Implications of the recast Renewable Energy Directive on Power-to-X fuels

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This thesis systemises the regulatory framework established by the recast Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (RED II) for synthetic Power-to-X (P2X) fuels. The aim is to identify and analyse the key regulatory challenges regarding the exploitation of raw materials, hydrogen and carbon dioxide (CO_2), as well as utilisation of the end products. Consequently, challenges regarding the production process of P2X fuels are taken into account. In order to assess the regulatory framework of the P2X fuels, it is essential to comprehend the regulatory environment set forth for hydrogen and CO_2, as the origin of the energy and the production process will define whether the P2X fuel falls within the category of renewable liquid and gaseous fuels of non-biological origin (RFNBOs) or recycled carbon fuels (RCFs). In light of my conclusions, I apply the findings made in this thesis in practice by evaluating the regulatory treatment of the P2X Joutseno pilot plant. Lastly, the thesis provides recommendations to develop the regulatory framework at the EU level as well as presents argumentation on how the provisions could be transposed into national legislation to facilitate further deployment of P2X fuels.

The analysis in this thesis is built on legal dogmatics and more specifically, theoretical environmental law. In addition, the tools provided by regulatory theory are utilised in order to take up a more comprehensive approach to the research questions. The primary object of the analysis is RED II. Moreover, to examine further development of the regulatory framework of P2X fuels, emphasis is given to several communications adopted by the European Commission (EC).

Although RED II recognises P2X fuels, the conclusions of this thesis suggest that it seems to lack the ability to adapt evolving technological innovations and the increasing demand for renewable and low-carbon transport fuels. Although further details of RED II are still to be introduced by the delegated acts to be adopted by the EC during 2021, the regulatory architecture and the particular requirements seem to take an overly critical approach towards RCFs and RFNBOs by undermining their potential and establishing unnecessary barriers. Due to these drawbacks, operators lack the encouragement to invest in P2X technologies compared to other competing pathways. The deficiencies undermining the appropriate incentives to RFNBOs and RCFs need to be thoroughly addressed to provide adequate regulatory certainty to support the large-scale introduction of P2X fuels.

Keywords: Power-to-X, P2X, synthetic fuels, renewable liquid and gaseous transport fuels of non-biological origin, RFNBOs, recycled carbon fuels, RCFs, energy, renewable energy, hydrogen, electricity, carbon dioxide

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Abbreviations

CCS	Carbon capture and storage
CCU	Carbon capture and utilisation
CO_2	Carbon dioxide
EC	European Commission
EGD	COM(2019) 640 final. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, the European Green Deal, on 11 December 2019
Energy System Integration Strategy	COM(2020) 299 final. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, Powering a climate neutral economy: An EU Strategy for Energy System Integration, on 8 July 2020
ETS	Emissions trading system
ETS Directive	Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814 (*OJEU L 76/3, 19.3.2018*)
EU	European Union
GHG	Greenhouse gas
GO	Guarantee of origin
Hydrogen Strategy	COM (2020) 301 final. 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, on 8 July 2020
Member States	The member states of the European Union
Paris Agreement	Paris Agreement on climate change following the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change 2015
PPA	Power purchase agreement

P2X	Power-to-X
RCFs	Recycled carbon fuels
RED	Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (*OJEU L 140/16, 5.6.2009*)
RED II	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 (recast) (*OJEU L 328/82, 21.12.2018*)
RFONBOs	Renewable liquid and gaseous transport fuels of non-biological origin
Waste Directive	Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (*OJEU L 312/3, 22.11.2008*)
2030 Climate Target plan	COM(2020) 562 final. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, Stepping up Europe's 2030 climate ambition, Investing in a climate-neutral future for the benefit of our people, on 17 September 2020

1. Introduction

1.1. Background

This thesis discusses the regulatory framework established by the recast Directive (EU) 2018/2001[1] on the promotion of the use of energy from renewable sources (RED II) for synthetic Power-to-X (P2X) fuels. The aim is to identify and analyse the key regulatory challenges regarding the exploitation of raw materials as well as utilisation of the end products. Consequently, challenges regarding the production process of P2X fuels are taken into account. Furthermore, the thesis provides recommendations for developing the regulatory framework in the European Union (EU) and on the national level to support the deployment of P2X fuels.

In December 2018, RED II entered into force as a part of the Clean Energy for all Europeans package.[2] Revision was required in order to keep the EU on track towards the ambitious climate targets set out in the Paris Agreement on climate change following the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change[3] (Paris Agreement). RED II establishes a binding EU-wide overall target for 2030 of at least 32% of energy from renewable sources, including a clause allowing a possible revision upwards by 2023.[4] Moreover, RED II introduces binding sector-specific subtargets. In the transport sector, the member states of the EU (Member States) must set an obligation on fuel suppliers to ensure that the share of renewable energy within the final consumption of energy is at least 14% by 2030.[5]

Furthermore, in December 2019, the European Commission (EC) introduced the European Green Deal[6] (EGD) to tackle climate and environment-related challenges. The EGD includes an initial roadmap covering all sectors of the economy as well as the key policies

[1] 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 (recast) (*OJEU L 328/82, 21.12.2018*).
[2] European Commission, Clean energy for all Europeans package.
[3] According to the Article 2 of the Paris Agreement, the agreement aims at strengthening the response to the threat of climate change at global level by limiting the increase of the global average temperature to well below 2 Celsius degrees compared to pre-industrial levels and by pursuing to limit the increase towards 1.5 Celsius degrees.
[4] Article 3 and Recital 8 of RED II.
[5] Article 14 of RED II.
[6] COM(2019) 640 final. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, The European Green Deal, on 11 December 2019.

and measures required to meet the target of climate neutrality by 2050. The EGD recognises the role of the transport sector as a significant emitter, as it accounts for a quarter of the EU's total greenhouse gas (GHG) emissions.[7] Although carbon dioxide (CO_2) emissions have reduced in other parts of the energy system, the curve is still on the rise in the transport sector.[8] According to the EGD, emissions reduction of 90% is required to remain on the path towards climate neutrality by 2050.[9]

Given the new climate targets introduced by the EGD, the EC will review and where necessary, propose to revise the relevant EU policy instruments by June 2021 to deliver the additional GHG emissions reductions.[10] In August 2020, the Commission launched a public consultation period on a possible revision of RED II and published an Inception Impact Assessment plan.[11] The aim of the revision is to ensure that the instruments of the EU's renewable policy are fit-for-purpose and contribute to the deployment of renewable energy sources. In this context, renewable synthetic liquid and gaseous fuels, as well as green hydrogen, are specifically mentioned. The extent of the required revision is indicated in the EC's communication Stepping up Europe's 2030 climate ambition[12] (2030 Climate Target plan) as well as in several strategies presented under the EGD. The 2030 Climate Target Plan supports increasing the EU-wide GHG emissions reduction target to at least 55% by 2030 compared to 1990. This requires that the share of renewable energy increases from 38% to 40% of gross final consumption by 2030.[13]

In July 2020, the EC published an EU Strategy for Energy System Integration[14] (Energy System Integration Strategy). The Energy System Integration Strategy recognises the inefficiency of the current separate vertical value chains across the energy system. It pro-

[7] COM(2019) 640 final, p. 10.
[8] COM(2019) 640 final. For more information regarding the emissions from transport sector, see IEA, Tracking Transport 2020 and European Environment Agency 2019a.
[9] COM(2019) 640 final, p. 10.
[10] COM(2019) 640 final, p. 10.
[11] Plan/2020/7536. For more information, visit European Commission, EU renewable energy rules – review.
[12] COM(2020) 562 final. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, Stepping up Europe's 2030 climate ambition, Investing in a climate-neutral future for the benefit of our people, on 17 September 2020.
[13] COM(2020) 562 final, p. 2 and 9.
[14] COM(2020) 299 final. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, Powering a climate neutral economy: An EU Strategy for Energy System Integration, on 8 July 2020.

poses policy and legislative measures to create an integrated energy system by establishing stronger links between the multiple energy carriers[15], infrastructures and consumption sectors.[16] Furthermore, a parallel communication called Hydrogen strategy for a climate-neutral Europe[17] (Hydrogen Strategy) was adopted by the EC to complement the Energy Sector Integration Strategy. The Hydrogen Strategy elaborates the opportunities and measures required to give a boost to the hydrogen economy as a part of the integrated energy system. Both strategies see direct electrification to be at the heart of the vision in the transition towards decarbonised transport sector, but they still recognise a variety of end-use applications where it is not feasible to use electricity directly. Thus, low-carbon fuels are identified as a significant opportunity to tackle the emissions in applications that are still relying on liquid fuels.[18] A Sustainable and Smart Mobility Strategy, to be adopted by the end of 2020, addresses the challenges of the transport sector and provides measures to tackle all emission sources.[19]

Based on the current discussion and research, P2X technology offers a promising route to the large-scale transformation towards decarbonisation of the hard-to-abate parts of the transport sector. P2X technologies allow indirect electrification by converting electricity into synthetic gases, e.g. hydrogen, methane and other gases and liquids, e.g. methanol, while simultaneously offering a long term storage solution and addressing the issue of intermittency of renewables.[20] This thesis narrows down the focus to a process where P2X technology is deployed to produce carbon-neutral or renewable liquid fuels for aviation, maritime and road transport. P2X process utilising hydrogen and CO_2 as raw materials are in the centre of the main interest.

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[15] Rosen – Koohi-Fayegh 2016, p. 10, energy in energy carriers can be used in the same form without converting it to another energy currency. Electricity, hydrogen and fossil fuels are examples of energy carriers, whereas energy sources such as wind and solar need to be converted to an energy currency before they can be utilised.
[16] COM(2020) 299 final, p. 1-2.
[17] COM(2020) 301 final. 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, on 8 July 2020. For discussion on the Hydrogen Strategy, listen Henderson – Lambert 2020.
[18] COM(2020) 299 final, p. 3 and COM(2020) 301 final, p. 1.
[19] COM(2020) 37 final. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions – Adjusted Commission Work Programme 2020, on 29 January 2020, Annex I.
[20] COM(2018) 773 final. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank, A Clean Planet for all, A European strategic long term vision for a prosperous, modern, competitive and climate neutral economy, p. 10. See also e.g. Christensen – Petrenko 2017, Hiilineutraali Suomi 2020, Malins 2017, Malins 2019, Malins 2020, Koj – Wulf – Zapp 2019, Soler 2020, Schnettler 2020, Saerle – Christensen 2018, Mete – Reins 2020.

Compared to the EU's trajectory towards carbon neutrality, Finland strives even further by aiming at becoming carbon-neutral by 2035 and carbon-negative soon after that.[21] According to a study prepared by LUT University, St1 and Wärtsilä, P2X solutions provide a significant opportunity to Finland in terms of economic profits and preserving the environment. Renewable and carbon-neutral liquid fuels are required to achieve the decarbonisation of the transport sector considering the given timeframe. Furthermore, the whole distribution infrastructure is currently built for liquid fuels, which restricts the use of alternative, gaseous fuels and direct electrification. Therefore, carbon-neutral fuels provide the most promising way to, in fact, achieve the emissions reduction targets to reach carbon neutrality in time.[22]

Various technologies for P2X fuels are in the development phase and a large-scale commercial production can be estimated to start within 5-10 years.[23] In December 2019, LUT University and a group of companies launched a feasibility study for an industrial-scale P2X Joutseno pilot plant utilising P2X technology to produce carbon-neutral fuels for transport sector. The plant would use excess hydrogen from Kemira's chlorate production complemented by additional hydrogen production through water electrolysis. CO_2 would be captured from Finnsementti's facility. These raw materials would be exploited to produce synthetic methanol, which would be further processed into gasoline, diesel and kerosene.[24]

1.2. Objective and Scope

This thesis systemises the regulatory framework established by RED II in light of the P2X fuels. The aim is to analyse and discuss the key regulatory challenges regarding the exploitation of raw materials as well as utilisation of the end products. Consequently, challenges regarding the production process of P2X fuels are taken into account. In order to assess the regulatory framework of the P2X fuels, it is essential to comprehend the regulatory instruments set forth for the raw materials. The origin of the energy and the characteristics of the production process will define whether the P2X fuel falls within the category of renewable liquid and gaseous fuels of non-biological origin (RFNBOs) or

[21] Government Programme 2019.
[22] Hiilineutraali Suomi 2020, p. 35 and 124, piloting of carbon-neutral synthetic fuels and promoting their production are mentioned as a quick measure to reduce emissions and promote the transition towards circular economy. See also Schönberg 2020.
[23] Sipilä – Kiuru – Nylund – Sipilä 2020, p. 46.
[24] For more information, see LUT University 2019 and Koistinen 2020.

recycled carbon fuels (RCFs). Depending on the outcome, the end products are subject to different amounts of support in the context of RED II.

The main focus of this thesis is narrowed down to RFNBOs. Due to their renewable origin, they are prioritised in RED II, but also subject to more detailed and stringent requirements. However, understanding the provisions set forth for RCFs is crucial as well to form a comprehensive understanding of the framework set forth for P2X fuels. In light of my conclusions on the regulatory framework of P2X fuels, I apply the findings made in the thesis in practice by evaluating the regulatory treatment of P2X Joutseno pilot plant. Although this thesis is an independent work of the actual feasibility study, the aim is to provide additional information for the project from legal perspective.

This thesis hypothesises that RED II does not enable the potential of P2X fuels in the transport sector and thus, limits the possibilities for a level playing field for them. The research question in the thesis is as follows: **What are the implications of RED II on P2X fuels?**

The following additional research questions further test the accuracy of the hypothesis:

1. How RED II regulates the raw materials utilised for the production of P2X fuels?
2. Under which definitions P2X fuels fall in RED II and how are they treated in RED II?
3. What are the main regulatory challenges for P2X fuels and what measures are required either on the EU or national level to facilitate their deployment further?

The hypothesis gets support from the commenced revision process of RED II. Despite the potential of P2X fuels, RED II has been proved unsuccessful to incentivise mainstreaming the use of renewable energy in terms of providing the necessary support and equal opportunities compared to other competing pathways. Hence, it is not only essential to revise the current RED II in order to correct the drawbacks it sets forth for P2X fuels but also to realise the actual potential they have in increasing the share of renewable energy in the transport sector. The technology is already available, but it lacks the appropriate regulatory environment. Furthermore, to avoid duplicating these flaws in the revised RED II, the strengths and disadvantages of the current regulatory framework need to be critically assessed. Consequently, the future measures to be adopted should be carefully considered in cooperation with stakeholders. Thus, the thesis sheds light on the issues regarding the P2X fuels and opens the floor for further discussion of the regulatory framework.

The primary focus of this study is on liquid, hydrogen and electricity-based transport fuels supplied to the road and maritime transport as well as aviation. Due to CO_2 utilised in the P2X production process, these fuels have a connection to the EU's emissions trading system (ETS). Therefore, issues relating to the ETS framework are discussed to the extent required to answer the research questions, concentrating on CO_2 accounting and the future of the system. Technical aspects of the P2X technology are considered insofar as necessary in terms of understanding the degree of technological readiness and providing background information of the P2X technology and thus, allowing the issue to be considered in depth from the legal perspective. Although the economic issues, including taxation and financing, have a significant impact on the profitability and attractiveness of P2X projects, they are left outside the scope of this thesis.

1.3. Research Method and Materials

In pursuance of systematising the substance of the EU regulatory framework with the main focus on RED II, this thesis builds its analysis on legal dogmatics.[25] As the aim is to discuss and analytically assess relevant legal norms and their contents and provide recommendations *de lege ferenda*, legal dogmatics offer appropriate tools to critically analyse P2X fuels in this context.[26] From a broader perspective, this thesis is placed within the realm of environmental law, and in particular, within the context of climate and energy law. Thus, instead of legal dogmatics, a more comprehensive approach by means of theoretical environmental law would be a more appropriate term to describe the method used in this thesis.[27]

However, as environmental law is a volatile part of the legal discipline, legal dogmatics, or theoretical environmental law may not be sufficient to be the core of this thesis.[28] Although the emphasis is given to said approaches, this thesis applies the tools provided by regulatory theory in order to take up a more comprehensive approach to the research

[25] Kokko 2014, p. 289-297.
[26] Kokko 2014, p. 293-294, the critical legal dogmatics offers a critical, value-based approach to analyse the legal order as well as to interpret and systemise norms. Furthermore, research using critical legal dogmatics as a method can also make recommendations for improving legislation.
[27] Määttä 2015, p. 11, theoretical legal dogmatics as such does no longer very well describe today's theoretically oriented environmental law research.
[28] See Kokko 2014, p. 286.

questions.[29] Regulatory theory in the field of environmental law seeks to find an appropriate regulatory framework for a specific purpose.[30] In environmental law, the approach of the regulatory theory is interested in, amongst other issues, the effectiveness, cost-efficiency, equality and the political acceptability of the regulation. In this thesis, the effectiveness and equality of the regulatory framework are of the most significant interest. Assessment regarding equality focuses on fair effort sharing between different operators in the transport sector.[31]

The primary object of the analysis in this thesis is the legislative work of the EU, RED II being the essential legislative instrument. Moreover, in order to evaluate further development of the framework, emphasis is given to several communications adopted by the EC. The research landscape around the theme of synthetic fuels varies from a thematic perspective. Previous studies regarding P2X fuels have been conducted mainly from a technological and economic perspective. Consequently, several sources from other academic fields are utilised. From a legal point of view, the existing material gives the emphasis on a framework set forth for biofuels and the studies focusing on P2X fuels have not proven to be very profound. Thus, the existence of relevant legal literature and in-depth analysis is rather limited. Due to these limitations, I participated in a number of workshops and webinars to obtain useful insight into the ongoing discussions regarding the research theme and to broaden my overall understanding of the P2X technology.

1.4. Structure

To fulfil the objectives mentioned above, the thesis consists of six chapters. The second chapter of this thesis outlines the legal framework established for P2X fuels in order to provide essential background information to allow the research questions to be thoroughly analysed. The chapter begins by demonstrating the concept of P2X and introducing drivers for these fuels. The second part of the chapter provides an overview of RED II narrowing down the focus to its objectives of the as well as the main definitions it provides for synthetic P2X fuels. The third chapter answers the first research question by outlining the legislative framework concerning the main raw materials used for producing synthetic P2X fuels. The fourth chapter tackles the second research question by analysing

[29] Kokko 2016, p. 39, in the field of Finnish environmental law, legal dogmatics and regulatory theory are often applied simultaneously.
[30] Kokko 2016, p. 38-39.
[31] See Kokko 2017, p. 1057-1058.

the provisions set forth for P2X fuels in the context of RED II. The answer for the third research question is provided throughout the thesis, although the main focus to fulfilling this objective is discovered in the fourth chapter. The fifth chapter complements this thesis by presenting a practical approach to this topic by elaborating the legislative issues in connection with the P2X Joutseno pilot plant.

2. Legislative Framework of Power-to-X Fuels

2.1. Introductory Remarks

In the first part of this chapter, I provide an overview of a P2X process where hydrogen and CO_2 are deployed as raw materials to produce synthetic transport fuels. The first aspect gives the reader an introduction regarding different options available to produce hydrogen and acquire CO_2. In addition, feasible routes to methanol are briefly discussed. The second aspect aims to address the drivers for P2X fuels and shed light on the advantages associated with them.

The second part of the chapter dives into the regulatory framework set forth for the P2X fuels by RED II. In order to test the hypothesis and to answer the research questions in the following chapters, I begin by identifying the reasons behind the recast and evaluate the objectives laid down for RED II. The final part of this chapter narrows down the focus to the two P2X fuel categories provided by RED II.

2.2. Characteristics of Power-to-X Fuels

2.2.1. Concept of Power-to-X Technology

There is no generally adopted definition for the term P2X.[32] Letter 'X' in the chain can refer to different categories such as products, product groups or final applications. For instance, the X can describe the product manufactured, such as Power-to-Hydrogen or Power-to-Methanol, or a product group, such as Power-to-Liquids or Power-to-Gas. In some cases, the X can be substituted by the sector of the final application, such as Power-to-Transport.[33] Here in this thesis, P2X is defined as a process chain used for converting

[32] Koj – Wulf – Zapp 2019, p. 865 and 867. P2X fuels are also referred in the literature as e-fuels, electro-fuels or synthetic fuels. See also Christensen – Petrenko 2017, the term CO_2 based synthetic fuel is used as well.
[33] See Koj – Wulf – Zapp 2019, p. 867 and 869.

electricity into liquid transport fuels, including the technical components associated with it. The term P2X is used as an umbrella term to cover both RCFs and RFNBOs.

