

Getting it right from the start: How to ensure the sustainability of electrofuels

Minimum criteria for Renewable Fuels of
Non-Biological Origin under RED II

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Executive Summary

Transport decarbonisation is a major challenge and direct electrification should be the preferred option, whenever technically and economically feasible. But fuels with a higher energy density will continue to play a role in certain transport modes, especially deep sea shipping and aviation. In this context, Renewable Fuels of Non-Biological Origin (RFNBOs) are expected to make a big contribution to reducing the climate impact of these transport segments. But RFNBOs are only as clean as the electricity used to produce them. The Renewable Energy Directive outlines a regulatory framework to ensure the sustainability of these gaseous or liquid RFNBO by requiring at least 70% greenhouse gas savings compared to their fossil fuel equivalent. The European Commission has been tasked to adopt a delegated act by the end of 2021, on how to calculate the greenhouse gas savings of RFNBOs. In effect, this implies that a very high share of zero-emission renewable electricity - at least ~80% - will be needed for RFNBO production to meet the 70% threshold.

This can be achieved with a direct connection between the RFNBO production and the renewable energy source or when grid electricity is almost completely renewable. However, the case where RFNBO production facilities are connected to a grid with a large share of non-renewable electricity will be most prevalent. In this case, determining whether the 70% greenhouse gas savings threshold is achieved is more complicated. When the RFNBO production relies partly on grid electricity, the producer needs to demonstrate to what extent the electricity used has been produced from renewable energy sources. The renewable energy used needs to be produced from *additional* renewable sources, i.e. not divert existing renewables away from being used in other sectors. To meet this requirement, **a RFNBO producer with a grid connection should be able to demonstrate**

that a Power Purchase Agreement is in place for new and unsupported renewable electricity generation. The Power Purchase Agreement should stipulate how the renewable power will match the demand profile of the RFNBO plant, ensuring e.g. that the electrolyser produces hydrogen only when the renewable power source is in operation, with full intraday matching (i.e. the ‘temporal correlation’ stipulated in the RED). To ensure a close link between the RFNBO facility and the renewable energy generator and avoid exacerbating existing grid congestion, the renewable energy source and the RFRNBO production facility should be situated in the same bidding zone (i.e. the ‘geographical correlation’ stipulated in the RED).

Guarantees of Origin are not an appropriate tool to ensure the sustainability of RFNBOs. They do not ensure additionality and also do not allow to establish a sufficiently detailed temporal correlation. Any Guarantees of Origin generated in the context of a PPA should be bundled and cancelled. This will avoid the risk of ‘double counting’ whereby renewable energy used in RFNBO production would also be counted towards achieving targets for renewables in other sectors. Guarantees of Origin should also not be allowed to help reduce the carbon intensity of the grid electricity used.

Apart from the carbon footprint of RFNBO production, the Commission should also develop sustainability criteria regarding impacts on water and land resources. In addition, the greenhouse gas methodology for RFNBOs should explore how non-fossil circular sources of carbon (via **Direct Air Capture**) can be encouraged for the production of synthetic hydrocarbons like e-kerosene.

Countries with an ambition for **RFNBOs exports should ensure that this industry helps the decarbonisation of the host country’s economy**, improves access to clean energy for the local population and handles the water and land impacts responsibly. Initially limiting RFNBO imports into the EU to those cases where strict additionality (direct connection or almost 100% renewable grid electricity) can be guaranteed should be a significant first step.

The focus in the Renewable Energy Directive should be on renewable fuels, not extend its scope to so-called ‘decarbonised’ or ‘low-carbon’ fuels (e.g. ‘blue’ hydrogen produced from fossil gas with Carbon Capture and Storage). The low-carbon status of blue hydrogen depends on optimistic assumptions about emissions throughout the full supply chain.

1. Introduction

1.1. Defining RFNBOs

The 2018 review of the Renewable Energy Directive (RED II) recognised this challenge for the transport sector and created a framework that outlines some broad principles for these electrofuels. The RED II introduced the first EU rules on Renewable Fuels of Non-Biological Origin. Or RFNBOs for short. The RED II provides a negative definition by clarifying that RFNBOs are fuels that are not biogas or biofuels, “the energy content of which is derived from renewable sources other than biomass”. In essence, RFNBOs will need to be produced from renewable electricity sources like hydro, wind, solar and geothermal. On the basis of this wide definition, RED II covers a wide range of RFNBOs, both liquid and gaseous: Electrofuels such as E-hydrogen, E-ammonia, E-methanol, E-diesel and E-kerosene, provided they are produced with renewable energy. Gaseous and liquid energy carriers, similar to RFNBOs, will also be used in other sectors than the transport sector, such as electricity generation (e.g. peaker plants), heating and cooling and industrial sectors. This is why getting this RFNBOs framework right is not only important for the transport sector, but also other sectors.

1.2. Where should RFNBOs be used?

As the European electricity grid decarbonises and renewable electricity sources start to dominate the EU’s power mix, electrification will be the main pathway to decarbonise many different sectors of the economy. Sectors that have relied predominantly on fossil fuels - oil for transport, gas for heating, coal and gas for industrial processes - will switch to using grid power, where wind and solar will play a major role. As a result, electrification will not only drive down emissions, but also increase the energy efficiency of the overall system. How? Applications using direct electricity use energy much more efficiently than fossil-fueled solutions. Electric vehicles are a case in point, as they consume only 25% of the energy that a conventional car uses.

Clearly, direct electrification is the preferred option, whenever technically feasible. For the transport sector, however, there are certain transport modes, where direct electrification is not technically feasible. Deep sea shipping¹ and aviation are two areas, where fuels with a higher energy density (compared to the energy density of lithium-ion batteries) will continue to play a role. To achieve full decarbonisation for ships and planes by mid-century, their fuels will need to be decarbonised.

Biofuels from food, feed or energy crops are not an option to supply fuels to shipping and aviation, as the majority of these biofuels increase rather than decrease greenhouse gas emissions, have negative

¹ Ferries, inland shipping and small coastal shipping can be electrified.

impacts on biodiversity and local communities.² Advanced biofuels, produced from agricultural waste and residues, only have a limited potential, and after 2030, their growth is likely to be constrained due to waste reduction policies and competing industries. We recommend to reserve any available sustainable advanced biofuels to the aviation sector, where they can help to curb the growth in emissions. Our projection is that in 2050, availability of sustainable advanced biofuels for the aviation sector could total 7,500 ktoe, meeting 11.4% of European aviation fuel demand.³ The remainder will need to be met with various kinds of electrofuels produced from renewable electricity. Growth forecasts for aviation will be crucial for determining the amount of advanced fuels and electrofuels needed. Changing attitudes towards flying and travel may reduce energy demand from the sector below what is currently projected, and therefore rendering more feasible the deployment of sustainable alternative fuels in the sector.

