Défense Terre

Leveling the Playing Field for Novel Fuel Technologies

Toward a Low-Carbon Fuel Policy Based on Performance

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PREFACE

In December 2015, world leaders agreed a new deal for tackling the risks of climate change. Countries will now need to develop strategies for meeting their commitments under the Paris Agreement, largely via efforts to limit deforestation and to reduce the carbon intensity of their economies. In Europe, these climate protection strategies will be developed via the EU's 2030 climate and energy framework, with a view to ensuring an integrated single market for emissions reduction technologies.

Existing EU energy policy for 2020 foresees an important role for bioenergy as a means of reducing carbon emissions from heating, power and transport, and yet there are concerns that this has led to a number of negative consequences related to the intensification of resource-use. If bioenergy is to continue to play a role in EU energy strategies for 2030, it seems wise to learn from the past to ensure that this is done in a manner that is consistent with the EU's environmental goals, including the 2 degrees objective.

With this in mind, the European Climate Foundation (ECF) has convened the *BioFrontiers* platform, bringing together stakeholders from industry and civil society to explore the conditions and boundaries under which supply-chains for advanced biofuels for transport might be developed in a sustainable manner. This builds on work developed in the ECF's *Wasted* platform in 2013-2014, which focused on waste- and residue-based feedstocks for advanced biofuels. This time around, there is an additional focus on considering land-using feedstocks and novel fuel technologies.

As the name *BioFrontiers* suggests, this discussion enters new territory and is faced with numerous gaps in knowledge. To facilitate a transparent and constructive debate between industry and civil society, the ECF has commissioned a number of studies to help fill such knowledge gaps. This is one such study. It does not represent the views of the members of the *BioFrontiers* platform, merely an input to their discussions. If this research also helps inform the wider debate on the sustainability of bioenergy, that is a bonus. I would like to thank Défense Terre for using the resources provided by the ECF to improve our understanding of these important issues.

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EXECUTIVE SUMMARY

Leveling the Playing Field for Novel Fuel Technologies: Toward a Low-Carbon Fuel Policy Based on Performance analyzes the regulatory treatment of thirteen novel fuel technologies or "NFTs" in the European Union and United States. The term "NFT" refers to transportation fuels that are produced using innovative processes and nontraditional feedstocks, in particular feedstocks that may result in these fuels falling outside legislative definitions of renewability. The NFTs considered fall into four categories: power-to-liquids; sunlight-to-liquids; bacterial conversion; and non-biological waste-to-energy. This report does not undertake an analysis of the comparative environmental performance of these technologies, but it is recognized that NFTs as a group show great potential to deliver greenhouse gas emissions reductions in the transport fuel sector.

The regulatory frameworks analyzed in this report include the Renewable Energy and Fuel Quality Directives in the European Union, the Renewable Transport Fuel Obligation in the United Kingdom, the Federal Imission Control Act in Germany, the Renewable Fuel Standard in the United States and the Low-Carbon Fuel Standard in California. The analysis provides the basis for recommendations on designing a regulatory framework for NFTs.

The report concludes that the uneven treatment of NFTs in regulatory frameworks can be addressed by moving toward a low-carbon fuel policy based directly on environmental performance. This could be in the form of a low-carbon fuel policy that promotes low-carbon fuels through eligibility criteria and levels of incentivizes that are based, at least in part, on carbon intensity. This is a departure from the historical focus by policymakers on proxy characteristics such as renewability. Given the lack of a universal definition of renewability, however, and the fact renewability does not always guarantee carbon savings, as is often the case with biofuels that cause indirect land-use changes, NFTs are better promoted on a level playing field where carbon intensity is the predominant consideration. Although there may be risks associated with large-scale development of NFTs, in general these risks can be managed.

Thus it is recommended that a low-carbon fuel policy be advanced to accommodate NFTs that has the following four key elements:

- Intermediate and Final Targets
- Process for Accommodating New Pathways
- Comprehensive Greenhouse Gas Accounting
- Safeguards to Mitigate Risks

Examples are provided throughout the report on how these elements are achieved in practice under the existing regulatory frameworks reviewed.

INTRODUCTION TO NOVEL FUEL TECHNOLOGIES

The transportation sector is currently grappling with strategies to reduce its greenhouse gas (GHG) emissions. It is well-accepted that a transition is required, one that weans this sector off fossil fuels and unsustainable biofuels, in particular those that result in large indirect emissions or unacceptable impacts on food security. Into this debate have entered novel fuel technologies (NFTs), a series of innovative approaches toward producing fuels—many of which have the potential to achieve significantly lower carbon intensities than fossil fuels. Unlocking these technologies, if done correctly, could prove to be a valuable part of the solution.

To date, NFTs have received uneven treatment in regulatory frameworks designed to promote low-carbon and renewable fuels. Although many have the potential to achieve significant carbon savings, those carbon savings are not always incentivized or even considered under existing regulatory frameworks. A primary challenge with NFTs is that they vary widely in their inputs and approaches to fuel production. For example, many NFTs fall outside traditional concepts of renewability, i.e. capable of being used without depletion or replaced with natural regeneration within a "short" timespan, and as a result are not considered renewable. In addition, the energy used for their production can vary widely, from being fully renewable (e.g. solar, wind, geothermal) to being partially renewable (e.g. grid), low-carbon (e.g. nuclear) or nonrenewable (e.g. fossil). Because of this, NFTs often do not fit neatly within the regulatory boxes that have been developed primarily to promote biofuels. There is also the possibility that some NFTs may be unsuitable for use on a commercial scale on public policy grounds, for instance if the production of novel fuels causes significant indirect emissions.

This report does not purport to provide an exhaustive review of NFTs and how they fit within various regulatory frameworks. Rather, the selection of NFTs and regulatory frameworks are intended to be instructive in order to help draw recommendations on future regulatory frameworks going forward. This report builds on and is indebted to a previous analysis of this question undertaken in the specific regulatory context of the United Kingdom (UK).[1] In the table below, based largely on that analysis, different companies and NFTs are presented based on our understanding of their respective inputs and processes and any differences would result in different conclusions.

Example Company	Fuel Output	Carbon Source	Hydrogen Source	Energy Source	Carbon-Hydrogen Release	Synthesis Process
Power-to-Liquid: Technologies that use electrical energy to break down water and carbon-dioxide (CO_2) into a combination of carbon-monoxide (CO) and hydrogen, which is then synthesized into fuels through different processes.						
Air Fuel Synthesis and **Carbon Recycling International**	Methanol	Captured CO_2	H_2O	Electricity (Grid)	Electrolysis of H_2O	Catalytic Synthesis
Audi E-Gas	Methane and Hydrogen	Captured CO_2	H_2O	Electricity (Grid)	Electrolysis of H_2O	Methanation
ITM Power-to-Gas	Methane and Hydrogen	Captured CO_2	H_2O	Electricity (Grid)	Electrolysis of H_2O	Methanation
Dioxide Materials and **Sunfire**	Synthetic Petrol/Diesel	Captured CO_2	H_2O	Electricity (Grid)	Electrolysis of CO_2	Fischer Tropsch
Sunlight-to-Liquid: Technologies that use solar energy to break down water and CO_2 into a combination of CO and hydrogen, which is then synthesized into fuels through different processes.						
Sandia National Laboratories	Ethanol and Methanol	Captured CO_2	H_2O	Concentrated Sunlight	Solar Breakdown	Catalytic Synthesis

Solar Jet	Kerosene	Captured CO_2	H_2O	Concentrated Sunlight	Solar Breakdown	Fischer Tropsch
Bacterial Conversion: Technologies that feed CO from point sources to bacteria that then excrete ethanol through a gas fermentation process and technologies that circulate CO_2 through an aqueous mix of nutrients and biocatalysts which continuously produce fuel molecules.						
LanzaTech	Ethanol	Captured CO	H_2O	Industrial Gas	N/A	Gas Fermentation
Joule / Audi	Ethanol and Synthetic Diesel	Captured CO_2	H_2O	Sunlight	CO_2 Fed to Cyano-bacteria	Bio-Catalysis
Non-Biological Waste-to-Energy: Technologies that recover energy from non-biological landfill material (e.g. plastics, tires, synthetic rubber) through conversion technologies (e.g. pyrolysis).						
Cynar and **Vadxx**	Synthetic Diesel and Kerosene	Plastics (Non-Recyclable)	Plastics (Non-Recyclable)	Synthetic Materials	Thermal Breakdown	Pyrolysis
Pyreco	Kerosene	Waste Tires	Waste Tires	Synthetic Materials	Thermal Breakdown	Pyrolysis
Velocys	Synthetic Petrol/Diesel	Plastics (MSW)	Plastics (MSW)	Synthetic Materials	Thermal Breakdown	Fischer Tropsch

Note: The categorization of bacteria as performing either an autotrophic or heterotrophic biological process is an important distinction that impacts how the fuels derived from the bacteria are sometimes treated under existing regulatory frameworks. Bacteria performing autotrophic biological processes (hereinafter referred to as "autotrophic bacteria") make chemical transformations, predominantly photosynthesis, using ambient energy absorbed from the environment, i.e. sunlight. In this instance, the autotrophic bacteria itself provides energy content to the resultant fuel by photosynthesizing sunlight. Bacteria performing heterotrophic biological processes (hereinafter referred to as "heterotrophic bacteria") make chemical transformations using the energy from substances that are ingested, such as carbon monoxide (CO) from an industrial waste gas, serving more in the role of process agent than feedstock. In the case of Lanzatech, the heterotrophic bacteria does not actually provide the carbon and energy content to the resultant fuel, but instead processes and transforms the carbon and energy from an industrial source.

Note: Captured carbon dioxide (CO_2) refers to both atmospheric and point sources.

Note: Energy source is obviously an important factor for determining whether the fuel is renewable and calculating its carbon intensity. But it is not always a straight-forward exercise to determine whether the energy source is renewable. Indeed, some power-to-liquid NFTs currently source their energy from the grid, which tends to be dominated by energy sources of fossil or nuclear origin. Different approaches have therefore been crafted to determine what portion of the fuels can be considered renewable when their energy is from the grid. For example, in the European Union (EU), fuels using energy from the grid can only count as renewable the portion that corresponds to the portion of renewable energy in the grid itself (based on either EU or national statistics). The Commission may present, by the end of 2017, a proposal allowing the whole of the electricity used to be counted as renewable, for instance in cases where the fuel is produced from renewable energy that has no grid connection, such as a stand-alone renewable energy power plants.

CHAPTER 1: LEGAL FRAMEWORKS IN EUROPE

EUROPEAN UNION – RENEWABLE ENERGY DIRECTIVE

The Renewable Energy Directive (RED), adopted in 2009, establishes "a common framework for the promotion of energy from renewable sources."[2] RED sets out volume renewable-energy targets to be met by EU Member States.[3] In the transportation sector, RED requires 10% of energy to be from renewable sources by 2020 (hereinafter "10% volume target").[4] Renewable sources are defined as "wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases."[5] For purposes of RED, fuels (or portions thereof) are considered either renewable or not.

Not long after RED's adoption, Member States submitted their National Renewable Energy Action Plans (NREAPs) indicating that the 10% volume target would be met primarily through food- and land-based biofuels.[6] However, following concerns that some first generation biofuels may have poor environmental performance and could exert undue pressure on food markets, the European Parliament and Council of the European Union reached agreement on amendments that put an increased emphasis on non-land-using biofuels for RED compliance. The amendments introduce, *inter alia*, measures to limit the contribution of food- and land-based biofuels at 7% while setting out additional measures to promote new types of renewable fuels.

I. Overview of Legal and Regulatory Framework

In RED, fuels other than those from fossil sources can be placed into two main categories: renewable and nonrenewable. Whether a fuel is renewable or not depends on whether its energy content is renewable.[7] The renewability of the energy content is determined by the renewability of the source energy that ends up embodied within the fuel and serves as the basis for accounting the contribution from that fuel.[8] For the purposes of setting incentive levels, some fuels are treated as having 2 to 5 times their actual energy content through the use of multipliers.[9] In addition, for biofuels, there is the additional requirement that the fuel meet certain sustainability criteria.

A. Renewable Fuels

Renewable fuels are those that count toward the 10% volume target. Renewable fuels can be further divided into two subcategories: criteria-compliant biofuels and renewable non-biofuels.

- ***Criteria-Compliant Biofuels***: Criteria-compliant biofuels are any "liquid or gaseous fuel for transport produced from biomass" that meet the sustainability criteria in RED.[10] To be produced from biomass means, in effect, that the energy content of the fuel derives from biomass as a renewable energy source. Biomass is defined as "the biodegradable fraction of products, wastes and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste."[11] This includes autotrophic bacteria when used as a feedstock, if the energy source is renewable. RED also defines "wastes," "processing residue" and "agricultural, aquaculture, fisheries and forestry residues" as follows:[12]

    - "Waste" means "any substance or object which the holder discards or intends or is required to discard." "[S]ubstances that have been intentionally modified or contaminated to meet that definition are not covered by this definition."[13]

    - "Processing residue" means "a substance that is not the end product(s) that a production process directly seeks to produce; it is not a primary aim of the production process and the process has not been deliberately modified to produce it."[14]

- "Agricultural, aquaculture, fisheries and forestry residues" means "residues that are directly generated by agriculture, aquaculture, fisheries and forestry; they do not include residues from related industries or processing."[15]

Although criteria-compliant biofuels are eligible for financial support,[16] the *contribution* from "cereal and other starch-rich crops, sugars and oil crops and crops grown as main crops primarily for energy purposes on agricultural land" toward the 10% target is capped at 7% of the final consumption of energy in transport in Member States in 2020.[17] Some criteria-compliant biofuels—mostly the so-called "second-generation" biofuels derived from wastes and residues—are further incentivized through the use of multipliers.[18]

Note: For purposes of determining compliance with the GHG savings requirement—an important sustainability criterion that must be met by all biofuels in order to be considered criteria-compliant[19]—default values for lifecycle GHG intensities are provided for most types of biofuels.[20] The Commission is also empowered to adopt delegated acts setting out additional default values for biofuels for which no default value has yet been provided.[21] In addition, regardless of whether a default value is provided or not, actual values may be calculated based on calculation methodologies provided in RED.[22]

- ***Renewable Non-Biofuels***: Renewable non-biofuels are, as their name implies, renewable fuels that are not considered biofuels, namely: (i) renewable liquid and gaseous transport fuels of non-biological origin, defined as "gaseous or liquid fuels other than biofuels whose energy content comes from renewable energy sources other than biomass, which are used in transport";[23] and (ii) carbon capture and utilization for transport purposes, if the energy source is renewable.[24] Renewable non-biofuels are not required to meet the sustainability criteria for biofuels,[25] and may be counted toward the 10% volume target and provided with financial support.[26] Renewable non-biofuels are further incentivized through the use of multipliers.[27]

  Note: Point and atmospheric sources of CO_2 are not considered biomass.[28] Moreover, when CO_2 is used as the carbon source it does not contribute to the energy content of the fuel.[29] This is because CO_2 has a lower heating value of zero and cannot be oxidized further.[30] The renewability of technologies to capture CO_2 and use it as an input for a fuel production process is therefore determined solely by the origin of the energy used, not the origin of the CO_2.[31]

B. Nonrenewable Fuels

Nonrenewable fuels are those that do not count toward the 10% volume target. Nonrenewable fuels can be divided into two subcategories: noncompliant biofuels and nonrenewable non-biofuels.