Hydrogen is a key player in the production of P2X fuels, although its contribution to the EU energy mix is relatively minor at the moment.[34] Hydrogen needs to be synthesised as it is not available in its pure form in the environment. Most of the industrial-scale hydrogen is currently produced through CO_2 intensive steam methane reforming. In this process, a hydrogen-containing substance such as natural gas or a fossil-based fuel is reacted with water steam in the presence of a metal-based catalyst. This process can also be utilised to produce hydrogen from biogas.[35]

Hydrogen can also be produced through water electrolysis. In this case, electricity is employed as a power source to break down water into hydrogen and oxygen.[36] Low temperature technologies, including alkaline and polymer electrolyte membrane, have relatively high readiness from a technological perspective. High temperature solid oxide electrolyser cell electrolysis provides higher efficiencies, but it is not commercially deployed on a full scale.[37] Provided that electricity is derived from renewable sources like wind or solar photovoltaic, and hydrogen is used in a fuel cell[38], the entire process would be considered carbon-neutral.[39]

Electrolysers are already well developed and commercially available. Still, the production costs with this technology are around double compared to the costs of fossil fuels due to the amount of electricity required for this process. Thus, integrating electrolysers to the energy system needs to focus on industrialisation as scale and efficiency improvements would reduce production costs. Furthermore, additional costs resulting from regulatory aspects of the use of electricity should be tackled. Ensuring a level playing field between different gases and storage technologies would further facilitate decreasing the costs of

[34] COM(2020) 301 final, p. 2, footnote 1, hydrogen production is still largely relying on fossil sources. Electrolysers account for less than 4% of the total hydrogen production in the EU. See also Fuel Cells and Hydrogen Joint Undertaking 2019 for a hydrogen roadmap to 2050.
[35] Rego de Vasconcelos – Lavoie 2019, p. 4 and Hydrogen Europe, Hydrogen Production. COM (2020) 301, p. 2, the hydrogen production emits 70 to 100 million tonnes CO_2 annually in the EU.
[36] en:former 2019, the oxygen is released into the air while the hydrogen can be deployed as such or refined further to other products.
[37] Malins 2017, p. 37.
[38] See Mujumber-Russel – Ciolkowski – Musschebroeck 2020, a chemical reaction involving hydrogen and oxygen generate electricity, heat and water in a fuel cell.
[39] Rego de Vasconcelos – Lavoie 2019, p. 4 and Hydrogen Europe, Hydrogen Production, hydrogen's carbon footprint is connected to the utilised production mode. If the hydrogen is produced trough electrolysis, the carbon intensity is directly associated with the source of the electricity.

hydrogen production from renewable electricity.[40] In addition, certain industrial processed produce hydrogen as a by-product. This hydrogen can be deployed as a raw material in P2X processes in case if an industrial symbiosis is possible. Such industrial processes are, for instance, the production of caustic soda, chlorine and paper industry.[41]

Carbon capture offers a link to P2X chain as the synthesis of liquid hydrocarbons requires CO_2 as a raw material. CO_2 can either be acquired from concentrated sources or extracted directly from the air. In terms of concentrated sources, CO_2 can be obtained from, for instance, combustion and industrial processes where CO_2 is released as a side stream. Almost a pure stream of CO_2 can be extracted from certain chemical processes, such as natural gas processing and ethanol fermentation. However, these sources are limited and not able to respond to the demand. Thus, CO_2 separation from other large industrial point sources is required.[42] In direct air capture, CO_2 is separated from ambient air either chemically or physically. The initial CO_2 concentration in direct air capture is significantly lower than when captured from the industrial point sources. Consequently, a large amount of energy is required for the separation process.[43] Furthermore, the technology is currently more mature with regard to capturing CO_2 from point sources.[44] CO_2 capture technologies are divided into post-combustion, pre-combustion and oxy-fuel combustion processes.[45]

Moreover, these point sources can be separated into fossil and biogenic sources. Fossil sources include, amongst others, fossil power plants and industrial processes such as iron and steel production as well as cement plants.[46] Biogenic sources are, for instance, biogas-upgrading plants and CO_2 derived from combustion of biogas and solid biomass. Furthermore, pulp and paper industry creates a large amount of CO_2 that is mainly biogenic.[47] CO_2 from a concentrated source is generally an attractive feedstock to produce P2X fuels due to the larger CO_2 concentrations and lower investment costs as investments in CO_2 extraction are not necessary.[48]

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40 Wind Europe 2019, p. 5.
41 Hydrogen Europe, Hydrogen Production.
42 Siegemund et al. 2017, p. 65 and Hyvärinen 2019, p. 18-19.
43 Liu – Sandhu – McCoy – Bergerson 2020, p. 3129, chemical separation is feasible e.g. utilising solvents or solid sorbents. physical separation can be achieved through phase changes.
44 Christensen – Petrenko 2017, p. 1.
45 See more Lee – Park 2015, p. 2-5, post-combustion is the most mature of these processes.
46 Hyvärinen 2019, p. 23.
47 Siegemund et al. 2017, p. 65 and Koj – Wulf – Zapp 2019, p. 867.
48 Siegemund et al. 2017, p. 65.

Synthesis of methanol by hydrogenation of CO_2 can be achieved by heterogeneous catalysis, homogeneous catalysis, electrochemical as well as photocatalysis.[49] Besides the direct use of methanol in methanol-fuelled vehicles and ships, it can also be converted further to liquid drop-in fuels.[50] Methanol synthesis could be achieved through sequential processes of olefin synthesis, oligomerisation and hydrotreating.[51] The first step is to catalytically dehydrate methanol to acquire a mixture of dimethyl ether, methanol and water. The mixture is then fed into a methanol-to-gasoline reactor where methanol and dimethyl ether are completely dehydrated to produce light olefins. These light olefins are oligomerised into higher olefins to produce paraffins, naphthenes and methylated aromatics. The methanol-to-gasoline catalyst restricts the reaction of the hydrocarbon synthesis. The final methanol-to-gasoline product has properties close to those of produced at refineries and can relatively easily be upgraded to meet various standards set forth for fuels.[52]

Fisher-Tropsch synthesis offers another way to fuel synthesis. In this option, synthesis of methanol by hydrogenation of CO_2 is not required. A reverse water-gas shift reaction is usually utilised to convert CO_2 to carbon monoxide.[53] The synthesis process uses hydrogen and carbon monoxide to produce a variable amount of hydrocarbons leading to a variety of chain lengths. The portion of compounds in the final products is contingent on the reaction conditions and catalytic bed used in the synthesis.[54] The liquid energy carriers can be further processed in a refinery to produce synthetic petrol, diesel or kerosene.[55]

2.2.2. Drivers for Power-to-X Fuels

GHG emissions from the transport sector are responsible for approximately one-quarter of the total GHG emissions in the EU. Transport is currently the only sector where GHG emissions have increased yearly since 2014 due to growing demand for passenger and freight transport. In 2017, emissions had increased by 2.2% compared to the levels of

[49] Guil-López – Mota – Llorente – Millán – Pawelec – Fierro – Navarro 2019, p. 3-5.
[50] Malins 2017, p. 17, Koj – Wulf – Zapp 2019, p. 869. See also Ott – Gronemann – Pontzen et al. 2012.
[51] Malins 2017, p. 17.
[52] Soler 2020, p. 30.
[53] The downside of the Fischer-Tropsch route is that CO_2 cannot be utilised as such.
[54] For a comprehensive overview of the production of renewable synthetic transport fuels from methanol, see Ruokonen 2020. For more on the Fisher-Tropsch synthesis, see e.g. Mahmoudi et al. 2017, p. 15-17, Hänggi et al. 2019, p. 565-567 and Jarvis – Samsatli 2018, p. 50-51. Fischer-Tropsch synthetis utilising fossil fuels as a feedstock is a mature, fully commersialised process implemented on a global scale. However, Fischer-Tropsch synthesis integrating renewable routes are less mature from a technological point of view and thus only at the early stages of commercialisation.
[55] en:former, E-fuels could advance the energy transition in the transport sector.

2016.[56] the transport sector is still highly oil-dependent as approximately 94% of the consumed energy was oil-derived in 2017 even though the use of biofuels doubled in the transport sector during the last decade.[57] The average share of renewable energy in gross final energy consumption[58] used in the transport sector rose from 7.4% in 2017 to 8.3% in 2018.[59] In light of the 10% renewable energy target set for 2020 in the original Renewable Energy Directive 2009/28/EC[60] on the promotion of the use of energy from renewable sources (RED), the trend in renewable energy shares remains below the required targets.[61] Currently, renewable energy is heavily relying on biofuels as around 90% of the renewable energy in the transport sector was bio-based in 2018. The remaining share of energy consisted mainly of renewable electricity.[62]

For the last decade, the transition from fossil-based fuels has been focused on increasing the share of first-generation biofuels in fuel blends.[63] Compared to conventional fossil fuels, the first-generation biofuels contribute to CO_2 emissions reductions and enhance the security of supply in the transition towards more intermittent energy production, awareness of the adverse impacts of the sourcing of these feedstocks has increased.[64] The main disadvantage is the limited feedstock, which has led to the food versus fuel -debate as the fuel production threatens food security.[65] First-generation biofuel production typically originates on croplands traditionally used for food production. Since such agricultural production is still necessary, exploiting the feedstock for producing biofuels may cause the extension of agriculture land to areas that would not otherwise be used for such purposes. These lands often include areas such as forests, wetlands and peatlands that are important in terms of carbon sinks. This process, called indirect land use change, releases

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[56] European Environment Agency 2019a, p. 11, European Environment Agency 2019b, p. 2-3 and 7 and EIA 2020, p. 76.

[57] European Commission 2020, EIA 2020, p. 76.

[58] According to Article 2(f) of RED, gross final consumption of energy refers to energy commodities delivered for energy purposes to industry, transport, households, services, agriculture, forestry and fisheries, taking into account the consumption of electricity and heat by the energy branch for electricity and heat production and including losses of electricity and heat in distribution and transmission.

[59] Eurostat, Renewable energy statistics.

[60] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (*OJEU L 140/16, 5.6.2009*).

[61] European Environment Agency 2019a, p. 11 and European Environment Agency 2019b, p. 2-3 and 7. Finland and Sweden are the only Member States who have reached the target of 10% energy from renewable sources of the total energy consumption in the transport sector.

[62] European Environment Agency 2019b, p. 6 and IEA, Renewables 2019.

[63] Malins 2020, p. 6, crops, rapeseed and palm oil are the main feedstocks used to produce first generation biofuels. Additionally, waste and residual materials are also used although to a lesser extent.

[64] Naik – Goud – Rout – Dalai 2010, p. 579.

[65] Mohr – Raman 2013, p. 117. See also Naik – Goud – Rout – Dalai 2010, p. 579. The impacts of the first generation biofuels production in food price spikes is controversial.

CO_2 stored in carbon sinks and reduces emissions savings sought by the increased use of biofuels.[66]

The issues regarding the first-generation biofuels have been acknowledged and the focus in policy development has moved towards advanced biofuels.[67] Although these biofuels have significant potential to offer, for instance, in terms of GHG emissions reductions, they do not come without constraints. Advanced biofuels are also associated with sustainability challenges, including soil carbon losses, use of extra fertiliser when residues are removed and indirect emissions resulting from diverting wastes and residues from their present uses.[68] Although current regulation is largely relying on advanced biofuels, scenarios show that they are not available in sufficient quantities in the long term allowing them to be the sole enablers to replace the fossil fuels in the transport sector.[69]

Similarly, electromobility, i.e. direct use of electrify in vehicles via batteries, is highly supported in the EU. However, direct electrification is not feasible in the scale needed in light of the renewable energy and climate targets, especially when considering heavy long-haul transportation, marine and aviation. Compared to conventional fossil fuels, lower energy density, higher costs and relatively slow recharging performance are disadvantages of battery-based electric vehicles.[70]

Several studies and policies have recognised the importance of P2X fuels.[71] P2X fuels offer numerous advantages. First, they contribute to climate targets by achieving CO_2 reductions and when renewable energy is used, also to the target of mainstreaming the use of renewable energy in the transport sector.[72] Secondly, P2X fuels can be refined to be compatible with the existing infrastructure. The possibility to use the infrastructure and applications that are already in place results in benefits in terms of cost savings as

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[66] Mohr – Raman 2013, p. 117 and European Commission, Renewable Energy – Recast to 2030 (RED II).
[67] COM(2014) 15 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the regions a policy framework for climate and energy in the period from 2020 to 2030, on 22 January 2014, p. 7.
[68] Harrison – Malins – Saerle – Baral – Turley – Hopwood 2014, p. 4 and 12-13.
[69] Soler 2020, p. 14.
[70] Schnettler 2020, p. 5, Diegemund et al. 2017, p. 117 and Fuel Cells and Hydrogen Joint Undertaking 2019, p. 6.
[71] See e.g. Christensen – Petrenko 2017, Hiilineutraali Suomi 2020, Malins 2017, Malins 2019, Malins 2020, Koj – Wulf – Zapp 2019, Soler 2020, Schnettler 2020, Saerle – Christensen 2018, Mete – Reins 2020.
[72] Soler 2020, p. 98 and en:former, P2X could advance the energy transition in the transport sector, due to the carbon capture process, the production of P2X fuels contribute to the circular economy. When the fuels are used, CO_2 that was bound is released to the atmosphere again during combustion. However, see Bracker 2017, it can be argued that the use of fossil-based CO_2 in a fuel production does not support purpose behind circular economy.

well as faster transition towards renewable energy system. Additionally, liquid P2X fuels are suitable to be used in the existing transport fleet without significant changes in the engine design. This would allow a faster transition towards renewable and carbon-neutral fuels already in short to medium term.[73]

Thirdly, P2X fuels have a relatively high energy density compared to conventional fossil fuels which allow them to be deployed in hard-to-abate sectors. High energy density also facilitates the storage of P2X fuels, which is a crucial issue to be considered in the energy transition due to the intermittency of renewable energy output. P2X fuels can be stored in large-scale stationary storages and mobile storages in vehicle tanks counteracting the fluctuations in the supply and contributing to enhancing energy security. Although there are already feasible technologies in place for storing electricity from seconds to weeks into, for instance, batteries and pumped hydro storages, P2X fosters an opportunity to store electricity also in large volumes and for longer periods of times due to the hydrogen's and P2X fuels' energy density.[74] Fourthly, compared to biofuels, the P2X chain has a lower associated sustainability risk. When P2X fuels are produced from renewable electricity, the land requirement is lesser compared to biofuel production. Furthermore, renewable electricity production requires less water than agriculture and no obvious substantial risks of air, water or soil pollution are associated with P2X technology.[75]

While there are significant advantages regarding the P2X technology as well as P2X fuels, the production costs form a significant barrier to the deployment in the short term since the costs are higher compared to the conventional fossil fuel production. Moreover, P2X fuels result in a low-carbon footprint only if zero-carbon renewable electricity is deployed for both electrolysis and as a process electricity. Even a supply of low-carbon electricity could lead to considerable emissions.[76] Drop-in P2X fuels produced from the current EU average grid electricity would have three times higher carbon intensity compared to the conventional liquid fossil fuels.[77] Thus, understanding the comprehensive picture of the lifecycle GHG emissions occurring from various potential production chains is necessary to develop a clear and robust eligibility and accounting requirements for these fuels.[78]

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[73] Perner – Bothe 2018, p. 20-24, Soler 2020 p. 98 Schnettler 2020, p. 5.
[74] Perner – Bothe 2018, p. 19 and Soler 2020, p. 98.
[75] Malins 2017, p. 3.
[76] Malins 2017, p. 4, utilising electricity with a low-carbon intensity of 25gCO_2e/MJ would only lead to 20-47% carbon saving depending on the efficiency of the conversion process.
[77] Malins 2017, p. 4.
[78] Christensen – Petrenko 2017, p. 6-7.

2.3. Recast Renewable Energy Directive

2.3.1. Objectives of the Recast Renewable Energy Directive

In December 2018, RED II entered into force as a part of the Clean Energy for all Europeans package.[79] Overall, the objective of RED II is to establish a common framework for promoting renewable forms of energy. The increased use of renewable energy contributes to the wider target of reducing GHG emissions in accordance with the Paris Agreement on climate change following the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change and the binding renewable energy target for 2030 advances this objective.[80] Another aim behind the 2030 target is to continue supporting the development of technologies based on renewable energy and thus, give certainty for investors.[81] In addition, developing renewable transport fuels is of primary importance for the EU's energy and environmental policy.[82]

RED II succeeded the original RED, adopted on 23 June 2009.[83] RED established common EU-wide set of rules for the use of renewable energy relied on legally binding national targets for each Member States of 20% energy to be produced from renewable energy sources out of the whole energy consumption in the EU by 2020. RED also included a sub-target of requiring renewable energy sources account for 10% regarding the energy consumed in the transport sector. Previous targets for the transport sector were established in the White Paper on Transport[84], according to which the long term emissions reduction strategy required cutting the emissions by 60% in 2050 compared with 1990 levels. The white paper aimed at supporting low-emission fuels, energy efficiency and multimodality of transport and traffic management. In 2016, the review process of the implementation of the white paper revealed that the progress was not in line with the targets.[85] A final

[79] See European Commission, Clean energy for all Europeans package.
[80] Recital 2 and Article 1 of RED II.
[81] Recital 9 of RED II, a renewable energy target defined at the EU level leaves Member States more discretion regarding the most appropriate measures to achieve the GHG reduction targets in terms of specific circumstances, national energy mix and a capacity to produce energy from renewable sources.
[82] Recital 2 of RED II.
[83] The RED amended and replaced the earlier Directive 2001/77/EC of the European Parliament and of the Council of 27 September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market (*OJEU L 283/33, 27.10.2001*) and the Directive 2003/30/EC of the European Parliament and of the Council of 8 May 2003 on the promotion of the use of biofuels or other renewable fuels for transport (*OJEU L 123/42, 17.5.2003*).
[84] COM(2011) 144 final. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, on 28 March 2011.
[85] SWD(2016) 226 final. The implementation of the 2011 White Paper on Transport 'Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system' five years after its publication: achievements and challenges, on 4 July 2016.

evaluation regarding the white paper will be completed by the end of 2020.[86] Furthermore, a range of new strategies and policies, such as the European Strategy for Low-Emission Mobility,[87] the Clean Energy for all Europeans package as well as the three Mobility Packages[88] were adopted during the recent years, indicating the EC's determination to address the shortfall in the emissions reductions.

In November 2016, the EC published a formal proposal[89] to recast RED in order to underpin the new renewable energy targets for the following decade. RED established renewable energy targets only until 2020, but there were also other compelling reasons requiring recasting the legislation. The EU climate and energy framework for 2030 agreed by the European Council in October 2014 was one of the main drivers.[90] The framework underlined the importance of ambitiousness in the EU's climate and energy policies to keep the EU on track with the commitments agreed in the Paris Agreement regarding the long term emissions reduction targets.[91] The EC explicitly emphasised in the proposal that the absence of updated climate legislation in the EU would risk the EU's position as a global leader in light of renewable energy targets. The EC also recognised that the continuation of unchanged policies would possibly lead to growing disparities between the Member States. The best performing Member States with the most ambitious climate policies would pursue increasing the share of renewable energy while the countries investing less would miss the incentive to change their current energy production and consumption manners.[92]

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[86] EIA 2020, p. 76.
[87] COM(2016) 501 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A European Strategy for Low-Emission Mobility. A European Strategy for Low-Emission Mobility, on 20 July 2016.
[88] COM(2017) 283 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Europe on the move. An agenda for a socially fair transition towards clean, competitive and connected mobility for all, on 31 May 2017.
COM(2017) 675 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Delivering on low-emission mobility, on 8 November 2017.
COM(2018) 283 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions, On the road to automated mobility: An EU strategy for mobility of the future, on 17 May 2018.
[89] COM(2016) 767 final/2. Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast), on 23 February 2017.
[90] COM(2014) 15 final.
[91] Paris Agreement on climate change following the 21st Conference of the Parties to the United Nations Framework Convention on Climate Change.
[92] COM(2016) 767 final/2, p. 2-3.

