FLORENCE SCHOOL OF REGULATION

ROBERT SCHUMAN CENTRE

POLICY BRIEF

Renewable hydrogen and the "additionality" requirement: why making it more complex than is needed?[1]

Highlights

- Additionality is a key requirement for the renewables-based electricity to be used by electrolysers to produce renewable hydrogen. Additionality could be defined as the requirement that renewables-based electricity used in electrolysers for the production of renewable hydrogen is additional to the renewables-based electricity which is used to meet the renewable penetration target with respect to final electricity consumption.
- Different approaches to additionality have been considered in the debate over the last year. All of them require some degree of temporal (and geographical) correlation between the consumption of electricity by the electrolysers and the generation of the additional renewables-based electricity.
- This Policy Brief questions whether a degree of temporal correlation is really necessary to ensure the additionality of the renewables-based electricity consumed by the electrolysers. The additionality of the renewables-based electricity consumed by the electrolysers could be ensured over a year-long period, in line with the way in which the general renewable energy penetration target is defined, by the implementation of a system based on guarantees of renewable origin. Such an approach would also facilitate the operation of electrolysers at their optimal utilisation rate.

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1. Additionality in the EU legislation

The development of renewable gases, and in particular of renewable hydrogen, is one of the main strategies to decarbonise the energy sector and the EU economy as a whole, as outlined in the EU Green Deal[2]. Renewable hydrogen is expected to replace fossil-based hydrogen in feedstock uses, and other fossil fuel-based energy vectors in hard-to-abate processes where electrification is not possible or not economically viable. Renewable hydrogen together with CO_2 is also the basis for carbon-neutral synthetic fuels.

In this context, in July 2020, the European Commission published the EU Hydrogen Strategy[3], designed to increase the hydrogen's role in Europe's clean energy transition towards carbon neutrality. In fact, as noted by the Commission, "*renewable electricity is expected to decarbonise a large share of the EU energy consumption by 2050, but not all of it. Hydrogen has a strong potential to bridge some of this gap, as a vector for renewable energy storage, alongside batteries, and transport, ensuring back up for seasonal variations and connecting production locations to more distant demand centres*"[4]. In the EU Hydrogen Strategy, the Commission clearly indicates that "*the priority for the EU is to develop renewable hydrogen, produced using mainly wind and solar energy*", since "*renewable hydrogen is the most compatible option with the EU's climate neutrality and zero pollution goal in the long term and the most coherent with an integrated energy system*"[5].

In order for hydrogen to be considered as renewable, one condition which should be met is the "*additionality of the renewable electricity used*"[6]. How to meet the additionality requirement has been the focus of much debate over the last year.

Additionality could be defined as the requirement that renewables-based electricity used in electrolysers for the production of renewable hydrogen is additional to the renewables-based electricity which is used to meet the renewable penetration target with respect to final electricity consumption[7]. In reality, such a target is not explicitly specified, since, in the 2018 Renewable Energy Directive (REDII)[8], the EU set the renewable penetration target in terms of total final energy consumption – "*the sum of: (a) gross final consumption of electricity from renewable sources; (b) gross final consumption of energy from renewable sources in the heating and cooling sector; and (c) final consumption of energy from renewable sources in the transport sector*"[9]. A separate sub-target is only foreseen for the share of renewable energy within the final consumption of energy in the transport sector, but not for renewable energy in final electricity consumption.

REDII already addresses the potential problem of double counting in the calculation of the share of energy from renewable sources, when one energy vector (e.g. electricity) is transformed into a different vector (e.g. hydrogen in electrolysers), by stating that "*gas, electricity and hydrogen from renewable sources shall be considered only once for the purposes of calculating the share of gross final consumption of energy from renewable sources*"[10]. In reality, the consumption of renewables-based electricity by electrolysers would not qualify as final consumption anyway and therefore would not contribute to the total final energy consumption from renewable sources.

However, additionality is a somewhat different requirement, having to do not only with the source of the electricity used in the electrolysers, but also with the fact that such electricity would have not been produced if the electrolysers had not required it.

2 The European Green Deal aims to overcome the challenges of climate change and environmental degradation by (i) transforming the EU into a modern, resource-efficient and competitive economy, and (ii) ensuring no net emissions of greenhouse gases by 2050 and economic growth decoupled from resource use, with no person and no place being left behind. For details see: A European Green Deal | European Commission (europa.eu).