- ***Noncompliant Biofuels***: Noncompliant biofuels are any "liquid or gaseous fuel for transport produced from biomass" that do not meet the sustainability criteria in RED.[32] Noncompliant biofuels are, for regulatory purposes, nonrenewable and cannot be counted toward the 10% target or provided with financial support.[33]

- ***Nonrenewable Non-Biofuels***. These are fuels that are not produced from biomass and whose energy content is not from a renewable source, e.g. fuels derived from the thermal breakdown of waste tires or plastics. Nonrenewable non-biofuels cannot be counted toward the 10% target.[34] Because nonrenewable non-biofuels are not considered biofuels, nothing in RED limits their ability to receive financial support from EU Member States. But, in general, EU Member States have not provided any significant support to nonrenewable non-biofuels because to do so would divert scarce resources toward fuels that cannot be used to meet the 10% volume target, which poses a unique challenge to those NFTs considered as nonrenewable non-biofuels under RED (*see* Chapter 3.II.A).

II. Analysis of Novel Fuel Technologies

Currently under RED, power-to-liquid technologies may be considered a partially renewable non-biofuel. RED lists “renewable liquid and gaseous transport fuels of non-biological origin” and “carbon capture and utilization for transport purposes” as renewable sources so long as the energy source is renewable. For the case of power-to-liquids, RED states that “for the calculation of the contribution from electricity produced from renewable sources and consumed… for the production of renewable liquid and gaseous transport fuels of non-biological origin… Member States may choose to use either the average share of electricity from renewable energy sources in the Union or the share of electricity from renewable energy sources in their own country.”[35] The energy in renewable liquid and gaseous transport fuels of non-biological origin produced from electricity may therefore not currently be counted as fully renewable, even if the electricity itself is directly from fully renewable power generation. There is a requirement on the Commission to consider presenting a proposal by the end of 2017 “permitting, subject to certain conditions, the whole amount of the electricity originating from renewable sources used to power all types of electric vehicles, and for the production of renewable liquid and gaseous transport fuels of non-biological origin to be considered.”[36] If such a proposal were adopted, it may allow power-to-liquid NFTs to be counted as wholly renewable.

Sunlight-to-liquid technologies derive energy entirely from solar power, and thus may be considered a wholly renewable non-biofuel.

Bacterial-conversion technologies have an unclear status due to the distinction between autotrophic and heterotrophic bacteria. The European Commission’s Directorate-General for Energy (DG Energy) has indicated that fuels derived from bacteria are characterized as renewable so long as the original energy source is renewable. It is therefore not always clear how to treat heterotrophic bacteria, because the energy content of the fuel may be originally derived from industrial energy sources that are not identified as renewable sources in RED.

Non-biological waste-to-energy technologies may be considered a non-renewable non-biofuel. These fuels rely on waste plastic or tires as their carbon and energy sources, neither of which can be considered renewable. As a result, these fuels do not count toward the 10% target, although State aid guidelines do not currently restrict their ability to receive financial support from Member States.

Thus the following conclusions can be drawn for novel fuel technologies under RED:

Company	Classification of Technology in RED
Power-to-Liquid	
Air Fuel Synthesis Carbon Recycling International Dioxide Materials Sunfire Audi E-Gas ITM Power-to-Gas	***Partially Renewable Non-Biofuel***. The energy source (electricity) counts as partially renewable based on the renewable fraction in the national or European electricity grid. This fuel qualifies as a renewable liquid and gaseous transport fuel of non-biological origin..
Sunlight-to-Liquid	
Sandia National Laboratories Solar Jet	***Renewable Non-Biofuel***. Given that the energy source (solar) counts as renewable under RED, this fuel qualifies as either a renewable liquid and gaseous transport fuel of non-biological origin or a fuel from carbon capture and utilization for transport purposes.

Bacterial Conversion	
LanzaTech	***Dependent on Energy Source***. RED focuses on the energy content of the fuel. DG Energy has indicated that fuel produced by heterotrophic bacteria would not be considered a biofuel unless the bacteria were fed with biological material, and would not be considered renewable unless the energy in the material (e.g. CO) fed to the bacteria was originally derived from a renewable energy source (the bacteria are effectively considered as a process agent). The eligibility for support under RED would therefore depend on whether the source energy of the process producing the waste gas was renewable, in which case the fuel could potentially qualify under renewable liquid and gaseous transport fuels of non-biological origin or carbon capture and utilization for transport purposes.
Joule / Audi	***Either a Criteria-Compliant Biofuel or a Renewable Non-Biofuel***. If the cyanobacteria are considered biomass-producing, then the fuel derived from it would be treated as criteria-compliant biofuel so long as the applicable sustainability criteria are met. If not, RED does not consider CO_2 to be biomass thus it is not a biofuel nor does the energy content of the fuel derive from the CO_2 (the source of CO_2 is irrelevant for purposes of RED), in which case, in the alternative, it could qualify as a renewable liquid and gaseous transport fuel of non-biological origin so long as the energy content comes from renewable sources.
Non-Biological Waste-to-Energy	
Cynar Vadxx Pyreco Velocys	***Nonrenewable Non-Biofuel***. This fuel is not derived from biomass and its energy content is not from a renewable source.

EUROPEAN UNION – FUEL QUALITY DIRECTIVE

The Fuel Quality Directive (FQD), revised in 2009, requires fuel suppliers to reduce the carbon intensity of the energy supplied in road transport by 6% by 2020 against the fuel baseline standard (hereinafter "6% decarbonization target").[37] The fuel baseline standard was set at 94.1 gCO_{2eq}/MJ,[38] meaning fuel suppliers must achieve a GHG intensity of 88.4 gCO_{2eq}/MJ by 2020. FQD is broader in scope than RED, focusing on lifecycle GHG intensities of all fuels and energy in the transport sector, not just a subset. To this end, FQD sets out reporting obligations and calculation methodologies for all fuels and energy in road transport in 2020.[39]

I. Overview of Legal and Regulatory Framework

FQD is a low-carbon fuel standard. As such, of particular relevance are the calculation methodologies used to determine lifecycle GHG emissions for each fuel. To the extent fuels have lifecycle GHG emissions below the fuel baseline standard, those fuels will be preferred over fuels that do not and, as a result, may extract a price premium.

FQD provides a relatively straight-forward approach. FQD first sets out the minimum information that suppliers must report to Member States.[40] This includes, in particular: (i) the total volume of each type of fuel or energy supplied, indicating where purchased and its origin; and (ii) life cycle GHG emissions per unit of energy.[41] To report on lifecycle GHG emissions, suppliers will use calculation methodologies outlined in EU legislation, which contain either default values or formulas to calculate lifecycle GHG emissions. Member States are required to ensure those reports are subject to verification.

FQD then requires suppliers "to reduce… life cycle [GHG] emissions per unit of energy from fuel and energy supplied by... 6% by 31 December 2020."[42] These reductions are supposed to be "as gradual[] as possible" so Member States are encouraged to set out intermediate targets of 2% by 31 December 2014 and 4% by 31 December 2017.[43] Thus, in effect, FQD contemplates three-year intervals for its major implementation milestones: in 2011, a fuel baseline standard was to be established and suppliers were to begin to report; in 2014, an indicative target of 2% may be established; in 2017, an indicative target of 4% may be established; and in 2020, the mandatory target of 6% must be met. This measured approach, which is in line with the policy of promoting gradual reductions, is designed to prevent abrupt disruptions and burdens which might otherwise undermine achievement of the 6% decarbonization target.[44] In practice, however, most Member States failed to set a 2014 target, although Germany has actively implemented the FQD since 1 January 2015.

Groups of suppliers may choose to meet the 6% decarbonization target jointly.[45] In those instances, the suppliers will be considered as a single supplier for purposes of compliance.[46]

In FQD, fuels can be placed into three main categories: renewable and nonrenewable, as in RED, plus another category for fossil fuels. Unlike RED, however, FQD is a low-carbon fuel standard hence how a fuel is categorized is not the only determinant of the level of support received but the predominant concern is how lifecycle GHG emissions are calculated for reporting and compliance purposes. The calculation methodologies are found in different EU legislation and some are still to be adopted.

A. Fossil Fuels

Fossil fuels are those whose raw materials derive from fossil sources, such as conventional crudes, natural gas, coal, natural bitumen and oil shale.[47] Default values for lifecycle GHG intensity for fossil fuels are provided in Council Directive (EU) 2015/652.[48]

B. Renewable Fuels

Renewable fuels are those that count toward the 10% volume target in RED and, as discussed above, can be further divided into two subcategories: criteria-compliant biofuels and renewable non-biofuels.

- ***Criteria-Compliant Biofuels***. The above discussion on criteria-compliant biofuels in RED is also applicable to FQD. Default values for lifecycle GHG emission savings are provided for most types of sustainability-criteria-compliant biofuels in FQD.[49] The Commission is empowered to adopt delegated acts setting out additional default values for biofuels for which no default value has yet been provided.[50] In addition, regardless of whether a default value is provided, suppliers may calculate actual values based on calculation methodologies provided in FQD.[51]

- ***Renewable Non-Biofuels***: The above discussion on renewable non-biofuels in RED is also applicable to FQD. Default values for three specific types of potential renewable non-biofuels are provided in Council Directive (EU) 2015/652, namely: (i) compressed synthetic methane produced from the Sabatier reaction of hydrogen from non-biological renewable energy electrolysis; (ii) compressed hydrogen in a fuel cell produced from electrolysis fully powered by non-biological renewable energy; and (iii) compressed hydrogen in a fuel cell produced from coal with carbon capture and storage (CCS) of process emissions.[52] The Commission is empowered to adopt, no later than 31 December 2017, delegated acts establishing GHG emission default values, where no such values have already been established, for other "renewable liquid and gaseous transport fuels of non-biological origin" and "carbon capture and utilization for transport purposes."[53]

C. Non-Renewable Fuels

Nonrenewable fuels are those that do not count toward the 10% volume target in RED and, as discussed above, can be divided into two subcategories for purposes of FQD: noncompliant biofuels and nonrenewable non-biofuels.

- ***Noncompliant Biofuels***: The above discussion on noncompliant biofuels in RED is also applicable to FQD. For purposes of FQD, biofuels that do not meet the sustainability criteria in FQD (hereinafter "noncompliant biofuels") are considered to have a default value of lifecycle GHG intensity equal to conventional crude oil or gas.[54]

- ***Nonrenewable Non-Biofuels***: The above discussion on nonrenewable non-biofuels in RED is also applicable to FQD. A default value for lifecycle GHG intensity is provided for "waste plastic derived from fossil feedstocks."[55] However, as these fuels are given a value (86 gCO_2e/MJ) close to the fossil fuel baseline carbon intensity, their value for compliance with FQD is limited.

To the extent that a calculation methodology for a specific fuel has not yet been adopted, it is unclear in that circumstance what treatment, if any, is to be given to that fuel for purposes of counting that fuel toward the 6% decarbonization target. Moreover, for nonrenewable non-biofuels without an established calculation methodology, such as those using waste tires, it is unclear how they would go about getting one. Before amendments to FQD, the Commission was empowered to establish the "methodology for the calculation of life cycle [GHG] emissions from fuels other than biofuels and from energy" and, with this broad mandate, adopted various calculation methodologies.[56] Now, however, after amendments to FQD, this broad mandate has been restricted and, rather than being empowered to adopt calculation methodologies for all "fuels other than biofuels and from energy content," the Commission is only empowered to set out default values for "renewable liquid and gaseous transport fuels of non-biological origin" and "carbon capture and utilisation for transport purposes."[57] To fill this void, Member States could set out calculation methodologies or default values into their national legislation but this would not resolve the problem identified above that for purposes of FQD compliance no calculation methodologies may exist at the EU level.

II. Analysis of Novel Fuel Technologies

For most NFTs, a calculation methodology has been or may be provided:

Company	Calculation Methodology
Power-to-Liquid:	
Air Fuel Synthesis Carbon Recycling International Dioxide Materials Sunfire	***No Default Value Currently Provided***. This fuel is not listed in Council Directive (EU) 2015/652 but the Commission is empowered to adopt a delegated act setting out default values for renewable liquid and gaseous transport fuels of non-biological origin and carbon capture and utilization for transport purposes, which are categories that could cover this fuel.
Audi E-Gas ITM Power-to-Gas	***More Information Required***. This fuel may fall within one of the default values provide in Council Directive (EU) 2015/652, in particular compressed synthetic methane produced from the Sabatier reaction of hydrogen from non-biological renewable energy electrolysis, compressed hydrogen in a fuel cell produced from electrolysis fully powered by non-biological renewable energy; and compressed hydrogen in a fuel cell produced from coal with CCS of process emissions. Otherwise, the Commission is empowered to adopt a delegated act setting out default values for renewable liquid and gaseous transport fuels of non-biological origin and carbon capture and utilization for transport purposes, which are categories that could cover this fuel.
Sunlight-to-Liquid:	
Sandia National Laboratories Solar Jet	***No Default Value Currently Provided***. This fuel is not listed in Council Directive (EU) 2015/652 but the Commission is empowered to adopt a delegated act setting out default values for renewable liquid and gaseous transport fuels of non-biological origin and carbon capture and utilization for transport purposes, which are categories that could cover this fuel.
Bacterial Conversion	
LanzaTech	***No Default Value Currently Provided***. This fuel is not listed in Council Directive (EU) 2015/652 but the Commission is empowered to adopt a delegated act setting out default values for carbon capture and utilization for transport purposes, which is a category that could potentially cover this fuel as the technology captures CO (a CO_2 precursor) from waste gases and converts is to useful products.
Joule / Audi	***No Default Value Currently Provided***. This fuel is not listed in Council Directive (EU) 2015/652 but the Commission is empowered to adopt a delegated act setting out default values for bacteria and renewable liquid and gaseous transport fuels of non-biological origin, which are categories that could cover this fuel depending on whether the cyanobacteria are considered biomass-producing.
Non-Biological Waste-to-Energy	
Cynar Vadxx Velocys	***Default Value Provided***. Council Directive (EU) 2015/652 sets out a default value for waste plastic derived from fossil feedstocks.
Pyreco	***Unclear***. No default value set out in Council Directive (EU) 2015/652 and the Commission is only empowered to adopt a delegated act setting out default values for renewable liquid and gaseous transport fuels of non-biological origin and carbon capture and utilization for transport purposes, which are categories that do not cover this fuel.