Thus, following the target endorsed by the European Council, RED II proposal proposed a set of policy measures to achieve a tightened share of 27% of renewable energy from the overall energy consumption in the electricity, heating, cooling and transport sectors by 2030.[93] Unlike RED, where the 20% share of renewable energy was translated into national targets providing the Member States with considerable discretion on the national measures, RED II relies on an EU-level binding target. The 2030 target is to be achieved by combining the Member States' national actions in cooperation with one another and the support of the framework and the measures provided in RED II.[94]

The European Parliament and the European Council proposed certain amendments to the proposal and the final version of RED II was agreed on 14 June 2018.[95] This version raised the EU-wide overall renewable energy target for 2030 from 27% to 32%. Furthermore, RED II introduced binding sector-specific sub-targets. In the transport sector, the Member States must set an obligation on fuel suppliers to ensure that the share of renewable energy within the final consumption of energy in the road and rail transport is at least 14% by 2030. The trajectory to achieve the targets are defined by each Member State in their integrated national energy and climate plans in accordance with the governance process under Regulation (EU) 2018/1999[96] on the Governance of the Energy Union and Climate Action. One of most significant difference between RED and the final version of RED II relates to the calculation rules of the national target, as in addition to the explicitly regulated calculation rules, the Member States have more choice to decide how the 14% target is calculated and which measures are used to achieve it. In addition, the Member States are afforded with increased flexibility to set their own more ambitious national targets both as regard to overall energy target and the sub-target for renewability in transport.[97]

[93] COM(2016) 767 final/2, p. 2.
[94] COM(2016) 767 final/2, p. 3.
[95] 2016/0382 (COD).
[96] Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (*OJEU L 328/1, 21.12.2018*).
[97] COM(2014) 15 final, p. 5. See also Sipilä – Kiuru – Jokinen – Saarela – Tamminen – Laukkanen – Palonen – Nylund – Sipilä 2018, p. 33.

The 14% objective is further subject to a sub-target for advanced biofuels produced from feedstocks in Part A of Annex IX. The required minimum level of these fuels to be supplied is 3.5% by 2030. Biofuels from feedstocks in Part B of Annex IX are capped at 1.7% in 2030 to address the sustainability risk associated with these feedstocks. Furthermore, RED II includes caps on conventional biofuels and on high indirect land use change risk biofuels.[98]

Although the Member States must transpose the provisions of RED II into national legislation by 30 June 2021, many important details are still subject to further assessment in the near or medium-term by the EC. The EC will review the overall 32% renewable energy target as well as the 14% sub-target for transport fuels by 2023. The provision allows a possible revision upwards. According to Recital 8 of RED II, the possible revision upwards is assessed by the EC in light of substantial cost reductions in the renewable energy production, international commitments as well as in case of a significant decrease in the energy consumption in the EU. In addition, the EC must review the feedstocks listed in Annex IX biannually. Pursuant to this assessment, the EC may decide to add feedstocks to the list, but any feedstocks that have been presented in the list cannot be removed.[99]

RED II grants the EC a power to adopt delegated acts[100] regarding the details of particular articles, including Articles 25, 27 and 28. Delegated acts usually contain measures of technical nature or other details that are necessary for an appropriate level of guidance for the provision to be fully applicable. This allows the legislator to focus on policy direction and objectives of the legislation instead of debates regarding decisions often very detailed and technical by nature. However, delegated acts may often result in additional delays in terms of industrial development and deployment of certain process routes, for instance,

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[98] Article 26 of RED II. Furthermore, the transition towards carbon-neutral and renewable fuels is also supported by Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure (*OJEU L 307/1, 28.10.2014*). The Directive establishes minimum requirements for Member States to provide alternative fuels infrastructure for, at least, electricity, natural gas and hydrogen. The Directive is currently undergoing a revision, and the EC is expected to adopt the initiative in 2021. The purpose of the initiative is to achieve greater harmonisation of efforts and expand the level playing field across fuels.

[99] Article 31 of RED II.

[100] See European Commission, Implementing and delegated acts. The EC adopts the delegated acts based on a delegation granted in the legislative act. The power of the EC to adopt delegated acts is precisely limited. Although the delegated acts can be used to supplement or amend certain provisions in the original legislation, the essential elements of the legislative act cannot be changed by a delegated act. After the EC has adopted the delegated act, Parliament and Council have an opportunity to object the act before the delegated act enters into force. The legal basis for the delegated acts is found in Article 290 of the Treaty of Lisbon amending the Treaty on European Union and the Treaty establishing the European Community (*OJ C 306, 17.12.2007*). Delegated acts are defined as non-legislative acts of general application to supplement or amend certain non-essential elements of a legislative act.

when a methodology needs to be adopted to verify some specific requirements laid down by a directive. This is also the case with RED II, as the lack of detailed guidance stalls the market development.[101]

Overall, I take the view that the current RED II is not capable of incentivising the production of P2X fuels on a scale needed as regard to the objectives set forth for RED II. Contrary to the aim to support the technologies based on renewable energy and provide certainty for the investors, RED II remains too ambiguous and shy of providing clear and robust encouragement and regulatory action on P2X fuels. Furthermore, by favouring biofuels and direct electrification knowingly over the P2X fuels, RED II fails to create a level playing field for P2X fuels and to identify their possibility to contribute in increasing the share of renewables in the transport sector and thus, in the broader context, to deliver GHG emissions reductions.

The future of the support provided for P2X fuels by RED II remains partly mired in uncertainty as further changes are lying ahead. In August 2020, before the provisions of RED II have even been transposed into national legislation, the EC commenced an inception impact assessment as regard to revision of RED II. The underlying reason behind the revision is to ensure that renewable energy contributes to the achievement of higher EU climate ambition set forth in the 2030 Climate Target Plan. The review includes a possible revision of the overall minimum renewable energy target of 32% in addition to the revision of the sector-specific measures. Moreover, certain actions proposed in several strategies and initiatives, including Energy Sector Integration and Hydrogen Strategies are possibly translated into legal measures. These could include increasing the use of renewables in the transport sector, promoting development and deployment of renewable and low-carbon fuels, including synthetic liquid and gaseous fuels and hydrogen, complemented by an establishment of a comprehensive terminology and certification system.[102] I welcome the revision process as these considerations seem promising as regards supporting the deployment and further development of P2X fuels. The EC will introduce the legislative proposal by June 2021.[103]

[101] See See Chiaramonti – Goumas 2019, p. 8.
[102] Plan/2020/7536, p. 2-3.
[103] Plan/2020/7536, p. 1.

2.3.2. Defining Power-to-X Fuels

RED II introduces two non-biogenic fuel categories.[104] According to Article 2(36) of RED II, RFNBOs are defined as liquid or gaseous fuels other than biofuels and biogas used in the transport sector. The definition requires that the energy content of the RFNBO is derived from renewable sources other than biomass.[105] Examples of RFNBOs are, for instance, hydrogen, ammonia, methane, methanol and Fischer-Tropsch fuels produced from renewable electricity.[106] When the energy content of the fuel is built on a mixture of renewable and non-renewable sources, only the share that attributed to renewable sources, excluding biomass, is considered as RFNBO when determining the RFNBO fraction of the fuel.[107]

Article 2(35) of RED II defines RCFs as liquid and gaseous fuels produced from a liquid or solid waste streams of non-renewable origin. The RED I requires that these waste streams do not qualify for material recovery under the waste hierarchy regulated in the Directive 2008/98/EC[108] on waste (Waste Directive).[109] Moreover, RCFs can also be produced from waste processing and exhaust gas of non-renewable origin that result as an unavoidable and unintentional consequence of the production process in industrial installations.

The definition of RCFs itself does not make explicitly clear what fuels actually apply under this definition but in general terms, it can be concluded that RCFs are fuels where the energy is derived from fossil origin carried in gaseous, liquid and solid waste streams. This refers to non-recyclable solid waste, such as plastic or rubber as well as non-biological municipal solid waste.[110] Likewise, surplus methanol derived from an existing methanol process that would have otherwise been released to the atmosphere could be defined

[104] Floristean 2019, p. 10.
[105] Malins 2020, p. 6.
[106] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 7.
[107] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 6.
[108] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (*OJEU L 312/3, 22.11.2008*).
[109] Article 4 of Waste Directive sets forth the principles of waste hierarchy. The first priority is given to prevention measures aiming at reducing the quantity and harmfulness of the waste. If prevention is not possible in the first place, the waste should be prepared for re-use or as a third option, recycled. If recycling is not an option, other recovery measures, such as energy recovery, are required. Provided that these measures are not feasible, disposal of waste presents the last alternative to waste management.
[110] Šerdoner 2020, p. 1, Mestre 2020, p. 7 and Malins 2020, p. 6. Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 9, in order to ensure that using waste in the fuel production does not uninsentivise and prevent improving material recycling in the future, the waste material in fuels are not considered in Member States targets regarding material recycling.

as RCF. In this scenario, methanol would be the product of a process where excess hydrogen from an existing process would be combined with CO_2 derived from another existing process. Furthermore, fuels incorporating energy from off-gases, meaning industrial waste processing or exhaust gases refer to, for instance, blast furnace gas, excess coke oven gas or refinery fuel gas and hence, qualify as RCFs. These gases can be further refined to ethanol, methanol or other end products.[111]

Although both RFNBOs and RCFs are identified in RED II, a number of regulatory issues still need to be evaluated and agreed on before the role of these fuels will be established in the EU's 2030 fuel mix.[112] With regard to RFNBOs and RCFs, RED II creates barriers that could delay and, in some cases, even discourage the development and deployment of P2X technologies in the short run. The main bottlenecks relate to the absence of a proper level playing field as well as issues arising out of the lack of genuine technology neutrality and non-discriminatory conditions.[113] Due to these barriers, investing in the P2X technologies will not attract the operators at least in the near future, as the regulatory framework does not provide adequate incentives compared to other competing pathways. The existing regulation creates uncertainties for both RFNBOs and RCFs, although other energy-related issues, such as issues regarding energy storage and grid balancing could benefit from their deployment.[114]

3. Raw Materials of Power-to-X Fuels

3.1. Introductory Remarks

In this chapter, I will test the hypothesis by evaluating how RED II stipulates the raw materials used for the production of P2X fuels. I begin by assessing the green value of hydrogen and the possibilities for verifying the origin. In the second part of this chapter, I analyse the impacts of the carbon sources available. I finish with an evaluation of CO_2 accounting, focusing on the relationship between RED II and the ETS. The approach used in this chapter is rather forward-looking as the regulatory frameworks relating to hydrogen and CO_2 assessed in RED II and ETS are still subject to revision.

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[111] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 9.
[112] Malins 2020, p. 6.
[113] See Chiaramonti – Goumas 2019, p. 9.
[114] Chiaramonti – Goumas 2019, p. 9.

3.2. Hydrogen

3.2.1. Assessing the Green Value of Hydrogen

Hydrogen is currently one of the key priorities in the EU's clean energy transition. Electricity is going to be the leading enabler, but a gap will remain where direct electrification is not a feasible option. Hydrogen has been considered to deliver a strong potential to bridge this gap to some extent. Furthermore, hydrogen is expected to play a crucial role in energy transition due to the wide variety of uses it has to offer. It can enable various applications to be used in industry, transport, power as well as in building sectors where it can be deployed as a feedstock, an energy carrier and storage as well as a fuel. Thus, hydrogen offers a way to decarbonise industrial processes and sectors that are still very emission-intensive and where CO_2 emissions reductions have been challenging to achieve and consequently, which are very urgent to decarbonise. In addition to multiple applications hydrogen has to offer, the most significant feature is that its use causes no CO_2 emissions and almost no air pollution. Moreover, rapid decrease in renewable electricity prices, technological developments and urgent need to cut emissions are facilitating the deployment of hydrogen.[115]

As hydrogen can be produced through a variety of processes, some of these processes are greener by nature, whereas some are more carbon-intensive. Due to this complex scenario where the carbon intensity of hydrogen may vary from very low to very high, there is a strong need to establish an EU-wide taxonomy for hydrogen. RED II did not take advantage of the opportunity to provide a common taxonomy for renewable and low-carbon hydrogen, even though it includes provisions regarding renewable gases. Still, RED II did not introduce clear and consistent definitions to categorise the various gases that are already used in the system. Thus, EU-wide criteria should be adopted, as the treatment of many hydrogen-based technologies are building on these definitions.[116] The lack of common taxonomy for renewable or low-carbon hydrogen may occur as a significant barrier for the deployment of hydrogen derived fuels.[117]

The Hydrogen Strategy acknowledges this issue by stating that in order to kick-start the growth of hydrogen, both the industry and investors need clarity and certainty in addition

[115] COM(2020) 301 final, p. 2.
[116] Hydrogen Europe 2019, p. 16.
[117] Floristean 2019, p. 11.

to a clear EU-wide understanding concerning the applicable hydrogen production technologies as well as the taxonomy on renewable and low-carbon hydrogen.[118] The Hydrogen Strategy recognises the need to swiftly introduce a supportive framework, including a common taxonomy and criteria for certification of renewable and low-carbon hydrogen.[119] This certification system could deploy the monitoring, reporting and verification processes of the existing EU ETS as well as provisions outlined in RED II. Such framework could be built on a lifecycle analysis considering the full GHG emissions and the existing methodologies introduced by CertifHy[120] together with industry initiatives. Furthermore, the system should be consistent with the EU taxonomy for sustainable investments[121]. Additionally, the roles of guarantees of origin (GO) and other sustainability certificates are assessed in the context of RED II to support the cost-effective production and trade across the EU.[122] According to the Hydrogen Strategy, the EC will establish a comprehensive taxonomy and EU-wide criteria for certification of renewable and low-carbon hydrogen as well as a common threshold for low-carbon hydrogen based on a full lifecycle GHG emissions by June 2021.[123]

Pursuant to CertifHy's green hydrogen criteria, hydrogen produced from renewable energy means hydrogen that is derived from renewable sources in accordance with Article

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[118] COM(2020) 301 final, p. 12.

[119] COM (2020) 301 final p. 22, the common taxonomy and the thresholds for low-carbon hydrogen are introduced by June 2021. COM (2020) 301 final, p. 3-4, The following definitions were deployed throughout the Hydrogen Strategy: *electricity-based hydrogen* means hydrogen produced by electrolysis of water irrespective the source of the electricity. The source of electricity determines the full lifecycle GHG emissions of the production of electricity-based hydrogen. *Renewable hydrogen* and *clean hydrogen* are used synonymously, and they refer to hydrogen produced through electrolysis of water. The electricity used for the production process is derived from renewable sources. The full lifecycle GHG emissions are close to zero. Furthermore, renewable hydrogen may be produced through biogas reforming or biochemical conversion of biomass provided that the sustainability requirements are followed. *Fossil-based hydrogen* means hydrogen that is produced through different processed deploying fossil fuels as feedstock. The full lifecycle emissions are high. *Fossil-based hydrogen with carbon capture* means fossil-based hydrogen where the emitted GHGes in the production process are captured. Although the GHG emissions are lower than without the capture, the effectiveness of the capture process needs to be taken into account, as a maximum of 90% of the GHG emissions can be captured. *Low-carbon hydrogen* includes fossil-based hydrogen with carbon capture as well as electricity-based hydrogen when the full lifecycle GHG emissions are significantly lower than in the current mainly fossil-based hydrogen production. Finally, *hydrogen-derived synthetic fuels* mean gaseous and liquid fuels produced from hydrogen and carbon. In order to consider these synthetic fuels renewable, the hydrogen part of the fuel should be renewable.

[120] CertifHy 2019, p. 4, CertifHy is a European project developing an EU-wide GO system for hydrogen in cooperation with various stakeholders.

[121] European Commissions, EU taxonomy for sustainable activities. Under the framework provided by Regulation (EU) 2020/852 of the European parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (*OJEU L 198/13, 22.6.2020*), an EU Technical Expert Group on sustainable finance published a technical report Taxonomy: Final report of the Technical Expert Group on Sustainable Finance 2020 containing a criteria for economic activities contributing to climate change mitigation or adaptation.

[122] COM(2020) 301 final, p. 12.

[123] COM(2020) 301 final, p. 22.

2(1) of RED II.[124] Energy from renewable sources, or renewable energy, refers to energy derived from renewable sources that are of a non-fossil origin. The article explicitly refers to wind, solar and geothermal energy, ambient energy, tide, wave as well as other ocean energy, landfill gas, sewage treatment, plant gas and biogas.[125]

In light of the articles of RED II focusing on the transport sector's renewable fuels requirements, the provisions and calculation rules are quite clear in terms of taking into account the renewable electricity used in the onsite hydrogen production, when the connection is based on a closed-loop system. However, in a situation where the electrolyser is connected to a power grid containing a diverse energy mix and co-located with other sources of power production, other instruments to account and trace the origin of electricity should be established.[126] In multi-fuel plants deploying both renewable and non-renewable sources for hydrogen production, only the part of hydrogen that is produced from renewable sources can be considered when calculating the amount of CertifHy green hydrogen. The contribution of each energy source is taken into account based on the energy content.[127]

CertifHy low-carbon hydrogen refers to a production batch or sub-batch which GHG footprint is equal or lower than a specified threshold. This threshold will be determined based on the requirements under RED II. As the current RED II lacks such threshold and requirements, CertifHy has established the limit to represent a reduction of 60% in comparison with the benchmark processes.[128] In the CertifHy system, the calculation of the GHG emissions of a production batch is based on the International Organization for Standardisation standards ISO 14044[129] and 14067[130]. Moreover, as RED II does not contain specific rules concerning hydrogen with this regard, the provisions in Annex V and VI of RED II are analogously applied. Furthermore, the system includes the lifecycle emissions from well-to-gate, meaning that the emissions starting from the extraction and

[124] CertifHy 2019, p. 6.
[125] Article 2(1) of RED II.
[126] Wind Europe 2019, p. 6-7.
[127] CertifHy 2019, p. 6, values laid down in the Annex III of RED II are used in order to determine the energy content of fuel. If a fuel is not included in Annex III, the appropriate European Standards Organisation's or as a last resort, the relevant International Organization for Standardisation's standards are used for determining the energy content of a fuel.
[128] CertifHy 2019, p. 7.
[129] ISO 14044, the standard includes guidelines and requirements for lifecycle assessment in light of environmental management.
[130] ISO 14067, the standard provides principles, guidelines and requirements for the quantification and reporting regarding carbon footprint of a specific product. The provisions in this standard are consistent with the above ISO 14044 standard.

processing of raw materials to the production of a marketable product are considered. The GHG emissions from electricity used in hydrogen production are considered to be zero when the electricity is from wind, solar photovoltaic or hydropower. However, the emissions emitted from building of the required production devices, transport and supply to the customers, use and product end life are not considered in the CertifHy system.[131]

Moreover, the Technical Annex[132] of the Taxonomy Report introduces thresholds for manufacturing hydrogen in light of direct CO_2 emissions, electricity use for hydrogen produced through electrolysis and the average carbon intensity of electricity exploited for hydrogen production.[133] These thresholds correspond to the performance of electrolysis with low-carbon energy and can be achieved by utilising carbon capture and storage (CCS). Furthermore, the thresholds reflect the CertifHy criteria developed in line with the most recent best market practises to certify green hydrogen.[134]

The priority in the EU is given to support the deployment of renewable hydrogen produced mainly by wind and solar energy, as renewable hydrogen is the most compatible option towards the EU's climate targets and zero pollution goal in the long term. However, the need for low-carbon hydrogen is recognised in the short and medium-term. Low-carbon hydrogen is required to swiftly reduce emissions from the currently highly emission-intensive hydrogen production and facilitate the parallel uptake of renewable hydrogen.[135] Nevertheless, one important issue challenging the regulators and policymakers to bear in mind is that the decision regarding the taxonomy does not take place in a regulatory void. The new terminology will have an immediate impact on the interpretation of the existing provisions and therefore, at the commercial level as well. For instance, the terminology for green or renewable hydrogen has a direct connection to the definition of renewable energy in Article 2(1) of RED II. Moreover, the definitions and taxonomy established for hydrogen will determine how the fuel supplier's obligation to ensure that the share of renewable energy in the transport sector is at least 14% will be applied under

[131] CertifHy 2019, p. 8.
[132] EU Technical Expert Group on Sustainable Finance, Taxonomy Report: Technical Annex, Updated methodology & Updated Technical Screening Criteria 2020.
[133] EU Technical Expert Group on Sustainable Finance 2020b, p. 181, the threshold for direct CO_2 emissions from producing hydrogen is 5.8 tCO_2e/t. The threshold for hydrogen produced through electrolysis has been set at 58 MWh/t Hydrogen or below and the average carbon intensity of electricity used for hydrogen manufacturing is at or lower than 100 gCO_2e/kWh.
[134] EU Technical Expert Group on Sustainable Finance 2020b, p. 182.
[135] COM(2020) 301 final, p. 5.

Article 25 of RED II, which stipulates mainstreaming the use of renewable energy with this regard.[136]

Based on this analysis, the key actions mentioned in the Hydrogen Strategy have an essential role to boost the demand and to scale-up the production. I emphasise that introducing a clear and robust terminology for both renewable and low-carbon hydrogen is paramount as the taxonomy gives an indication to hydrogen producers on the level of support they can expect in terms of contributing towards the renewable targets. Furthermore, the terminology will have an impact on the certification of the hydrogen. As the legislator has not seized the opportunity to introduce a common terminology during the recast of RED II but rather left it to the operators to develop, the existing categorisation established by CertifHy should be considered as a stepping stone for the EC taking into account other existing policies and the experiences of stakeholders.