1.3. Sustainability criteria for RFNBOs in RED II

The RED II introduces two important sustainability criteria for the RFNBOs. First of all, **the greenhouse gas emissions savings from the use of RFNBOs must be at least 70 % in comparison to a fossil fuel compara**(article 25.2 RED II). This criterion of 70% greenhouse gas savings must be applied from 1 January 2021, if Member States want to count the contribution of RFNBOs towards their RED II transport target. More detailed and binding rules on how to count the renewables' content of RFNBOs (and therefore also their carbon footprint) are forthcoming: The European Commission will adopt a delegated act on this by the end of 2021, which will allow the greenhouse gas savings of RFNBOs to be calculated. This will be important to not only determine the greenhouse gas savings but also the contribution of RFNBOs to the RED II targets and the transport target in particular. The RED II makes clear that RFNBOs are only as clean as the electricity used in their production.

The RED II distinguishes between 3 cases of RFNBO production:

1. Direct connection - without grid connection: If the RFNBO plant only has a “direct connection to an installation generating renewable electricity” - without a grid connection -, the production process of the RFNBO is considered to be 100% renewable and therefore zero-emissions.
2. Grid connection - claiming average renewables share in grid electricity: If the electrolyser relies exclusively on grid electricity, the RED II stipulates that “the average share of electricity from renewable sources in the country of production, as measured two years before the year in question, shall be used to determine the share of renewable energy”. Important to note: This average share of renewable electricity can only count non-biomass renewable energy,

² T&E (2020) *Biofuels: 10 facts*. Retrieved from

<https://www.transportenvironment.org/what-we-do/biofuels/10-facts>

³ T&E (2018) *Roadmap to decarbonising European aviation*. Retrieved from

<https://www.transportenvironment.org/publications/roadmap-decarbonising-european-aviation>

subtracting the share of renewable electricity produced with biomass.⁴ However, that grid electricity would need to be very low-carbon to meet the RED II's 70% greenhouse gas savings requirement. According to a literature review by Bellona, the carbon intensity of the grid electricity for hydrogen via electrolysis would need to be well below ~149gCO₂/kWh (estimated break even point with fossil natural gas) and less than ~90gCO₂/kWh for synthetic hydrocarbons (estimated break even point with fossil counterparts).⁵ Except for Sweden and EEA members like Norway and Iceland (thanks to their grids' heavy reliance on geothermal and hydropower), there is currently no country in the EU whose grid electricity has a high share of renewables and matches the above-mentioned carbon intensity figures or will achieve this in the near future. As a result, option 2a is unlikely to materialize in the EU before 2030.⁶

3. Grid connection - claiming a higher renewables share than average share of grid electricity: There is also an option whereby the operator can demonstrate that the grid electricity contains a higher share of renewables, provided "the renewable properties and other appropriate criteria have been demonstrated, ensuring that the renewable properties of that electricity are claimed only once and only in one end-use sector". Moreover, the RED II makes it clear that an electrolyser cannot claim any renewables, there must be a clear link between the renewable generation and the electrolyser's operation according to recital 90 of the RED II. When an RFNBO operator wants to count grid electricity as renewable, "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" is required.

Why the rather complex rules for case 3? The higher the operating hours / load factor for the electrolyser, the more cost-competitive the production of renewables-based hydrogen can be. Sourcing renewable electricity via the grid may, however, be an important option to enable a sufficiently high number of operating hours for electrolysers where there are less favourable conditions for the production of renewable electricity. A recent T&E report on decarbonising freight showed that 2,800 full-load hours are considered realistic in order to provide a load factor of 30 percent for an electrolysis plant in the megawatt range. The resulting hydrogen cost level ranges between 2.33 to 4.00/kgH₂, excluding transport and distribution costs. Today, offshore wind facilities in the North Sea can reach more than 3,600 full-load hours on average and would therefore be

⁴ For example, by subtracting the Guarantees of Origin for electricity produced from biomass from the average share of renewable electricity.

⁵ Bellona (2020) *Response to the EU Hydrogen Strategy*. Retrieved from

<https://bellona.org/publication/consultation-response-08-06-eu-hydrogen-strategy>

⁶ Should the EU allow RFNBO imports into the EU from countries where RFNBO production relies on grid power, it remains to be seen how the average share of electricity in the two years previously would be determined. It is unclear which datasets would be sufficiently up-to-date to allow RFNBO producers to claim high-renewables and very low-carbon grid electricity.

suitable for the production of electricity-based fuels, if their total electricity production was devoted to it.⁷

This issue of the “renewable properties and other appropriate criteria” brings us to a second criterion for RFNBOs under the RED II: **Additionality**. Additionality means that “the expected increase in demand for electricity in the transport sector beyond the current baseline is met with additional renewable energy generation capacity” (article 27.3 RED II). For the direct use of electricity in EVs, the Commission is only tasked with elaborating “a framework” with different options for the Member States on how to put additionality into practice. For the indirect use of electricity by means of RFNBOs, the RED II is more restrictive. Additionality for RFNBOs means “the fuel producer is adding to the renewable deployment or to the financing of renewable energy” (recital 90 RED II). In other words, *new*, additional renewable capacity needs to be built or financed by the fuels producer.

1.4. Why are sustainability criteria and additionality of renewables for RFNBOs so important?

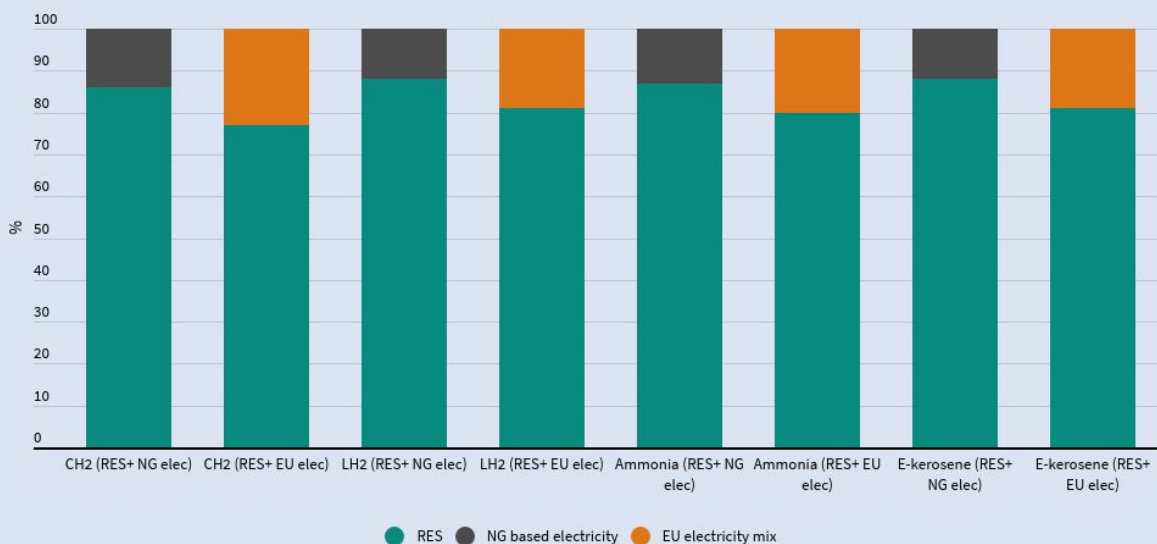
For RFNBOs to meet the requirements under RED II to deliver at least 70% greenhouse gas savings compared to a fossil fuel comparator, a very high share of zero-emission renewable electricity - at least ~80% - will be needed to meet that threshold. Figure 1 below demonstrates the minimum share of renewable electricity that is needed for different types of electrofuels. Whether renewables are complemented by electricity generated by a gas turbine or by electricity from the grid with an average carbon intensity for the EU28, the results are clear: All types of RFNBOs will need to be produced with a share of renewables in the input electricity that is ~80% or higher.