UNITED KINGDOM – RENEWABLE TRANSPORT FUEL OBLIGATION

In the UK, the Energy Act of 2004 establishes the Renewable Transport Fuel Obligation (RTFO), the legislative vehicle through which the UK government promotes renewable transport fuels.[58] The Administrator—currently the Department for Transport (DfT)—implements RTFO through the issuance of an RTFO Order and its subsequent amendments.[59]

I. Overview of Legal and Regulatory Framework

The Energy Act of 2004 sets out the broad parameters of the legal framework within which the UK government can impose an RTFO but leaves the overwhelming majority of the details to be determined by the Administrator's subsequent interpretation and implementation through an RTFO Order. The first RTFO Order was made in 2007, and has subsequently been amended.[60] Among other things, the Energy Act of 2004 empowers the Administrator to take actions by RTFO Order that can be broadly categorized as follows:

- ***Set Renewable Fuel Targets on Suppliers.*** The Administrator is authorized to "[i]mpose on each transport fuel supplier… the obligation… to show that during a specified period the specified amount of renewable transport fuel was supplied... to… the [UK]."[61]

- ***Determine Eligibility of Renewable Transport Fuels.*** The Administrator is authorized to "make provision about how amounts of transport fuel are to be counted or determined for purposes of [RTFO],"[62] including the "amounts of renewable transport fuel to count towards discharging the [RTFO],"[63] the "amounts of renewable transport fuel of a specified description to count towards discharging such obligation only up to a specified amount,"[64] what "proportion of any renewable transport fuel of a specified description is attributable to a specified substance, source of energy, method, process or other matter to count towards discharging such obligation"[65] and "how that proportion is to be determined."[66]

- ***Impose Conditions on Renewable Transport Fuels.*** The Administrator is authorized to require that "specified conditions are satisfied in relation to [the] supply [of renewable transport fuels]" before those fuels count towards discharging RTFO.[67] The Administrator has broad authority to impose conditions on renewable transport fuels whenever the effect "within the U.K. or elsewhere, of the production, supply or use of fuel [] effects either: (a) carbon emissions; (b) agriculture; (c) other economic activities; (d) sustainable development; or (e) the environment generally."[68]

The Energy Act of 2004 includes several definitions but provides significant discretion to DfT as Administrator in interpreting existing definitions and providing new ones through the RTFO Order and subsequent amendments. As a result, DfT, without further authorization from the UK Parliament, has the authority to shape RTFO, although DfT primarily uses that authority to transpose and comply with RED and any amendments to RED.

A. Meeting the Renewable Transport Fuel Obligation

Suppliers of transport fuel to the UK may meet their RTFO in the following ways: first, by accruing a specified amount of RTF Certificates (RTFCs) through the supply of renewable transport fuel; second, procuring RTFCs on the market from other suppliers;[69] or, third, discharging their obligation by payment.[70] The failure to comply with their RTFO may subject suppliers to civil penalties.[71] In successive RTFO Orders, the percentage by volume of renewable transport fuel that must be supplied was gradually increased to 5% before being decreased to the current requirement of 4.75% in 2013.[72] The current RTFO (Amendment) Order 2015 does not propose to change this percentage-by-volume amount.[73] Under RTFO, suppliers of less than 450,000 litres during the compliance year are exempt from the volume mandate while all suppliers of less than 10 million litres also have their first 450,000 litres exempt.[74]

B. Renewable Transport Fuels

The Energy Act of 2004 defines renewable transport fuel as follows:[75]

> "[R]enewable transport fuel" means—
>
> (a) biofuel;
>
> (b) blended biofuel;
>
> (c) any solid, liquid or gaseous fuel (other than fossil fuel or nuclear fuel) which is produced—
>
> (i) wholly by energy from a renewable source; or
>
> (ii) wholly by a process powered wholly by such energy; or
>
> (d) any solid, liquid or gaseous fuel which is of a description of fuel designated by an RTF[O] order as renewable transport fuel."

Whereas subparagraphs (a), (b) and (c) of the definition of "renewable transport fuel" provides DfT with less discretion to interpret what falls within them, subparagraph (d) provides DfT with significant discretion by creating a catch-all category for any DfT-designated renewable transport fuel.

In subsequent amendments to the RTFO Order, DfT has provided interpretations and definitions such that renewable transport fuels can be categorized as follows:

- ***Biofuel***. The Energy Act of 2004 defines "biofuel" as "liquid or gaseous fuel that is produced wholly from biomass."[76] DfT further defines "biomass" as "the biodegradable portion of: (a) products, wastes and residues from agriculture, forestry and related activities, or (b) industrial and municipal waste."[77] DfT now also requires biofuels to meet the sustainability criteria in RED, as transposed in RTFO, in order to count toward RTFO.[78]

- ***Blended Biofuel***. The Energy Act of 2004 defines "blended biofuel" as "liquid or gaseous fuel consisting of a blend of biofuel and fossil fuel."[79] DfT now also requires blended biofuels must meet the sustainability criteria in RED, as transposed in RTFO, in order to count toward RTFO.[80]

- ***Wholly Renewable Fuels***. This category includes "[a]ny solid, liquid or gaseous fuel (other than fossil fuel or nuclear fuel) that is produced (i) wholly by energy from a renewable source or (ii) wholly by a process powered wholly by such energy."[81] DfT defines "fossil fuel" as "coal, substances produced directly or indirectly from coal, lignite, natural gas, crude liquid petroleum, or petroleum products."[82] DfT defines "petroleum products" as "the following substances produced directly or indirectly from crude, that is to say, fuels, lubricants, bitumen, wax, industrial spirits and any wide-range substance (meaning a substance whose final boiling point at normal atmospheric pressure is more than 50°C higher than its initial boiling point)."[83] Within RTFO, renewable sources eligible under this category are wind, solar heat, water (including waves and tides), geothermal sources and biomass.[84]

- ***Other Renewable Fuels***. This category includes any "solid, liquid or gaseous fuel which… is produced wholly or partly from a relevant feedstock, and… does not fall within [one of the above categories]."[85] DfT defines "relevant feedstock" as covering: "(i) products, wastes or residues of biological origin from agriculture (including both vegetal and animal substances), forestry, and related industries including fisheries and aquaculture; and (ii) industrial or municipal waste of biological origin."[86] Therefore, while the Energy Act of 2004 and RED allow that renewable fuels may include fuels derived from a range of feedstocks, the current definition of renewable transport fuel under RTFO is limited to certain renewable fuels of biological origin.

This definition of "relevant feedstock" was also relied upon elsewhere in RTFO. For example, DfT defined "wholly renewable fuel" and "partially renewable fuel" as those from "relevant feedstocks."[87] DfT also adopted a formula for determining the number of RTFCs that are generated by a specified volume of renewable transport fuel as a function of "sustainable feedstocks" and "sustainable wastes," which by definition must be derived from "relevant feedstock."[88] Thus, while one stated purpose of RTFO (Amendment) Order 2011 was to expand the definition of "renewable transport fuel" to "cover partially renewable fuels,"[89] the new definition of "relevant feedstock" served to limit the scope of RTFO to only supporting fuels whose feedstock is of biological origin thereby transposing the requirements of RED applicable at that time. One can imagine a fuel derived from carbon feedstock emitted from geothermal vents which, through a processed powered by renewable geothermal energy, produces fuel with an extremely low GHG emissions profile. This fuel is by definition within the Energy Act of 2004 a "renewable transport fuel"—such a fuel would meet the definition in Section 132(1)(c) and is listed as a "wholly renewable fuel" above. Unfortunately, this fuel would not generate RTFCs for failure to be derived from a relevant feedstock, i.e. a feedstock of biological origin, and is therefore not supported by RTFO. DfT anticipates undertaking consultations in 2016 to consider the inclusion of fuels that are not derived from feedstock of biological origin within a 2017 amendment to the RTFO Order.

II. Analysis of Novel Fuel Technologies

Almost all NFTs are currently unsupported by RTFO as they do not use biogenic feedstock.

Although power-to-liquid and sunlight-to-liquid technologies would fall within subparagraph (c) of the definition of "renewable transport fuel" in the Energy Act of 2004, the definition of "relevant feedstock" in the RTFO (Amendment) Order 2011 and its downstream implications limit their ability to contribute toward discharging RTFO in its current form. Bacterial-conversion and non-biological waste-to-energy technologies do not fall within RTFO, in its current form, since their carbon sources are not considered biological and their energy sources are not considered renewable.

The following conclusions can be drawn for NFTs reviewed here under RTFO:

Company	Status under RTFO
Power-to-Liquid	
Air Fuel Synthesis Carbon Recycling International Dioxide Materials Sunfire Audi E-Gas ITM Power-to-Gas	***Does Not Generate RTFCs Under RTFO***. Currently not allowed to contribute toward discharging RTFO for failure to use "relevant feedstock" of "biological origin." ***Potentially a Wholly Renewable Fuel under the Energy Act of 2004***. This fuel could qualify as a wholly renewable fuel if non-fossil source of energy is used.
Sunlight-to-Liquid	
Sandia National Laboratories Solar Jet	***Does Not Generate RTFCs Under RTFO***. Currently not allowed to contribute toward discharging RTFO for failure to use "relevant feedstock" of "biological origin." ***Potentially a Wholly Renewable Fuel under the Energy Act of 2004***. This fuel could qualify as a wholly renewable fuel if non-fossil source of energy is used.

Bacterial Conversion	
LanzaTech	***Does Not Generate RTFCs Under RTFO***. Currently not allowed to contribute toward discharging RTFO for failure to use "relevant feedstock" of "biological origin." ***Renewable only if waste gas comes from processes using renewable energy***. This fuel could qualify as a wholly renewable fuel under the Energy Act of 2004 if a non-fossil energy source is used for the process generating waste gas, but this is not understood to be the case for the existing facilities.
Joule / Audi	***Does Not Generate RTFCs Under RTFO***. Currently not allowed to contribute toward discharging RTFO for failure to use "relevant feedstock" of "biological origin." ***Potentially a Wholly Renewable Fuel under the Energy Act of 2004***. This fuel could qualify as a wholly renewable fuel if non-fossil source of energy is used.
Non-Biological Waste-to-Energy	
Cynar Vadxx Pyreco Velocys	***Not Renewable***. This fuel is not of biological origin and does not qualify as a wholly renewable fuel because it is not produced wholly by energy from a renewable source of wholly by a process powered by such energy.

GERMANY – FEDERAL IMISSION CONTROL ACT

In Germany, Section 37a-37g of the Federal Imission Control Act (BImSchG) implements the essential obligations arising from RED and FQD as they relate to transport fuels placed on the market in Germany.[90] The federal government is empowered to modify certain provisions of the BImSchG in order to meet Germany's RED and FQD obligations as they relate to transport fuels. This is done through subsequent ordinances issued without further consent of the *Bundesrat*. It should be noted that a complete review of subsequent ordinances relating to BlmSchG has not been undertaken and the analysis presented here is based solely on the text of BlmSchG and therefore does not represent a complete picture of the state of NFTs under BlmSchG.

I. Legal Overview and Regulatory Framework

The BImSchG sets out the initial parameters for implementation of RED and FQD obligations relating to transport while leaving the federal government some flexibility to modify the implementation of the program through ordinances.

A. Obligated Parties

The obligations established under the BImSchG apply to "obligated parties" defined, in general, as "[a]nyone who, be it commercially or within the framework of business undertakings, places fuels (petrol or diesel)… on the market" and are "the party liable to pay taxes within the meaning of the Energy Act."[91] There are limited exemptions for parties that otherwise meet this definition, such as those supplying fuels for defense or other governmental purposes,[92] and the federal government retains the authority to stipulate that obligations "only arise when a certain minimum quantity of fuel is placed on the market."[93]

B. Biofuels and GHG Obligations

Obligated parties must ensure that: (i) they place the requisite share of biofuels—as measured by energy content—as a percentage share of the total fuels they placed on the market through 2014; and (ii) that the GHG emissions of the total fuels they place on the market is reduced as a percentage of the reference value of GHG emissions of the fuels they placed on the market from 2015.[94]

- ***Biofuels Target.*** From 2010 through 2014, obligated parties were required to ensure the minimum share of petrol- and diesel-replacing biofuels which they place on the market was at least 6.25% of the total fuel they place on the market in each calendar year, as measured by the energy content of the fossil petrol or fossil diesel plus the biofuels share.[95] Both pure biofuels and the share of biofuels mixed with certain fossil fuels can be used to fulfil this obligation.[96]

- ***GHG Reduction Target.*** "From 2015, obligated parties must ensure that the [GHG] emissions of the fossil petrol and fossil diesel placed on the market thereby together with the [GHG] emissions of the biofuels placed on the market thereby are reduced by a percentage" as follows: 3.5% from 2015, 4% from 2017 and 6% from 2020.[97] The calculation of these reference values for GHG emissions are set forth in BImSchG Section 37a(4) and Section 14 of the Biofuel Sustainability Ordinance (as amended), respectively.[98] Biofuels which the European Commission has decided may not be considered biofuels for failure to meet the sustainability criteria set forth in Article 17 or Article 7c of RED and FQD, respectively, shall be treated as fossil petrol or diesel in the above calculation of GHG emissions.[99] Both pure biofuels and the share of biofuels mixed with certain fossil fuels can be used to fulfil this obligation.[100]

The most important aspect of BlmSchG is that BlmSchG only imposes a GHG reduction target on obligated parties from 2015 onwards and the volume target for biofuels does not apply beyond 2014.