However, I underline that on the other hand, the regulatory framework has to be precise enough to provide operators with necessary guidance, the regulation needs to be flexible and forward-looking not to stifle innovation. As the hydrogen economy is expected to scale-up with a high speed already in short to medium term, the progress in technological solutions and infrastructure will take huge steps forward. Thus, the legislator needs to ensure that the adopted terminology remains up to date in light of the regulation in the energy sector but also considering the technological developments.

3.2.2. Verifying the Origin of Hydrogen

The terminology to be adopted for hydrogen will also have an impact on the GO system.[137] RED II defines GOs as electronic documents which provide evidence to a final customer that the share or quantity of energy was produced from renewable sources.[138] RED II requires the extension of the current GO scheme to cover also renewable gas, including hydrogen. However, only electricity suppliers have an obligation to use the GOs to show that a given share of the energy has been produced from renewable energy

[136] See Conti 2020a, p. 7.
[137] Hydrogen Europe 2019, p. 7.
[138] Article 2(2)(12) of RED II.

sources. Thus, the Member States must create a GO system but energy suppliers producing other than electricity may choose whether to exploit it or not.[139]

RED II also recommends the Member States to consider the option to include energy from non-renewable sources under the GO system.[140] Such low-carbon GOs are necessary to demonstrate and recognise the contribution of non-renewable gas to decarbonisation. Including both renewable and low-carbon gases under the GO system provides consistent EU-wide policy to prove final customers the origin of such gases and facilitates the trade across borders.[141] It should be noted that a well-functioning GO system increases hydrogen consumption by creating a market pull and improving the overall business case for hydrogen.[142]

For the most part, the characteristics of the GO system already in place for electricity apply to renewable hydrogen.[143] The language of RED II is partly identical to Article 15 of RED regarding electricity, although Article 19 of RED II makes certain changes and clarifications. In addition to extending the GO system to cover all energy from renewable sources[144], the most notable updates include provisions regarding received support from support schemes and the system's compliance with specific standards. In cases when a renewable energy producer gets funding from a support scheme, the market value of GO for such product must be determined in the relevant support scheme.[145] Furthermore, the Member States and the other competent bodies assigned to oversee the GO system must make sure that the requirements on the issuing, transferring and further cancellation of GOs comply with the standard CEN – EN 16325. However, this standard is currently revised for the purposes of establishing an accurate, reliable and fraud-resistant GO system suitable to cover the new sources of energy included in the GO system.[146]

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139 Recital 59 of RED II.
140 Recital 59 of RED II.
141 Hydrogen Europe 2019, p. 16 and 17 and Wind Europe 2019, p. 7, a clear distinction between the renewable GOs and low-carbon GOs must be ensured in order to provide customers and operators a clear framework.
142 Mete – Reins 2020.
143 Velazquez Abad - Dodds 2020, p. 4.
144 Article 19(1) of RED II.
145 Article 19(2) of RED II.
146 Article 19(6) of RED II and Regatrace 2020. the European Standard CEN – EN 16325 is currently subject to an update in order to establish an accurate, reliable and fraud-resistant GO system that is suitable to cover the new sources of energy included in the GO system.

Due to the physical disparities between electricity and gases, tracking the origin of energy is not similar.[147] Compared to electricity, gases, including hydrogen, are more challenging in terms of the GO system because of, for instance, their different uses and delivery. Also, gas itself is usually not an end product as it is often diverted to transport fuels or other products. The application also impacts the taxation of the gas as well as the required quality. Moreover, when compared to electricity, gas is not entirely homogenous as the number of disparities may vary.[148]

The value of GOs is sensitive to whether it is voluntary to disclose the origin of the energy for customers or mandatory for the purposes of compliance. Further, the scope and volume of the market also impact the value of the GOs and whether the system is consistent with possible support schemes in place. Thus, policies and legislation having an impact on these factors will result in influencing the development of the hydrogen markets significantly.[149] However, although the use of GOs is mandatory to disclose the renewable origin of electricity to a final customer and they have proven to be successful in facilitating the use of power purchase agreements (PPA), the prices have been relatively low compared to the wholesale price of electricity as the demand of consumers for renewable electricity falls behind the supply of a GO verified electricity.[150]

Overall, a harmonised framework is required to guarantee the tradability of the GOs across borders despite certain differences in national structures of the GO systems.[151] Such a system could be based on the already operating system established by CertifHy, although further improvements would still be needed. CertifHy has developed an EU-wide framework for hydrogen GO system for the purposes of achieving the envisages laid

[147] Velazquez Abad - Dodds 2020, p. 4. Wind Europe 2019, p 19, the main difference between electricity and hydrogen is that hydrogen is a chemical energy carrier created of molecules whereas electricity is derived of electrons. Chemical energy has more diverse transportation and storage possibilities compared to electricity.
[148] Klimscheffskij – Bröckl – Vanhanen – Värre 2019, p. 8. Listen also Conti – Pototsching – Wood et al. 2020, due to the qualities of hydrogen, it would be appropriate to consider whether hydrogen should be treated as a separate energy carrier under RED II, instead of a subcategory under gases. See also Energiateollisuus ry 2020, p. 2, it is recommended that the use GOs for hydrogen and other gases should be separated when implementing RED II to Finnish legislation as the development of the hydrogen economy is of great interest in the EU and thus, there are upcoming policy measures focusing only on hydrogen. In this case, GOs for hydrogen and other gases should not be used crosswise.
[149] Velazquez Abad - Dodds 2020, p. 11, allowing double counting of GOs and other incentives could foster market growth at the early stages of market development. Nevertheless, the Article 19(2) of RED II explicitly requires Member States to ensure that a unit of renewable energy is only taken into account once.
[150] See Timpe – Seebach – Bracker – Kasten 2017, p. 9-11 and Malins 2019, p. 22.
[151] Discussed in Conti – Pototsching – Wood et al. 2020.

down by RED II and ensuring a harmonized system across the Member States.[152] Inconsistent national bottom-up developments could possibly hamper establishing operative European markets for green and low-carbon hydrogen. CertifHy would offer the Member States certain options to establish their own GO registries while still allowing them to take advantage of the CertifHy system. However, the national implementation of the GO system is under progress in many Member States, and the risk of emerging operational barriers may arise if incompatible systems are created.[153]A CertifHy GO includes information on the hydrogen production plant, support received under any support schemes, production time, source of energy and GHG intensity. As a result, hydrogen falls either under green hydrogen or low-carbon hydrogen. The CertifHy system allows GOs to be transferred independently of the energy to which it originally relates. Furthermore, a GO is cancelled either when the given hydrogen is consumed or converted into another form of energy, ensuring that the unit of hydrogen is taken into account only once.[154]

As the targets for green hydrogen are ambitious, an instrument facilitating an optimal combination of renewable energy vectors could offer a solution.[155] One approach would be to abandon the current idea of renewable electricity versus renewable gas and instead, consider them as energy vectors. An enhanced GO system could provide support for meeting renewable energy targets in a cost-effective way. Additional benefits could be achieved in terms of promoting sector integration and facilitating a harmonised standardisation of GOs. An enhanced GO system should indicate the renewable origin of the energy. It could indirectly complement decarbonisation targets, although the GO system would only aim at increasing the share of renewable energy to meet renewable energy targets. Moreover, it would support the integration of renewable electricity and gas as energy vectors.[156] Furthermore, it could be considered whether the GO system should be

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[152] Floristean 2019, p. 11 and 17-18, in addition to GOs, CertifHy has prepared supply certificates to demonstrate the share of renewable energy in the transport sector. In order to monitor the fulfilment of those targets, a certification and tracking instrument is required. Conditions for issuing supply certificates may be different than the ones applied for GOs as pursuant to Article 19 of RED II, the sole purpose of a GO is to disclose the origin of the energy to the final customer. To avoid contradictory claims from suppliers and end-users as well as double counting, both systems would benefit from similar certification and tracking guidelines. However, the impact of Article 25(2) of RED II on existing and upcoming tracing and tracking schemes should be still further assessed. This is the case particularly with the green hydrogen and low-carbon hydrogen labels proposed by CertifHy and those labels for supply certificates must meet the requirements specified in Article 25(2) of RED II as well as the delegated acts issued under the directive.
[153] Floristean 2019, p. 11 and 15.
[154] Floristean 2019, p. 11-12 and 21, CertifHy has launched a pilot scheme for renewable and low-carbon GOs where the first GO was issued in December 2018.
[155] COM(2020) 301, p. 3, at least 6 GW of renewable hydrogen electrolysers should be installed by 2024 and 40 GW by 2030 in the EU.
[156] Discussed in Conti – Pototsching – Wood et al. 2020.

expanded further to cover all sectors, technologies and energy carriers in the economy in order to facilitate trade and investments into renewable energy technologies. In addition, a stronger link between the GOs and the ETS could be created by requiring the GOs to include the necessary information of, e.g. emissions reductions, to allow them to be tradable under the ETS.[157]

Although GOs have the potential to facilitate hydrogen uptake, the current GO system has some limitations set forth by RED II. The inclusion of other energy carriers into the GO system under RED II has been a step forward. Still, to fully support achieving the renewable energy targets, the GOs should become statutory for all energy carriers included in the GO system, as at the moment, using GOs is at the discretionary of the energy suppliers than electricity. Limiting the function of GOs to only inform the final customer of the renewable origin of the given share or quantity of energy restricts their full potential. The definition of a GO in RED II should be reviewed to include a market value in addition to an informative value. GOs providing a consistent price signal could be deployed to assess the costs of technologies and renewable vectors. This would deliver overall efficiency in terms of achieving the sector-specific renewable energy sub-targets as well as further support sector coupling. Lastly, in addition to final customers, the GOs could be applicable also for suppliers, large consumers and distributors. These changes would foster decarbonization efforts through an increased share of renewable energy.[158]

In Finland, the Ministry of Economic Affairs and Employment has prepared a draft proposal for act on guarantees of origin of energy to transpose the provisions of RED II into national legislation. As an additional requirement compared to the minimum standards set forth by RED II, the proposal would set a requirement to disclose the origin of the gas, including hydrogen, when the gas is reported to be of renewable origin, subject to exceptions. The draft proposal was circulated to stakeholders for consultation until 24 August 2020. The proposal will be assessed before the Parliament in February 2021.[159]

I conclude that in light of the current renewable and climate objectives, a broader and more comprehensive EU-wide GO system could stimulate scaling up the hydrogen pro-

[157] Discussed in Conti – Pototsching – Wood et al. 2020 and Riechmann – Roberts 2020. See also Conti 2020b and listen Pototsching – Glachant - Conti et al. 2020.
[158] Discussed in Conti – Pototsching – Wood et al. 2020.
[159] TEM040:00/2019.

duction better. Nevertheless, as the industry will need significant investments for hydrogen, the possibilities to enhance the system should be explored in cooperation with the stakeholders to attain the most suitable and supportive outcome for the parties involved.

3.3. Carbon Capture and Utilisation

3.3.1. Carbon Sources

Complete elimination of CO_2 from all parts of the economy cannot be achieved even if various energy sectors were fully integrated, as it would require removing all carbon-containing energy vectors from the system. Thus, a circular carbon economy based on cyclic utilisation of carbon is necessary to guarantee that no new fossil-based carbon is added to the energy supply chain.[160] The EC supports this approach in the Energy System Integration Strategy, where it explicitly mentions the aim to enable carbon capture, storage and utilisation to support the profound decarbonisation of the energy system. The Energy System Integration Strategy recognises the role of CCS in industrial processes where the emissions are hard to abate. Complementing the existing process with CCS offers them a possibility to continue operating in a climate-neutral economy.[161] Article 3(1) of the Directive 2009/31/EC[162] of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide defines geological storage of CO_2 as 'injection accompanied by storage of CO_2 streams in underground geological formations.'[163]

In addition, carbon capture and utilisation[164] (CCU) appears as an alternative to the permanent storage of CO_2. CCU can be defined as a group of technologies exploiting CO_2 as a feedstock and converting it into value-added products. From a system perspective, in a CCU process, CO_2 is captured either from an industrial exhaust stream or directly from the atmosphere utilising direct air capture followed by a conversion of CO_2 to a carbon-

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[160] COM(2020) 299, p. 13 and SAPEA 2018, p. 19.
[161] COM(2020) 299 final, p. 13.
[162] Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 (*OJEU L 140/114, 5.6.2009*).
[163] See Talus 2013, p. 205 and Ramboll – Institute for Advanced Sustainability Studies – Universität Kassel Center for Environmental Systems Research – IOM Law – DE Delft 2019, p. 30, In light of CCS, the EU took the global lead by introducing the Directive 2009/31/EC on the geological storage of carbon dioxide. The aim was to have a legislative framework in place when CCS technologies take off and support future technical developments.
[164] SAPEA 2018, p. 9.

intensive product. After the product has been used, the carbon atoms are disposed either by disposing the product or the associated decomposition products, typically in the form of CO_2.

Utilising CO_2 as a raw material for P2X technology to produce synthetic fuels, gases, and feedstock reduces the amount of conventional fossil fuels required.[165] Furthermore, this allows CO_2 to serve as an energy vector.[166] Although there have been major developments over the last decade, a lack of incentives and perceived barriers decelerates the deployment of CCS and CCU technologies in full-scale. Even though these barriers do not prevent stakeholders from utilising CO_2 in their processes, they remain cautious in making large-scale investments due to vagueness in regulatory developments in the future.[167]

In light of the P2X fuel production, RED II narrows down the focus to the renewability of the energy supply instead of restricting the source of CO_2 in the production chain. Therefore, all sources of CO_2 are allowed in P2X fuel production.[168] Potential CO_2 sources can be divided into three categories: CO_2 captured from the atmosphere, CO_2 captured from industrial point source processes emitting biogenic carbon and CO_2 captured from industrial point source processes emitting fossil carbon.[169] Depending on the origin of CO_2 and the process employed, P2X fuels may account for very different levels of GHG emissions.[170] Furthermore, different carbon capture alternatives have different associated energy intensity. In general, the less energy is required for capture and concentration, the more concentrated CO_2 streams are. With the current state of technological development, direct air capture is approximately four times more energy-consuming compared to capturing CO_2 from concentrated industrial point sources. Thus, utilising industrial sources is currently more attractive from an operator's point of view.[171]

The GHG benefits resulting from the production and use of P2X fuels arise from displacing the conventional fossil fuels burned in transport rather than sequestering CO_2, pro-

[165] COM(2020) 299 final, p. 13.
[166] Liu – Sandhu – McCoy – Bergerson 2020, p. 3130.
[167] Ramboll – Institute for Advanced Sustainability Studies – Universität Kassel Center for Environmental Systems Research – IOM Law – DE Delft 2019, p. 30.
[168] Malins 2017, p. 58.
[169] Malins 2017, p. 56.
[170] COM(2020) 299 final, p. 13.
[171] Malins 2017, p. 56.

vided that the net carbon balance of the whole production chain is lower than of the equivalent of fossil fuel.[172] In case when fossil-based energy is the original source of the carbon in CO_2, the mitigation potential of the emissions in the P2X process with CCU system is around 50% compared to reference processes where CCU is not utilised. When CCU is not deployed, carbon is emitted to the atmosphere at two stages. First, from an industrial or power source and second, from the use of fuels. On the other hand, when CCU is used, carbon is emitted to the atmosphere only during the consumption of the fuel since the emissions at the first stage are captured. Also, emissions from extraction, upgrading and refining processes are not formed in this case.[173] However, it should be noted that absorbing and recycling CO_2 from industrial processes does not avoid the emissions released from the original combustion processes.[174]

When considering lifecycle emissions such as conversion efficiencies and environmental resources, the actual emissions reduction potential is probably lower than 50%.[175] Furthermore, CO_2 emissions reduction potential of the P2X system with CCU has been demonstrated to be minimal as the renewable electricity exploited in the CCU process could provide much higher offset in some other part of the energy system.[176] Thus, it has been argued that CCU is a feasible option only in more mature states of the energy transition when the applications requiring a large amount of electricity have been decarbonised. In this scenario, the role of fossil-based CCU would be to support in stabilising the intermittency of the electricity system as well as to allow the use of renewable electricity in those parts of the energy system where direct electrification cannot be achieved. As long as the power sector is not covered mostly by renewable energy, CCU would not add value in the energy transition. Arguably, especially the fossil-based CCU would even hamper the rapid transition towards the low-carbon economy.[177]

Concerns regarding the utilisation of fossil-based CCU have been brought forward as utilisation of the fossil-derived CO_2 would arguably cut the incentive of the industrial operators to decarbonise their processes. However, the ETS and other decarbonisation

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172 Christensen – Petrenko 2017, p. 2.
173 SAPEA 2018, p. 37.
174 Malins 2017, p. 58.
175 SAPEA 2018, p. 37. See also Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 23-25, due to the higher energy consumption of direct air capture, the impacts on climate are similar whether CO_2 is captured from the air or from an installation before the emissions are released to the air.
176 SAPEA 2018, p. 37-38.
177 SAPEA 2018, p. 37-38 and Scibioh – Viswanathan 2018, p. 11.

instruments and measures should make the fossil-based industrial operations highly unprofitable. Long term scenarios suggest that fossil-based CO_2 P2X conversions into transport fuels may become irrelevant.[178] Furthermore, there are no evident environmental benefits that would support deploying only non-fossil CO_2 sources to produce P2X fuels at the moment. Requirements regarding the origin of CO_2 could increase the costs of the production processes, the overall energy consumption and reject the fossil industry operators as potential project financers and co-operator and thus hinder the deployment of the synthetic fuels.[179]

However, it is essential to emphasize the necessity of carbon efficiency and origin of the sources when proceeding further with the energy transition.[180] Fully carbon-neutral P2X fuels require CO_2 to be derived from biogenic sources or the atmosphere.[181] These P2X routes utilising renewable sources of CO_2 can achieve either zero or even negative carbon emissions provided that CO_2 remains in the technical carbon chain. Compared to the CCU using fossil CO_2, CCU processes deploying renewable sources operate in a cyclic manner, and no CO_2 is released to the atmosphere.[182] When direct air capture is used, the amount of CO_2 in the atmosphere remains the same even after the fuel has been burned. Therefore, the renewable-based CCU system may result in close to zero emissions. However, the full lifecycle emissions must be carefully considered to make sure that there is no carbon leakage at any state or component of the process. Using CO_2 from biogenic sources, such as combustion of biomass, may result in a low-carbon footprint depending on the production process. They have the potential to reach negative carbon emissions provided that the carbon is permanently stored instead of releasing the re-emitted emissions into the atmosphere.[183]

Based on this assessment, I conclude that utilising high-concentration industrial point sources is justified with the current stage of technological development compared to expending high amounts of energy in absorbing CO_2 from the atmosphere. Furthermore, allowing CO_2 to be captured from industrial sources enables lower costs and thus, drives faster market uptake of P2X fuels. However, in the medium to long term, a revision is required to review the need to establish rules to encourage the transition towards direct

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[178] SAPEA 2018, p. 38.
[179] Malins 2017, p. 58.
[180] Kärki – Thomasson – Melin – Suomalainen – Saastamoinen – Hurskainen – Mäkikouri 2019, p. 1.
[181] COM(2020) 299 final, p. 13.
[182] SAPEA 2018, p. 38.
[183] SAPEA 2018, p. 39-40.

air capture, although a well-functioning ETS should be the main instrument to make fossil-based industrial operations unprofitable.[184]

3.3.2. Carbon Dioxide Accounting

The logic behind the CCU technologies and processes differs from the existing regulatory framework. CCU processes require a tailored GHG accounting methodology that allows taking unique features into account. The current regulation is not adequately designed for this kind of activities where CO_2 is captured from one sector regulated by specific legislation, such as the cement industry, regulated under the ETS[185], and subsequently re-emitted in another sector, such as the transport sector, regulated under effort sharing sector by the Regulation (EU) 2018/842[186] on binding annual greenhouse gas emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement. These overlapping scopes of regulation create challenges in attributing incentives while narrowing down the focus to avoid double counting of the emissions reductions.[187] For example, tracing the carbon streams under the monitoring, reporting and verification framework[188] cannot be completed entirely under the existing Commission Regulation (EU) No 601/2012[189] on the monitoring and reporting of GHG

[184] See also Malins 2017, p. 8.

[185] ETS legislation consists of several directives, regulations and guidelines including Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for GHG emission allowance trading within the Community and amending Council Directive 96/61/EC (*OJEU L 275/32, 25.10.2003*), Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the GHG emission allowance trading scheme of the Community (*OJEU L 140/63, 5.6.2009*) and Directive (EU) 2018/410 of the European Parliament and of the Council of 14 March 2018 amending Directive 2003/87/EC to enhance cost-effective emission reductions and low-carbon investments, and Decision (EU) 2015/1814 (*OJEU L 76/3, 19.3.2018*) (ETS Directive) and the Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (*OJEU L 315/1, 14.11.2012*) have a direct impact to the development of CCU technologies.