3 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, Brussels, 8.7.2020, COM(2020) 301 final (EU Hydrogen Strategy)

4 EU Hydrogen Strategy, page 1.

5 EU Hydrogen Strategy, page 5.

6 EU Hydrogen Strategy, footnote 28 (even though the footnote seems to include a typo: "additionally" instead of "additionality").

7 The definition is sometime formulated with the inclusion of an additional requirement, that the additional renewables-based electricity is produced by new generation capacity. The need for this additional requirement for the purpose of ensuring that renewable hydrogen is produced using renewables-based electricity is questionable.

8 Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.

9 REDII, article 7(1), first subparagraph.

10 REDII, article 7(1), second subparagraph.

2. Approaches to additionality

The debate so far has identified a number of ways in which additionality could be ensured, and which could be categorised as follows.

- Physical link: additionality would be ensured through the development of new renewable electricity generation capacity physically linked to the electrolysers. This is probably the simplest and most obvious approach to additionality. Besides the obvious geographical constraints, this option also has the disadvantage of limiting the operation of the electrolysers to the periods when the new renewable generation capacity produces[11]. Depending on the location and the technology, these periods might well be shorter than what would make electrolysers run at an efficient utilisation rate.
- Commercial link: additionality would be ensured through the development of new renewable electricity generation capacity[12] commercially linked, through a power purchase agreement, to the electrolyser. In this case, the electricity would be wheeled through the public network and therefore, in principle, the electrolyser could consume electricity and produce hydrogen even at times when the commercially-linked renewable electricity capacity does not produce. Therefore, arrangements should be put in place to ensure adequate temporal correlation (contemporaneity) between the production of the renewable generation capacity with which the electrolyser is commercially linked through the power purchase agreement and the production of hydrogen in the electrolyser[13]. This approach also establishes an obvious link – albeit of a commercial rather than physical nature - between the renewable electricity production and the electricity consumption by the electrolyser. Therefore, it imposes the same limitation on the number of hours in which the electrolyser would be able to produce renewable hydrogen[14]. Moreover, it would require arrangements to deal with deviations between the renewable electricity generation and the electrolyser's consumption profiles.
- (System-wide) marginal technology approach: in this case, the electricity consumed by the electrolyser would be considered as from renewable sources, and therefore the produced hydrogen as renewable, only in those hours when renewables are the marginal technology in the market merit order and therefore an increase in electricity consumption would be likely to be met by additional renewable-based electricity production. Eventually, with the share of renewables in the electricity system increasing, this approach might not impose severe limitations on the number of hours electrolysers would be able to operate and produce renewable hydrogen. However, until then, this approach may severely limit renewable hydrogen production, possibly even more than in the case of the approaches based on physical or commercial links. A variant of this requirement - or, in fact, in most cases, another way to express it - is one in which, in order for the produced hydrogen to qualify as renewable, the electrolyser would have to use renewables-based electricity which would otherwise have been spilled or curtailed[15].

11 This limitation could be partially overcome by having multiple new renewable electricity generation units, of different technologies and in different locations, physically connected to the electrolyser; a clearly inefficient solution.

12 Note that, if the power purchase agreement were concluded with existing renewable generation capacity, it would be difficult to ensure the additionality of renewable generation, as the additional electricity demand might well be met by fossil fuel-based generation, if this is the marginal technology in the market merit order.

13 A similar requirement is envisaged in REDII for the production of renewable liquid and gaseous transport fuels of non-biological origin. See recital (90) in REDII

14 This limitation could be partially overcome by having multiple new renewable electricity generation units, of different technologies and in different locations, commercially linked, through power purchase agreements, to the electrolyser; most likely an inefficient solution.

15 However, there may be instances in which renewables-based electricity is the marginal technology, but the increase of demand by the electrolysers leads to other technologies being dispatched to cover it.

The following table presents the main advantages and the challenges associated with each of the three approaches identified above.