Put differently, the production of electrofuels will need to minimize its reliance on grid electricity, even when the grid electricity used is relatively low-carbon. Electrofuels producers that establish themselves in an EU Member State with higher-carbon grid electricity will be at risk of not meeting the greenhouse gas threshold of REDII or will need to rely close to 100% of renewable electricity (or forego a grid connection to the electrolyser altogether). If efuels would rely exclusively on electricity with a carbon intensity equal to the EU’s average grid mix, their carbon footprint would be 3 times higher than their fossil fuel comparator (around 300 gr CO₂eq/MJ).⁸

⁷ T&E (2020) *How to decarbonise the French freight sector by 2050?* Retrieved from https://www.transportenvironment.org/sites/te/files/publications/2020_05_TE_how_to_decarbonise_the_french_freight_sector_by_2050_final.pdf

⁸ Cerulogy (2017) *What role is there for electrofuel technologies in European transport’s low carbon future?* Retrieved from https://www.transportenvironment.org/sites/te/files/publications/2017_11_Cerulogy_study_What_role_elctrofuels_final_0.pdf Pp. 60 (figure 11).

RFNBOs: Share of renewable electricity required to meet the 70% carbon savings under RED II



This figure shows the approximate shares of RES required to meet 70% GHG reduction (i.e. 28.2 g CO_{2e}/MJ) from the fossil fuel comparator of 94 g CO_{2e}/MJ, for different fuels. **Sources:** Electrolysis efficiency of 76 % (Wachsmuth et al., 2019); Carbon intensity of EU electricity mix = 86 g CO_{2e}/MJ (T&E LCA study, 2020); ammonia and e-kerosene synthesis efficiencies are taken from Ricardo Energy & Environment (2020).

Figure 1 RFNBOs: Share of renewable electricity required meet the 70% carbon savings under RED II

1.5. Blue hydrogen, low carbon? It depends ...

Fossil hydrogen, even when combined with carbon capture and storage is not a zero-emission fuel. A study by Ricardo Energy & Environment reviewed the evidence on blue hydrogen, which is produced from steam methane reforming of fossil gas combined with Carbon Capture and Storage. The available evidence shows that the lifecycle emissions are lower than unabated fossil gas, but that the associated emissions are still significant. **The low-carbon status of blue hydrogen depends on optimistic assumptions about emissions throughout the full supply chain:** upstream emissions, the capture rate of CCS, leakage of CO₂ during CO₂ transport and storage.⁹ The wide range in the

⁹ For more details, see the Ricardo E&E (2020) *Renewable electricity requirements to decarbonise transport in Europe with electric vehicles, hydrogen and electrofuels* (section 7.3. 'Environmental risks with blue hydrogen'.)

estimates of lifecycle emissions of blue hydrogen – between 30 and 99 g CO₂/kWh – shows the level of uncertainty about the low-carbon status of blue hydrogen. Fossil hydrogen’s ‘low carbon’ status depends on a number of assumptions:

1. Labelling fossil hydrogen zero-emissions ignores the issue of fugitive methane along the fossil gas value chain: Particularly since the growth of shale gas, measurements of fugitive methane have called into question the status of fossil gas as a lower-carbon fuel. The contribution of the oil and gas industry to global methane concentrations has been underestimated, recent research shows.¹⁰
2. Steam methane reforming technologies currently achieve only a 60% CO₂ capture. Higher – even up to 90% – capture rates are only possible, but require the development of advanced gas reformers.¹¹
3. Carbon capture and storage is an energy-intensive process, involving an energy penalty of up to 40%.¹²
4. To avoid issues of public acceptance, the CO₂ captured from producing fossil hydrogen in the EU is likely to be injected in depleting oil and gas wells. For all but one of the 17 large scale-scale carbon capture and storage in operation, enhanced oil recovery is the primary storage for the captured CO₂.¹³ Without a very high CO₂ price in the EU’s Emissions Trading System, the business case for carbon capture and storage without enhanced oil recovery will not improve.

These issues are unlikely to be resolved by 2030. Therefore, the EU should not undertake any measures to promote ‘decarbonised gases’. Blue hydrogen is not a realistic long-term solution to achieving full decarbonisation.

Retrieved from

<https://www.transportenvironment.org/publications/electrofuels-yes-we-can-%E2%80%A6-if-we%E2%80%99re-efficient>

¹⁰ Scientific American (2020) *Methane Emissions from Oil and Gas May Be Significantly Underestimated*. Retrieved from

<https://www.scientificamerican.com/article/methane-emissions-from-oil-and-gas-may-be-significantly-underestimated/>

Environmental Defence Fund (2020) *European Satellite Data Reveals Extreme Methane Emissions in US Oil & Gas Field*. Retrieved from

<https://www.edf.org/media/european-satellite-data-reveals-extreme-methane-emissions-us-oil-gas-field>

¹¹ UK Committee on Climate Change (2018) *Hydrogen in a low-carbon economy*. Retrieved from <https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy/>

¹² Umweltbundesamt (2018) *Carbon Capture and Storage*. Retrieved from <https://www.umweltbundesamt.de/themen/wasser/gewaesser/grundwasser/nutzung-belastungen/carbon-capture-storage#grundlegende-informationen>

For example, compressing and liquefying the CO₂ alone represents a significant use of energy, suggested to be as high as 12%

¹³ Bui, Mai *et alia* (2018). Carbon capture and storage (CCS): The way forward. in *Energy and Environmental Science*. Retrieved from <https://doi.org/10.1039/C7EE02342A>

2. How to account for the (*additionality of*) renewables used for RFNBO production with a grid connection?

The European Commission is tasked in the RED II to elaborate detailed rules on RFNBOs by the end of 2021, in particular for the RFNBO facilities with a grid connection. Two questions must be resolved: How to ensure that the renewables used are additional, i.e. does not divert non-biomass renewable electricity from the grid? How to monitor the share of renewable power supplied? What is outlined below is applicable to the case of RFNBO production with a grid connection claiming a higher renewables share than average share of grid electricity (case 3 mentioned in section 1.3).