[186] Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual GHG emission reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement and amending Regulation (EU) No 525/2013 (*OJEU L 156/26, 19.6.2018*).

[187] Ramboll – Institute for Advanced Sustainability Studies – Universität Kassel Center for Environmental Systems Research – IOM Law – DE Delft 2019, p. 171.

[188] See European Commission, Monitoring, reporting and verification of EU ETS emissions.

[189] Commission Regulation (EU) No 601/2012 of 21 June 2012 on the monitoring and reporting of GHG emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council (*OJEU L 181/30, 12.7.2012*).

emissions and Commission Implementing Regulation (EU) 2018/2067[190] on the verification of data and on the accreditation of verifiers.

Currently, the ETS monitors emissions at installation level where installations and their processes are regulated under the ETS monitoring and reporting system. Companies with operations subject to the ETS are required to submit a monitoring report, including either direct measurement or an estimation of the GHG emissions to be emitted from their activities. However, this kind of assessment procedure is not optimal from the CCU's perspective. Instead, a lifecycle assessment would allow companies to account and express GHG emissions savings more clearly, as some or all of the GHG emissions savings may take place outside the scope of the ETS. Basically, lifecycle assessment considers the GHG emissions resulting from CCU throughout the process chain. This approach requires establishing criteria for a reference process or using the conventional route as a reference. The methodology of the lifecycle assessment reflects more adequately the actual GHG emissions in a project-based approach as it enables considering different installations and various processes involved in the CCU process chain.[191]

Although the origin of CO_2 in P2X fuels is not regulated in RED II, legitimate concern has risen regarding double counting of the emissions savings achieved from replacing the conventional fossil fuels with P2X equivalents. This issue has been recognised in the Energy Sector Integration Strategy, as it states that proper monitoring, reporting and accounting the actual emissions and removals of CO_2 related with the production are necessary to reflect the factual emissions accurately. Following a new circular economy action plan for a cleaner and more competitive Europe[192], the EC will explore the possibility to develop a regulatory framework for certification of carbon removals complementing the current system for monitoring and reporting the GHG emissions. The new framework would include robust and transparent guidelines for carbon accounting.[193]

[190] Commission Implementing Regulation (EU) 2018/2067 of 19 December 2018 on the verification of data and on the accreditation of verifiers pursuant to Directive 2003/87/EC of the European Parliament and of the Council (*OJEU L 334/94, 31.12.2018*).
[191] Ramboll – Institute for Advanced Sustainability Studies – Universität Kassel Center for Environmental Systems Research – IOM Law – DE Delft 2019, p. 218-219.
[192] COM(2020) 98 final. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A new Circular Economy Action Plan For a cleaner and more competitive Europe, on 11 March 2020.
[193] COM(2020) 299 final, p. 16 and COM(2020) 98 final, p. 13.

If the GHG reduction benefits delivered by replacing fossil fuel by these CO_2 based synthetic fuels are allowed to count towards the GHG reduction targets in more than one sector at the same time, the total sum of the emissions reductions will, in fact, be lower than the reported emissions savings. However, it should be noted that the risk to misleading emissions accounting is lower regarding P2X fuels produced from concentrated sources compared to CO_2 captured directly from the air.[194]

In order to avoid double counting of CO_2 from fossil sources, there are two accounting possibilities. First, the GHG emissions reductions from P2X fuels could be accounted for the benefit of the industrial sector. In this case, the GHG savings are not attributed to the renewable energy targets in the transport sector. The second option is to consider these P2X fuels to fall into the category of low-carbon fuels allowing them to be counted towards the renewable targets in the transport sector. This necessitates that the industrial sector is not credited for the GHG reductions when the captured CO_2 is further supplied for P2X fuel production.[195] One critical issue with regard to CCU from renewable sources relates to the assignment of CO_2 credit and whether it would be granted to the supplier of the renewable energy or the user of the product or both of them.[196]

As emissions in the transport sector have been hard to abate, it supports the decision to count P2X fuels towards its renewable energy targets. Furthermore, this could enhance the value of decarbonisation in the transport sector and hence, support the development of P2X technologies. The GHG emissions reductions credited in the transport sector should not be counted for the second time under the ETS by rewarding the industrial sector and the installation at which CO_2 is captured. Moreover, crediting carbon capture for producing P2X fuels under ETS would impair the incentive to cut the emissions hindering the efficiency of the long term decarbonisation plans. Also, allowing the double counting would also result in over-incentivising P2X fuels production compared to other decarbonisation measures.[197] On the contrary, if industrial actors were still required to

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194 Christensen – Petrenko 2017, p. 2

195 Malins 2017, p. 8 and Christensen – Petrenko 2017, p. 2, allowing double counting violates the basic principles of GHG accounting. Double counting favours one or more sectors by creating an illusion that the without providing any actual benefit. Furthermore, if would reduce the incentive of the sector to achieve actual GHG reductions through other means. If the double counting would be allowed, a situation where the use of synthetic fuels would consider towards the renewable energy targets in RED II, the emission reductions would count towards the ETS in the industrial sector as well as towards CO_2 standards for vehicles.

196 SAPEA 2018, p. 38.

197 Malins 2017, p. 58.

cover their emissions by obtaining emissions allowances under the ETS, decisions regarding CO_2 utilisation, sequestration and reduction would be equally attractive from this perspective, delivering the most cost-effective outcome.[198]

In light of the lifecycle assessment, the combustion of P2X fuels is treated as carbon-neutral provided that CO_2 is either captured from the atmosphere or absorbed from waste gas streams that would otherwise be released to the atmosphere. This treatment has similar aspects as emissions reductions accounting regarding some crediting projects as well as biofuels accounting, where the emissions are not considered as the emitted carbon atoms were recently captured from the atmosphere. This treatment is justified as long as the assumption is that CO_2 would have otherwise emitted to the atmosphere. However, as the technologies regarding CCU become more widespread, re-evaluating the lifecycle assessment is appropriate.[199]

In RED II, all renewable energy accounted towards the transport sector's sub-target also counts towards the target of the EU's overall share of renewable energy. However, with regard to P2X fuels, counting both the energy in the fuel as well as the electricity used in the production process, would result in counting the energy of the same fuel twice towards the same target. Moreover, it would reduce the amount of renewable energy needed to achieve the decarbonisation targets by creating a false illusion of fulfilling the commitments in the transport sector.[200] These concerns are reflected in RED II, which does not allow double counting.[201]

ETS Directive only exempts CCS from surrendering emissions allowances.[202] However, Recital 14 recognises CCU by defining the support of the ETS for innovative renewable and low-carbon technologies. According to the Recital 14 of ETS Directive, the main incentive in the long term arising from the Directive 2003/87/EC establishing a scheme for GHG emissions allowance trading for new technologies building on renewable energy

198 Malins 2017, p. 58-59.
199 Malins 2017, p. 56.
200 Christensen – Petrenko 2017, p. 3.
201 Article 7 of RED II.
202 ETS Directive allows transferring CO2 for the purposes of emission reduction only under very limited conditions in order to close the potential loopholes pursuant to the rules set forth in MMR. Under the MMR, the inherent CO2 should only be transferred to other installations covered by ETS. Furthermore, transferring pure CO2 should only occur for storing CO2 to geological storage. Having said that, these conditions should still not eliminate the possibilities for future innovations.

as well as for breakthrough innovation in the field of low-carbon technologies and processes, including CCU, is the carbon price signal. Furthermore, allowances do not need to be surrendered for avoided or permanently stored CO_2 emissions.

Moreover, for the purposes of supplementing the resources that are already utilised to accelerate demonstration of commercial phase CCU installations and innovative renewable-based technologies, allowances should be deployed to provide guaranteed rewards for utilisation of CCS or CCU installations, new technologies based on renewable energy as well as industrial-scale innovation in low-carbon technologies and processes upon a condition that an agreement regarding knowledge sharing has been entered into. Thus, as the articles in the operative part of ETS Directive must be interpreted in accordance with the preamble recitals, CCU may have a potential role as a carbon reduction measure provided that CO_2 emissions are avoided or permanently stored.[203]

The EGD sees the ETS as an effective tool in reducing GHG emissions and requires it to be revised to have better compatibility with the updated climate targets. As a part of the revision process, the ETS will target new sectors of the economy where the decarbonisation has not been successful. The EC considers proposing to extend the ETS to cover road transport and maritime sectors.[204] The EC sees that a further expansion of the ETS to include all emissions of fossil fuel combustion and incorporating them in the ETS would deliver significant benefits through effectiveness and administrative viability. In light of the benefits expected in the transport sector, the EC identifies the opportunity to capture emissions while incentivising to a comprehensive and long-lasting effect on transport solutions through a robust price signal.[205] The expanded ETS could utilise an upstream trading system regulating at the level of fuel distributors. The new framework should address any risk of double counting, evasion or loopholes considering the entities covered by the existing downstream system for different sectors. Furthermore, an operational framework in terms of monitoring, reporting and verification is of great importance. These considerations will be taken into account in the EC's proposal to be handed over by June 2021.[206]

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203 Ramboll – Institute for Advanced Sustainability Studies – Universität Kassel Center for Environmental Systems Research – IOM Law – DE Delft 2019, p. 179, CCU processes may be eligible to receive support under the Innovation Fund. For more information on the Innovation Fund, visit European Commission, Innovation Fund.
204 COM(2019) 640 final, p. 11.
205 COM(2020) 562 final, p. 14.
206 COM(2020) 562 final, p. 14-15.

In conclusion, I argue that the current regulatory framework in place for hydrogen and CO_2 is inadequate and should be developed further. RED II stipulates hydrogen to some extent, but the current rules contain considerable constraints in terms of lacking terminology and certification criteria. Furthermore, the existing GO system does not necessarily enable the full potential of hydrogen, and thus, measures to enhance it should be considered. Although RED II does not stipulate the use of CO_2 in the P2X fuel production, the link and consistency between RED II and the ETS should be strengthened to allow appropriate accounting of CO_2 emissions reductions.

4. Classification of End Products

4.1. Introductory Remarks

In this chapter, I will test the hypothesis stating that RED II does not enable the potential of P2X fuels and therefore, limits the possibilities for a level playing field by answering the second research question and thus, demonstrating how P2X fuels are treated in RED II. This chapter examines P2X fuels in two separate categories, RFNBOs and RCFs. As regards to RFNBOs, perhaps the most attractive aspect is its potential scalability, as RFNBOs can be produced from renewable electricity with fewer sustainability issues than biofuels. However, the downside of the production is the energy losses resulting from the conversion processes.[207] As large amounts of electricity are required for RFNBO production, RED II aims at guaranteeing that the source of the electricity is renewable and contributes to the renewable energy targets by adding renewable electricity production.[208] Stricter requirements regarding the additional renewable electricity may impose significant barriers on the RFNBO operators and market development. Still, conversely, more flexible approaches may undermine the objectives of RED II if not prudently implemented.[209] RCFs are not renewable by origin.[210] However, their regulatory framework in the context of RED II is elaborated in order to assess the treatment of P2X fuels produced from excess hydrogen derived from industrial processes. RCFs are not subject to as detailed requirements and rules as RFNBOs but on the other hand, they do not either receive as much support.

[207] Malins 2020, p. 14.
[208] Article 27(3) and Recital 90 of RED II.
[209] See Malins 2020, p. 14.
[210] Article 2(35) of RED II.

Each subchapter identifies the core aspects of the regulatory treatment of RFNBOs and RCFs and aims to point out the related advantages and challenges, focusing on the barriers RED II establishes for the deployment of P2X fuels. Details of the regulatory framework are still unclear in many places as RED II foresees the EC to adopt delegated acts providing more details. Thus, the analysis in these cases is based on a preliminary assessment provided by the EC and literature. Although the third research question has and will be answered throughout the thesis, the final subchapter contributes explicitly to this objective, as it presents and evaluates measures that could support the deployment of P2X fuels. I will use the threads made in this chapter as a bridge to assessing the regulatory treatment of P2X Joutseno pilot plant discussed in the fifth chapter.

4.2. Renewable Liquid and Gaseous Transport Fuels of Non-Biological Origin

4.2.1. Contribution Towards Renewable Targets

RFNBOs contribute to increasing the share of renewables in the parts of the transport sector that are expected to be highly dependent on liquid fuels in the long term.[211] Thus, under Article 25(1) of RED II, the Member States have an obligation to take RFNBOs into account when calculating the minimum share of renewable energy in the transport sector, regardless if they are utilised as intermediate products with a purpose to produce conventional fuels. However, the calculation rules with this regard put RFNBOs at a disadvantage compared to biofuels and electricity. According to Article 27(2), the share of biofuels and biogas produced from the feedstock listed in Annex IX can be calculated twice towards the transport sector's renewable energy target. Furthermore, the share of renewable electricity supplied to road transport can be considered four times its energy content. RED II does not provide RFNBOs with similar multipliers to incentive their production, except when delivered to aviation and maritime, where the multiplier is 1,2 and thereby, significantly lower than of biofuels and electricity.[212]

What is more, RED II also includes other policy measures restricting the level playing field between RFNBOs and biofuels. Article 25(1) requires that the contribution of advanced biofuels and biogas produced from the feedstock listed in Part A of Annex IX must be at least 3,5% by 2030. Although Recital 83 recognises that an obligation requiring

[211] Recital 90 of RED II.
[212] Article 27(2), the share of fuels produced from other sources than food and feed crops can be considered 1,2 times their energy content when supplied to aviation and maritime.

fuels suppliers to deliver a particular share of fuels from renewable sources can offer investors certainty and facilitate the utilisation of biofuels, RFNBOs and electricity further, RED II sets forth such an obligation only for biofuels. However, a positive aspect from the RFNBOs point of view is that Article 25(1) allows the Member States to decide to exempt fuel suppliers that are supplying electricity or RFNBOs from the biofuel distribution obligation. I point out that until RED II has been transposed into national legislation, fuel producers do not know whether they need to comply with this requirement or not. This may stall the investment decisions and thus delay the roll-out of RFNBOs. Furthermore, the requirement to produce biofuels may be burdensome for some operators, which may limit the size of the investments made in RFNBOs.

From a broader view, Article 7 of RED II regulates the calculation of the gross final consumption of renewable energy. However, the language of this article is rather ambiguous regarding how the electricity used to produce RFNBOs should be calculated towards this share and subsequently, towards the overall renewable energy target of 32% under Article 3(1). Article 7(1) includes three categories that are added together in the calculation: first, gross final consumption of renewable electricity, second, gross consumption of renewable energy in the heating and cooling sector and third, final consumption of renewable energy in the transport sector. According to Article 7(4), RFNBOs, biofuels and biomass fuels are taken into account when calculating share in the transport sector. However, RFNBOs are considered towards the first category, gross final consumption of renewable electricity only when calculating the amount of renewable electricity produced in a Member State. Biofuels and biomass fuels are not subject to the same restriction.[213]

It should be noted that language of paragraph 4 a) of Article 7 refers to 'calculating the quantity of electricity produces from renewable sources.' In contrast, paragraph 1 a) refers to 'gross final consumption of energy from renewable sources'. The context emphasises the ambiguity here between the production and consumption as if for instance, an RFNBO process having a 50% energy conversion efficiency, the RFNBO process requires double the energy that is finally consumed in the transport sector by the consumer of the fuel. The most consistent option to count the energy delivered to RFNBO production would be by final energy supplied for consumption. Provided that this is the interpretation aimed

[213] Article 7(4) of RED II.

at, it is unclear why the energy should be calculated in the category for renewable electricity instead of renewable transport energy.[214]

The contrary interpretation, counting the renewable electricity input used in RFNBO processes towards the renewable energy targets based on the energy input instead of output would mean double counting RFNBOs towards the renewable energy targets.[215] To clarify this ambiguity, the EC should provide further guidance by stating that RFNBOs should be considered towards overall renewable energy targets on the basis of the energy content of the fuel instead of the input electricity.[216] However, this accounting issue with RFNBOs has more weight if the overall EU-wide renewable energy target of 32% is reached but not much exceeded. In case the target would be significantly exceeded, the possible double counting of RFNBOs towards the overall renewable energy share would not be as important in terms of the requirement to install new renewable energy capacity.[217]

4.2.2. Requirement for Additional Renewable Electricity Generation Capacity

RED II addresses the large electricity consumption required for RFNBO production by establishing several safeguards to guarantee that the electricity used in this process contributes to its objectives. Thus, Recital 90 states that the electricity used for producing RFNBOs should be derived from a renewable origin to ensure their contribution towards the GHG emissions reduction targets. In the context of RED II, the renewable sources are identified in Article 2(1) of RED II.[218] Moreover, Recital 90 necessitates an element of

[214] See Malins 2019, p. 14, this option would treat RFNBOs equally with renewable bio-based fuels, as a certain amount of, for example, renewable diesel produced from biomass would count the same as the same amount of renewable RFNBO diesel.
[215] Malins 2019, p. 14-15. See also Malins 2017, p. 62-65 and 76, a Member State using having the maximum supply of RFNBOs meeting its target for the use of renewable energy in the transport sector under Article 25 would need an increased supply of renewable energy for electricity or heating and cooling whereas a Member State fulfilling its obligations using only advanced biofuels. See also Saerle – Christensen 2018, p. 14, Article 25 of RED II allows counting twice the energy content of biofuels used in the transport sector. However, the net effect differs from the double counting of RFNBOs in the context of Article 7. Article 25 allows double counting of biofuels towards the transport sector's sub-target, but not towards the overall renewable energy target under Article 3. Thus, using advanced biofuels could reduce the total amount of renewable energy in transport fuels but it would not cut the amount of renewable energy used in the EU.
[216] Malins 2019, p. 15.
[217] Saerle – Christensen 2018, p. 14.
[218] See Malins 2019, p. 8, renewability by a direct physical definition is treated as 'a property of a physical flow of electric current applicable only for flows of electrons driven by a potential difference generated using renewable sources of energy.' Such a strict definition may be limiting and even counterproductive in

additionality.[219] This requires the fuel producer to either enhance the deployment of renewables or their financing.[220] Additionality is achieved when a particular type of fuel consumption, in this case, the consumption of RFNBOs, results in additional renewable electricity generation with the expectation that without the increased supply and consumption and the contractual relations between the parties in the markets, it would not have occurred.[221]

Article 27(3) of RED II establishes three options for calculating the renewable shares of electricity used for RFNBO production.[222] It should be noted that despite the approach deployed, the use of RFNBOs should result in at least 70% GHG emissions reductions under Article 25(2).[223] The first option is the average grid electricity approach, according to which the share of renewable energy is determined based on the average share of renewable electricity in the given Member State, measured two years before the year of RFNBO production. As regards to this option, there is no consensus on whether the average share of renewable energy refers to non-biomass based energy or overall fraction of renewable energy in a given country. On the one hand, the definition of RFNBOs under Article 2(36) requires that the energy content must be derived from other sources than biomass.[224] On the other hand, it can be argued that Article 27 is more specific and would thus override Article 2 in this context. Hence, the average share would refer to all renewable electricity derived from any renewable sources, including biomass.[225] I note that it is of significant importance to provide clarification on how the average share of renewable electricity in the grid should be construed in this context as it impacts the possibilities of the Member States with a high fraction of biomass-derived energy production to produce RFNBOs under this approach.

light of the policy objects. Defining energy sources as renewable or non-renewable stems from political agreements.

219 Recital 90 of RED II.

220 Malins 2019, p. 8-9, additionality is compared to a hypothetical counterfactual scenario where the RFNBO would not exist, and thus, more renewable electricity would not have been generated in the first place. Furthermore, the contrasting scenario, where the RFNBO facility would not exist but the amount of renewable electricity would still be generated but instead of supplying the electricity to RFNBO facility, it would be distributed to the grid. From the perspective of absolute additionality, note Seebach – Timpe 2015, p. 22-23. Absolute additionality requires that the share of renewable electricity in voluntary markets is purchased from a new production facility that is not benefitting from any existing renewable energy support schemes and where the electricity produced is not considered towards national targets.

221 Timpe – Seebach – Bracker – Karsten 2017, p. 11.

222 Klessmann – Wietschel – Schröder – Wachsmuth 2020, p. 2, RED II does not restrict combining these options in the RFNBO production.

