are only allowed to be in a different onshore bidding zone if electricity is transported 'against the flow' (second clause), i.e. from higher to lower prices. Normally, electricity flows from regions with low prices to high prices. The second clause only permits electricity to flow in the reverse direction, so that it alleviates congestion rather than aggravates it. In fact, Article 4.5 states that Member States can introduce additional criteria concerning the location of renewable energy production and electrolysers. It is to be expected that electrolysers will be stimulated to be placed in regions with abundant renewable generation, for example near the onshoring of offshore wind or near large solar and wind parks.

Offshore bidding zones do not yet exist, but are a proposed solution to combine offshore wind farms with extended interconnection capacity between countries (Nieuwenhout, 2022).

7.5 Derogations and exemptions

As explained above, the PPA-option in the draft DA Additionality is the most relevant for practical purposes, as the direct line option is commercially not very attractive and there are currently no EU Member States with >90% renewable electricity penetration. The criteria for this option that we have assessed, especially the ones on renewable electricity being new to the system, temporal correlation and geographical correlation, are by themselves robust and well-designed. As long as they are not compromised they will guarantee additionality is preserved in the system. There are however some derogations and exemptions in the draft text, some of which may reduce the effectiveness of the Act. In this section we explore mainly the transitional phase of the DA on Additionality and its so-called grandfathering clause.

In *Annex B* we treat two exemptions with more limited impact: electrolysers for R&D purposes and the activation of electrolysers on downwards dispatch signals. We conclude that neither of these exemptions has a significant effect on emissions.

Transitional phase (art. 7)

Additional renewable generation and state aid

Article 4.2 points (a) and (b), on the 36 month limit for additional generation and state aid respectively, only come into force from 1 January 2027. This means that electrolysers making use of the PPA option can count the hydrogen produced before 2027 as renewable even if their PPA is concluded with a renewable electricity generator that has existed for more than three years already or has received net financial support.

Temporal correlation

Electricity can be produced/stored and consequently used for the production of renewable hydrogen within the same *month* rather than the same *hour* until 31 December 2026 (Art. 4.2.c 1&2), as long as no state aid other than capex support is received.

In summary, both the additionality proper of the renewable electricity generator and the temporal correlation are being suspended during the transitional phase. In line with our assessment of these criteria, this will lead to additional emissions during the transitional period. The extent of the additional emissions may be limited, though, as they only would result from electrolysis capacity that is online before 1 January 2027. Given the almost non-existing current electrolysis capacity in the EU and the long lead time for investment decisions to be made, total electrolysis capacity will likely still be relatively small by 2027. On the other hand, the mere opportunity offered by this transitional phase (and even more that of the grandfathering clause, see below) might actually accelerate the development of electrolysers being planned and built before that date. In any case, it would be ill-advised to extend the derogation on temporal correlation to a later date.

Grandfathering (art. 8)

Article 4.2 points (a) and (b), on the 36 month limit for additional generation and state aid respectively, do not apply for any electrolysis installation that comes into operation before 1 January 2027. This derogation is everlasting, which makes it a so-called grandfathering clause.

The Delegated Act does clearly state in Art. 8 that the derogations do not apply to any capacity additions, even though the date of initial operation of the expansion may be set equal to the date of initial operation of the original installation as per Art. 3(b) and Art. 4.2(a).

The effect of this derogation and the grandfathering is that an initial wave of electrolysis capacity comes online under favourable regulation, much faster than additional renewable generation comes online. This leads to a one-time setback for the amount of renewable electricity available for the power sector. These clauses actually cause *recarbonisation* of the power sector, since increasing amounts of electricity from existing renewable sources are funnelled towards the production of hydrogen. This will leave the power sector no other choice than to increase generation from fossil assets. Even when electrolysers would follow rules for temporal correlation on an hourly basis, less renewable electricity will be left for the power sector. All the while, the hydrogen counts as renewable, while it in fact results in additional emissions in the power sector. Since the derogation is indefinite, the renewable electricity 'taken away' from the power sector before 1 January 2027 is never 'given back' by realising additional renewable generation later on.