C. Meeting Biofuels and GHG Reduction Obligations

The critical limiting factor to the ability of fuels derived from NFTs to contribute toward the biofuel and GHG reduction targets of the BImSchG is the definition of biofuel.

- ***Biofuel.*** Biofuel is defined in the BImSchG as follows: "biofuels constitute energy products entirely produced from biomass within the meaning of Biomass Ordinance (*Biomasseverordnung*) of 21 June 2011 (*BGBl.* I p. 1234) which was most recently amended by the Ordinance of 21 July 2014 (*BGBl*. I p. 1066) in their current versions. Energy products partially produced from biomass shall be deemed to constitute biofuel to the amount of this share."[101] BlmSchG contains several further definitions and requirements for various subcategories of biofuels, *e.g.* biodiesel, bioethanol, vegetable oil, hydrogenated biogenic oil (HVO) and biomethane, but all of these definitions first require that the fuel in question be considered a biofuel, i.e. produced from biomass.[102] However, the BMlSchG does provide an exception for biodiesel, i.e. fatty acid methyl ester (FAME), and HVO whereby these fuels "must be considered to be biofuel to the full extent" even where they are only "partially produced from biomass."[103]

Without the benefit of translated versions of the Biomass Ordinances defining the terms used in the definition of biofuel, it is assumed that the words "produced from biomass" mean the fuel is derived from biomass feedstock. If this definition of biofuel still stands, then most NFTs (except those produced from biogas feedstock) would currently not be taken into account for purposes of meeting the biofuels or GHG reduction obligations.

Obligated parties can meet their GHG reduction targets by either placing biofuels on the market or by transferring the fulfilment of their obligations to other obligated and non-obligated parties.[104] GHG reduction quantities in excess of the minimum amounts required can be carried forward and applied to obligations in the subsequent year.[105] Where a party fails to meet its GHG reduction target, the party must pay a predetermined fine per kilogram of CO_2-e above its GHG reduction obligation.[106]

II. Analysis of Novel Fuel Technologies

As stated above, the limitation that only biofuels produced from biomass may be taken into account for purposes of meeting the GHG reduction target for 2015 and beyond currently prevents most fuels produced by NFTs from being taken into account under BlmSchG. At the time of the last major changes to the BmlSchG, Council Directive (EU) 2015/652 was still under negotiation and accounting rules for fuels other than biofuels were not included in FQD. However, BlmSchG authorizes the federal government, without seeking further consent from the *Bundesrat*, to implement changes to the BmlSchG to allow fuels produced from NFTs to be taken into account for purposes of meeting its GHG reduction target.[107] Among other things, the federal government can:

- ***Regulate with Due Consideration of Technological Advances to Include NFTs.*** The federal government can determine "that certain energy products are deemed to constitute biofuels" or "that certain energy products are no longer deemed to constitute biofuels" in derogation of the definitions provided in Section 37b.[108] While such fuels must still comply with RED and FQD sustainability criteria, where applicable, under Section 37a(4)-(5), the federal government can abrogate the requirement that fuels taken into account for purposes of meeting the GHG reduction targets must be produced from biomass thereby enabling accounting for fuels produced by NFTs. Other implementing powers allow for the accounting of fuels of non-biological origin as well.

- ***Establish, in the Context of Fulfillment of Obligations, Certain Additional Requirements.*** The federal government can impose "ecological and social requirements as to a sustainable production of the biomass or the protection of natural habitats or if the biofuel achieves a particular [GHG] reduction" and define those requirements.[109] In sum, the federal government has wide-reaching authority to address social or ecological threats posed by biofuels. However, because the ability to impose “ecological and social requirements” is limited to the “production of biomass,” the law as written does not empower the federal government to address most of the risks presented by NFT feedstocks and processes.

- ***Restrict How Specific Biofuels May Be Credited Against the Obligations or Set a Minimum Share of Particular Biofuels for the Fulfillment of Obligations.*** The federal government can discourage or promote the production of biofuels by crediting certain biofuels more than others and requiring a minimum amount of certain types of biofuels.[110] Thus, demand for particularly environmentally-friendly fuels can be created quickly through mandates or subtargets while less desirable fuels can be phased out through restrictions or a cap as their negative effect become known. Both powers are intended for implementing the new requirements related to Directive (EU) 2015/1513 on indirect land-use change (ILUC).

- ***Set the Calculation Method for GHG Emissions for Biofuels.*** The federal government is granted authority to set the calculation method for GHG emissions from biofuels in derogation of existing recognized proofs or other calculation methods.[111]

In sum, while the BImSchG currently excludes nearly all fuels produced by NFTs, the legislation empowers the federal government to, by ordinance and without further consent of the *Bundesrat*, amend the legislation to include fuels produced by NFTs. However, additional information on the ordinances adopted to date is needed before a complete understanding of how NFTs fit into BlmSchG can be definitively stated. The English translations of these ordinances were not made available to the authors in time for analysis and inclusion in this report.

CHAPTER 2: LEGAL FRAMEWORKS IN NORTH AMERICA

UNITED STATES – RENEWABLE FUEL STANDARD

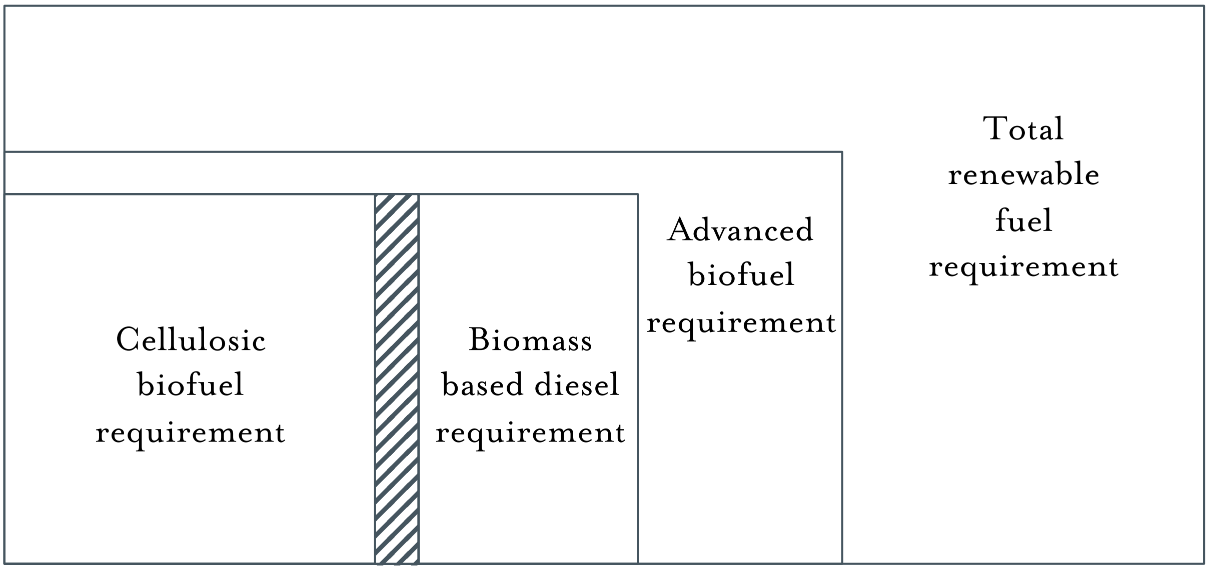
In the US, the Renewable Fuel Standard (RFS) is the legislative vehicle through which the federal government promotes the development, production and use of renewable fuels in transportation.[112] This aim is principally accomplished through volume mandates that require transportation fuel sold in the US to contain a minimum volume of "renewable fuels." The original RFS Program (RFS1) was created by the Energy Policy Act of 2005.[113] It was later revised and expanded into the current RFS Program (RFS2) under the Energy Independence and Security Act of 2007 (EISA), a legislative act of the US Congress.[114]

The legal framework of RFS2 is established under EISA. As a result, changes to the legal text of RFS2 can only be occasioned by a subsequent legislative act of the US Congress. Legislation directly impacting the operation and aims of RFS2 has not been enacted since 2007 and no such legislation is pending. Since 2007, however, unforeseen adverse consequences of certain renewable fuels have been exposed while other fuels have emerged with the potential to be more sustainable and environmentally friendly. The US Environmental Protection Agency (EPA) is the federal administrative agency charged with developing and implementing regulations to achieve the goals of RFS2. Since the passage of EISA, EPA has promulgated numerous regulations interpreting and implementing RFS2.[115] However, EPA has only a limited ability to expand on EISA, namely in those instances where explicit decision-making authority has been delegated to it by the US Congress or where interpretation or clarification is required because "the statute is silent or ambiguous with respect to the specific issue" and clarification of ambiguous terms or harmonization of inconsistent provisions within EISA is required to further the legislative goals of the US Congress.[116]

I. Overview of Legal and Regulatory Framework

The primary vehicle through which RFS2 promotes renewable fuels is through volume mandates, termed a renewable volume obligation (RVO), applicable to most gasoline and diesel producers and importers in the US ("obligated parties").[117] The production or import of a gallon of qualifying renewable fuel generates a corresponding renewable identification number (RIN) or credit that can be used to demonstrate compliance with an obligated party's RVO.[118] Obligated parties with a surplus or deficit of RINs in any calendar year can carryover or trade RINs with other obligated parties.[119]

Under EISA, there are four categories of renewable fuels—renewable fuel, advanced biofuel, biomass-based diesel and cellulosic biofuel—with corresponding volume mandates. The volume mandates of RFS2 are not mutually exclusive but rather nested so that the overarching category "renewable fuel" and its overall volume target encompasses the other three subcategories of renewable fuels, i.e. advanced biofuels, biomass-based diesel and cellulosic biofuels, and their targets.[120] Similarly, the definition of advanced biofuels and its overall volume target encompasses both biomass-based diesel and cellulosic biofuels.[121] This nested relationship is presented in the below diagram taken from EPA regulations interpreting and implementing RFS2.[122]



This nested approach means that, for a fuel to count toward any of the RFS2 volume mandates, it must meet, at a minimum, the definition and 20% lifecycle GHG emissions savings threshold for "renewable fuel." Production or importation of a RIN-generating renewable fuel can be used toward compliance with one or more than one of the volume mandates depending on its characterization. If a fuel also meets the more stringent definition and lifecycle GHG emissions savings threshold of another category in addition to any other criteria, the RINs it generates will also count toward those volume targets. The potential for fuels to generates RINs from two, or even three, RFS2 volume targets places greater value on certain fuels more than others and is one way in which RFS2 creates incentives to produce more environmentally friendly renewable fuels.

Note: EPA has established a petition process whereby a party can petition EPA to consider new pathways for purposes of determining compliance with lifecycle GHG emissions savings thresholds.[123]

The four categories of renewable fuels are as follows.[124]

A. Renewable Fuel

The first category is renewable fuels.[125] EISA defines "renewable fuel" as "fuel that is *produced from renewable biomass* and that is used to replace or reduce the quantity of fossil fuel present in a transportation fuel" and that has, unless grandfathered or exempt, lifecycle GHG emissions of at least 20% less than baseline lifecycle GHG emissions.[126] A central feature of the definition of renewable fuel under RFS2 is the requirement that it be "produced from renewable biomass." EISA defines renewable biomass as:[127]

- *Planted Crops and Crop Residues*. Must be harvested from agricultural land cleared or cultivated at any time prior to the enactment of this sentence that is either actively managed or fallow, and nonforested.

- *Planted Trees and Tree Residues*. Must be from actively managed tree plantations on non-federal land cleared at any time prior to enactment of this sentence, including land belonging to an Indian tribe or an Indian individual, that is held in trust by the United States or subject to a restriction against alienation imposed by the United States.

- *Animal Waste Material and Animal Byproducts*.

- *Slash and Pre-Commercial Thinnings from Non-Federal Forestlands*. Non-federal forestlands includes forestlands belonging to an Indian tribe or an Indian individual, that are held in trust by the US or subject to a restriction against alienation imposed by the US, but not forests or forestlands that are ecological communities with a global or State ranking of critically imperiled, imperiled, or rare pursuant to a State Natural Heritage Program, old growth forest, or late successional forest.

- *Cleared Biomass*. Biomass obtained from the immediate vicinity of buildings and other areas regularly occupied by people, or of public infrastructure, at risk from wildfire.

- *Algae*. Algae are considered a source of "renewable biomass under EISA.[128] EPA has repeatedly interpreted the algae category of biomass to include other bacteria that are not, scientifically speaking, "algae" in order to further promote the development of algae and algae-like microbes as a feedstock for renewable fuel.[129] Cyanobacteria, which EPA has already included within the definition of algae, are currently used by one company, Joule, as the autotrophic bacteria in the fuel production process. EPA has similarly found diatoms to be included within the EISA definition of "algae" but has not included microcrop angiosperms.[130] Based on EPA's expansive interpretation of the term "algae" within EISA, it is possible that certain other autotrophic bacteria used by NFTs may also have their bacteria classified as "algae" by EPA.

- *Separated Yard Waste or Food Waste, Including Recycled Cooking and Trap Grease.* Following subsequent interpretations by EPA to harmonize inconsistencies among EISA provisions, this category has been defined to include biogas[131] and certain municipal solid waste residues that could include some portion of "non-recyclable plastic and rubber of fossil origin" in limited circumstances.[132] However, EPA has stated that feedstock from "non-biogenic materials such as plastics that were unable to be recycled due to market conditions" cannot produce RIN-generating fuel.[133]

Note: Renewable fuels are those that are "produced from renewable biomass."[134] To date, EPA has consistently interpreted the words "produced from renewable biomass" to mean "made from feedstocks that meet the definition of renewable biomass."[135] It does not include the processing agent or part of the fuel synthesis process or fuel production technology.[136] According to EPA, this means "that RINs could only be generated if it can be established that the feedstock from which the fuel was made meets EISA's definitions of renewable biomass including land restrictions."[137] While EPA does anticipate new emerging fuels that do not fit within its existing analytical framework,[138] it is unclear how much interpretive freedom EPA has to permit a listed source of renewable biomass, such as algae, which is used as a processing or synthesizing agent, e.g. autotrophic bacteria and heterotrophic bacteria, rather than a feedstock in the fuel production process *per se* to result in RIN-producing fuel. Although the term "feedstock" is not defined within the RFS, in another unrelated section within EISA, the term "feedstock" is defined as "the raw material supplied for use in manufacturing, chemical, and biological processes."[139] The plain meaning of this definition suggests that "feedstock" can potentially encompasses any of the raw materials used in the production of fuel and not just the input that supplies the energy content to the fuel which EPA has, to date, scrutinized to determine whether the feedstock is renewable biomass. While definitions outside RFS may aid EPA in interpreting the term "feedstock" within the RFS, because the definition is in another section of EISA and not the RFS, it is not binding on EPA and EPA has, to date, taken a much more limited view of what constitutes feedstock under the RFS.