2.1. Additionality: PPAs for new and unsupported renewable electricity

Additionality is key: hydrogen production must add to the deployment of renewables or add to the financing of additional wind, solar and other renewables. Competition with the decarbonisation of the power sector must be avoided at all cost, as deviating existing renewable capacity from the grid will lead to indirect emissions by bringing fossil generators ‘into the money’ in power markets.¹⁴ The RED II clearly wants to avoid a situation, whereby RFNBOs are counted as fully renewable, when an installation starts producing RFNBO before connecting to an installation generating renewable electricity. RFNBO producers need to provide certainty that a particular renewable energy installation or installations like a wind farm (additional renewable capacity) is built or financed by them. How can this be verified? Several options are available, mainly Guarantees of Origin (GOs), Guarantees of Origin+ (GO+) or Power Purchase Agreements (PPAs)¹⁵.

¹⁴ The additionality only presents itself when electricity is used in power-2-X applications, using an electrolyser. This is currently the most advanced technology, but there are also other technologies under development that use high-temperature thermochemical processes for the production of solar fuels. This type of technology does not compete with grid-based electricity in the same way as electrofuels do. See <https://synhelion.com/>

¹⁵ A power purchase agreement (PPA) is a legal contract between an electricity generator (provider) and a power purchaser (buyer, typically a utility or large power buyer/trader). The PPA defines all of the commercial terms for the sale of electricity between the two parties, including when the project will begin commercial operation, schedule for delivery of electricity, penalties for under delivery, payment terms, and termination. A PPA is the principal agreement that defines the revenue and credit quality of a generating project and is thus a key instrument of project finance.

Why not opt for the existing system of Guarantees of Origin to determine the renewable energy content of RFNBOs?¹⁶

GOs are a tradable instrument that cannot offer the same reliable financing as PPAs do. **The sale price of GOs is not guaranteed and there is no direct link between the market value of GOs and the revenue required to make new investments in renewable power attractive.** Indeed, GO prices have generally been very low compared to the wholesale price of electricity and low compared to the additional revenue needed for renewable power to compete with fossil power generation on the market. Hence, additionality with GOs is harder to achieve, as GOs do not allow renewables developers to cover their costs. The lack of long-term price certainty also complicates the financing of renewables projects .

Verifying every single GO (for location of the electricity asset, date of start of operation and time of generation of the specific electrons) linked to an RFNBO facility would be onerous. Yet, this does not mean that GOs will play no role at all: To comply with the RED II's demand that "the renewable properties of that electricity are claimed only once and only in one end-use sector", the GOs generated under the PPA should not be allowed to be used to prove compliance in other sectors like power or heating & cooling. When renewable energy is used in an electrolyser, the corresponding GOs should be bundled under the relevant PPA and cancelled. GOs should not be used to comply with the renewable fuel targets of the RED because only the final consumption of energy from renewable sources should count towards achieving the renewable energy targets (article 7.1(c) RED II). See also section 2.4 on how to avoid double counting of RFNBOs.

Comparing the different options, Power Purchase Agreements offer the best way forward, and for several reasons. Unlike alternative methods like GOs, PPAs **provide a price certainty for developers of renewables projects.** This is important for the business case of RFNBO production, as the electricity cost represents more than half of all the costs involved. PPAs are contracts in which a RFNBO producer commits to buy the output of a renewable power project, often for a fixed price, which allows renewables developers to fully cover their costs. PPAs are a well-established instrument for developers of renewables projects, whereby corporate buyers purchase power and renewable certificates directly from a renewable energy generator. Such PPAs can be designed to be flexible to meet the needs of the RFNBO producer: They can be short-term (even seasonal), but also longer-term, up to 15 years and even longer. PPAs may or may not include grid balancing services.

¹⁶ See Annex I for an overview of the advantages and disadvantages of the different options.

PPAs come in several forms:

1. A direct connection (via a ‘private wire’),
2. A ‘sleeved’ PPA whereby the RFNBO producer buys electricity from the renewables developer, while “paying the grid operator some form of grid access fee for that electricity to be ‘sleeved’ across the grid and supplied at the physical location of the renewable electricity buyer’s facilities”
3. A ‘virtual’ PPA whereby “the generator sells power to a local electric utility and the corporate consumer separately purchases electricity from its own local electric utility”.¹⁷

An example will help to present how a PPA could be used by an efuels producer: A hydrogen producer running an electrolyser could conclude a PPA for multiple renewable energy sources (e.g. wind and solar power and even battery storage). By combining several technologies, a firmer generation shape can be generated, resulting in higher operating hours for the electrolyser. The hydrogen producer concludes the PPA with an energy service provider, who in turn contracts third parties who own wind and solar installations. The hydrogen producer pays the agreed electricity price under the PPA to these third parties and a ‘sleeving fee’ to the energy service provider for supplying the power of the wind and solar assets, the price for the bundled GOs and - if necessary - the price for the residual power demand not supplied by the renewable generation.¹⁸

A second reason why PPAs offer a useful way forward is that they **simplify the verification process** of a clear link between the electricity production unit and the fuel production. As a minimum, the power (MW) used at any time under the PPA should not exceed the power that is being generated by the renewable energy installation(s).¹⁹ In the context of a PPA, it should be possible to monitor the quantity of renewable electricity purchased and the amount of electricity consumed in RFNBO production. Utilities have the data to assess the link between the renewable power generation and the RFNBO facility. The new regulatory framework should ensure that this data is shared with the regulatory authorities or certification bodies to verify the additionality claims of the RFNBO. The administrative capacity of authorities to check PPAs will need to be built up to ensure an independent

¹⁷ Chris Malins (2019) p. 31. Virtual PPAs can be more complex, if the renewables developer and the RFNBO facility are not on the same electricity grid, in which case “the PPA contract works through a ‘contract for difference’. Under this contract for difference, a strike price is agreed for the electricity sold by the power generator to the local utility. If the price received is below the strike price, then the corporate consumer makes up the difference. If the price received is above the strike price, then the power generator pays the excess to the corporate consumer”.

¹⁸ For an overview of the many types of PPAs, see Re-Source (2020) *Introduction to Corporate Sourcing of Renewable Electricity in Europe*. Retrieved from <http://resource-platform.eu/files/toolkit/RE-Source-introduction-to-corporate-sourcing.pdf>

¹⁹ Efuels producer could also combine multiple PPAs to ensure that the electricity consumption of their electrolysers are covered.

verification of PPAs.²⁰ Until now, Guarantees of Origin have been the only tool to track renewable energy production.