This would lead to additional emissions even when a mature hydrogen market has been established and is therefore not necessary. The grandfathering clause of Art. 8 should at least be capped by a sunset clause (expiry date) to limit the additional emissions.

7.6 DA on GHG emission savings

The criteria discussed above are proposed in the DA Additionality. As mentioned in Chapter 3, the DA on GHG emission savings offers another option to make hydrogen count as renewable in list item 6 of the Annex to the DA:

If the number of full load hours the electrolyser is producing is equal to or lower than the number of hours in which the marginal price of electricity was set by installations producing renewable electricity or nuclear power plants in the preceding calendar year, grid electricity used for the production of renewable hydrogen may be attributed a GHG emission value of zero g CO_2-eq./MJ.

This clause will in practice not result in zero additional emissions from electrolysis as only the *amount* of full load hours is matched, while there is no relation between the *time* these hours occur. For true zero emissions, this clause should be supplemented by the requirement to only enable the electrolyser *during the same hours* in which the marginal price of electricity is set by renewable or nuclear plants (temporal correlation). There is however a strong economic incentive to align electrolyser operation with low power prices and thereby with the hours where the marginal generator is a renewable or nuclear generator.

Although absolute zero emissions are not guaranteed, this option is expected to be close enough to true zero in practice, such that any additional emissions remain within acceptable limits.

7.7 Conclusion

The basic additionality rules as proposed in the draft DA Additionality (apart from derogations/grandfathering) are robust enough to safeguard that any additional electricity demand for electrolysis will be met by renewable sources only. If these rules stay intact and derogations are limited, there is no need for concern that electrolysis might lead to an increase in power sector emissions. Loosening these rules or allowing broad derogations would, however, endanger the additionality principle and allow for net emission increases.

Especially the condition on renewable electricity capacity to be new (<36 months) and the temporal and geographical correlations as proposed in the draft DA are important to guarantee that additionality is really preserved. The PPA option, for which these are important criteria, will be a very commonly used one in practice. If the temporal and geographical criteria would be loosened with regard to their current form for the long term (i.e. hourly correlation and allowing only for the neighbouring bidding zone), this would directly lead to a loss in factual correlation between production of renewable electricity and production of the hydrogen, with increasing emissions as a very likely consequence.

In summary, we categorise the exemptions as being either relatively harmless, with limited environmental impact, or problematic, leading to significant greenhouse gas emissions:

Exemptions with limited impact in DA

- research, testing and demonstration (Art. 4.3);
- downwards redispatch (Art. 4.4);
- transitional phase until 31-12-2026 (Art. 7):
  - additional renewable generation;
  - state aid;
  - temporal correlation relaxed to monthly.
- DA on GHG emission savings.

Problematic exemptions in DA

- grandfathering without sunset clause (Art. 8).

Problematic exeption not in DA, but part of discussion

- extension of relaxation on temporal correlation beyond 1 January 2027;
- scrapping of geographical correlation or relaxation from bidding zones to countries;
- relaxation of cut-off percentage of high RE penetration regions (Art 4.2) from >90% to >70%, or from bidding zones to countries.

Loosening these rules or allowing broad derogations would, however, endanger the additionality principle and allow for net emission increases.

8. Renewable H_2 build-out vs additionality: reconciliation possible?

Among the parties involved in the debate, there is no disagreement that hydrogen is desired and required for decarbonisation of certain sectors. However, not all parties agree on the timing of green hydrogen supply ramp-up in the EU. The main issue here is whether this ramp-up can wait for sufficient renewable electricity capacity to be available.

The EU has multiple policy objectives with regards to hydrogen:

1. Ensure that any hydrogen used is produced with sufficiently low emissions in order to provide effective abatement.
2. Provide a sufficient amount of such renewable hydrogen to hard-to-abate sectors.
3. Establish a domestic European renewable hydrogen supply chain, to ensure security of supply.