Note: There is no process by which EPA can consider new sources of "renewable biomass." In order for most NFTs to be included within the RFS there will need to be a legislative act of the US Congress that fundamentally changes the definition of "renewable fuel" to include fuels made from feedstocks other than the seven types of renewable biomass currently listed.

Note: The EISA definition of "renewable biomass" is not a description of the characteristics of qualifying biomass, but rather an exclusive list of specific types of biomass that are predetermined to be "renewable biomass" under the legislation. Thus, for the purpose of determining what NFTs may generate RINs and thus receive the full policy support of RFS2, EISA "require[s] [renewable fuels] be made from feedstocks that qualify as 'renewable biomass.' EISA's definition of the term "renewable biomass" limits the types of biomass as well as the types of land from which the biomass may be harvested."[140] For purposes of assessing whether certain NFTs can generate RINS under EISA, categories for algae and separated yard waste or food waste are of particular relevance.

Note: EISA does not establish general sustainability requirements for all renewable fuels. Instead, it limits the feedstocks from which "renewable fuel" can be produced to "renewable biomass." Within the definition of "renewable biomass," the sources of feedstocks for renewable fuels are specifically listed and defined in such a way to include land-use restrictions.[141] If future legislation modifying RFS2 to include NFTs followed this practice, then as new sources of feedstock for these renewable fuels were identified they could be defined in a manner that includes feedstock-specific or other sustainability criteria depending on the environmental threat posed by the feedstock's generation or extraction.

B. Advanced Biofuel

The second category is advanced biofuel.[142] EISA defines "advanced biofuel" as "renewable fuel, other than ethanol derived from corn starch" and that has lifecycle GHG emissions of at least 50% less than baseline lifecycle GHG emissions.[143] It covers the following types of fuels:[144]

- Ethanol derived from cellulose, hemicellulose, or lignin.
- Ethanol derived from sugar or starch (other than corn starch).
- Ethanol derived from waste material, including crop residue, other vegetative waste material, animal waste, and food waste and yard waste.
- Biomass-based diesel.
- Biogas (including landfill gas and sewage waste treatment gas) produced through the conversion of organic matter from renewable biomass.
- Butanol or other alcohols produced through the conversion of organic matter from renewable biomass.
- Other fuel derived from cellulosic biomass.

Advanced biofuels must also meet the requirements of "renewable fuel" under EISA, i.e. only renewable fuels "produced from renewable biomass" can count as advanced biofuels and therefore all advanced biofuels must be "produced from renewable biomass." However, because the definition of advanced biofuel includes biofuels made from feedstocks that are not explicitly listed under the definition of renewable biomass, e.g. ethanol from waste material and biogas from landfill gas, EPA has been forced to interpret the definition of "separated food or yard waste" expansively to include biogas in order to reconcile the two definitions. In addition, by definition, all qualifying biomass-based diesel and cellulosic biofuels also qualify as advanced biofuels.

C. Biomass-Based Diesel

The third category is biomass-based diesel.[145] EISA defines "biomass-based diesel" as "renewable fuel that is biodiesel" and that has lifecycle GHG emissions that are at least 50 percent less than the baseline lifecycle GHG emissions."[146] As defined, all biomass-based diesel must meet the requirements of "renewable fuel" under EISA, i.e. only renewable fuels can count as biomass-based diesel and therefore all biomass-based diesel must be "produced from renewable biomass."

D. Cellulosic Biofuel

The fourth category is cellulosic biofuel.[147] EISA defines cellulosic biofuel" as "renewable fuel derived from any cellulose, hemicellulose, or lignin that is derived from renewable biomass" and that has lifecycle GHG emissions that are at least 60 percent less than the baseline lifecycle GHG emissions.[148] As defined, all cellulosic biofuel must meet the requirements of "renewable fuel" under EISA, i.e. only renewable fuels can count as cellulosic biofuels and therefore all cellulosic biofuel must be "produced from renewable biomass."

II. Analysis of Novel Fuel Technologies

At present, it appears that only NFTs using biomass as feedstock or autotrophic bacteria may be capable of generating RIN-producing fuel under RFS2. EPA has established "a petition process whereby a party can petition the Agency to consider new pathways for GHG reduction threshold compliance."[149]

The below table summarizes the state of NFTs under RFS2.

Company	RIN Generating / Reason
Power-to-Liquid	
Air Fuel Synthesis Carbon Recycling International Dioxide Materials Sunfire Audi E-Gas ITM Power-to-Gas	***Depends on Energy Source.*** If no renewable biomass feedstock is used, it does not generate RIN. Biogas, however, is considered a renewable biomass feedstock.
Sunlight-to-Liquid	
Sandia National Laboratories Solar Jet	***Does Not Generate RIN.*** As no renewable biomass feedstock is used, it does not generate RIN.
Bacterial Conversion	
LanzaTech	***Probably Not***. Heterotrophic bacteria are not performing the traditional feedstock role.
Joule / Audi	***Probably***. Autotrophic bacteria are performing the traditional feedstock role.
Non-Biological Waste-to-Energy	
Cynar Vadxx Pyreco Velocys	***Does Not Generate RIN***. MSW feedstock is not considered separated yard waste or food waste.

CALIFORNIA – LOW-CARBON FUEL STANDARD

In California, the Low Carbon Fuel Standard (LCFS) aims "to reduce the carbon intensity of California's transport fuels by at least 10 percent by 2020."[150] The California Air Resources Board (CARB) is the "state agency charged with monitoring and regulating sources of emissions of [GHGs] that cause global warming in order to reduce emissions of [GHGs]."[151] In this capacity, and following the broad mandates of Assembly Bill No. 32,[152] CARB promulgates and adopts rules and regulations that set forth, *inter alia*, the accounting, reporting and operating procedures of LCFS.

I. Overview of Legal and Regulatory Framework

LCFS applies to all refiners, blenders, producers and importers ("providers") of transportation fuels in California.[153] Compliance may be met through market-based methods by which those exceeding the performance required by LCFS shall receive credits that may be applied to future obligations or traded to those not meeting LCFS.[154]

"Regulated parties," which are determined by applying certain rules, mostly consist of providers.[155] Regulated parties must meet average carbon intensity (CI) requirements for the transport fuels they supply to California according to the compliance schedules.[156] CI is defined as "the amount of lifecycle [GHG] emissions, per unit of energy of fuel delivered" expressed in grams of CO_2 equivalent per megajoule (gCO_{2eq}/MJ).[157] Lifecycle GHG emissions are defined as "the aggregate quantity of [GHG] emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes)… related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential."[158]

If a regulated party achieves a lower CI for its transport fuel in a compliance period it will generate LCFS credits.[159] The lower the CI of the fuel supplied, the greater number of LCFS credits the fuel will generate, which creates an incentive for suppliers to continue to improve the CI of their fuels and supports the introduction of NFTs with low CI values. The credits generated can then be banked, borrowed and traded with other regulated parties and also used toward compliance with other CARB programs in California although credits from other CARB programs cannot be used toward compliance with LCFS.[160] Linkages with other renewable fuel programs in the region, e.g. Oregon, Washington and British Colombia, are under consideration. Conventional fuels such as gasoline and diesel have assigned CI values above the allowable compliance threshold. A regulated party supplying only those fuels would need to purchase LCFS credits on the market in order to comply with LCFS.

LCFS does not mandate specific fuel volumes of low-carbon fuels. Nor does it mandate the use of particular fuels or feedstocks. Instead, it is a fuel-neutral, performance-based standard that focuses exclusively on CI and does not contain additional environmental or social safeguards, such as sustainability criteria, although CARB has recently announced that sustainability criteria are being developed in 2016.[161] The LCFS compliance schedule can be achieved through the introduction of either a large amount of low-carbon fuel with a CI value just below the required CI threshold, a lesser amount of low-carbon fuel with a CI value well below the required CI threshold, or through some combination thereof.

LCFS divides fuels into two types, conventional and alternative, which can be placed into one of three categories: fully regulated fuels, opt-in fuels, and exempt small-scale non-biomass based fuels.[162]

A. Fully Regulated Fuels

Fully regulated fuels, as the name implies, are fully regulated under LCFS:

Conventional Fuels

- California Reformulated Gasoline ("gasoline" or "CaRFG")
- California Diesel Fuel ("conventional diesel fuel" or "ULSD")

Alternative Fuels

- Fossil Compressed Natural Gas ("Fossil CNG") derived from non-North American Sources
- Fossil Liquefied Natural Gas ("Fossil LNG")
- Fuel Blend Containing Greater than 10% Ethanol by Volume
- Fuel Blend Containing Biomass-Based Diesel
- Denatured Fuel Ethanol ("E100")
- Neat Biomass-Based Diesel ("B100")
- Any Other Liquid or Non-Liquid Fuel (considered to be any fuel not specifically listed in another category for which quantity supplied exceeds the threshold for the exemption available to small-scale non-biomass-based fuel)

Regulated parties supplying fully regulated fuels must demonstrate compliance with the applicable CI schedules.[163] When a fuel is not specifically listed but is supplied in such a quantity so as to exceed the threshold for "exempt small-scale non-biomass-based fuel," that fuel will fall into the catch-all category of "any other liquid or non-liquid fuel," thus making it a fully regulated fuel under LCFS.

LCFS establishes CI compliance schedules for fully regulated (conventional) fuels that get progressively lower from 2011 to 2020.[164] Regulated parties supplying fully regulated (alternative) fuels must establish a fuel pathway accounting for their well-to-wheel emissions using to one of the CI Lookup Table fuel pathways that closely corresponds to the regulated party's fuel pathway or using Method 2A or 2B (discussed below).[165]

B. Opt-In Fuels

Certain alternative fuels are identified in LCFS as "opt-in fuels." Opt-in fuels are "presumed to have a full fuel-cycle, carbon intensity that meets the compliance schedules." Opt-in fuels do not have a CI obligation,[166] and consist of:[167]

Alternative Fuels

- Fossil Compressed Natural Gas ("Fossil CNG") derived from North American Sources
- Biogas Compressed Natural Gas
- Biogas Liquefied Natural Gas
- Electricity
- Compressed or Liquid Hydrogen ("Hydrogen")
- Fuel Blend Containing Hydrogen ("Hydrogen Blend")

Providers of these opt-in fuels are not required to provide CI values to demonstrate their compliance with the compliance schedules. Opt-in fuels may elect, however, to opt into LCFS in order to generate LCFS credits that can then be sold on the market to other regulated parties. A regulated party that supplies opt-in fuels and has elected to opt in may later opt out using a straight-forward process under LCFS.[168] In order to opt into LCFS, an alternative fuel must establish a fuel pathway accounting for their well-to-wheel emissions according to one of four calculation methods:

- ***Method 1***. Select a CI pathway from the Lookup Table

- ***Method 2A***. Create a customized lookup table CI value (modified method 1) whereby a regulated party may propose modifications to one or more inputs to the pathway (but cannot add any new inputs) and use the approved models to generate CI values

- ***Method 2B***. Propose the generation of a new pathway, e.g. any pathway where the calculation of the fuel's lifecycle GHG emissions requires the introduction of at least one new input, using the approved model (the CA GREET Model) or using another model equivalent to the approved model has that been submitted for approval[169]

- ***2020 CI***. Choose a 2020 CI value specified for gasoline or diesel substitutes (whichever applies) and assume that CI value.[170]

C. Exempt Small-Scale Non-Biomass Based Fuels

LCFS contains a catch-all exemption for alternative fuels that are neither biomass-based nor supplied to California in aggregate volume of 420 million MJ (3.6 million gasoline-gallon equivalent) or more per year.[171] For exempt small-scale non-biomass based fuels, LCFS does not apply. This is intended to facilitate pilot and small-scale production and use.[172]

II. Analysis of Novel Fuel Technologies

To the extent aggregate volumes are below the threshold for exempt small-scale non-biomass based fuels, which would appear to be the case for many NFTs at the moment, i.e. those NFTs are not currently within LCFS. However, for most NFTs a single commercial facility would exceed the threshold volume. While operating as an exempt fuel, NFTs will not be able to generate LCFS credits, i.e. they will not benefit financially from their low CI values. However, the target of these NFTs is to ultimately become mainstream and they will need to eventually satisfy the requirements of the fully regulated fuels or opt-in fuels, depending on the type of fuel produced. As it stands now, the use of Method 2A permits an NFT to create a customized lookup table CI value (modified method 1) whereby a regulated party may propose modifications to one or more inputs to the pathway (but cannot add any new inputs) and use the approved models to generate CI values under LCFS § 95486(c). A review of existing pathways is necessary to determine if any existing pathways will permit the individual NFTs to utilize Method 2A at this time. It is not believed that sufficiently similar pathways exist for most of the NFTs under consideration. Most NFTs therefore will use Method 2B to generate a new pathway for its fuel.[173] Under Method 2B, the regulated party proposes the generation of a new pathway, e.g. any pathway where the calculation of the fuel's lifecycle GHG emissions requires the introduction of at least one new input, using the approved model (the CA GREET Model) or using another model equivalent to the approved model has that been submitted for approval.[174] The information required of a successful application under Method 2B are set forth in LCFS.[175] But changes may be forthcoming.

In December 2014, CARB published a Proposed Regulation Order that would overlay a two-tiered system for obtaining a fuel pathway on top of the existing four methods discussed *supra*.[176] At this stage it is believed that all of the NFTs under consideration would fall into "Tier 2," which includes all fuels "produced using one or more innovative production methods," which include but are not limited to "use of unconventional feedstocks" and "carbon capture and sequestration."[177] The primary purpose of the two-tiered system is to fast-track approval of Tier 1 applications while devoting additional resources to Tier 2 applications.[178] Tier 2 applicants can still use Method 2A or Method 2B, whichever is applicable based on the criteria discussed above, such as whether a new input is added to the pathway.