223 The draft methodology for assessing GHG emissions reductions is discussed in chapter 4.2.1.

224 See e.g. Malins 2019, p. 19.

225 Discussed in Klessmann – Wietschel – Schröder – Wachsmuth 2020.

The advantage of this approach is its simple administrability as the assessment is based on available data.[226] Due to the 70% GHG emissions savings threshold, this option is applicable only in the Member States with a high fraction of renewable electricity in their grid. This approach is expected to have more weight in the future when national grids are largely relying on renewable electricity. Furthermore, the major differences in the share of renewable electricity give substantial regulatory advantage under this accounting option to the production of RFNBOs in countries with a higher share of renewables in their grid average.[227] As the share of renewable electricity is expected to increase throughout the application period of RED II, the data on the grid average may understate the actual share of renewables in the grid at the time of RFNBO supply.[228]

The disadvantages of the grid average approach relate to climate concerns. This approach does not guarantee that additional renewable capacity is used in the RFNBO production, leading possibly to indirect emissions. In other words, an RFNBO installation would not have any obligation to make any additional investment in renewable power capacity. Furthermore, the RFNBO industry would not necessarily facilitate increasing the share of renewables in the energy production, and therefore, it can be argued whether this approach actually contributes in delivering required GHG emissions reductions that are eventually the main objective behind RED II. The Member States with a large share of renewable electricity generation are likely to exceed the renewable energy targets significantly. The electricity consumption of an RFNBO installation may be fully compensated by increased fossil electricity generation, or by increase fossil-derived electricity imports, while still complying with EU or national renewable energy targets. However, the market in the Member States with a very high fraction of renewables might be predicted to respond to the increased electricity demand with additional renewable electricity capacity, even if the RFNBO installation would not make a direct investment in the renewable electricity generation.[229]

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[226] Malins 2019, p. 16, the Also Klessmann – Wietschel – Schröder – Wachsmuth 2020, p. 15 and Malins 2019, p. 16, RED II does no set any requirements for imports of RFNBO from third countries. Thus, grid average approach can be applied in third countries where timely and reliable grid electricity statistics are available.

[227] Malins 2019, p. 16. For detailed information on the renewable shares in each Member State, see Eurostat.

[228] Malins 2019, p. 16.

[229] Malins 2019, p. 18-19, in this case, adding a fully fossil electricity powered RFNBO facility to the grid would not have a significant impact on the overall national renewable electricity average.

In the grid average approach, the lifecycle GHG intensity for RFNBOs depends on whether a single average value, combining both the renewable and non-renewable fractions of the fuel, is calculated or whether a separate value is determined for the renewable share. If a single average value is used, RFNBOs would be eligible for support only in countries with a substantial share of zero or close to zero-carbon electricity production in order to meet the 70% emissions savings threshold set for RFNBOs in Article 25(2) of RED II.[230] On the contrary, if a separate value is determined for the renewable share of the fuel, the carbon intensity is expected to be low for this part due to low GHG intensity of renewables in general. The GHG intensity of the non-renewable fraction may be high depending on the origin of the electricity, but it would not be penalised under RED II. Consequently, lifecycle assessments treating these two electricity streams separately would possibly result in an RFNBO installation causing a net increase of emissions in the transport sector considering all fuel produced, while still being credited for producing the renewable fraction of the fuel as low-carbon.[231]

Details regarding the second and third option are still under development, as Article 27(3) calls the EC to adopt a delegated act establishing a methodology containing comprehensive rules for the operators to comply. The second option, direct connection approach, allows electricity to be considered as fully renewable if obtained from a direct connection to renewable electricity facility. This approach is building on two requirements: first, the timing of the renewable electricity facility commissioning and second, an exclusively supply of electricity through a direct connection. Under the first requirement, the installation must become operative after or at the same time as the facility producing the RFNBOs.[232] According to the preliminary views presented on the delegated act, an appropriate timeframe could be a quarter of a year.[233] To fulfil this requirement, a certification body, to be determined by the Member States, would verify the commissioning date of the renewable electricity facility and certify the renewable electricity claim, provided that the second requirement is also met.[234]

[230] Malins, 2019, p. 18, this would require approximately 90% of the supply being produced by renewables.
[231] Malins 2019, p. 18, lifecycle assessment based on separating the renewable and non-renewable electricity streams is inconsistent with the lifecycle assessment for biofuels, as it is required that in a single physical process the co-products are calculated together with their emissions determined on an energy basis.
[232] Article 27(3) of RED II.
[233] Discussed in Klessmann – Wietschel – Schröder – Wachsmuth 2020.
[234] Discussed in Klessmann – Wietschel – Schröder – Wachsmuth 2020.

The second requirement entails that the facility is either not connected to the grid and if it is, evidence must be provided to prove that the electricity is supplied directly from the renewable electricity facility without any additional electricity coming from the grid.[235] Thus, the renewable electricity facility must produce more electricity than is required for RFNBO production. If the renewable electricity facility is not connected to the grid, the surplus electricity not used for electricity production is curtailed. The certification body would verify the lack of a grid connection and the presence of a direct connection and certify the renewable electricity claim for the entire consumption of the electricity. However, if the renewable electricity facility is connected to the grid, the certification body verifies the renewable electricity, based on the provided power generation and consumption data the amount of electricity supplied to the RFNBO installation through a direct connection. The advantage of the direct connection with a connection to the grid is that the excess electricity not required for RFNBO production can be supplied to the grid. However, a strict temporal correlation between electricity production and consumption is required.[236]

The aim behind the direct connection approach is to guarantee the use of renewable electricity in the RFNBO production. The requirement concerning the timing of the renewable electricity facility commissioning seeks to assure the element of additionality by preventing the RFNBO installation from benefiting of any existing renewable electricity capacity.[237] However, the requirement on additionality imposes high additional costs on RFNBO producers. It should be noted that even despite the direct connection, the fulfilment of the strict definition of additionality depends on the case and specific policy considerations. In case if the electricity is considered towards Member States' renewable electricity targets, it allows decreasing renewable energy production elsewhere in the system. Although double counting is not allowed when reporting their overall renewable energy shares to the EU, it might still be possible through particular incentives used in the Member States' national legislation. Thus, a direct connection as such cannot ensure the additional renewable electricity production unless such double counting is precluded.

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[235] Malins 2019, p. 5 provides a simplified example assessing the renewability of the input electricity used to produce RFNBOs under the second option. A fuel produced from renewable electricity, produced in a wind farm located in an island with a direct connection to a RFNBO production installation and without a connection to any grid, used to produce fuel being transported to the EU for the purposes to be blended into the fuel supply, would be considered renewable. Thus, the fuel would be treated renewable as electricity consumed in the production process would be generated specifically for the purposes of producing RFNBOs and the supplied electrons would come directly from the windfarm in question.
[236] Klessmann – Wietschel – Schröder – Wachsmuth 2020, p. 22.
[237] Malins 2019, p. 19.

However, the question is more complicated with regard to a direct connection to a facility with a grid connection. For instance, if a relatively small RFNBO installation were to be connected to large renewable electricity facility already in the planning phase, it would not be guaranteed whether the RFNBO installation would have actually contributed in adding more renewable electricity capacity.[238]

Although the aim behind the direct connection approach is clear and somewhat justified, I note that this option would create a significant burden for RFNBO producers. With the current level of technological and market development, the requirement of direct connection creates a considerable barrier for the deployment of these fuels for instance, when considering the size of the further investments required in addition to the actual RFNBO installation. Furthermore, the direct connection approach would be demanding from an administrative point of view, as demonstrating the additionality seems to be rather challenging. This approach does not consider the increasing need for large-scale energy storages to balance the fluctuations of intermittent electricity supply of renewables. Also, the temporal correlation between the commissioning dates should be more flexible. Projects face delays due to multiple reasons, and it would be nonsensical to have either a completed RFNBO installation or renewable electricity facility not operational.

The third option, renewable grid electricity approach, provides another opportunity to count electricity as fully renewable. Electricity should be produced entirely from renewable sources, and the 'renewable properties and other appropriate criteria have been demonstrated, ensuring that the renewable properties of that electricity are claimed only once and in one end-use sector.'[239] In the renewable grid electricity approach, fulfilling the additionality requires the fuel producer to add to renewable electricity by financing.[240] Recital 90 of RED II elaborates the underlying objectives of this option. The methodology to be developed in a delegated act should ensure a temporal and geographical correlation between the electricity production unit and the fuel production by means of a bilateral renewables PPA. For example, if RFNBOs are produced while the contracted renewable generation unit is not producing electricity, the RFNBOs cannot be taken into account as fully renewable. Furthermore, the requirement of geographical correlation means that, for

[238] Malins 2019, p. 19.
[239] Article 27(3) of RED II.
[240] Recital 90 of RED II.

instance, in case of electricity grid congestion, RFNBOs can be considered as fully renewable provided that the renewable electricity, as well as the fuel production installations, are located on the same side in terms of the congestion.

Although this provision provides more flexibility in determining the fulfilment of renewability and additionality requirements, the methodology is somewhat ambiguous.[241] Still, the renewable grid electricity approach is likely to be the most attractive option from the RFNBO producers' point of view at least in the short term. This option is also expected to be utilised to complement especially the other two options when necessary. As regards the sourcing of electricity, GOs and PPAs could provide appropriate tools for demonstrating the origin.[242]

In light of the additionality, the draft methodology narrows down the focus to new, unsubsidised renewable electricity assets and existing, previously subsidised renewable electricity assets.[243] When considering the temporal correlation, options under evaluation contain contracted assets or any renewable electricity facilities with geographical connection with full intraday matching requiring that the entire load and production should correlate at intraday granularity. Another option is that any renewable electricity facilities or renewable electricity generation at a system level with partial temporal correlation, where only part of the load and production should be matched and the correlation should be either daily or monthly level. Out of these options, the contracted renewable electricity assets would settle closest to the working of RED II. However, in this case, the RFNBO production would be dependent on the electricity production of the specific renewable electricity facility. As regards the requirement of geographical correlation, the draft methodology suggests that the RFNBO production installation and the renewable electricity facility should be located in the same country or the same bidding zone. The disadvantage of this approach is identified to be the possible grid bottlenecks.[244]

[241] Article 25(3)7 of RED II.
[242] Klessmann – Wietschel – Schröder – Wachsmuth 2020, p. 33.
[243] Klessmann – Wietschel – Schröder – Wachsmuth 2020, p. 35, newness is tied to the commission date of the RFNBO installation. Contrary, existing refers to a renewable electricity facility deployed before the cut-off date. Subsidised renewable electricity assets either were, are or will be directly subject to public subsidies. Reverse, any direct capital or operational support has never been granted to unsubsidized renewable electricity assets. Furthermore, RED II does not explicitly make any references to surplus electricity. However, the draft methodology suggests that from the perspective of the deployment, the surplus electricity cannot be additional from the renewable electricity facility but saved electricity could be considered as additional. Surplus electricity could mean electricity when the prices in the spot markets are negative or an actual physical curtailment.
[244] Klessmann – Wietschel – Schröder – Wachsmuth 2020, p. 37-38.

The draft methodology recognises the strict requirements set forth to the RFNBOs and the possible barriers they create for scaling up the production. Thus, the draft methodology foresees some flexibility to ease the short term scale-up of RFNBO production. As the RFNBO markets are still expected to be relatively small, negative effects from lowering the safeguards provided by RED II would be limited.[245]

To my mind, the draft methodology at this stage seems to confirm the expectation that the considerations made as regards the renewable grid electricity approach are going to establish requirements that may stall the uptake of RFNBOs and reduce the attractiveness of these fuels. Hence, it is paramount that clear and robust rules are outlined in the delegated act to allow investors to make informed decisions. Furthermore, I support adopting at least a certain level of flexibility to the rules for the short term as the technology is quite new, and the market relatively small. Flexibility in the early stages of the market development could encourage investors to finance RFNBO production.

4.2.3. Verifying the Origin of Electricity: GOs and PPAs

GOs and PPAs could provide appropriate tools to demonstrate the origin of the electricity for the renewable grid electricity approach under Article 27(3). This chapter elaborates the issues of the existing GO system and assesses different alternatives presented in the literature to enable the system to meet the requirements of RED II. Moreover, as RED II recognizes PPAs as potential instruments to treat the electricity used in RFNBO production as fully renewable, the suitability of various PPAs are analysed in this context.

A functioning market already exists for the GOs of renewable electricity in the EU.[246] The GO system operates completely electronically and separates the renewable origin from the physical electricity and contractual relations in the markets. When an electricity supplier cancels a GO for a given share of renewable electricity supply, the supplier and consumer can claim that the electricity was derived from renewable origin. Furthermore, the system is overall flexible and can be employed at low transaction costs. Thus, the stakeholders in the RFNBO industry might see this as an appealing option to make claims on renewability of the electricity used for RFNBO production.[247]

[245] Klessmann – Wietschel – Schröder – Wachsmuth 2020, p. 46.
[246] The GO system is regulated under Article 19 of RED II.
[247] Malins 2019, p. 24. Timpe – Seebach – Bracker – Karsten 2017, p. 9.

Although GOs can be used to ensure the renewability of the given share of electricity, the system does not offer appropriate tools to ensure additionality. Although trading GOs contribute to supporting the production of renewable electricity through or across the supply chain, purchasing GOs would not itself increase the additional renewable electricity capacity. Instead, in the absence of regulation, the market forces would determine the level of additional renewable electricity produced for RFNBO production. The incompetence of the GO system may impose a risk of indirect emissions, as there would be no regulation in place to prevent the new demand from being met by fossil-derived electricity generation. Thus, using the existing GO system as such would create a theoretical risk of increasing the net emissions in the 2030 timeframe. [248]

Several adjustments to the GO system have been presented to improve its ability to tackle the requirements of renewability and additionality in RFNBO production. The first option, called GO New, would limit the eligible GOs to renewable electricity facilities that come into operation after, or at the same time as the RFNBO installation. This option would require creating a bifurcated market where the GOs from pre-existing renewable electricity facilities could be utilised as before, and the GO News from renewable electricity facilities coming into operation in the future could be used in the RFNBO production. Nonetheless, similarly to the existing GO system, this approach does not offer the necessary tools for ensuring that additional renewable electricity generation would be driven. Thus, this option would not likely have an advantage over the existing system.[249]

The second option to improve the GO system to meet the requirements set forth by RED II is to issue GOs only for additional renewable electricity generation. Under this approach, the GO system would again be separated into two instruments, the GOs that are already in use and new certificates, called GO+. This option recognises two situations where such additional renewable electricity production can occur. First, when renewable electricity is derived from new and unsupported production facilities and second, when surplus electricity generation would otherwise have been curtailed. Overall, the GO+ system would comply with the existing provisions of Article 19 of RED II complemented by corresponding additions and be built on existing reporting and tracking mechanisms. However, a harmonised definition for additionality should be introduced in order to ensure functioning EU-wide markets. This approach offers certain advantages for electricity

[248] Timpe – Seebach – Bracker – Karsten 2017, p. 29 and Malins 2019, p. 24.
[249] Malins 2019, p. 25-26.

suppliers and consumers, the most important being the possibility to verify both the origin of the electricity as well as its additionality by a single GO+ certificate.[250]

The third option, GO^2 run by ECOHZ[251], provides an alternative solution to fulfil the requirement of additionality by adding to the financing of renewable energy. The GO^2 system is based on the existing GO system. In the GO^2 system, customers can voluntarily make payments into a fund used for financing additional renewable energy production.[252] Despite this, GO^2 system would not create a direct connection between the additional electricity produced and the amount of electricity consumed by the RFNBO installation.[253] Furthermore, the fund could be formed after the RFNBO installation becomes operative, which would result in a delay between the consumption of the electricity and the introduction of additional renewable capacity. Another concern arises of the sufficiency of the scale of the fund, as the new instrument would also lead to increased administrative expenses. Still, the main barrier from a practical point of view is that establishing the GO^2 system would create a significant administrative burden both for the RFNBO producers but also the system operators.[254]

Thus, based on this analysis, I recognise that the current GO system does not include the necessary tools to ensure that the objectives established by RED II on the additionality would be met. Simply cancelling GOs for consumed electricity would not necessarily create a push for additional renewable electricity generation. Although the Member States with a higher share of the renewable electricity capacity could, in theory, be expected to respond to the increased demand by renewables, the risk of increasing indirect emissions is still present as the ETS prices are not high enough to provide the additional safeguard. Based on the analysis of the three options presented above, the GO+ system would seem the most appropriate approach to meet the requirements of RED II.[255]

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[250] Timpe – Seebach – Bracker – Karsten 2017, p. 12-13. See also Malins 2019, p. 26.
[251] See ECOHZ, ECOHZ offers renewable energy solutions globally to customers from various businesses, organisations and electricity providers.
[252] ECOHZ, GO^2.
[253] Malins 2019, p. 28, in case if such a system would become mandatory for RFNBO producers in the EU, the revenue from the system could be allocated to facilitate a corresponding amount of electricity required for the fuel production.
[254] Malins 2019, p. 28.
[255] See Malins 2019, p. 39.

However, on the other hand, I emphasise the role of the ETS to make fossil-based energy production unprofitable for the operators. Utilising GOs to provide evidence of the renewable origin of electricity would be the most comfortable option for the RFNBO producers as it would not unnecessarily add their administrative burden and thus, impose additional costs. Furthermore, introducing new systems would again result in delays as regards to the market uptake of the RFNBOs. If the GO system would be updated for the purposes of serving the requirements of RED II better, the update should be done in co-operation with the stakeholders ensuring that no additional regulatory barriers would be established.

Recital 90 of RED II recognizes power purchase agreements PPAs as a potential instrument to treat the electricity as fully renewable.[256] Article 2(17) defines renewables power purchase agreement as 'a contract under which a natural or legal person agrees to purchase renewable electricity directly from an electricity producer.'[257] Corporate PPAs[258] are further divided into two leading contract models, physical corporate PPAs, including private wire PPAs and sleeved corporate PPAs, and synthetic corporate PPAs. In physical corporate PPA, the electricity producer sells the power directly to the corporate consumer. On this account, electricity is transferred from the producer's electricity balance to the buyer's electricity balance as a physical supply of electricity. A private wire PPA requires the electricity producer and consumer to share a direct connection to allow the electricity transfer directly from the production facility without utilising a grid from a third party. In such cases, the buyer typically buys all electricity produced in the facility for its entire operational life. Under a sleeved PPA, the buyer purchases the electricity, or an agreed fraction of the production, and pays the grid operator a grid access fee. The operator then sleeves the electricity through the grid and supplies it to the physical location of the con-

[256] Article 15(8) of RED II requires Member States to evaluate any regulatory and administrative barriers in place for PPAs. Furthermore, Member States should remove the identified barriers and facilitate their uptake. PPAs should not be subject to any disparate or discriminatory produces or charges.

[257] Reid – Dingenen 2019, p. 6 and FWPA 2019, p. 5, Generally, PPA refers to an agreement under which an electricity producer agrees to buy a certain amount of electricity at an agreed price and for a certain period of time. For the electricity producer, a PPA provides a stable price of the produced electricity over the long term and thus, creates better prospects to decide on the investment. Furthermore, entering into a PPA with an electricity producer with renewable electricity in a development phase may support financing the additional capacity. From purchaser's point of view, PPAs assure an agreed price for the electricity in addition to achieving sustainability targets by ensuring the supply of renewable electricity for the purchaser.

[258] FWPA 2019, p. 15, in corporate PPAs, the contract is signed between the electricity producer and a corporate electricity consumer. Agreements with electricity suppliers selling the electricity again to a third party, are referred as utility PPAs.

sumer's facility. Synthetic corporate PPAs are derivative agreements, where the electricity producer virtually sells the produced renewable electricity to a corporate consumer. In this case, electricity can be sold across separate energy markets.[259]

In light of the requirements provided by RED II for RFNBOs, physical PPAs have certain advantages. First, the direct relationship between the electricity producer and consumer allows providing certification of the renewable origin of the electricity. Furthermore, such physical PPAs enable contracting with the electricity producer in the early phases of the planning process. Thus, this may be an appropriate tool for demonstrating the requirement of additionality.[260] However, in certain cases, a PPA includes provisions regarding balancing services offered by the grid operator. Such services allow the RFNBO installation to optimise its operational hours, which may not be aligned temporally with the electricity production due to the intermittency of renewables. Hence, this arrangement may not be in line with the objects of RED II, as it calls for temporal and geographical correlation between the production and consumption of the electricity. On the contrary, utilising synthetic PPAs without temporal correspondence would provide an FRNBO producer more flexibility compared to physical PPAs.[261]

Assessing the renewability aspect of electricity used for RFNBO production would require sufficient oversight, as the correspondence between the quantity of the electricity purchased under the PPA and the electricity consumed for RFNBO production need to be monitored. A PPA-based approach would thus lead to a more significant administrative burden compared to a system based on GOs, where a basic reporting procedure is already in place. Moreover, when evaluating the element of additionality under PPAs, it is important to acknowledge that a PPA is a bilateral agreement between two legal entities, whereas GOs are tradeable in the markets. Entering into a PPA expresses the intent of the purchaser to support the given renewable electricity project over a long term. Hence, ensuring the revenue streams can contribute to delivering additional renewable energy capacity.[262]

[259] Reid – Dingenen 2020 2019, p. 6-9 and FWPA 2019 p. 15-17.
[260] Reid – Dingenen 2019, p. 9.
[261] Malins 2019, p. 31.
[262] Malins 2019, p. 32.