The Renewable Energy Directive (RED), which the DAs treated in this study are supplementing, is concerned with the first objective. Its primary goal is to stimulate the production and use of renewable energy. Because energy carriers are branded as 'clean' by the RED, producers are eligible for certain subsidies, can secure more attractive financing and command premium prices. The RED is only effective if it maintains stringent environmental standards, such that any energy carrier or fuel branded as renewable by the RED does indeed result in significant emission savings. For the production of renewable hydrogen, the strict additionality rules safeguard this.

It must be emphasised that the additionality criteria are only applicable if the generated hydrogen is to count as renewable hydrogen. Hydrogen from electrolysis is always allowed to be produced while disregarding the additionality criteria, but then the hydrogen is (rightfully) not counted as renewable anymore.

The establishment of a European supply chain for the production of renewable hydrogen, including the production of the electrolysers themselves on EU soil, is not a goal of the RED. It is a policy objective inspired by concerns on security of supply and a desired autonomy of the EU in certain areas. Without judging on the legitimacy of these other policy objectives, which is obviously outside the scope of this study, we refer here to the so-called Tinbergen's rule[14], which states that the number of policy objectives cannot exceed the number of policy instruments. Ergo: additional policy instruments, different from the RED, are required to make sure that not only the used hydrogen is renewable, but that the hydrogen is available in sufficient amounts to decarbonise the sectors that depend on it and that (at least part of it) comes from European soil. These other policy instruments should, at the same time, not jeopardise the RED's objectives to develop renewable energy and to safeguard the standards that determine what is renewable, and what is not.

14 Jan Tinbergen (1903-1994) was an influential Dutch economist and Nobel prize laureate.

9. Conclusions

In this study on the additionality of renewable electricity for hydrogen production, we assessed the proposed criteria for additionality in the context of the dual ambitions of the EU to achieve a rapid expansion of both renewable electricity in general and renewable hydrogen.

First outlining the context of the issue of additionality, we listed the various policy targets of the EU regarding the development of renewable electricity and renewable hydrogen. We found that the current concerns on energy security, fuelled by the war in Ukraine, led the Commission to propose to further strengthen several of these targets in the RePowerEU Plan.

Our assessment of the first public responses to the draft Delegated Act on Additionality revealed a wide gap between the positions of NGOs and representatives of industry. While the NGOs are warning for increasing emissions and the risk of double counting of renewable energy, industry parties express concerns that strict additionality criteria may hinder the development of a mature hydrogen market in the EU.

Diving deeper into the matter, in *Chapter 5*, we compared the dual ambitions of the EU mentioned above and concluded that the Commission's own projections for new renewable electricity capacity in 2030 are insufficient to fully decarbonise the power sector, cover newly emerging demand from electrification *and* produce the desired 10 Mton/y of renewable hydrogen. Developing even more renewable electricity capacity would probably meet with several practical constraints such as the limited availability of skilled labour and materials.

Next, in *Chapter 6* we analysed why additionality is so crucial from a climate policy perspective. We found that hydrogen can only be rightly called renewable if it is produced from additional renewable electricity. If this is not the case, total CO_2 emissions will increase as a result of the application of hydrogen. This is because producing hydrogen from fossil electricity generates far more CO_2 emissions than producing it directly from natural gas, and because the application of hydrogen only leads to a limited decrease in emissions in end use. This also means that, from an emission reduction perspective, as long as renewable electricity is scarce, it should be applied to replace fossil electricity production rather than fossil hydrogen.

In *Chapter 7*, we assessed the provisions in the draft DA Additionality one by one, to see whether the criteria proposed would indeed guarantee additionality in practice. In the process, we clarified that the option to buy renewable electricity under a Power Purchase Agreement (PPA) will be used the most in practice.

From our assessment of the criteria for this option — especially the ones on renewable electricity being new to the system, temporal correlation and geographical correlation — we found that they are by themselves robust and well-designed. As long as they are not being compromised, they will guarantee additionality is preserved in the system and emissions are limited as much as possible.