One important change to the CARB assessment process for Tier 2 applications concerns the "indirect carbon intensity" treatment of certain inputs. This issue is not addressed directly in the existing LCFS, where "indirect emissions" are considered, or in the Proposed Regulation Order, but was discussed in greater detail in the Concept Paper published by CARB in July 2014. This paper introduced concepts that CARB would consider addressing in the Proposed Regulation Order and its subsequent implementation. While it includes extensive discussion of issues relevant to NFTs, such as classification of waste, it should be understood that the elements on waste classification were not included in the readopted LCFS order, and thus are not yet adopted. The content of the Concept Paper should therefore be understood only as indicative of possible future rulemaking activity. That Concept Paper states:

> In order to ensure that all material and energy inputs into the production process are fully and completely accounted for… staff will develop clear guidelines covering input

accounting. These guidelines will specify *that no input can be designated as a "waste" unless its current and foreseeable future alternative fate is final disposal. Final disposal is defined as either landfilling or destruction* (through, e.g., incineration). The CIs of inputs that receive "waste" designations under the LCFS will include only the transportation, conveyance, handling, and processing steps to which those inputs are subject. *Waste inputs would inherit no CI increment from the processes that originally generated them*. As energy and other markets diversify over time, however, fewer and fewer materials and energy sources are sent to final disposal. As a result, staff will require extensive, thorough, and third-party-verified data before granting a "waste" designation to any input.

Most inputs that are not designated as wastes will inherit their share of the CI associated with the processes that generated them. Fuel pathways in which steam from other, unrelated processes (e.g., power plants) is used, for example, will inherit the full CI from the process that generated that steam (e.g., a natural gas boiler).

Some inputs may receive "low-value byproduct" designations. Although these inputs are not wastes, the markets into which they are sold (when they are not used as fuel production inputs) are limited, and the market prices they receive are low…. When th[ese inputs are] diverted into [fuel] production, [they] must come into that process with a non-zero CI. Given [their] low-value byproduct status, however, [they] should not inherit [their] full share of the GHG emissions from the [original] production [process]. It should, instead, *receive the CI of the product that replaces it in the … market after it is diverted into [fuel] production*. This "displacement" method will be the preferred approach to account for low-value byproducts used as fuel production inputs."[179]

CARB has not yet published the guidelines for input accounting that will accompany the new Tier 2 assessment procedure in the Proposed Regulation Order. However, based on the above statements, energy source and feedstock inputs for the NFTs under consideration will be classified as either: (i) waste (assigned a CI of zero); (ii) process CI (assigned the input's share of the CI of the process that produced it); or (iii) low-value byproduct (with a CI of the product that replaces its alternative use).[180]

Without the benefit of formal revisions to the regulation or guidelines, it can be speculated that non-recyclable plastics used as a feedstock, for example, would be classified as "waste" if they are destined for final disposal through landfilling or destruction, i.e. incineration without energy recovery. Under the principles outlined in the Concept Paper, for fuels derived from CO industrial gas, the classification would depend on the fate of the gas in the absence of support for the fuel under LCFS. For example, if the gas is to be released to the atmosphere (i.e. a form of final disposal) or flared (i.e. incinerated) it would be classified as waste. However, if the CO would have otherwise been combusted to produce energy, the fuel could instead inherit the CI of the product, e.g. grid energy, which replaces it.

The below table summarizes the treatment that the carbon sources for NFTs may receive if the principles outlined in the Concept Paper were implemented under LCFS.

Company	Treatment of Carbon Source / Observations
Power-to-Liquid	
Air Fuel Synthesis Carbon Recycling International Dioxide Materials Sunfire Audi E-Gas ITM Power-to-Gas	***Depends.*** Eligible for LCFS credits if the carbon intensity of the pathway (carbon intensity of input electricity plus liquid fuel production process) is assessed to be below the fossil baseline

Sunlight-to-Liquid	
Sandia National Laboratories Solar Jet	***Depends.*** Eligible for LCFS credits if the carbon intensity of the pathway (carbon intensity of liquid fuel production process) is assessed to be below the fossil baseline
Bacterial Conversion	
LanzaTech	***Depends.*** Eligible for LCFS credits if the carbon intensity of the pathway (carbon intensity of input CO plus liquid fuel production process) is assessed to be below the fossil baseline. If the energy source is CO currently used for another purpose, such as energy generation, it could be treated as a low-value by-product and inherit the CI of a replacement product identified through system expansion analysis. If the CO is currently released directly into the atmosphere, i.e. vented, or incinerated, it will likely be considered a waste and assigned a CI of zero.
Joule / Audi	***Depends.*** Eligible for LCFS credits if the carbon intensity of the pathway (carbon intensity of liquid fuel production process) is assessed to be below the fossil baseline
Non-Biological Waste-to-Energy	
Cynar Vadxx Pyreco Velocys	***Depends.*** Eligible for LCFS credits if the carbon intensity of the pathway (carbon intensity of input material plus liquid fuel production process plus any combustion emissions assigned to the pathway) is assessed to be below the fossil baseline. If the carbon source would otherwise be diverted to recycling or energy recovery, it may be considered a low-value by-product and inherits the CI of the replacement product. If the carbon source would not be diverted to recycling, it is a waste with an upstream CI of zero. For non-biodegradable waste plastics otherwise destined for landfill, there is also a question as to whether combustion emissions would be counted against the fuel (as in the FQD default values). If so, these fuels would likely be of limited LCFS compliance value.

CHAPTER 3: DESIGNING A REGULATORY FRAMEWORK FOR NOVEL FUEL TECHNOLOGIES

This chapter sets out considerations relevant to designing a regulatory framework for NFTs. It first provides a review of the risks associated with the selected NFTs reviewed herein, providing suggestions on risk mitigation. Then, based on the review of treatment of NFTs in the selected regulatory frameworks, provides observations on designing a future regulatory framework that aims to promote GHG emissions reductions in the transport sector.

I. Risk and Risk Mitigation

Although NFTs avoid many pitfalls associated with biofuels—land-use changes, ecosystem degradation, food insecurity—new risks could arise with large-scale deployment. At the moment, most of these risks are abstract and conceptual. Some of the risks identified may be managed simply by the economics of novel fuel production (for instance risks that would only be realized if the value of waste materials reached a level that was above what the supply chain would realistically support). Others could be addressed with procedural protections ensuring comprehensive accounting of lifecycle GHG emissions. The EU has, however, an admittedly poor track record of success on this point, as evidenced by recent failures to include emissions from indirect land-use changes into calculation methodologies for biofuels and emissions from extraction and processing of natural bitumen (tar sands) into the calculation methodologies for unconventional crudes. It should therefore not be taken for granted that carbon accounting in European policy would capture the full lifecycle implications of all NFTs.

It is the position of the authors of this report that these challenges can be overcome by advancing an overall vision for low-carbon fuels that is merit-based. By this, it is meant that NFT proponents promote comprehensive accounting of lifecycle GHG emissions from the outset coupled with robust procedural mechanisms designed to prevent suboptimal outcomes. Before articulating such an approach, a review of the general risks associated with NFTs is provided. These risks can be viewed within three broad categories: (i) risks associated with the carbon source; (ii) risks associated with the energy source; and (iii) regulatory risks.[181]

A. Potential Risks Associated with the Carbon Source

Many potential risks associated with NFTs derive from their carbon source, and a review of the selected NFTs reviewed in this report has identified the following main ones:

Carbon Source	Risks	Likelihood
Point Source CO_2	Placing a value on carbon pollution may: ▪ promote additional fossil-fuel facilities; ▪ extend the lifetime of the existing fossil-based assets; ▪ provide incentives to accelerate emissions beyond business-as-usual. In addition, to the extent emission reductions at the point source are credited under a trading scheme, it could result in a double counting of the benefit of the NFT.	Low
Atmospheric CO_2	No known or perceived risks associated with capturing atmospheric CO_2.	None
Geothermal CO_2	Possible acceleration of the natural venting process of geothermal vents.	Low
Waste Plastics and Tires	Placing a value on waste plastic and tires that would otherwise be: ▪ landfilled prematurely releases carbon otherwise sequestered in landfills on a semi-permanent basis; and ▪ recycled could displace other more productive uses, such as re-use, recycled or alternative forms of energy recovery. In addition, a primary aim of waste management is to reduce the use of plastic and packaging as an initial matter thus placing a value on its use at end of life could present an obstacle to this objective.	Moderate to High

Carbon-Monoxide (CO) from Industrial Waste Gas	It is conceivable that placing a value on CO generation could: ▪ promote additional fossil-fuelled facilities; ▪ extend the lifetime of the existing fossil-based assets; or ▪ provide incentives to accelerate emissions beyond business-as-usual. In addition, in some cases CO will already be utilised for energy recovery, and displacing the CO could result in substitution with fossil energy.	Low to Moderate

These risks can be grouped into the categories below, with additional comments provided on their likelihood and potential mitigation measures.

Risk	**Likelihood and Risk Mitigation**
Promote or Extend the Lifetime of Fossil-Based Facilities and Assets	At present, the value on carbon pollution is not considered significant and, therefore, it seems unlikely that NFT deployment would promote fossil-fuel facilities or extend the lifetime of existing fossil-fuel assets. Although there is the potential that combustion efficiencies could be tinkered with to increase production, in particular for CO, this would require further assessment. Where NFT deployment demonstrates an environmental benefit over the status quo or alternative uses, such as the release of CO into the atmosphere or its combustion for energy recovery, the NFT could be mandated in other legislation regulating the industry as a “best available technology.” Such a mandate could be stand-alone or be incorporated into overall fuel policies.
Accelerated Emissions	At present, the likelihood is unknown but considered likely to be low, but one measure to mitigate any risk could be that inclusion of a criterion requiring such projects to demonstrate that the emissions would have occurred under business-as-usual, i.e. are not being accelerated.
Release from Semi-Permanent Sink	This risk raises larger issues related to overall waste management. While it is recognized that waste-to-energy provides a waste-reduction benefit where that waste would otherwise be disposed in landfill—a legitimate environmental-policy objective in itself—the practice of converting such waste releases the embedded carbon. For this reason, with the exception of biodegradable waste plastics, which decompose and emit CO_2 in a relatively short timeframe, full accounting of the GHG emissions for semi-permanent sinks should be assessed and incorporated into the calculation methodologies for lifecycle GHG emissions.
Displacement Assessment of Current Practice	Full accounting of the GHG emissions resulting from the displacement of grid energy produced by burning waste, enhanced oil recovery or any other current practice should be assessed and incorporated into calculation methodologies for lifecycle GHG emissions.
Displacement of Productive Uses	To the extent carbon sources could be put to a more-productive environmentally friendly uses, such as recycling, those alternative uses should be encouraged. In practice, however, incentives to recycle are not always certain or forthcoming and, therefore, some flexibility could be provided so as not to discourage the use of wastes such as plastics and tires for fuels where this would result in an environmental benefit over disposal. In such cases, policy should seek to avoid creating obstacles to a primary objective of waste management, i.e. to reduce the use of plastic and packaging as an initial matter.

B. Risks Associated with the Energy Source

The following general risks have been identified.

Risk	**Risk Mitigation**
Displacement of Renewable Energy	In some cases, the renewable energy used to produce fuels could otherwise be put on the energy grid. In such cases, there may be a policy decision to be made about whether it is preferable to supply renewable energy for heat and power applications or for transport applications. In other cases, this is not the case, for example: (i) the energy is generated in the process creating the fuel; (ii) it is not otherwise possible to transport the energy efficiently to the grid; or (iii) the renewable energy facility was created specifically to service the fuel production facility. In those cases, no

	displacement of renewable energy is forthcoming. Where (as in Europe) there are targets for the generation of renewable energy that include both heat and power generation and transport applications, it may be necessary to impose rules to prevent the same renewable megajoules being counted twice into overall renewables targets (once when supplied to a fuel production facility and once when supplied to the vehicle).

C. Regulatory Risks

The following general risks have been identified.

Risk	Risk Mitigation
Discouraging Direct Regulation	There is a risk that developing an industry using wastes for fuel production could discourage direct regulation of waste generation that could be equally beneficial or preferable from an environmental perspective. Such potential direct regulation includes, for example, legislation that requires recycling or other use of plastics or tires (that would otherwise be landfilled) or the combustion of CO for energy or CCS (that would otherwise be emitted into atmosphere). In those instances, what was a waste would become a useful by-product or environmental mandate. This risk is jurisdiction-specific and subject to many uncertainties, thus difficult to mitigate. One approach could be to require periodic assessment of direct regulation of the feedstock in different jurisdictions and, where environmentally preferable practices are identified, to adapt the calculation methodologies accordingly such that the best-practice is the feedstock's assumed alternative fate.
Accounting	To the extent calculation methodologies for lifecycle GHG emissions do not include all major direct and indirect emissions consequences, the regulatory incentive may be mis-calibrated. This risk requires the presence of robust procedural mechanisms.
Double Counting	There is the potential that the carbon savings are double-counted, such as under the EU Emissions Trading Scheme (or another emissions trading scheme) and FQD (or another low-carbon fuel standard). It is not unusual in low-carbon fuel policies globally to allow fuels to qualify for multiple regulatory incentives, and thus the extent to which such double counting is considered a risk rather than a feature will vary by jurisdiction. If such double counting is considered undesirable, the risk could be mitigated by requiring producers of fuel derived from waste industrial gases or CCS to provide evidence or declare that the GHG emissions savings have not been claimed in the jurisdiction in which the point source of emissions is regulated prior to counting towards fuel mandates, and make this evidence or declaration subject to periodic independent audits.

II. Recommendations on a Future Regulatory Framework

A. Moving Away from the Concept of Renewability

NFTs have received uneven treatment in regulatory frameworks designed to promote renewable fuels, in particular under RED in the EU and RFS in the US. This is attributable to the absence of a universally accepted definition of renewability thus policymakers tend to rely on lists. As a result of this approach, RED and RFS have reached (or would be expected to reach) divergent conclusions on the NFTs, according to the assessment of those regulatory frameworks in the preceding chapters:

EU Renewable Energy Directive	NFT	US Renewable Fuel Standard
Partially renewable	**Air Fuel Synthesis** **Carbon Recycling International** **Audi E-Gas** **ITM Power-to-Gas** **Dioxide Materials** **Sunfire**	Depends

Renewable	**Sandia National Laboratories** **Solar Jet**	Nonrenewable
Depends	**LanzaTech**	Probably Not
Renewable	**Joule / Audi**	Probably
Nonrenewable	**Cynar** **Vadxx** **Pyreco** **Velocys**	Nonrenewable

To the extent the objective is decarbonization of the transport sector, however, it is a fair question whether the concept of renewability is helpful from a NFT perspective. Literature reviewed and commentators interviewed for this report identified several issues.