Similarly to the GO+ system, PPAs could be subject to certain requirements to provide evidence that additional renewable electricity is financed. Such PPA+ system could impose certain requirements on the agreements. For instance, it could be necessary that the PPA agreement would be directly made between the renewable electricity and RFNBO producer and that all GOs or GO+ certificates, depending on the policy decisions, associated to the share of supplied electricity would be transferred to the RFNBO producer. The combination of GO+ certificates and PPA+ system would considerably increase the possibility that the electricity used for RFNBO production would add the renewable electricity generation capacity.[263] However, it should be noted that limiting GO+ and PPAs to new renewable electricity facilities and curtailment could exclude some cases, where the additionality is met.[264]

Based on this elaboration of various GO and PPA approaches, I conclude that providing evidence to demonstrate the renewability and additionality of the electricity used for RFNBO production under the renewable grid electricity approach seems to be rather challenging. Although these requirements are essential safeguards for achieving the underlying objectives of RED II, the lack of clear methodology creates uncertainty around the RFNBO industry hindering the deployment and restricting their full potential. As the detailed rules are to be adopted by the EC by 31 December 2021, further delays are to be expected as necessary monitoring and verification processes should be established to comply with the adopted methodology. Therefore, a certain level of flexibility with the requirements should be allowed at least in the short term.

4.2.4. Methodology for Assessing Greenhouse Gas Emissions Savings

As a baseline prerequisite, Article 25(2) of RED II requires that using RFNBOs should result in GHG emissions savings of at least 70% as of January 2021. Although RED II does not yet provide rules for calculation, Article 28(5) foresees the EC to adopt a delegated act by 31 December 2021 specifying the methodology for assessing GHG emissions savings from RFNBOS and RCFs. To avoid unnecessary repetition, the assessment presented in this chapter applies to both RFNBOs and RCFs unless stated otherwise. According to preliminary considerations and draft calculation methodology presented by the

[263] Malins 2019, p. 33.
[264] Discussed in Klessmann – Wietschel – Schröder – Wachsmuth 2020, an example of such situation is when facility previously supported by government support schemes were financed in order to keep the facility operational. See also Malins 2019, p. 33.

EC, the fossil fuel comparator used in the assessment would be defined under Annex V of RED II, being 94 gCO_2eq/MJ.[265]

One possible starting point for the lifecycle assessment of RCFs and FRNBOs could be to evaluate whether the supply of a feedstock used for fuel production responds to the demand.[266] The draft calculation methodology regarding the energy inputs focuses on the rigidity or elasticity of the source. The source is defined to be rigid when the supply of the source of input is steady and thus cannot be expanded to respond to increased demand. In case of a rigid input, the difference in terms of emissions is assessed between before and after using the input for fuel production. Likewise, the source is defined as elastic provided that the supply can be expanded to meet increased demand.[267]

In terms of a rigid input as regards to RCFs, including for instance municipal waste and blast furnace gas, where the input is rerouted from an existing process, the GHG emissions are assessed by accounting the GHG impact of diverting the input from its current use. In this situation, the emissions can either be negative, for example in cases when the waste is otherwise burnt without any recovery of energy, or very high provided that the existing use prevents large amounts of GHGs. In elastic input, including for instance natural gas and crude oil, where additional input is produced, the GHG emissions of the input are the additional emissions resulting from supplying more of the input for fuel production.[268] Most of the inputs are either elastic or rigid, but co-products may lead to cases where a clear distinction is not feasible. The parameter depicting the elasticity of the supply can be described as the fraction of the co-product in the total value of the products in the process. Furthermore, in order to prevent a sudden transition from rigid inputs to elastic and to keep most of them in either category, a transition region is considered as an attractive option. The inputs that are qualifying for this transition region are subject to proportional combination of both options.[269]

Another essential element to consider as regards the lifecycle assessment is the appropriate timeframe for data collection. One approach would be to assess the displacement of electricity generation based on the average GHG intensity of the electricity in the given

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[265] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 13.
[266] Malins 2019, p. 10.
[267] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 15 and 18. See also EU Innovation Fund, Calls for proposals 2020, the rigid versus elastic methodology is also exloited in the EU's Methodology for calculation of GHG emission avoidance for Innovation Fund.
[268] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 19-21 and Malins 2020, p. 10.
[269] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 19-21.

country two years before the calculation.[270] However, since the average GHG intensity of electricity is progressively decreased, this backwards-looking approach may overemphasize the emissions penalty resulting from increased electricity demand. On the other hand, this approach may also overstate any emission credits resulting from increasing electricity supply to the grid.[271] Another approach would be based on a forward-looking assessment, as it would consider the expected GHG intensity of the electricity production over the full operational life of the project.[272]

Furthermore, one possible approach to simplify the emissions accounting would be to separate emissions into three categories. Major inputs, meaning more than 80% of emissions from all inputs would be calculated based on actual emissions provided that the source is known. Minor inputs, i.e. less than 15% of emissions from all inputs, would be calculated based on emissions intensity from literature-hierarchy. Lastly, de minimis inputs, referring to less than 5% of emissions, would be ignored.[273]

When robust rules for assessing the renewability of the electricity have been established, the methodology for RFNBOs' lifecycle assessment needs to address a situation where all input electricity used for producing RFNBOs fulfils the requirements to count as fully renewable. Further, a situation where only some fraction of the input electricity can be treated as renewable should be taken into account. When only a part of the electricity input meets the criteria to be counted as renewable, the methodology needs to specify whether to use a single average GHG intensity for both fractions of the fuel or assign different GHG intensities for both streams. This approach could allow a process to output a nominally renewable electricity fraction with low GHG intensity and therefore, to qualify for support. From another point of view, a nominally assigned fossil fraction with very high GHG intensity would not necessarily be a subject to any GHG-related penalties. Thus, a single average GHG intensity should be calculated.[274] Moreover, in case if an RFNBO is further processed for its final use as a transport fuel, the supplier of this final

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270 See Joint Research Centre 2016, the lifecycle assessment guidance for the Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels and amending Council Directive 93/12/EEC (*OJEU L 350/58, 28.12.2998*) is based on this backwards-looking approach.
271 Malins 2020, p. 10.
272 See EU Innovation Fund, Calls for proposals 2020, such forward-looking lifecycle assessment is used in the Innovation Fund.
273 Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 22 and 13, furthermore, emissions from manufacture of machinery and other equipment are not considered in assessing the GHG emissions savings.
274 Malins 2020, p. 22.

fuel calculates the emissions associated to the intermediate product using the methodology set forth for RFNBOs, and then adds the emissions resulting from the subsequent steps.[275]

The methodology adopted under the delegated act needs to ensure that credits for avoided emissions are not given for CO_2 that has already received an emissions credit under any other provisions. Therefore, captured CO_2 that has already been credited under the ETS could not be used for producing carbon-neutral fuels. When CO_2 is captured for the purposes of using it as a raw material in fuel production processes, no credit for the capture should be issued to the emitting installation.[276] The proposed methodology endorses this approach.[277] Furthermore, the preliminary methodology does not make distinctions between the carbon sources. The reasoning behind this decision is that the direct air capture requires higher energy consumption than obtaining CO_2 from concentrated point sources.[278]

4.3. Recycled Carbon Fuels

4.3.1. Contribution Towards Renewable Targets

RCFs are not renewable by the origin, and thus, the potential climate benefits should be distinguished from other environmental impacts arising from their contribution to the circular economy in terms of waste management.[279] Therefore, RED II appears critical of these fuels.[280] The most noteworthy point is that RCFs are only an opt-in case in RED II.[281] According to Article 25(1) of RED II, the Member States have the discretion to decide whether they will take RCFs into account for the calculation of the minimum share of renewable energy in the transport sector. As a consequence, the potential market for RCFs depends on the number of the Member States choosing to include RCFs when transposing RED II into national legislation.[282] The EU and the Member States should

[275] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 6.
[276] Malins 2020, p. 22.
[277] Discussed in Edwards – Padella – O'Connell – Prussi – Scarlat 2020.
[278] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 23-25.
[279] See Malins 2020, p. 8 and Sipilä – Kiuru – Nylund – Sipilä 2020, p. 53.
[280] Chiaramonti – Goumas 2019, p. 10.
[281] See Chiaramonti – Goumas 2019, p. 10.
[282] Malins 2020, p. 6.

promptly provide operators a clear and robust policy framework as timing is crucial especially in terms of successful industrial development.[283]

Recital 89 of RED II further elaborates this by acknowledging that supporting RCFs can contribute to the decarbonisation target of the transport sector provided that the minimum emissions saving threshold, to be introduced by a delegated act, are met. Furthermore, RCFs can contribute by increasing energy diversification in the transport sector. Thus, it is appropriate that these fuels are included in the obligation of fuel suppliers to meet the 14% renewable target. However, the Member States are still given the option not to take these fuels into account. Recital 89 concludes by stating that even though RCFs may be considered towards the policy objectives in the transport sector, they are still not counted towards the overall target on the share of renewable energy in the EU.

Moreover, the fuel suppliers producing RCFs are subject to an obligation to produce fuels from the feedstock listed in Part A of Annex IX to ensure the contribution of advanced biofuels and biogas of at least 3,5% by 2030. Unlike the case with RFNBOs, the Member States may not exclude RCF producers from complying with this requirement.[284] According to my understanding, the purpose behind this requirement is to ensure that the RCF producers still contribute to the renewable energy targets by increasing the share of biofuels and biogas.

4.3.2. Minimum Thresholds and Methodology for Greenhouse Gas Emissions Savings

RED II sets forth minimum thresholds for GHG emissions savings for biofuels, ranging from 50% to 65%, depending on the year the installation has become or becomes operative, to RFNBOs with a requirement of 70%.[285] Article 25(2) foresees the EC to adopt a delegated act establishing a minimum threshold for GHG emissions savings from the use of RCFs by 1 January 2021. The limit should be based on a lifecycle assessment that considers the specificities of each fuel.

Such GHG saving requirement serve at least three roles. First, establishing a threshold can be deployed to control the uncertainty arising the actual net climate impacts resulting

[283] Chiaramonti – Goumas 2019, p. 10.
[284] Article 25(1) of RED II.
[285] Articles 29(10) and 25(2) of RED II.

from the use of alternative fuels as a lifecycle assessment contains several reservations. Second, setting a higher threshold for the required GHG savings allows the indirect consideration of some terms causing emissions that are not included in the lifecycle assessment. Third, the requirement aims at avoiding a situation, where significant investments are made in fuels delivering only modest benefits in terms of emissions reductions. The third role of the emissions savings threshold applies to RCFs similarly as to other alternative fuels. Depending on the structure of the required lifecycle assessment, there should be fewer uncertainties regarding the actual GHG emissions savings compared to biofuels if all significant emissions terms are included in the lifecycle assessment. This could imply that the EC could set the threshold lower for RCFs compared to the requirement for biofuels.[286] Regardless of this, I consider this to be very unlikely as RED II has adopted a much more cautious and critical approach on RCFs compared to biofuels.

As mentioned in chapter 4.2.1., Article 28(5) calls the EC to adopt a delegated act by 31 December 2021 establishing the methodology for assessing GHG emissions savings from RFNBOS and RCFs. Thus, the threshold will be set before the methodology providing the details to be considered in calculating the emissions, potentially causing more uncertainty to the operators.[287] Furthermore, I note that when deciding whether the Member States were to include RCFs into their national legislations, the detailed criteria and requirements considering the GHG emissions reductions are not yet adopted. Therefore, some Member States may postpone this decision causing additional uncertainty to RCF producers and impeding the market development.

4.4. Measures to Support Deployment

Providing equal opportunities allowing competition and providing a sound investment environment based on a predictable regulatory framework is at the heart of the EU's energy regulation policy.[288] The analysis regarding the regulatory framework of hydrogen and CO_2 as well as the treatment of the end products has demonstrated that RED II does not enable the full potential of P2X fuels due to the inflexibility and ambiguity of the regulatory architecture. Although I have identified certain barriers and potential measures

[286] Malins 2020, p. 21.
[287] Chiaramonti – Goumas 2019, p. 10.
[288] ACER – CEER 2019, p. 5.

to address these constraints throughout this thesis, I will pinpoint some additional considerations in this chapter.

I support the revision of RED II as increasing the existing renewable energy targets upwards is necessary to reach the level of ambition set forth by the EGD.[289] Furthermore, the role of RED II should be reassessed to ensure its contribution towards these objectives by appropriately supporting the increase in the share of renewable energy and accelerating the transition towards a more integrated energy system.[290] The necessary level of support for renewable P2X fuels as well as green hydrogen should be assured, taking low-carbon solutions into account particularly in short to medium term.[291] The renewable energy target of 14% in the transport sector should be significantly increased. Moreover, the calculation rules and multipliers should be revised. A level playing field should be established between RFNBOs and biofuels, that are already supported through multipliers. One feasible measure to support a wider uptake of P2X fuels would be to establish a dedicated sub-target for RFNBOs, similar to the one currently in place for advanced biofuels under Article 25(1) of RED II to level the playing field and boost their contribution towards the renewable energy targets.

The possibility to include P2X fuels into the Finnish distribution obligation system has been recently assessed in a report published by the Ministry of Economic Affairs and Employment in September 2020.[292] In Finland, the share of biofuels in road transportation will be gradually increased to 30% by 2030. Furthermore, the target for advanced biofuels will be 10% by 2030. Although RED II allows considering the energy content of biofuels and biogas produced from the feedstock listed in Annex IX twice, the double counting will be phased out in Finland as of 2021.[293]

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289 See Plan/2020/7536.
290 See COM(2020) 299 final.
291 See COM(2020) 301 final.
292 Sipilä – Kiuru – Nylund – Sipilä 2020.
293 Section 5 of the Act on Promoting the Use of Biofuels for Transport 446/2007 (*Laki biopolttoaineiden käytön edistämisestä liikenteessä*, as amended) and Article 27 of RED II. In 2019, the current distribution obligation for biofuels under the Act on Promoting the Use of Biofuels for Transport 446/2007 was amended partially to meet the new requirements of RED II, by, e.g. imposing a distribution obligation for years 2021-2030 and setting an additional obligation for advanced biofuels for the same period. Finland's targets in the transport sector are significantly more ambitious than what is required under RED II. See also Sipilä – Kiuru – Nylund – Sipilä 2020, p. 20, the current biofuel distribution obligation neutral for all gasoline and diesel distributors, where the distributors can achieve the targets by actually bringing more biofuels into road transport. A system building on energy shares is straightforward as all biofuels are considered to account as zero in the transport CO_2 emissions balance. The actual emissions GHG emissions reductions are verified by applying the sustainability criteria, implemented nationally under the Act on Biofuels and Bioliquids 393/2013 (Laki biopolttoaineista ja bionesteistä, as amended).

The impacts of the sustainability criteria and certification requirements on the market entry and competitiveness of RFNBOs can only be thoroughly assessed after the EC has adopted the delegated acts in accordance with Articles 27(3) and 28(5) of RED II. Prior to that, RFNBOs can only be included in the distribution obligation with a trial or an exemption permit, as there are no GHG emissions reduction values determined and no default values are set out in the annexed of RED II. Once sustainability criteria and calculation rules have been established, RFNBOs can be included in the distribution obligation. The certification of the renewability and the possibility to include the fuel under the obligation are the essential elements with this regard. The report concludes that the RFNBOs that are compatible with the existing distribution infrastructure can be included in the current distribution obligation provided that they meet the sustainability criteria. The inclusion of hydrogen in the distribution obligation cannot be further specified at this stage, as hydrogen vehicles, infrastructure and renewable production are still in the early stages of development. On the contrary, all hydrogen in transport is emissions-free, also when used as an intermediate product. Hence, the direct use of hydrogen in transport does not reduce emissions.[294]

RCFs are not classified as renewable fuels, and thus, they are not considered as zero-emissions in transport. Therefore, the inclusion of these fuels in the distribution obligation is not justified, as they do not reduce emissions from road transport. However, depending on the methodology to be specified in a delegated act under Articles 25(2) and 28(5) of RED II, they can achieve relative GHG emissions savings. The need for policy measures arises from the promotion of circular economy instead of the emissions savings to be achieved by utilising renewable energy. If a reduced CO_2 intensity that can be taken into account in national emissions levels is to be created for RCFs through the delegated acts, the eligibility for the distribution obligation will have to be re-examined. In this case, it should be assessed whether the distribution obligation should be changed to a CO_2 based system. The report suggests that inclusion of these fuels in the distribution obligation could be reconsidered in 2025, as the commercialisation of RCFs has taken steps forward, and the regulation at the EU level has become more precise.[295]

[294] Sipilä – Kiuru – Nylund – Sipilä 2020, p. 45-51.
[295] Sipilä – Kiuru – Nylund – Sipilä 2020, p. 52-53, in Finland, RCFs can be proposed to be considered for the 14% minimum requirement for transport sector of RED II, but they are not likely to have a significant impact on Finland's emission reduction targets.

I support the recommendation to include RFNBOs to distribution obligation. My proposition consists of two options. First, the obligation would be made neutral as regards the fuel type. In this case, the suppliers could have the option to fulfil the target share either by supplying biofuels or RFNBOs to transport. This would allow the fuel suppliers to decide on the most appropriate way to operate while still contributing to the renewable targets. In the second option the biofuel distribution obligation would be maintained but a similar requirement would be implemented to RFNBOs. In this case, the fuel suppliers would be required to deliver both biofuels and RFNBOs to the transport. This option would also guarantee a level playing field for both fuel types. Both options would support the deployment of RFNBOs by creating an incentive for wider market uptake and thus supporting investors to make informed investment decisions as these fuels would have demand. Considering RCFs, I recognise the challenges highlighted in the report and support the suggestion to reconsider their inclusion in the distribution obligation once the delegated acts have been adopted. However, I note that if they are not included in the distribution obligation, other measures to facilitate their deployment should be considered.

This thesis has demonstrated that regulating developing technologies can appear as a two-edged sword, especially in the energy sector. On the one hand, regulation is required to guarantee the achievement of renewable energy and emissions reduction targets, but at the same time, strict and restrictive rules can stifle innovation.[296] The EGD emphasises the role of innovation, new technologies and climate neutral solutions in the trajectory towards the decarbonisation objectives.[297] Regulators and stakeholders recognise the need to remove unnecessary barriers to allow pilot projects, especially first of a kind and small-scale pilots, to develop before the legislative changes take place.[298]

Innovation-friendly regulatory approaches and procedures are gaining increasing attention. Innovation-friendly regulation facilitates the development and adoption of new innovations. The aim is to integrate such an approach to all features of regulation from innovation-friendly agenda setting to regulatory processes and implementation practices. In terms of regulatory processes, engaging a wide range of stakeholders would support integrating the innovation perspective and preparing flexible and technology neutral legislation. Innovation-friendly implementation practices can be achieved, for instance,

[296] Mete – Reins 2020.
[297] COM(2019) 640 final.
[298] ACER – CEER 2019, p. 17.

through regulatory sandboxes.[299] A regulatory sandbox refers to a safe testing environment, allowing innovators to experiment with new technologies and business models that may not be fully compatible with the existing regulatory framework. Furthermore, they enable regulators to harness new perspectives and instruments that could be utilised when developing a regulatory environment to accommodate them.[300]

A number of Member States are currently testing different types of sandbox models in the energy sector that enable minor derogations from existing legislation.[301] Thus, a need for an EU-wide umbrella for regulatory sandboxes should be assessed.[302] A more cohesive approach could accelerate the decisions on required legislative changes and avoid replicating similar pilots in each Member State.[303] EGD predicts major changes in the energy sector, focusing on innovative clean tools especially as regards hydrogen and processes facilitating sector integration.[304] There is an urgent need for a regulatory environment that allows for experimenting with new and emerging technological solutions and business models. I note that this would be an optimal time to assess the suitability of such regulatory processes further at the EU level, as it could also facilitate P2X related technologies to develop. Furthermore, such an innovation-friendly approach should be adopted when transposing RED II into national legislation.