To establish to what extent these criteria are under pressure, we also assessed the exemptions and derogations in the draft DA Additionality, the provisions of the DA on GHG emission savings and some proposed amendments to the criteria in the draft text. We found that the exemptions and the transitional phase proposed in the DA Additionality, as well as the DA on GHG emission savings, have limited impact on the preservation of additionality. Although the transitional phase and the option to count electricity as renewable offered in the latter DA are not properly in line with the concept of additionality, they likely would not lead to large amounts of additional emissions.

However, the grandfathering clause in the DA Additionality (Art. 8) would be more problematic as long as it lacks a sunset clause. It would lead to recarbonisation of the power sector and cause additional emissions even after the transitional phase has ended. Also proposals to extend the relaxation of the temporal correlation (monthly instead of hourly), to relax the geographical correlation (e.g. country instead of bidding zone) or to relax the cut-off percentage for the definition of high renewable electricity penetration areas (>70% instead of >90%) would undermine the preservation of additionality and should be discouraged from a climate policy perspective.

Finally, we briefly discussed to what extent the various policy objectives of the EU concerning renewable electricity and renewable hydrogen may be reconciled. We stressed the principle that a single policy instrument should not be used to serve different policy objectives at the same time. So, even though there may be a political desire to quickly develop a renewable hydrogen supply chain within the EU, this should not compromise the provisions of the REDII, the Delegated Acts supplementing it or its successor REDIII, as they form the backbone of the EU's legislative framework on the development of renewable energy, including renewable hydrogen.

10. References

- ACER. 2022. *Acer has decided on alternative electricity bidding zone configurations* [Online] Available at: https://www.acer.europa.eu/events-and-engagement/news/acer-has-decided-alternative-electricity-bidding-zone-configurations. 27-9-2022.

- Allen & Overy, 2022. RED II Draft Delegated Acts — *The missing pieces of the EU's hydrogen puzzle*. [Online]Available at: https://www.allenovery.com/en-gb/germany/news-and-insights/publications/red-ii-draft-delegated-acts-the-missing-pieces-of-the-eus-hydrogen-puzzle
[Accessed August 2022].

- Baker McKenzie, 2022. *EU Hydrogen Policy Developments — Additionality Requirement. When can electricity-based hydrogen be deemed 'Renewable' and 'Sustainable' and why do the labels matter?*. [Online] Available at: https://www.bakermckenzie.com/en/insight/publications/2022/07/eu-hydrogen-policy-developments
[Accessed August 2022].

- Bellona, Climate Action Network, Client Earth et al., 2022. *RFNBO production needs strict criteria to ensure emission reductions, reduce fossil fuel dependency, and prevent increasing energy prices for consumers.* [Online] Available at: https://caneurope.org/content/uploads/2022/06/NGO-letter-on-RFNBO-production.pdf
[Accessed August 2022].

- Bellona, 2021. *Cannibalising the Energiewende? 27 Shades of Green Hydrogen*. [Online] Available at: https://network.bellona.org/content/uploads/sites/5/2021/09/Impact-Assessment-of-REDII-Delegated-Act-on-Electrolytic-Hydrogen-CO2-Intensity.pdf
[Accessed August 2022].

- Bellona, 2022. *Explainer on the delegated acts on RFNBOs and GHG emission reductions.* [Online] Available at: https://network.bellona.org/content/uploads/sites/3/2022/06/Explainer-on-the-Delegated-Acts-on-RFNBOs-and-GHG-emissions-reductions-2022.pdf

- Bellona, 2022. *Explainer on the Delegated Acts on RFNBOs and GHG emission reductions.* [Online] Available at: https://network.bellona.org/content/uploads/sites/3/2022/06/Explainer-on-the-Delegated-Acts-on-RFNBOs-and-GHG-emissions-reductions-2022.pdf
[Accessed August 2022].

- Bird & Bird, 2022. *It's finally here: The EU Commission's draft delegated act on renewable hydrogen.* [Online] Available at: https://www.twobirds.com/en/insights/2022/germany/it-is-finally-here-the-eu-commissions-draft-delegated-act-on-renewable-hydrogen
[Accessed August 2022].

- CE Delft, 2021. *Effects of the Fit for 55 Package on the Dutch Aviation Sector*, Delft: s.n.