For the purpose of RFNBO's additionality, it is crucial that the PPA agreed between a utility and an RFNBO producer should contract a renewable electricity facility that offers *unsupported* renewable generation capacity. *Unsupported* means that the renewable electricity generation is not being incentivised by other instruments (feed-in-tariffs or green certificates, which are ultimately paid for by the residential and industrial electricity consumers at large via their electricity bill). In other words, **the PPAs should cover the full price of the electricity supplied to the electrolyser as well as the transmission costs.** A national register of subsidies for renewable energy can guarantee that the renewable asset does not take away financial resources for the deployment of renewable energy in other sectors.

Supporting 'new' renewable electricity means that renewable **electricity generation comes into operation before or at the same time as the RFNBO facility.** Because constructing renewable electricity assets like an offshore wind park tends to take considerably longer than building an electrolyser facility, a transition period could be considered. During such a transition, an electrolyser can be linked to an existing renewable energy generator as long as the PPA takes effect within a couple of years of the electrolyser starting operations.

Why are PPAs a better option than other schemes like GO+?

GOs are well-known instruments and already play an important role in enabling consumers to 'green' their electricity consumption. Building on that concept, a proposal has been elaborated to build on the GO system in the RED and introduce a new concept of GO+: All the existing rules of the RED would apply to both GOs and GO+.²¹ The main difference would be that **GO+ would only be awarded to new and unsupported renewable energy generation plants.** However, the current GO system does not allow the establishment of the temporal correlation required under the RED. Just like a regular GO, a GO+ would be issued for each 1MWh of electricity generated, albeit for new and unsupported renewable electricity. Both GO or GO+ confirm that one 1MWh of renewable energy was generated, but does not disclose any details over the timeframe, when this energy was generated. Hence, the information provided by the GO+ would not be sufficiently detailed to prove a 'temporal correlation', i.e. closely matching the demand of the electrolyser with the renewable

²⁰ Cerulogy (2019) *What does it mean to be a renewable electron?* Retrieved from

https://theicct.org/sites/default/files/publications/Cerulogy_Renewable-electrons_20191209.pdf p. 33

²¹ OEKO (2017) *Improving the accounting of renewable electricity in transport within the new EU Renewable Energy Directive*. Retrieved from

<https://www.transportenvironment.org/publications/how-make-renewable-energy-directive-red-ii-work-renewable-electricity-transport>

generation. A PPA can be designed to spell out how the demand and the renewables' supply will be matched (see section 2.2 below). Secondly, a GO+ remains a market-based instrument, whose price depends on supply and demand. This is another reason why GO+ may not be the best-suited approach to ensure long-term price certainty to developers of renewable generation assets with a long lifetime.

PPAs are already a well-known instrument for stable project financing for developers of renewables' projects and the corporate sourcing of renewable energy. PPAs are a flexible tool and leave room for tailor-made solutions in terms of ownership. Last but not least, recital 90 of RED II already refers to bilateral renewables PPAs as a way to demonstrate a temporal and geographical correlation between renewable electricity generation and fuel production. For these reasons, T&E believes that a system built around PPAs for renewable power will enable RFNBO producers to better meet the requirement of RED II on additionality as well as temporal and geographic correlation.

2.2. A 'temporal and geographic correlation' between electricity generation and RFNBO production

The RED II is clear that RFNBO producers should not be allowed to cherry pick the cheapest renewables to power their electrolysers. According to recital 90, there needs to be a temporal and geographical correlation between the renewable electricity generation and the RFNBO plant. Building a utility-scale solar plant in Spain and operating a RFNBO facility running on German grid power is not an option. An RFNBO plant running on solar power cannot run 24 hours per day.

PPAs can be used to ensure compliance with the **temporal correlation**. How? The PPA should outline how the renewable power will match the demand profile of the RFNBO plant, ensuring e.g. that the electrolyser produces hydrogen only when the renewable power source is in operation, with full intraday matching. The PPA should guarantee that the full consumption of the electrolyser under the PPA is covered. **Using day-ahead forecasts can ensure every hour of renewables' production and consumption is matched**, thereby allowing to determine whether the produced RFNBOs can be counted as 100% renewable.²²

With regard to the geographic link between the renewable electricity generation and the RFNBO plant, the RED II does not offer much detail. **Having the RFNBO facility and the renewable energy generation inside the same bidding zone should be considered sufficient to meet the requirement for a geographic correlation**. However, the grid operator should confirm that the grid connection between producer and user of the electricity does not pass a zone of grid congestion,

²² See Annex II for more details of how temporal correlation can be stipulated in the context of a PPA.

exacerbating already existing congestion on grids with a high share of renewables. One exception to this general rule would be - in cases where the congestion happens in one direction - to allow the PPA to build renewable generation on the undersupplied side of the congestion and the electrolyser on the oversupplied side. In case an RFNBO facility is situated in an area to take advantage of otherwise curtailed renewable electricity, the electrolyser needs to be situated geographically in proximity to the structural congestion in the area of the bidding zone and rely on that otherwise curtailed electricity only during those hours of the year when surpluses actually occur. The most well-known example of such one-way grid congestion is Germany, where excess wind power in Northern Germany cannot get to demand centers in Southern Germany due to lack of transmission capacity. Building the electrolyser in the North while ensuring that the PPA adds to renewable generation capacity in the South would be one option to count otherwise curtailed renewable electricity as additional. However, relying only on curtailed renewable electricity is unlikely to result in sufficient operating hours for the electrolyser, thereby undermining its economic viability.

A strict interpretation of the temporal and geographic correlation from the start is crucial and preferable over an initial transition period of several years with less stringent requirements.

There are a number of good reasons for this. First of all, a high level of ambition will drive innovation. For example, instead of oversizing the renewable generation asset in order to achieve sufficient operating hours for the electrolyzer, RFNBO producers could innovate by exploring a hybrid set-up, combining solar, wind and other renewable sources as well as integrate some storage, to ensure temporal correlation. Secondly, the argument that e.g. temporal correlation should be initially measured in days or even weeks is problematic, because a grandfathering of less strict requirements would distort competition for RFNBO production facilities that start operations, when stricter requirements enter into force. Thirdly, the demand for RFNBOs will be driven by policy: an fuels mandate for jet fuel, Contracts for Difference for shipping and aviation electrofuels. RFNBO producers will be competing with each other, not against fossil fuels. Last but not least, the text of the RED II does not provide any legal basis for the Delegated Act to introduce such transitional measures.