First, renewability is defined by lists, not clear principles on what constitutes a renewable source. This means legislators, in effect, pick the winners and losers based more on politics than sound policy. This places smaller companies at a disadvantage—something that cannot be easily rectified for those NFTs that are not listed. Moreover, listing may not even be appropriate for fuels, in general, and NFTs, in particular, given the diversity of carbon and energy sources and pathways and processes, which is not as great a concern in power generation.

Second, parallel targets for both renewable energy and decarbonization can lead NFTs that cannot check the renewable box to face difficulties marketing or securing support for their fuels. For example, in Europe, EU Member States required to meet the 10% renewable target in RED while ensuring that fuel suppliers meet 6% decarbonization target in FQD will tend to support and promote those fuels that can accomplish both.

Third, the concept of renewability does not reward lifecycle GHG savings. For example, while the threshold in the GHG savings criterion in RED and RFS provides some assurances of reductions in lifecycle GHG emissions as compared to the fossil fuel comparator, those fuels that reduce lifecycle GHG emissions beyond the threshold do not benefit from the additional lifecycle GHG reductions. These policies can therefore fail to promote fuels with the best carbon performance, which can work to the detriment of NFTs where they can achieve significantly lower lifecycle GHG emissions than, say, most food- and land-based biofuels.

For these reasons, from an NFT perspective, low-carbon fuel policies under which eligibility is based primarily on environmental performance that is not stifled by cross-consideration of characteristics like renewability offer the best approach. This could be delivered through a low-carbon fuel standard (such as are in place in Germany and California) in which credits are determined entirely by assessed carbon performance, or it could be delivered by a low-carbon fuel policy where eligibility for support is based on compliance with one or more threshold criteria.

While such performance-based eligibility criteria would be the ideal option, it is recognized that concepts of renewability (or concepts of biological origin) have been introduced into climate change policy, and that it may not be possible to remove these concepts from a broader policy perspective. For instance, the EU will have both a GHG emissions reduction target (40%) and a renewables target (27%) for 2030. Similarly, in some cases lists of eligible fuels may also be considered more desirable than generalized eligibility criteria from a regulatory perspective. It may therefore be more expedient to adjust or provide exceptions to notions of renewability in order to accommodate many NFTs.

In Europe, some NFTs would be accommodated if the system boundary of the concept of "renewability" was expanded in RED to include waste as a renewable source. Such a determination could be made on the basis that in the medium term, production of some wastes cannot be readily eliminated, and therefore for practical purposes such wastes, like traditional renewable energy resources, are an energy resource that is constantly being renewed. While such a change in definition may be possible in principle, one would be concerned that diluting the definition of renewability could have broader undesirable or unintended consequences for the promotion of low-carbon renewable energy (for instance increasing incentives for waste incineration), and therefore a high-level adjustment to the definition of renewability to accommodate NFTs is not recommended. For those NFTs that cannot be fit into a traditional definition of renewability but which can still be demonstrated to deliver good carbon performance, a preferable alternative might be to create a category of exceptions within the law, which could be counted towards renewables targets for compliance purposes without being treated as fundamentally renewable. In the European context, it might be appropriate to delegate the power to determine such exceptions to the European Commission, based on criteria such as carbon intensity, impact on existing material flows and long-term potential. Such a solution would not be neat, but explicitly creating such a category would significantly improve the outlook of genuinely low-carbon NFTs that are currently caught in a legislative cul-de-sac.

B. Toward Low-Carbon Fuel Policy Based on Performance

In reviewing the various regulatory frameworks from an NFT perspective, certain conclusions can be drawn on the key elements of any low-carbon fuel policy that rewards performance while promoting sound environmental solutions. For example, following the German model which abandons the concept of renewability beginning in the transport sector in 2015—focusing instead on decarbonization—the EU could make a similar transition, building on the mandates and structure of FQD.[182] There are several operational examples of such policies, and they have the advantage that they provide clear incentives to constant improvement in process efficiency and GHG benefits. On the other hand, there is a question over how well they perform as technology development drivers, given that expensive new technologies with great long term potential may be forced to compete with established options with lower costs but less role in long-term decarbonisation.[183] There are also challenges in setting carbon intensities (for instance uncertainty in ILUC emissions) which can make it difficult to correctly calibrate incentives across technologies.

Alternatively, the EU could adopt a system in which eligibility for support was based on environmental performance against a broader set of criteria, which could include but need not be limited to some threshold for carbon emissions, but in which level of support was not directly determined by carbon performance. Under such a system it would be possible to provide enhanced incentives for fuel technologies in need of greater commercialization support, due for instance to high capital requirements or higher technology risk. RED, with its double incentives for certain pathways, would provide an example of such a framework if the renewability requirement were removed.

Any such framework would benefit from incorporating elements of the implementation of California's LCFS, in particular the ease with which it can accommodate new pathways and adapts calculation methodologies, buttressed by the assurance of transparency and public participation. With this in mind, what follows are recommendations on the four key elements of a low-carbon fuel policy based on performance: (i) intermediate and final targets; (ii) process for accommodating new pathways; (iii) comprehensive GHG accounting; and (iv) safeguards to mitigate risks.

1. Intermediate and Final Targets

The future regulatory framework should set out mandatory intermediate and final targets. This is the approach taken by BlmSchG in Germany and LCFS in California,[184] which not only ensures measurable progress toward the final target but also sends a market signal that unlocks investment to commercialize or scale up low-carbon fuels. An outgrowth of annual low-carbon fuel supply or decarbonisation targets could be the ability to allow regulated entities to carryover or hold back excess credits from year-to-year.[185]

2. Process for Accommodating New Pathways

Policymakers must be able to include new pathways as they emerge. At present, this is often not the case and where it is the process is too burdensome. Instead, FQD contains a list of default values in Annex IV (there is a similar list in RED) for known fuels and fuel pathways that, in effect, dictates which fuels can count toward its mandate.[186] While the list has proven fairly comprehensive and includes the fuel pathways used by most biomass-based fuels, it has inhibited the market penetration of other fuels with significant lifecycle GHG savings. Policymakers should be empowered to incorporate these fuels within a future low-carbon fuel policy. To do so, a new fuel pathway application process would need to be developed whereby the European Commission (or a national regulator) is empowered to determine the lifecycle GHG emissions of NFTs and impose any conditions necessary to ensure their sustainability or safeguard against potential negative social or ecological consequences of their large-scale production.

In this regard, LCFS could serve as an example. In order to minimize the administrative burden, LCFS has several application processes (and a proposal to create one more) depending on the novelty of the new fuel pathway. Fuels produced using existing pathways are streamlined through the application process, while those introducing at least one new input receive slightly more scrutiny. Fuels "produced using one or more innovative methods," which includes those that "use [] unconventional feedstocks," such as NFTs, are subject to the most rigorous evaluation.[187] As an important complementary measure, to ensure the thoroughness of the evaluation of new fuel pathways, the application process should be transparent and open to public participation via a notice and commenting process. Such participation is guaranteed under both the US RFS and the California LCFS.[188] In this way, sources of direct or indirect GHG emissions or potentially negative social or ecological consequences associated with the fuel's production—ones that may be overlooked by policymakers or omitted by applicants—can be brought into the process and evaluated. Finally, the evaluation of a fuel or fuel pathway should be subject to periodic review, either as a matter of course or by petition from the public, to enable policymakers to address consequences or indirect impacts that were not foreseen at the time of the original application process but have subsequently come to light.

3. Comprehensive Greenhouse Gas Accounting

In a low-carbon fuel policy in which either crediting or eligibility is determined by carbon intensity, calculation methodologies that provide a good characterisation of the overall lifecycle GHG emissions performance are paramount. These calculation methodologies should be inclusive of all quantifiable direct and indirect GHG emissions. Otherwise, miscalibrated incentives and suboptimal outcomes will result. Moreover, any approach should not exclude complex sources of indirect emissions that may be difficult to quantify, but instead begin with a comprehensive mandate similar to those contained within LCFS and RFS to account for all "direct and significant indirect emissions" within the assessment of lifecycle GHG emissions.[189] To the extent significance is left to the discretion of the policymaker, a predetermined threshold would be an important backstop. In a low-carbon fuel policy, It is important that all significant emissions are quantified, even where there is uncertainty in the quantification. For a low-carbon fuel policy in which eligibility is partly or entirely criteria-based, it may be possible to set conditions that should allow indirect emissions to be avoided, as an alternative to quantification (for instance a low indirect effects condition).

Other aspects merit mention. In California, for example, the applicant has the burden to prove the pathway is accurate to a level of scientific defensibility.[190] In the absence of scientific defensibility, the fuel pathway is not approved and the fuel is left out of LCFS. This precautionary approach maximises the chance that each credit generated under LCFS represents genuine lifecycle GHG savings. In other words, rather than ignoring complex sources of indirect GHG emissions, fuel producers are required to account for all potential sources of emissions raised by policymakers with the knowledge that in the absence of a scientifically defensible model they cannot benefit from inclusion in LCFS.

Moreover, in attempting to quantify the GHG emissions associated with NFTs, future regulatory frameworks would be well served to ensure the proper characterization of the feedstock in order to account for indirect emissions. In California, for example, under the Concept Note for LCFS re-adoption, it is suggested that this could be achieved by characterizing the carbon intensity of feedstocks as either waste, process carbon intensity (CI) or low-value by-product:

- *Waste*. A feedstock whose final fate is disposal through landfilling or incineration will receive a CI of zero, e.g. non-recyclable plastics.

- *Process CI*. A feedstock that is not waste but has no alternative use as products receive a proportion of the CI of the process that produced them.

- *Low-Value By-Product*. A feedstock where the use for fuel displaces other existing uses receives the CI of the product that replaces them on the market, such as CO that must be replaced by grid energy. This could be achieved in two ways: first, for each specific fuel, review whether the feedstock in question is wasted or has an existing use to determine its status as a waste or low-value by-product; or, second, for each feedstock, review whether it is common practice for the feedstock to be wasted or have an existing use to determine its status as a waste or low-value by-product.

While this report does not endorse these definitions per se, it is felt that the lens through which CARB views indirect carbon emissions is a useful starting point.

4. Safeguards to Mitigate Risks

Policymakers must be empowered (and emboldened) to create safeguards to mitigate risks. For example, as done with RTFO, policymakers should be able to require that "specified conditions are satisfied in relation to [the] supply" of transport fuels to ensure any risks associated with NFTs can be mitigated.[191] While the sustainability criteria in RED are an attempt by policymakers to head off adverse consequences associated with biofuels, it is unfair to expect regulators to anticipate all future adverse consequences in advance, in particular given the large number of feedstocks now becoming available. The language used to describe the authority of policymakers in the UK under RTFO provides a useful model. There, policymakers were given broad authority to impose conditions on renewable transport fuels whenever "the production, supply or use of fuel [] effects either: (a) carbon emissions; (b) agriculture; (c) other economic activities; (d) sustainable development; or (e) the environment generally."[192] Similar empowerment at the EU level would allow for the adoption of mitigation measures, to the extent deemed necessary, prior to NFT deployment.

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1 E4tech and ECOFYS, Novel Low Carbon Transport Fuels and the RTFO: Sustainability Implications: Scoping Paper for the UK Department for Transport (March 2015).

2 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/ECRED, Article 1 [hereinafter "RED"], Article 1.

3 RED, Article 3.

4 RED, Article 3(4).

5 RED, Article 2(a).

6 See RED, Article 4.

7 E4tech and ECOFYS, Novel Low Carbon Transport Fuels and the RTFO: Sustainability Implications: Scoping Paper for the UK Department for Transport (March 2015), Section 2.2.4, fn. 20.

8 See e.g. RED, Articles 3(4), 5(3)-(5) and Annex III; see also *Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels*, Section 5.1.

9 *See* RED, Article 3 and Annex IX.

10 RED, Articles 2(i) and 17; *See also* Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC, [hereinafter "FQD"], Articles 2(9) and 7b.

11 RED, Article 2(e).

12 RED, Article 2(u) ("residues that are directly generated by agriculture, aquaculture, fisheries and forestry; they do not include residues from related industries and processing").

13 *See* RED, Article 2(p) (which states that waste is defined as in Article 3(1) of Directive 2008/98/EC); WFD, Article 3(1).

14 RED, Article 2(t).

15 RED, Article 2(u).

16 RED, Article 17(1).

17 RED, Article 3(4)(d).

18 RED, Article 3 and Annex IX.

19 RED, Article 17(1).

20 *See* RED, Annex V.

21 RED, Article 19(7).

22 RED, Article 19 and Annex V.

23 RED, Article 2(ta).

24 RED, Annex IX, Part A(r)-(t).

25 *See e.g.* RED, Article 17 (titled "sustainability criteria for biofuels").

26 RED, Article 17(1).

27 RED, Article 3 and Annex IX.

28 E4tech and ECOFYS, Novel Low Carbon Transport Fuels and the RTFO: Sustainability Implications: Scoping Paper for the UK Department for Transport (March 2015), Section 2.2.4, fn. 20.

29 RED, Article 2(a); *see also* E4tech and ECOFYS, Novel Low Carbon Transport Fuels and the RTFO: Sustainability Implications: Scoping Paper for the UK Department for Transport (March 2015), Section 2.2.4.

30 RED, Article 2(a); *see also* E4tech and ECOFYS, Novel Low Carbon Transport Fuels and the RTFO: Sustainability Implications: Scoping Paper for the UK Department for Transport (March 2015), Section 2.2.4.

31 RED, Article 2(a); *see also* E4tech and ECOFYS, Novel Low Carbon Transport Fuels and the RTFO: Sustainability Implications: Scoping Paper for the UK Department for Transport (March 2015), Section 2.2.4.

32 RED, Article 2(i); *see also* FQD, Article 2(9).

33 RED, Article 17(1).

34 RED, Article 17(1).

35 RED, Article 3(4)(c).

36 RED, Article 4(4).

37 FQD, Article 7a(2)(a); *see also* FQD, Article 2(8) of Directive 98/70/EC (defines "supplier" as "the entity responsible for passing fuel or energy through an excise duty point or, if no excise is due, any other relevant entity designated by a Member State").