- Cefic, 2022. *Cefic Statement on the Delegated Act Art. 27 (3) RED II*. [Online] Available at: https://cefic.org/app/uploads/2022/06/Delegated-Act-Art-27-3-RED-II-v.2-Final.pdf
[Accessed 23 8 2022].

- Clienth Earth, 2022. *Delegated Acts on Hydrogen. Methodologies to assess GHG emissions savings and for production of RFNBOs*. [Online] Available at: https://www.clientearth.org/media/vr4pmmjp/clientearth-comments-on-proposed-delegated-acts-relating-to-rfnbos-220617.pdf
[Accessed August 2022].

- EC, 2018. *DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018on the promotion of the use of energy from renewable sources (recast) [REDII]*. [Online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN [Accessed August 2022].
- EC, 2020a. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An EU strategy to harness the potential of offshore renewable energy for a climate neutral future.* [Online] Available at: https://ec.europa.eu/energy/sites/ener/files/offshore_renewable_energy_strategy.pdf [Accessed August 2022].
- EC, 2020b. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A hydrogen strategy for a climate-neutral Europe. COM(2020) 301 final*. [Online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0301&from=EN [Accessed August 2022].
- EC, 2021a. *Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law').* [Online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R1119&from=EN [Accessed 12 August 2022].
- EC, 2021b. *DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive 2018/2001 as regards the promotion of energy from renewable sources.* [Online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0557&from=EN [Accessed August 2022].
- EC, 2021c. *Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on ensuring a level playing field for sustainable air transport.* [Online] Available at: https://ec.europa.eu/info/sites/default/files/refueleu_aviation_-_sustainable_aviation_fuels.pdf [Accessed 1 9 2022].
- EC, 2022a. *COMMISSION DELEGATED REGULATION (EU) …/... supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council.* [Online] Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/7046068-Production-of-renewable-transport-fuels-share-of-renewable-electricity-requirements-_en [Accessed August 2022].
- EC, 2022b. *COMMISSION DELEGATED REGULATION (EU) …/... supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council.* [Online] Available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12713-Renewable-energy-method-for-assessing-greenhouse-gas-emission-savings-for-certain-fuels_en [Accessed August 2022].
- EC, 2022c. *Communication from the European Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions — RePowerEU Plan.* [Online] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0230&from=EN [Accessed August 2022].
- EnergyPost.eu, 2022. *Possible impact of the delegated acts on import of hydrogen in the EU.* [Online] Available at: https://energypost.eu/possible-impact-of-the-delegated-acts-on-import-of-hydrogen-in-the-eu/ [Accessed August 2022].