Approach to additionality	Advantages	Challenges
Physical link	• Clearest link between renewables-based electricity and renewable hydrogen	• Limited utilisation of electrolysers
Commercial link	• Clear contractual link between renewable-based electricity and renewable hydrogen	• Limitations in the utilisation of electrolysers • Need to ensure the required temporal (and geographical) correlation between renewables-based electricity production and the electrolyser's consumption and how to handle deviations
(System-wide) marginal technology	• System-scale "logical" link between renewable electricity and renewable hydrogen	• Possibly even greater limitations in the utilisation of electrolysers, at least until most electricity is produced from renewable sources

3. The temporal correlation between generation and consumption: how important for additionality?

All the above approaches to additionality rest of the assumption that, in order for the produced hydrogen to be considered as renewable, a degree of temporal correlation is needed between the production of the additional renewables-based electricity and the consumption of electricity by the electrolyser. However, the question needs to be asked whether such a correlation is really necessary to ensure the "additionality" of the electricity consumed by the electrolyser, especially taking into account the way in which the renewable energy penetration target is expressed in the legislation. In fact, in REDII, the renewable energy penetration target is expressed on an annual basis, i.e. "*the share of energy from renewable sources in the Union's gross final consumption of energy in 2030 is at least 32 %*", which will now be increased to 40%[16]. Legislation does not require that, at every point in time, renewables account for a specific share of final energy consumption, but only that the target be achieved over a year (e.g. 2030). It is accepted therefore that, in some hours, renewables would achieve a higher penetration, while, in other hours, they could fall short of the average annual target.

The challenge with the additionality requirement is that, unless it is established as part of a consistent approach to account for all renewables-based electricity – or even energy – to be produced and consumed, the temporal correlation is probably the most direct way to ensure that the renewables-based electricity consumed by the electrolysers to produce renewable hydrogen is indeed additional to what would have been generated anyway, even if the electrolysers had not been in operation[17]. The same could also be said for the requirement that the additional renewables-based electricity be produced by new generation capacity.

However, if one were able to guarantee that, at the end of the year, the consumption of electricity by the electrolysers had increased the generation of electricity from renewable sources by an equal amount, would it really matter that such an increase had occurred exactly at the same times when the electrolysers were consuming? Or that

16 Proposal for a Directive of the European Parliament and of the Council amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652, Brussels, 14.7.2021, COM(2021) 557 final.

17 The temporal correlation, in the context of a commercial link as defined in the text, is in fact referred to in Recital (90) of Directive (EU) 2018/2001, as an example, when defining the methodology that the Commission should develop, by means of delegated acts, to ensure that renewable fuels of non-biological origin contribute to greenhouse gas reduction: "renewable fuels of non-biological origin cannot be counted as fully renewable if they are produced when the contracted renewable generation unit is not generating electricity".

the additional renewables-based electricity had been produced by new generation capacity?

A more flexible approach to the temporal correlation requirement would make it easier to reconcile the intrinsic variability of the renewables-based electricity generation profile with the demand for renewable hydrogen which requires a flatter production profile. An approach which would only require a matching of the additional renewables-based electricity generation and the consumption of the electrolysers over the year would then facilitate the operation of electrolysers at their optimal utilisation level, overcoming some of the limitations imposed, to different degrees, by the three approaches outlined in the previous section.

One problem which might emerge from the temporal mis-match between the electricity consumption of the electrolysers and the additional renewables-based electricity generation is that the increased electricity demand from the electrolysers might be at least partly met, in some periods, by additional production from fossil fuel-based generators, possibly the most polluting ones. This is indeed a possibility. However, as long as the approach to additionality guarantees that, over the year, the electricity demand from the electrolysers is met by additional renewables-based electricity generation, the increase in renewables-based electricity generation would exceed, in other periods, the electricity demand from electrolysers, displacing some fossil fuel-based generation. Indeed, there is no guarantee that the carbon content of the additional generation to meet the electrolysers' demand at times when it exceeds the additional renewables-based electricity generation would be the same or lower than the carbon footprint of the fossil fuel-based generation displaced by the additional renewables-based electricity production at other times, but this is also the kind of situation which is accepted when aiming for the overall renewable penetration target (by not requiring a fixed share of renewables at all times, it is accepted that the average carbon content of electricity generation varies hour by hour).

The following table presents the main advantages and the challenges of the two extreme approaches to temporal correlation: (a) the requirement for strict simultaneity between the additional renewables-based electricity generation and the electricity consumption of the electrolyser; and (b) the flexibility of requiring that the additional renewables-based electricity generation matches the electricity consumption of the electrolyser over a year-long period[18].