2.3. Accounting for the carbon intensity of the grid power used

While the RED II provides a basic framework to determine the renewable share of RFNBOs, no details are given on how the RFNBOs can meet the greenhouse savings target of at least 70% from 2021. The proposed greenhouse gas methodology - as presented during a stakeholder meeting on 18 June 2020 offers a useful starting point by distinguishing between the rigid and elastic sources of energy sources involved in RFNBO production.²³

²³ T&E (2020) *Which renewable transport fuels deliver substantial carbon reductions?* Retrieved from <https://www.transportenvironment.org/publications/which-renewable-transport-fuels-deliver-substantial-carbon-reductions>

The RED II rightfully considers *additional* non-biomass renewable energy sources to be ‘**elastic**’ and to have zero-emissions, as it does not divert renewable energy sources away from other uses. When an RFNBO producer relies on grid electricity - produced from a mix of fossil as well as renewable sources - to supplement the renewable electricity sources contracted under a PPA, the carbon intensity of that electricity is ‘**rigid**’: That electricity could have been used by other users. This is why such rigid inputs should be considered to have the grid’s average carbon intensity per year. The renewable electricity on the grid cannot be counted as additional, because doing so would divert its consumption away from other electricity consumers. RFNBO producers should not be allowed to use GOs to reduce the average carbon intensity of grid electricity. For more on the greenhouse gas methodology to calculate the carbon savings from RFNBOs, we refer for more details to a letter that was sent to the European Commission on 9 July 2020.²⁴

2.4 Avoid double counting of RFNBOs

RFNBOs should only count in terms of their contribution to meeting the final energy consumption of the transport sector, not in terms of the primary energy needed to produce the electrofuels. In other words, they should only count on the basis of the energy content in the combusted fuel. Should a Member State interpret the RED II as counting the energy input, this would effectively double count RFNBOs towards overall targets (given the 50% energy conversion efficiency of the RFNBO process). **The RFNBO framework should make clear that the renewable electricity consumed during RFNBO production cannot count towards overall member states’ renewables targets** (which also includes the power and heating & cooling sector), as this double counting could allow a reduction in renewable power generation elsewhere in the system.

3. Other environmental impacts

3.1. Water

Producing RFNBOs by means of electrolysis using renewable electricity will require significant volumes of water. While significant in absolute terms, the water-related impacts of producing RFNBOs should be compared relative to the water use involved in producing other fuels. Compared to biofuels made from food or feed crops, the water demand for renewable electricity and electrolysis is far lower. Concretely, electrofuel production requires about 9 litres of purified water as an input for every kilogram of hydrogen produced. In terms of MJ of energy stored in

²⁴ T&E (2020) *Which renewable transport fuels deliver substantial carbon reductions?* Retrieved from <https://www.transportenvironment.org/publications/which-renewable-transport-fuels-deliver-substantial-carbon-reductions>

hydrogen, 0.07 litres of purified water are needed (requiring 0.17 litres of seawater to be desalinated, equivalent to 9 litres of purified water as an input for every kilogram of hydrogen). For comparison, the total lifecycle water requirements to produce 1 MJ of first generation biofuel are between 33 and 476 litres, about 500 times higher.²⁵

In arid areas like the Middle East and North Africa, RFNBO production can indeed lead to additional water stress, but its development would not fundamentally alter the scale of water demand compared to existing patterns of water use, at least at the national level. Agriculture would continue to dwarf the water demand by RFNBOs, even if a country in the Middle East or North Africa would produce an amount of electrofuel equivalent to 50% European aviation fuel demand.

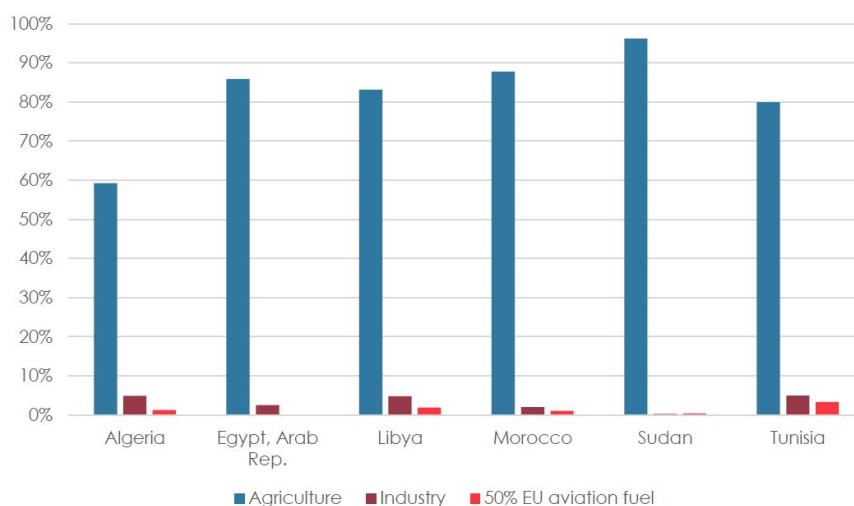


Figure 13. Percentage of national freshwater withdrawals used by agriculture and industry in 2014, and required to supply 50% of EU aviation fuel from electrokerosene

Compared to nuclear and fossil power plants, electrolysis would only use a tiny fraction of the water that these generators mostly use for the purpose of cooling. The total water volume required to produce the RFNBOs for the transport sector amounts to 270 billion litres. Fossil and nuclear power plants use about 68,000 litres of water. Despite its relatively low water consumption, RFNBO production should not be situated in areas with limited rainfall and where groundwater levels are already stressed. One important caveat should be added: Electrolysis

²⁵ Ricardo E&E (2020) *Renewable electricity requirements to decarbonise transport in Europe with electric vehicles, hydrogen and electrofuels* (section 5.1.) Retrieved from <https://www.transportenvironment.org/publications/electrofuels-yes-we-can-%E2%80%A6-if-we%E2%80%99re-efficient>

requires highly-purified water, whereas nuclear and fossil power plants can use untreated river or sea water. This is why coastal areas may be better suited for RFNBO production: Desalination plants can pre-treat the water to the required level of purity. The energy penalty for relying on desalination is small, just 0,1 % of the electricity required for the electrolysis. The waste product of desalination is brine, which needs to be treated and reintroduced to the environment responsibly.

As is the case in other large industrial projects and especially in cases where the local environment is arid, **any RFNBO facility should undergo a local water availability assessment and ensure that the necessary wastewater treatment facilities are available.** This element should be included in the EU sustainability framework.

3.2. Land and soil

Similar to water needed for RFNBO production, the land and soil impacts should be compared to the impacts of producing other fuels, biofuels in particular. The renewable electricity generation needed to supply the electricity to the electrolyzers is the most land intensive aspect of RFNBO production. In contrast to biofuels, however, it is not necessary to use high quality agricultural land for renewable electricity generation. Overall, RFNBOs are dramatically less land intensive. Lower value land is likely to be cheaper for project developers. Furthermore, RFNBO production will have no significant impact on soil quality. In sharp contrast, biofuels produced by conventional, intensive, agriculture have well documented problems associated with nitrogen pollution and contribute to biodiversity loss.²⁶ While less land and soil-intensive than biofuels, the land required for the additional renewable electricity generation needed is significant. This is why large RFNBO projects - like other major industrial projects - should be subject to public consultation of the local population.