- EU Industry, 2022. *Joint statement of the EU industry: Pragmatic regulatory framework necessary for hydrogen market.* [Online] Available at: https://www.fuelseurope.eu/publication/joint-statement-of-the-eu-industry-pragmatic-regulatory-framework-necessary-for-hydrogen-market/ [Accessed 23 8 2022].
- Euractiv, 2022. *Hydrogen industry scores EU win with draft 'additionality' proposal.* [Online] Available at: https://www.euractiv.com/section/energy/news/hydrogen-industry-scores-win-with-eus-draft-additionality-proposal/ [Accessed August 2022].
- European Federation of Energy Traders, 2022. *EFET response to the EU Commission proposal for the RED II Delegated act on renewable liquid and gaseous transport fuels of non-biological origin.* [Online] Available at: https://efet.org/files/documents/220617%20CNSG%20RES%20GAS%20WG%20CR%20RFNBO.pdf [Accessed 23 8 2022].
- Europex, 2022. *Europex response to Commission consultation on RED II draft. Delegated Acts on RFNBOs & GHG Savings Methodology.* [Online] Available at: https://www.europex.org/consultation-responses/europex-response-to-commission-consultation-on-red-ii-draft-delegated-acts-on-rfnbos-ghg-savings-methodology%ef%bf%bc/ [Accessed 23 8 2022].
- Freshfields Bruckhaus Deringer, 2022. *What makes hydrogen "renewable"? — a quick look at the Commission's draft delegated act.* [Online] Available at: https://sustainability.freshfields.com/post/102hqwt/what-makes-hydrogen-renewable-a-quick-look-at-the-commissions-draft-delegat [Accessed August 2022].
- Global Alliance Powerfuels, 2022. *Position paper on the Delegated Act of Article 27 REDII.* [Online] Available at: https://www.powerfuels.org/fileadmin/powerfuels.org/Dokumente/Global_Alliance_Powerfuels_position_paper_REDII_D.A._Art._27_fin.pdf [Accessed 23 8 2022].
- Hydrogen Europe, 2022. *Summary and implication of the proposed Delegated Act on additionality of renewable for the production of RBNBOs under the Renewable Energy Directive.* [Online] Available at: https://hydrogeneurope.eu/wp-content/uploads/2022/05/220523-Summary-DA-Additionality_-final-.pdf [Accessed 23 8 2022].
- Hydrogen Industry Cluster, 2022. *Hydrogen and additionality. Position paper in relation to delegated act RED II Art. 27.3.* [Online] Available at: https://www.waterstofnet.eu/_asset/_public/WIC/positionpapers/Waterstof-in-de-Deltaregio.pdf [Accessed 23 8 2022].
- NLR, 2022. *Novel propulsion and alternative fuels for aviation towards 2050*. [Online] Available at: https://reports.nlr.nl/server/api/core/bitstreams/af600792-5757-48d8-b153-45513acf97d9/content [Accessed October 2022].
- RWE, 2022. *New Delegated Act puts brakes on green hydrogen*. [Online] Available at: https://www.rwe.com/en/press/rwe-ag/2022-05-23-new-delegated-act-puts-brakes-on-green-hydrogen [Accessed 23 08 2022].

Colophon

Delft, CE Delft, October 2022

This publication is prepared by:
Maarten de Vries, Chris Jongsma, Emiel van den Toorn and Nina Voulis

Publication code: 22.220358.116

Client: Air Products

Renewable hydrogen / EU regulation / Decarbonisation of industry /

CE publications are available from www.cedelft.eu

CE Delft

Committed to the Environment

Through its independent research and consultancy work CE Delft is helping build a sustainable world. In the fields of energy, transport and resources our expertise is leading-edge. With our wealth of know-how on technologies, policies and economic issues we support government agencies, NGOs and industries in pursuit of structural change. For 40 years now, the skills and enthusiasm of CE Delft's staff have been devoted to achieving this mission.

Annex

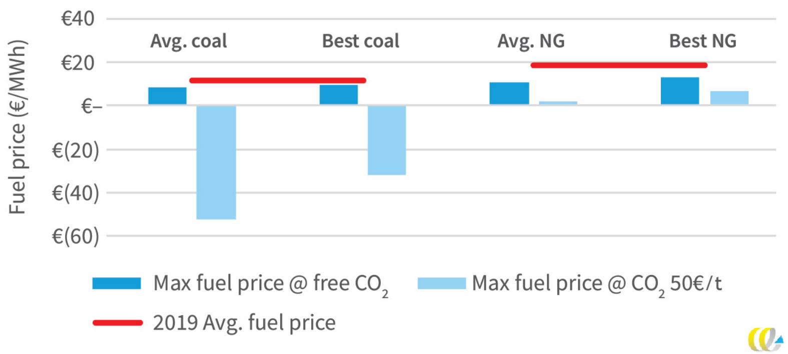
A. Explanation on art. 4.2c price limits

In this Annex we shed some light on the rationale behind the price limits of 20 €/MWh or 0.36 the price of an ETS emission allowance in Article 4.2c of the DA. As a reminder, Article 4.2c states that grid electricity can be considered renewable if the hourly price of electricity is below a certain limit.

We will put these price limits in perspective by demonstrating that these prices are too low to operate fossil plants economically. This means that at the price limits specified in the Delegated Act, additional demand will be met by either renewable sources or fossil plants operating at a loss. We will show that this is the case for both price limits by comparing the marginal costs of average and best in class coal-fired and natural gas fired power plants[15].