Approach to temporal correlation	Advantages	Challenges
Strict simultaneity	• Guarantees that the consumption of the electrolysers is covered, at all times, by additional renewables-based electricity generation	• Limits the utilisation of electrolysers, or • Require greater renewables-based electricity generation capacity in order to support the operation of electrolysers at their optimal utilisation rate
Matching over a year	• Allows the operation of the electrolysers at their optimal utilisation rate limiting the need for larger renewables-based electricity generation capacity	• Possibly increases the carbon footprint of electricity production, given the effect on the generation mix of non-renewable technologies characterised by different emission levels

4. The geographical correlation between generation and consumption.

Additionality might also require some degree of geographical correlation between the generation of the additional renewables-based electricity and the consumption of the electrolysers, in order for the hydrogen which the latter produce to be considered as renewable[19]. There is no definition of geographical correlation in legislation, but it is to be understood as referring to geographical proximity based on the network topology.

In the case of the physical link, the geographical

18 As the renewable energy penetration target is defined on an annual basis, there is no sense in extending the flexibility over any longer period.

19 In the case of renewable fuels of non-biological origin, the already-mentioned Recital (90) in REDII (see footnotes 10 and 13) refers to "*a temporal and geographical correlation between the electricity production unit with which the producer has a bilateral renewables power purchase agreement and the fuel production*". This correlation will be defined through a methodology developed by the Commission by means of delegated acts.

correlation has a trivial meaning, as the direct link between the renewable generation capacity and the electrolyser ensures such a correlation. The geographical correlation becomes a slightly more complex concept in the case of the commercial link, for which two criteria are possible: (a) the commercially-linked renewables-based generation capacity and the electrolyser should be connected to the same (interconnected) network; or (b) apart from the commercially-linked renewable generation capacity and the electrolyser being connected to the same (interconnected) network, there should be no congestion between their respective locations, so that the additional renewables-based electricity production can reach the electrolyser.

It is clear that the additional requirement under option (b) above – the absence of network congestion between the location of the additional renewable generation capacity and the location of the electrolyser – loses much of its relevance as the time horizon over which the temporal correlation is defined extends, as, in this case, this requirement would impose a geographical restriction only if the congestion were persistent over the entire chosen time horizon.

5. Conclusions

The consideration presented in the previous sections suggest that an approach could be considered which, while ensuring that the demand for electricity from the electrolysers is met by additional renewables-based electricity generation, it does not require this to happen at each point in time, but only over a predefined period[20]. In essence, given that the renewable penetration target needs to be achieved and it is verified over a year-long period, one could require that the increase in the demand for electricity by the electrolysers wanting to produce renewable hydrogen be met by additional renewable-based electricity over a year-long period.

So far, this approach to the additionality requirement has not been seriously considered as it was deemed not to comply with an intuitive notion of additionality. However, as indicated above, some degree of temporal mis-match between the electricity demand from the electrolysers and the additional renewables-based electricity generation would be fully in line with the overall policy approach to renewable penetration in the electricity system.

However, a strict requirement for the increase in renewable-based generation to match, on an annual basis, the additional demand for electricity from electrolysers would need to be imposed and an approach to enforce it would need to be devised. As indicated in a Report published by the Florence School of Regulation[21], a mechanism based on guarantees of origin, or, in fact, guarantees of renewable origin, certifying the renewable nature of the energy production against which they are issued, could ensure that the demand for electricity from electrolysers wishing to produce renewable hydrogen is met by additional renewable-based electricity over any predefined period of time – a year, or a shorter period if policymakers so prefer. This mechanism, if extended to all energy vectors beyond electricity[22], could also provide an accounting system for ensuring the achievement of the renewable penetration target in final energy consumption. This mechanism could also be used to provide a basic level of support to renewable energy production, promoting the achievement of the overall target at least cost; however, in this case, legislation, currently limiting the use of guarantees of origin to disclosure purposes, would need to be amended.

Moving beyond strict (indeed, instantaneous) temporal correlation between the electrolysers' electricity demand and the additional renewables-based electricity generation, while preserving the requirement that this demand is met, over the year or a shorter period, by additional generation from renewable sources, would allow electrolysers to operate at their optimal utilisation rate, capacity and therefore, *ceteris paribus*, reduce the hydrogen production costs, thus enhancing the contribution of renewable hydrogen to decarbonisation.

20 In this case, the requirement that the additional renewables-based electricity is produced by new generation capacity could also be dropped.

21 Florence School of Regulation, Upgrading Guarantees of Origin to promote the achievement of the EU renewable energy target at least cost, by Alberto Pototschnig and Ilaria Conti, Research Project report, January 2021.

22 REDII extended the issuing of guarantees of origins also to energy vectors other than electricity.

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