Lastly, the ETS should undergo a revision to ensure its efficient contribution to the climate objectives.[305] An effective and extended ETS would eventually make fossil-based energy production unprofitable by increasing the prices of emissions allowances. Instead of posing significant barriers to new renewable and low-carbon technological solutions through strict regulation, the carbon price should robustly steer market behaviour towards a low-carbon economy.[306]

To conclude, this evaluation shows that the regulatory choices of RED II impose significant shortcomings on RFNBOs and RCFs that will have a negative impact on the feasi-

[299] Salminen – Halme 2019, p. 1 and 5.
[300] Schittekatte 2020.
[301] ACER – CEER 2019, p. 17.
[302] At the EU level, there are already programs in place to facilitate regulatory fitness and performance. See e.g. European Commission, REFIT.
[303] ACER – CEER 2019, p. 17.
[304] COM(2020) 301 final and COM(2020) 299 final.
[305] COM(2019) 640 final, p. 11.
[306] See e.g. COM(2020) 562, p. 12-16.

bility of such projects. These shortcomings, including incomplete and ambiguous regulatory framework, challenging requirements concerning demonstrating the origin of the electricity as well as unfavourable calculating rules confine the equal opportunities of P2X fuels compared to other competing alternatives. Therefore, the regulatory framework of P2X fuels should be enhanced to offer a robust and supporting environment triggering the required investments and enabling their market uptake in large-scale.

5. Power-to-X Joutseno Pilot Plant

In this chapter, I apply the findings made throughout this thesis in practice by assessing the regulatory treatment of the P2X Joutseno pilot plant. I emphasize that the preliminary conclusions reached regarding the P2X Joutseno project are based on my current understanding of RED II before the details of the regulatory framework are published at the EU level through the delegated acts. Furthermore, this assessment does not take into account the implementation decisions to be made in Finland when transposing the provisions and requirements of RED II into national legislation.

In December 2019, LUT University and a group of companies launched a feasibility study for an industrial scale synthetic fuels pilot plant. The fuel production process would be based on P2X technology with the aim to produce carbon-neutral fuels for the transport sector. The production process is illustrated in Figure 1. The P2X Joutseno pilot plant would use excess hydrogen from Kemira's chlorate production produced through electrolysis utilising electricity from the grid. Currently, this excess hydrogen is released to the atmosphere as it has no other use. Furthermore, additional hydrogen would potentially be produced by utilising water electrolysis. The electricity used for this process would be derived from the grid. CO_2 would be captured from Finnsementti's facility and purified at the site. These raw materials would be combined to produce synthetic methanol, which would be further processed into gasoline, diesel and kerosene.

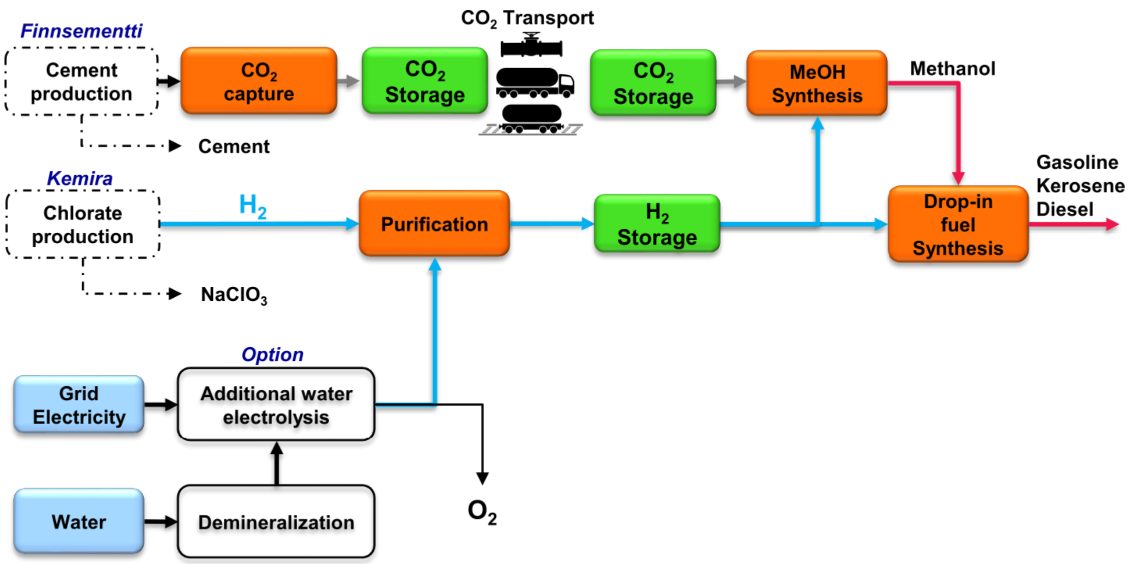

Figure 1 P2X Joutseno process, adapted from Gas Industry Transition 2020, p. 25.

Hydrogen Derived from Industrial Processes

The origin of the energy and the characteristics of the production process will define whether the hydrogen will fall under the definition of RFNBO or RCF. First, narrowing down the focus to the hydrogen obtained from Kemira's chlorate production, it can be concluded that the energy content of the hydrogen is currently not derived from renewable origin and thus, the definition of RFNBO would not apply.[307] However, as hydrogen is an exhaust gas of non-renewable origin produced as an unavoidable and unintentional consequence of the chlorate production process in Kemira's industrial installation, the fuel produced from such hydrogen could be covered by the category of RCF.[308]

The definitions of RFNBOs and RCFs in RED II and the examples provided by the EC[309] do not offer clear interpretation guidelines for circumstances where both categories could in principle apply. Hence, it is unclear whether the fuel would qualify as RFNBO if renewable electricity, fulfilling the requirements set forth for RFNBOs, would be used in Kemira's processes and the required emissions savings threshold would be met, as the hydrogen would still be an unavoidable and unintentional consequence of the industrial chlorate production process. However, the EC is expected to provide further guidance regarding borderline cases in the delegated acts to be adopted during the course of 2021.

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[307] Article 2(36) of RED II.
[308] Article 2(35) of RED II.
[309] Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 5-9.

The regulatory framework of RCFs is currently incomplete and subject to further decisions and details concerning the essential provisions. The level of support they will receive in the context of RED II depends on whether the Member States, in this case, Finland, decides to take RCFs into account when calculating the minimum share of renewable energy used in the transport sector. If RCFs are decided to be left out, they will not receive any additional support compared to the use of conventional fossil fuels in this regard. On the other hand, even if RCFs would be included in the obligation of fuel suppliers to meet the 14% renewable target, they would still not be counted towards the overall target of 32% on the share of renewable energy in the EU. Furthermore, the RCF suppliers are subject to the obligation to produce advanced biofuels and biogas to contribute to increasing the share of renewables in the transport sector.[310] RED II foresees the EC to adopt a delegated act by 1 January 2021 establishing the minimum threshold for GHG emissions savings of RCFs through a lifecycle assessment considering the specificities of each fuel.[311] The methodology for assessing these GHG emissions savings resulting from the use of RCFs and RFNBOs will be introduced by another delegated act introduced by 31 December 2021.

Requirements for Renewable Electricity

Fuels derived from the additional hydrogen produced separately from Kemira's chlorate production through water electrolysis could potentially be classified under the definition of RFNBOs, depending on the origin of the electricity used for electrolysis. According to the current considerations, the electricity would be derived from the grid. The baseline requirement is that the GHG emissions savings resulting from the use of RFNBOs should be at least 70%.[312] Under the first option, the average share of the renewable electricity in Finland is used when determining the share of renewable electricity used for the production of RFNBOs, measured two years before the production year in question. However, this option does not reach the required 70% threshold with the recent average renewable energy shares.[313] The second option allows the grid electricity to be counted as fully renewable if it is produced exclusively from renewable sources. This requires

[310] Article 25(1) and Recital 89 of RED II.
[311] Articles 25(2) and 28(5) of RED II.
[312] Article 25(2) of RED II. See also Edwards – Padella – O'Connell – Prussi – Scarlat 2020, p. 6, in case if the energy content of a fuel is built on a mixture of renewable and non-renewable sources, only the share that attributed to renewable sources is considered as RFNBO when determining the RFNBO fraction of the fuel.
[313] See Tilastokeskus for data on the renewable energy shares in Finland.

demonstrating the renewable properties and other appropriate criteria of the given electricity. With this regard, RED II calls the EC to adopt a delegated act by 31 December 2021 establishing a methodology and detailed rules for the operators to comply with.[314]

Compared to RCFs, RED II provides a higher level of support for RFNBOs. The Member States are obliged to take RFNBOs into account when calculating the share of renewable energy in the transport sector. Furthermore, the Member States may exempt RFNBO producers from the requirement to produce advanced biofuels and biogas. Besides the renewable target in the transport sector, RFNBOs are also considered towards the share of renewable energy in the EU's gross final consumption.[315]

Source of CO_2

RED II does not restrict the source of CO_2 used in the P2X fuel production. Thus, capturing the fossil-derived CO_2 from Finnsementti's industrial operations is feasible. The methodology regarding the GHG emissions savings from RCFs and RFNBOs, to be adopted by the EC by 31 December 2021, ensures that CO_2 capture that has already received an emission credit under any provision of law is not credited for the second time in the context of RED II.[316] The credit for avoided emissions is either considered towards the ETS or RED II.

Conclusions

Taken together, there are certain regulatory uncertainties with both fuel types that are still to be clarified. At this point, this assessment suggests that the regulatory framework of the P2X fuels deploying the excess hydrogen derived from Kemira's chlorate production would not receive much support, if any, in the context of RED II. P2X fuels building on additional hydrogen production would be treated more favourably, provided that renewable electricity would be used and requirements set forth for RFNBOs would be met. However, under certain circumstances, derogations from regulation may be authorised for the purposes of testing and using new technology. This would allow piloting novel

[314] Article 27(3) or RED II see also Recital 90 of RED II. GOs and PPAs could possibly be deployed for demonstration purposes, although the existing systems and contract models could require certain adjustments to meet the requirements set forth in RED II. If the renewable properties and other appropriate criteria are not demonstrated and/or if the 70% threshold is not met, the fuel is treated similar to conventional fossil fuels in this context.

[315] Articles 25(1) and 7 of RED II.

[316] Article 28(5) of RED II.

technologies within more lenient regulatory constraints. The eligibility for such derogations would be a significant opportunity for the P2X Joutseno pilot plant, and thus, this possibility should be examined further.

Considering future developments, the delegated acts to be adopted during 2021 will provide detailed rules for the operators to comply with and consequently a clearer picture of the regulatory treatment of P2X fuels. Moreover, some of the delegated acts may include a certain level of flexibility for the short term in order to prevent the requirements from stalling the scale-up of P2X fuels, especially with regard to RFNBOs.[317] RED II offers the Member States some room for manoeuvre to implement a more favourable framework on P2X fuels as long as the minimum requirements are met. Furthermore, outside of the scope of this thesis, the issues relating to taxation and financing should also be taken into account as they will have an impact on the profitability of these fuels.

RED II will most likely undergo major changes in the near future due to the ongoing revision process commenced by the EC under the EGD. The revision process aims to ensure that the instruments in the EU's energy policy are fit-for-purpose and contribute to the utilisation of renewable sources.[318] The extent of the required revision is indicated in the 2030 Climate Target Plan and in the Energy System Integration and Hydrogen strategies, which both recognise the need to remove barriers and facilitate the deployment of renewable and low-carbon fuels, particularly hydrogen-based solutions.[319] Therefore, it may be expected that the revision of RED II would result in a higher level of support concerning the P2X fuel production.

6. Concluding Remarks

In this thesis I have tested the hypothesis stating that RED II does not enable the full potential of P2X fuels in the transport sector and limits their possibilities for a level playing field. Even though RED II recognises P2X fuels, this hypothesis has proved to be accurate as RED II seems to lack the ability to adapt evolving technological innovations and increasing demand for renewable and low-carbon transport fuels. Although I acknowledge that the details of RED II are still to be introduced by the delegated acts, the

[317] Discussed in chapter 4.2.2. See Klessmann – Wietschel – Schröder – Wachsmuth 2020, p. 46.
[318] Plan/2020/7536. For more information, visit European Commission, EU renewable energy rules – review.
[319] See COM(2020) 562 final, COM(2020) 299 final and COM(2020) 301 final.

regulatory architecture and particular requirements seem to take an overly critical approach towards RCFs and RFNBOs by establishing safeguards and that will negatively impact on their development. Due to these barriers, operators lack the encouragement to invest in P2X technologies compared to other competing pathways. The deficiencies undermining the appropriate incentives to RFNBOs and RCFs need to be thoroughly addressed to provide adequate regulatory certainty to support the large-scale introduction of P2X fuels.

In the near future, RED II will probably be subject to changes due to the ongoing revision process initiated under the EGD. As a result, the renewable energy targets will likely be increased to step to the trajectory towards the more ambitious emissions reduction objectives set forth in the EGD and the 2030 Climate Target Plan. Hence, it is of essential importance to improve the regulatory framework to include appropriate incentives to promote a larger role for P2X fuels in the 2030 timeframe. In the best-case scenario, the ongoing revision will lead to clear and robust rules providing necessary support particularly for hydrogen derived renewable and low-carbon solutions in the transport sector. The EDG and the relevant strategies recognise the apparent need for P2X fuels and their technological development. Hence, the regulatory environment should reflect the demand.

The research question guiding this thesis was to identify what are the implications of RED II on P2X fuels. For this purpose, I defined three additional research questions to test the accuracy of the hypothesis: 1) How RED II regulates the raw materials used for the production of P2X fuels? 2) Under which definitions P2X fuels fall in RED II and how are they treated in RED II? 3) What are the main regulatory challenges for P2X fuels and what measures are required either on the EU or national level to facilitate their deployment further? Before diving into these research questions, I provided an overview of P2X fuels and introduced RED II to allow these questions to be thoroughly assessed.

To answer the first research question, I evaluated how RED II stipulates hydrogen and CO_2 used as raw materials in the P2X process. Even though RED II stipulates hydrogen e.g. explicitly in the context of GOs and implicitly as regards the P2X fuels, it did not seize the opportunity to provide a comprehensive taxonomy for green and low-carbon hydrogen. To establish a supportive framework, an EU-wide, clear and robust taxonomy and certification criteria for hydrogen should be adopted as the treatment of several hydrogen-based technologies are building on these definitions. The taxonomy will have a direct connection to the interpretation of RED II, and thus, it will indicate the hydrogen producers the level of support they can expect in terms of contributing towards the renewable energy targets. I underline that although the regulatory framework should be precise enough, it should adopt a flexible and forward-looking approach not only to allow but also support technological development.

Considering the possibilities to verify the origin of hydrogen, RED II extends the current GO system to cover renewable gases, including hydrogen and recommends the Member States to consider including energy from non-renewable sources. Although this was a step forward, RED II also establishes certain limitations. Therefore, the GO system as regards hydrogen could be enhanced to contribute to the renewable energy targets cost-effectively, promote better sector integration and facilitate harmonised standardisation. Potential measures to enable scaling up the hydrogen economy could be making the GO system statutory for all energy carriers, broadening the definition of GOs to serve also other purposes than disclosing customers and extending the applicability to suppliers, large consumers and distributors. Nevertheless, the possibilities to enhance the system should be assessed in cooperation with the stakeholders to attain the most appropriate outcome for the parties involved.

RED II narrows down the focus on the renewability of the energy supply in the P2X production process, instead of restricting the source of CO_2. Utilising industrial point sources is justified with the current stage of technological development and energy transition, as the direct air capture requires significantly more energy and increases costs for the P2X projects. Moreover, a legitimate concern regarding double counting of the emissions savings in the ETS and RED II has been identified. A stronger link and consistency between them should be established to allow appropriate accounting of CO_2 emissions reductions. Outside the scope of RED II, a suitable regulatory framework needs to be introduced for CCU as the current legislation mostly recognises only CCS solutions. Overall, these findings demonstrate that the regulatory framework set forth for hydrogen and CO_2 is still incomplete and therefore, further measures and decisions are required to provide a regulatory environment that facilitates the exploitation of these raw materials for the production of P2X fuels.

To answer the second research question, I evaluated the treatment of P2X fuels in RED II. At this point, the main challenges are the incompleteness of their regulatory framework and the barriers imposed on deployment of these fuels. Although RED II requires the Member States to take RFNBOs into account towards the overall EU renewable energy targets as well as the sub-target in the transport sector, it does not offer equal backing compared to biofuels, which are supported by means of a dedicated quota and multipliers as regards the calculation rules. Furthermore, the accounting rules concerning the share of renewable electricity used for RFNBO production create a significant burden for the producers. Particularly, the requirements set forth to demonstrate the renewability and additionality of the grid electricity used in the RFNBO production appear challenging. Thus, fit-for-purpose rules with a certain level of flexibility should be adopted in the delegated acts.

RED II takes a more critical approach to RCFs. As they are not renewable by the origin, they are not counted towards the overall target on the share of renewable energy in the EU. The Member States are left with discretion to decide whether to consider RCFs towards the renewable energy sub-target in the transport sector, as they contribute to the decarbonisation objectives and increase the energy diversification. However, the main issues, i.e. the threshold for the required emissions savings and the methodology for assessing these savings, determining the detailed regulatory framework for RCFs are still subject to further clarification to be introduced by two separate delegated acts. Altogether, these issues and uncertainties inevitably raise concerns as to the feasibility of the RFNBO and RCF projects. The current regulatory treatment of P2X fuels in RED II reduce their attractiveness in the eyes of potential investors and thus, hampers their development and market uptake.

The answer to the third research question was discussed throughout the thesis. In addition to the main regulatory challenges identified above, the measures I proposed focused on improvements supporting the deployment of P2X fuels by removing barriers and establishing equal opportunities between various competing pathways. Establishing a dedicated sub-target for P2X fuels, revising the current multipliers and providing for a certain level of flexibility considering the most restrictive requirements would serve these purposes. Furthermore, extending the Finnish distribution obligation to cover RFNBOs is essential to create demand for these fuels. Inclusion of RCFs should be reconsidered once the delegated acts have been adopted. However, I note that if RCFs are not included in the distribution obligation, other measures or amending the system to CO_2 based should be considered to promote their deployment.

Furthermore, I argue that instead of establishing overly restrictive requirements on renewable and low-carbon technologies, a higher carbon price and hence, a well-functioning ETS would be more efficient tool to steer market behaviour towards a low-carbon economy. This would allow adopting a more technology-neutral approach to achieve renewable energy and climate objectives. Lastly, innovation-friendly regulatory practices and processes should be employed to address the issue of inflexibility of the EU regulatory architecture. These types of processes could facilitate the development of P2X related technologies in the EU as they would enhance the communication between the stakeholders and legislators and thus, improve the functionality regulations. Moreover, such an innovation-friendly approach should be adopted when transposing provisions of RED II into national legislation. Overall, the implications of the measures to be adopted should be carefully scrutinised to avoid replicating the current flaws in the future.

The assessment of the regulatory treatment of the P2X Joutseno pilot plant suggests that the current regulatory framework provided by RED II is not very supportive at this stage. Based on my research and interpretation, the P2X fuel utilising the excess hydrogen from Kemira's chlorate production would currently fall under the category of RCFs, and therefore, would not receive much support in the context of RED II. P2X fuels derived from water electrolysis of additional hydrogen production would be treated more favourably provided that renewable grid electricity would be used. If the renewable properties and other appropriate criteria could be demonstrated, the fuel would qualify as RFNBO. However, derogations from regulation may be authorised for the purposes of testing and using new technology in certain situations. The eligibility for such derogations would be a major opportunity for the P2X Joutseno pilot plant, and thus, this possibility should be further investigated. Although the regulatory environment does seem to create certain hindrances at the moment, I note that the revision of RED II would probably address these barriers at some level and provide more support for P2X fuels.

Overall, the regulatory aspects of the P2X fuels have not been widely explored in legal literature, although a discussion around the topic has rapidly increased during the recent years. In addition to somewhat limited research material, the main constraint faced by this thesis was the incomplete regulatory framework. As RED II foresees the delegated acts to adopt detailed methodology concerning many key aspects of the provisions on RFNBOs and RCFs, the analysis is left only to rely on the current state of the regulation. However, my thesis has an important role in identifying the regulatory issues of P2X fuels in the context of RED II at this stage and in opening the floor for further discussion on the required improvements. This thesis offers a starting point for future research by indicating various issues where further research is needed. Moreover, as RED II and the EU's energy policy are undergoing a reform, the placement of P2X fuels in the regulatory environment should be closely followed.

The final conclusion of this thesis is that despite the apparent potential of P2X fuels, RED II has not been able to provide adequate incentives and a level playing field for them. Nevertheless, I remain optimistic that the revision of RED II will succeed in tackling the most significant barriers and recognise the ability of P2X fuels to contribute to the renewable energy targets and from a broader perspective, to achieving the decarbonisation objectives.