For fossil plants to operate profitably at power prices of 20 €/MWh, fuel has to be very cheap and CO_2 prices have to be near zero. *Figure 9* shows that the maximum fuel price to operate profitably at 20 €/MWh electricity price is (far) below the 2019 fuel price level, which already presents a period with low fossil fuel prices. This holds even if the CO_2 price is zero.

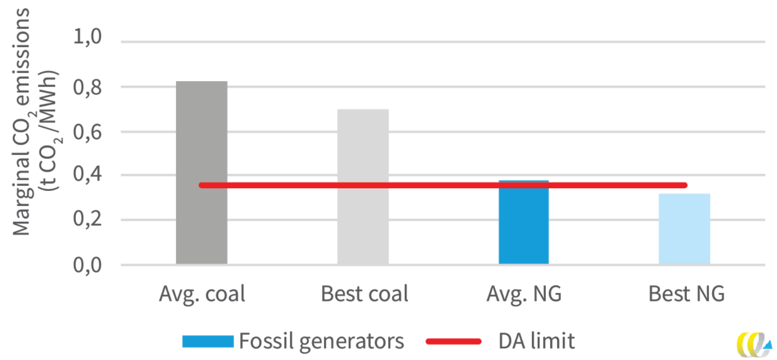
Figure 9 — Maximum fuel prices for fossil operators to operate profitably at 20 €/MWh power price, compared to low historic (2019) fuel prices



15 Average coal plant efficiency: 40.5%, best coal plant efficiency: 47.5%, average natural gas plant efficiency: 54%, best natural gas plant efficiency: 64.3%.

The limit on 0.36 times the ETS price might appear somewhat arbitrary, but it prevents polluting plants from providing electricity, even if fuel prices are low. The rule implies that, *even when fuel is free*, plants with higher marginal emissions than 0.36 ton CO_2/MWh (or 360 g CO_2/kWh) cannot operate profitably. *Figure 10* illustrates that this is indeed the case for all coal plants and all but the most efficient natural gas plants (>57% efficiency). In practice, fuel costs are not zero and fossil generators cannot turn a profit if electricity prices are below 0.36 times the ETS price.

Figure 10 — Comparison of marginal emissions of fossil generators with the limit of 0.36 ton CO_2/MWh



B. Explanation on Art. 4.3 & 4.4

Research, testing and demonstration (Art. 4.3)

Installations for research, testing and demonstration are exempt from Article 4.2b (installation for renewable electricity has not received support). This clause cannot lead to circumventing the additionality requirements on a large scale, however, for the simple reason that small R&D facilities lack the required scale to be commercially interesting.

Downwards redispatch (Art. 4.4)

Electricity can be considered renewable if it is consumed during an imbalance settlement period when renewable energy sources are downwards redispatched and the additional consumption of electricity has led to a reduction in downwards redispatch. Below we briefly explain what this means. This clause does not violate additionality, but it also does not provide any major economic benefits to the electrolyser operator.

The previous rules on temporal correlation in Article 4.2c related to the hourly electricity price, as resulting from the day-ahead auction. The day-ahead auction reflects the expected production and consumption of electricity on the next day. Any deviations from this expectation are resolved by the transmission system operator (TSO) through balancing markets. For example: if the weather is sunnier than expected, more electricity is generated from solar panels, resulting in an excess of electricity. The TSO then gives a signal to all contracted assets in the balancing pool to generate less electricity or consume more electricity (downwards redispatch). If renewable sources are downwards redispatched, any *additional* electricity consumed for the production of hydrogen can be counted as renewable, since it would have been curtailed if not consumed by the electrolyser.

In practice, this clause results in little additional hydrogen production. This Article namely requires three simultaneous conditions:

1. There is a downwards redispatch signal (happens frequently, roughly 50% of the time).
2. Renewable assets participate in the balancing market and are redispatched downwards (still relatively rare).
3. The electrolyser reacts to (price) signals on the balancing market and consumes more electricity than was planned based on day-ahead prices.

During these periods, the marginal electricity does indeed come from curtailed renewable generation and hence can be considered to be clean.