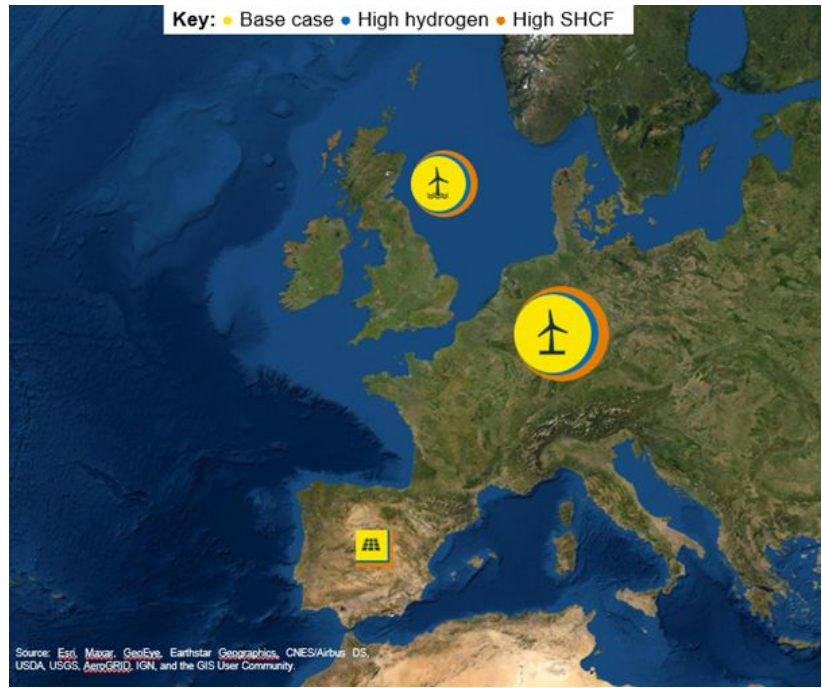
If a significant share of the RFNBOs needed for the hard-to-decarbonise transport modes would be produced inside the EU, significant areas of land or marine areas will be needed according to a 2020 study by Ricardo E&E.²⁷ T&E commissioned this study to analyse the feasibility of decarbonising

²⁶ See for example the findings in the report by NGO Feedback on the environmental impacts of using an energy crop like maize in anaerobic digesters to produce biogas. Relying on maize monoculture for anaerobic digestion actually leads to net emissions increases, mainly as a result of indirect land use change. Moreover, the leftover digestate after anaerobic digestion has similarly negative soil impacts as synthetic fertilisers pose (e.g. nitrates leaching into waterways and groundwater).

Feedback (2020) *BAD ENERGY - Defining the true role of biogas in a net zero future*. Retrieved from <https://feedbackglobal.org/bad-energy-the-perverse-promotion-of-energy-from-food/>

²⁷ Ricardo E&E (2020) *Renewable electricity requirements to decarbonise transport in Europe with electric vehicles, hydrogen and electrofuels* (section 4.4.) Retrieved from <https://www.transportenvironment.org/publications/electrofuels-yes-we-can-%E2%80%A6-if-we%E2%80%99re-efficient>

transport with renewable energy and to compare the impacts of a greater reliance on electrofuels, even for transport modes where direct electrification is possible. The areas shown on the map indicate the surface required for each of the three technologies to provide *one third of the electricity requirements of the three scenarios*. Relying on solar PV for one third of the base case would require an area about half the size of Belgium (16.664 km²). In terms of land area used, solar is the most efficient and can be deployed on rooftops. The disadvantage of non-solar is that it is more difficult to use the land for other purposes like agriculture. A greater reliance on onshore wind would require more land area, just over 5 times more than solar. Relying on onshore wind for one third of the base case would require an area just slightly smaller than the size of Portugal (86.891 km²). However, generous spacing between turbines will increase energy yields and allow other activities like agriculture to be co-located beside wind farms. Offshore wind is still more expensive than onshore wind, but has the advantage of higher energy yields. As a result, offshore wind requires just half the space needed by onshore wind. Relying on offshore wind for one third of the base case would require an area about the size of Denmark (43.579 km²).



4. Carbon-based RFNBO: Sourcing ‘clean’ carbon

An EU-level framework on RFNBOs must address the carbon source that will be used during Fischer-Tropsch processes for the production of carbon-containing RFNBO. T&E remains committed

to the principle that RFNBOs should use CO₂ captured from the air as the carbon-based feedstock. Direct Air Capture of CO₂ is the only source of carbon that is fully compatible with the EU's stated target of becoming a net-zero economy by 2050.

During a stakeholder meeting in June 2020, the Joint Research Center of the European Commission presented its proposal on how to deal with the carbon source for RFNBOs. T&E regrets that the proposed greenhouse gas methodology does not offer any specific support for circular sources of carbon, as obtained via Direct Air Capture. Not promoting atmospheric sources of carbon entails two risks: There is a risk that the CCU from fossil sources will potentially lead to lock-in of fossil sources of CO₂. Industries will invest in CCU units nearby their operations and this will be long-lasting infrastructure that will complicate the transition from fossil to clean, circular sources of carbon. And secondly, the major cost difference between CCU and DAC is not addressed and will result in a potential delay in DAC development. A dedicated policy push to rapidly close the gap between carbon from industrial point sources and circular sources of carbon is needed.

To counter the above-mentioned risks, we propose that the GHG methodology confirms the principle that investments in fossil carbon from industrial point sources need to be phased out by 2025. Investments made in CCU from industrial point sources before 2025 could be grandfathered in, i.e. the installations producing CCU fuels from point sources and constructed before 2025 would be allowed to be used as an eligible source of carbon under RED II. This is an important signal to investors that in the mid-term only circular sources of carbon will be acceptable in the production of RFNBOs.

In addition, the methodology should also distinguish between different sources of fossil carbon. Not all ETS sectors should be allowed to sell their carbon to RFNBO producers. There should be no role for the use of CCU in the EU energy sector, the generation of power and heat. Why? There are many technological options to decarbonise the energy sector more rapidly. The use of fossil fuels in the power and heat sector must be phased-out extremely rapidly and enabling CCU risks delaying this necessary phase-out.

Last point on this, CO₂ from bioenergy industries should not be allowed, because of the negative climate and environmental impacts associated with the use of biomass, especially land-based, for energy purposes.

For more on the greenhouse gas methodology to calculate the carbon savings from RFNBOs, we refer to the more detailed letter that was sent to the European Commission on 9 July 2020.²⁸ The upcoming

²⁸ T&E (2020) *Which renewable transport fuels deliver substantial carbon reductions?* Retrieved from <https://www.transportenvironment.org/publications/which-renewable-transport-fuels-deliver-substantial-carbon-reductions>

revision of the Renewable Energy Directive in 2021 - as part the European Green Deal - must provide clarity on how to promote circular sources of carbon for use in RFNBO production.

5. RFNBOs exports from non-EU countries: how to avoid another resource curse

One of the recent projects that proposed large-scale imports of RFNBOs from developing countries to the EU is called ‘Congo Green Hydrogen’. It concerns a mega-project for a 44 GW hydropower project in the Democratic Republic of Congo, double the size of the Three Gorges Dam in China. Media reports indicate that the Africa envoy of the German government would be willing to support the project with studies on social and environmental impacts.²⁹ While this project is still in the very early stages and may never come to fruition, it is very concerning that the promoters of such a mega-project to produce hydrogen do not mention how this project could help to decarbonise the Democratic Republic of Congo’s own economy or provide energy access to millions of Congolese people.

Lessons must be learnt from past projects to produce fossil fuels or biofuels outside the EU, especially in the developing world. While exports of RFNBOs rely on renewable energy, this does not entail that such projects come without impacts. RFNBO production can add to water shortages and occupy large tracts of land, thereby negatively impacting food security and local economies. Potentially even displacing local populations. Principles such as the free, prior and informed consent of the local population and transparency about the size of such projects and their local impacts are crucial.

Both the EU as well as the countries with an ambition to export RFNBOs must explore how this new industry can also help address the lack of energy access (if applicable) and the decarbonisation of the country’s economy. The ‘host countries’ should explore how producing RFNBOs can help boost renewables deployment more generally in those countries, further augmenting the additional renewables required for RFNBO production. As future importer of RFNBOs, the EU can incentivise such a dynamic by **devising a mechanism whereby the production of RFNBOs for export is combined with investments in the decarbonisation of the local economy**. A scenario whereby the best renewables locations are used for RFNBO production while the local energy mix continues to rely on fossil fuels must be avoided at all cost. A future international trade in RFNBOs needs to help bring down global emissions, helping the decarbonisation efforts of both importers and exporters

²⁹ Wehrmann, B. (2020, September) *Germany eyes green hydrogen production with new dam project on the Congo River*. Retrieved from <https://www.cleanenergywire.org/news/germany-eyes-green-hydrogen-production-new-dam-project-congo-river>

Insisting on strict additionality for RFNBOs imported from outside the EU can be a first step to make this happen. This is why **RFNBO imports from outside the EU - at least initially - should only be allowed, if they are produced with a direct connection to a renewable source, i.e. without a grid connection or from grids with a very low-carbon and non-biomass based electricity mix.**³⁰ Such an approach will make it easier for certification bodies to verify the carbon footprint of the produced RFNBOs. Given the better renewables potential in exporting countries, limiting RFNBO imports to these two cases will not have a negative impact on the cost-competitiveness of the fuels produced. Once better international databases with up-to-date and reliable data (on carbon intensity of grid electricity, grid congestion, temporal data) have been developed, RFNBO production using grid electricity can also be considered. This can be a win-win, as such additionality also guarantees a level-playing-field for RFNBO production in the EU.

Ambitious sustainability criteria for RFNBO that can be internationally agreed will not be sufficient. They need to be put into practice. Mandatory certification procedures and effective test methods are also needed, including third-party independent auditing and monitoring by public authorities. Given the big price difference between e.g. fossil kerosene and renewable e-kerosene, there is a considerable fraud risk.³¹ The EU should strive to have an internationally accepted and enforceable regulatory framework for RFNBO to be in place in the next couple of years.

Meanwhile, the EU should not wait to jumpstart the production of RFNBOs inside the EU. Adopting demand-side policies that will drive the use of RFNBOs in shipping and aviation, where direct electrification is not feasible, will be crucial to make this happen. This is possible, as the renewables potential in the EU far exceeds the electricity demand from the grid and transport in 2050.³² There is also a window of opportunity in the 2020s for a European electrofuels industry to ramp up production of renewables-based electrofuels and - in doing so - drive down the cost of electrolyzers, synthesis reactors, storage solutions, etc. This will position EU industry well to export these technologies and deploy these on a large scale in areas outside the EU from 2030 onwards. From 2030, cheaper imports of electrofuels from countries with better renewables potential will likely play an important role in meeting the surge in demand for these fuels in shipping and aviation (as well as other industrial sectors). But for that to happen, the EU must do its homework first by establishing a regulatory framework on the sustainability of electrofuels.

³⁰ In other words, only cases 1 and 2 referenced in section 1.3 of this briefing.

³¹ The experiences with advanced biofuels are instructive here: Fraudulent used cooking oil (UCO) which hasn't been used for cooking, but which in reality is virgin palm oil, has been falsely declared as UCO biodiesel under Europe's Renewable Energy Directive, with fraudsters cashing the generous incentives.

³² Ricardo E&E (2020) *Renewable electricity requirements to decarbonise transport in Europe with electric vehicles, hydrogen and electrofuels* (section 4.3.) Retrieved from <https://www.transportenvironment.org/publications/electrofuels-yes-we-can-%E2%80%A6-if-we%E2%80%99re-efficient>

Further information

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Annex I

	What?	Advantage	Disadvantage
GO	Certificate for renewable energy	Already exists	Low price due to oversupply, no guaranteed finance
GOnew	GO, but only for new RFNBO plants	New, but builds on current system	Same risk of oversupply as GO, compared to RFNBO demand
GO+	GO, but only for new & unsupported plants	New, but builds on current system	If market builds more RES-E then RFNBO demands, GO+ value down and additionality at risk.
PPA	Agreement between purchaser and RES-E generator to pay price over an agreed period	Guarantees long-term financing, not dependent on value of certificates	Departs from GO, verification of renewability (e.g. balancing services)

Annex II: Determining ‘temporal correlation’

There are 3 ways that the PPA can ensure this temporal correlation:

1. Pro-rata: Fixed ratio between full power generated by the renewable electricity asset and power delivered to the electrolyser;
2. Full electrolyser load: Electrolyser uses all available power up to its capacity through PPA;
3. Optimised electrolyser load: Similar to 'full load', but power with the most expensive price is fed into the grid instead of electrolyser.

The matching of supply and demand can be done on the basis of day-ahead forecasts of renewables potential, which have achieved a high level of accuracy. While an instantaneous match would be overly onerous, day-ahead forecasts offer a broad enough time-span.

The RED II also allows a fourth option, namely a baseload operation of the electrolyser. This means that the grid complements the power supply for the electrolyser, when the renewable electricity asset is not producing sufficient volumes, ensuring a constant power supply. The shares of RFNBOs that are produced with renewables are counted as 100% renewable. However, the renewables content of the RFNBOs produced with grid power will be determined on the basis of the average share of electricity from renewable sources in the country of production, as measured two years before the year.

Nevertheless, it will be important for all 4 options to regularly account (e.g. yearly) the exact amounts of electricity consumed and hydrogen produced, balancing the surplus hours (when the day-ahead forecasts underestimated the renewables generated) and the shortfall hours (when the day-ahead forecasts overestimated the renewables generated)