38 Council Directive (EU) 2015/652 of 20 April 2015 laying down calculation methods and reporting requirements pursuant to Directive 98/70/EC of the European Parliament and of the Council relating to the quality of petrol and diesel fuels, Annex II.

39 FQD, Articles 7a(3) and 5.

40 FQD, Article 7a(1); *see also* Article 2(8) (defining "supplier" as "the entity responsible for passing fuel or energy through an excise duty point or, if no excise is due, any other relevant entity designated by a Member State").

41 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, Article 2(7) (defining "greenhouse gas emissions per unit of energy" to mean "the total mass of CO_2 equivalent greenhouse gas emissions associated with the fuel or energy supplied, divided by the total energy content of the fuel or energy supplied (for fuel, expressed as its low heating value)"); Directive 98/70/EC, Article 2(6) (defines "lifecycle greenhouse gas emissions as "all net emissions of CO_2, CH_4 and N_2O that can be assigned to the fuel

(including any blended components) or energy supplied", which includes "all relevant stages from extraction,… transport and distribution, processing and combustion, irrespective of where those emissions occur").

42 FQD, Article 7a(2)(a).

43 FQD, Article 7a(2)(a).

44 FQD, Article 7a(2).

45 FQD, Article 7a(4).

46 *See* FQD, Article 7a(4); Council Directive (EU) 2015/652, Recital 16, Annex III and IV (rules and reporting for joint suppliers); *see also* FQD, Article 7a(5) (Commission may adopt implementing acts).

47 Council Directive (EU) 2015/652, Annex I.

48 Council Directive (EU), 2015/652, Annex I, Part 2, Point 5.

49 FQD, Article 7d and Annex IV.

50 FQD, Article 7d(7).

51 FQD, Article 7d and Annex IV.

52 Council Directive (EU), 2015/652, Annex I, Part 2, Point 5.

53 FQD, Article 7a(5a).

54 Council Directive (EU) 2015/652, Annex I, Part 1, Point 3(e).

55 Council Directive (EU) 2015/652, Annex I, Part 2, Point 5.

56 *See* FQD, Article 7a(5) (empowering provision); Council Directive (EU) 2015/652 (act adopted under that empowering provision).

57 FQD, Article 7a(5a).

58 *See* Energy Act of 2004, Ch. 20 – Part 2: Ch. 5 – Renewable Transport Fuel Obligation [hereinafter "Energy Act of 2004].

59 *See* Energy Act of 2004 at ¶125. Powers of the Administrator, i.e. Renewable Fuels Agency (RFA) and later the Department for Transportation (DfT), were established by RTFO Order 2007 and transferred to the DfT by RTFO (Amendment) Order 2011. *See* RTFO Order 2007, 2007 No. 3072 Transport—Energy: Sustainable and Renewable Fuels, (25 Oct. 2007) [hereinafter "RTFO Order 2007"] at Part 3 and The Schedule; RTFO (Amendment) Order 2011, 2011 No. 2937 Transport—Energy: Sustainable and Renewable Fuels, (7 Dec. 2011) [hereinafter "RTFO (Amendment) Order 2011"].

60 *See* RTFO Order 2007.

61 *See* Energy Act of 2004 at ¶124(1)-(2)(b).

62 *See* Energy Act of 2004 at ¶126(1).

63 *See* Energy Act of 2004 at ¶126(2)(a).

64 *See* Energy Act of 2004 at ¶126(2)(b).

65 *See* Energy Act of 2004 at ¶126(2)(d).

66 *See* Energy Act of 2004 at ¶126(2)(e).

67 *See* Energy Act of 2004 at ¶126(2)(f).

68 *See* Energy Act of 2004 at ¶126(3)-(4).

69 RTFO Order 2007 at Part 4 (setting forth the conditions and procedures for the issuance, transfer and surrender of RTFCs).

70 RTFO Order 2007 at Part 5 (setting forth the conditions and procedures for payment in lieu of surrendering RTFCs).

71 *See* Energy Act of 2004 at ¶¶127-129; *see also* RTFO Order 2007 at Part 6 (setting forth the conditions and procedures for the imposition of civil penalties).

72 *See e.g.* RTFO (Amendment) Order 2013, 2013 No. 816, Transport—Energy: Sustainable and Renewable Fuels, (8 Apr. 2013) ["RTFO (Amendment) Order 2013"] at ¶7.

73 *See* RTFO Order 2007 at Part 2; RTFO (Amendment) Order 2015, 2015 No. 534, Transport—Energy: Sustainable and Renewable Fuels, (15 Apr. 2015).

74 RTFO Order 2007 at Part 2: 4(2) and 4(4)(b); *see also* RTFO (Amendment) Order 2011 at ¶5(b).

75 Energy Act of 2004 at ¶132(1).

76 Energy Act of 2004 at ¶132.

77 RTFO Order 2007 at Part 1: 2(2).

78 RTFO (Amendment) Order 2011 at Schedule Sustainability Criteria and Explanatory Note.

79 Energy Act of 2004 at ¶132.

80 RTFO (Amendment) Order 2011 at Schedule Sustainability Criteria and Explanatory Note.

81 Energy Act of 2004 at ¶132(1).

82 RTFO Order 2007 at Part 1: 3(3)

83 RTFO (Amendment) Order 2007 at Part 1: 3(8).

84 *See* Energy Act of 2004 at ¶132.

85 RTFO Order 2011 at Part 4(5).

86 RTFO Order 2011 at Part 3(2).

87 *Compare* RTFO Order 2011, Parts 4(3) and 4(5) *with* RTFO Order 2011, Part 3(2).

88 *Compare* RTFO Order 2011, Part 7(4) *with* RTFO Order 2011, Part 3(2).

89 RTFO (Amendment) Order 2011 at Explanatory Note.

90 *See* Act on the Prevention of Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibration and Similar Phenomena - Federal Immission Control Act (BImSchG) in the version published on 17 May 2013 (BGBl. I p. 1274), last

amended by Article 76 of the Order of 31 August 2015 (BGBl. I p. 1474) [hereinafter BImSchG]. The text referenced is the English translation of this legislation provided to Defense Terre by ICCT.

91 BImSchG at Section 37a(1)-(2).

92 BImSchG at Section 37a(1).

93 *See* BImSchG at Section 37d(3)(4).

94 BImSchG at Section 37a(3)-(4).

95 BImSchG at Section 37a(3). Within this target, obligated parties have individual targets for the minimum share of petrol- and diesel-replacing fuels respectively.

96 *See* BImSchG at Section 37a(5).

97 BImSchG at Section 37a(4).

98 *See* BImSchG at Section 37a(4). This calculation includes the energy quantities of fossil petrol and diesel fuels placed on the market plus the energy quantities of biofuels placed on the market in a defined set of years using reference values set forth in "recognized proofs" found in the Biofuel Sustainability Ordinance with certain biofuels meeting the definitions in Section 37a(4), paragraphs 1 – 4 treated as fossil fuels for purposes of the calculation.

99 BImSchG at Section 37a(4)(5).

100 *See* BImSchG at Section 37a(5).

101 *See* BImSchG at Section 37b(1).

102 *See* BImSchG at Section 37b(2)-(6).

103 *See* BImSchG at Section 37b(2) and (5).

104 *See* BImSchG at Section 37a(6)-(7).

105 *See* BImSchG at Section 37a(8).

106 *See* BImSchG at Section 37c(1)-(2).

107 *See* BImSchG at Section 37d(3). In addition to the specific powers discussed in Section II of this memorandum, the federal government "shall be authorized to decree by ordinance, without requiring the consent of the *Bundesrat*, more detailed provisions for the implementation of sections 37a to 37c as well as of the ordinances based on subsection (2)."

108 *See* BImSchG at Section 37d(2)(1).

109 *See* BImSchG at Section 37d(2)(3)-(4).

110 *See* BImSchG at Section 37d(2)(7)-(8).

111 *See* BImSchG at Section 37d(2)(9)-(15).

112 *See generally* 42 U.S.C. §7545(o)—Regulation of Fuels.

113 *See* Energy Policy Act of 2005, Pub. L. 109-58—July 29, 2005 [hereinafter "Energy Policy Act of 2005"].

114 *See* Energy Independence and Security Act of 2007, Pub. L. 110-140—Dec. 19, 2007 (hereinafter "EISA").

115 *See* 40 CFR Part 80—Regulation of Fuels and Fuel Additives.

116 *See Chevron U.S.A. v. NRDC*, 467 U.S. 837, 843 (1984).

117 *See* EPA, Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program, 75 Fed. Reg. 14,721 [hereinafter RFS2 Regulation] (listing and discussing the designation of obligated parties under RFS2). A number of small producers and small refineries are exempt from the volume mandates of RFS2. *See* RFS2 Regulation at 14734-35.

118 *See* RFS2 Regulation at 14684-85.

119 *See* RFS2 Regulation at 14719-20 and 14733.

120 *See* RFS2 Regulation at 14,673-75.

121 *See* RFS2 Regulation at 14,723.

122 RFS2 Regulation at 14,674.

123 RFS2 Regulation at 14680, 14869-70; *see e.g.* http://www.epa.gov/otaq/fuels/renewablefuels/new-pathways/index.htm.

124 *See* EISA at §201(1) (providing definitions of key terms in RFS2); *see also* RFS2 Regulation at 14,673 (listing and discussing the categories of renewable fuel under RFS2).

125 *See* EISA at §202(a)(1).

126 EISA at §201(1)(J) (emphasis added); RFS2 Regulation at 14,677; *see also* EISA at §202(a)(1) (renewable fuels from all facilities that produced renewable fuels or where construction commenced prior to December 19, 2007, and in some cases December 31, 2009, are grandfathered or exempt).

127 EISA at §201(1)(I) (emphasis added).

128 EISA at §201(o)(1)(I).

129 RFS2 Regulation at 14697.

130 *See* RFS2 Regulation at 14697.

131 *See e.g.* RFS2 Regulation at 14704-07.

132 RFS2 Regulation at 14705-06, 14874.

133 RFS2 Regulation at 14715.

134 EISA at §201(o)(1)(J).

135 RFS2 Regulation at 14673, 14681. EPA's fuel pathway portal lists "Feedstock" and states "What is it: a type of renewable biomass that is converted into renewable fuel." *See* EPA, *What is a Fuel Pathway?*, available at: http://www.epa.gov/otaq/fuels/renewablefuels/new-pathways/what-is-a-fuel-pathway.htm.

136 *See e.g.* RFS2 Regulation at 14685 (stating that EISA contains "a separate definition of 'renewable biomass' which identifies the feedstocks from which renewable fuel can be made").

137 RFS2 Regulation at 14697; *see also* RFS2 Regulation at 14681 and 14870.
138 RFS2 Regulation at 14680.
139 EISA at §452(a)(3).
140 RFS2 Regulation at 14681.
141 RFS2 Regulation at 14691.
142 *See* EISA at §201(o)(1)(B).
143 *See* EISA at §201(o)(1)(B); RFS2 Regulation at 14,677.
144 EISA at §201(1)(B) (emphasis added).
145 *See* EISA at §201(o)(1)(D).
146 EISA at §201(1)(D); RFS2 Regulation at 14,677.
147 *See* EISA at §201(o)(1)(E).
148 EISA at §201(1)(E) (emphasis added); RFS2 Regulation at 14,677.
149 RFS2 Regulation at 14680, 14869-70; *see e.g.* http://www.epa.gov/otaq/fuels/renewablefuels/new-pathways/index.htm.
150 Office of Governor Arnold Schwarzenegger, Executive Order S-01-07 (Jan. 18, 2007) at ¶1; *see also* Assembly Bill No. 32, California Global Warming Solutions Act of 2006 (Sept. 27, 2006).
151 Assembly Bill No. 32, California Global Warming Solutions Act of 2006—Division 25.5, §38510 (Sept. 27, 2006).
152 *See e.g.* Assembly Bill No. 32, California Global Warming Solutions Act of 2006—Division 25.5, §38562(d) (Sept. 27, 2006).
153 Office of Governor Arnold Schwarzenegger, Executive Order S-01-07 (Jan. 18, 2007) at ¶4.
154 Office of Governor Arnold Schwarzenegger, Executive Order S-01-07 (Jan. 18, 2007) at ¶4.
155 LCFS Final Regulation at § 95484(a).
156 LCFS Final Regulation at § 95481(a)(54); see also LCFS §§ 95482.
157 LCFS Final Regulation at § 95481(a)(16).
158 LCFS Final Regulation § 95481(a)(38).
159 *See* LCFS Final Regulation § 95485 (setting forth the method of determining the quantity of credits generated.
160 LCFS Final Regulation at § 95485(c)(1)-(2).
161 *See* CARB, *LCFS Monitoring, Verification and Sustainability* (Public Workshop 6 Nov. 2015), *available at* http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/mvs_pres-110615.pdf.
162 LCFS Final Regulation at §§ 95480.1(a)-(c).
163 *See* LCFS Final Regulation at §§ 95482 (gasoline or diesel) or 95483 (substitutes)
164 *See* LCFS Final Regulation at §95482(b)-(c).
165 LCFS Final Regulation §§ 95486(a)(2) and Tables 6-7.
166 LCFS Final Regulation at § 95480.1(b).
167 LCFS Final Regulation at § 95480.1(b).
168 LCFS Final Regulation at § 95480.3(c)
169 LCFS Final Regulation at § 95486(d)(2).
170 LCFS Final Regulation at §95480.3(b)(3).
171 LCFS Final Regulation at § 95480.1(c)(1).
172 LCFS Final Regulation at § 95480.1(c)(1).
173 LCFS Final Regulation at § 95486(d).
174 LCFS Final Regulation at § 95486(d)(2).
175 LCFS Final Regulation at § 95486(c)-(f)
176 *See* CARB, *Proposed Regulation Order: Subchapter 10. Climate Change, Article 4 Regulations to Achieve Greenhouse Gas Emissions Reductions, Subarticle 7. Low Carbon Fuel Standard*, (Dec. 30, 2014) [hereinafter "Proposed LCFS Regulation"], available at: http://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15appa.pdf.
177 Proposed LCFS Regulation at §95488(b)(2)(F).
178 *See* ARB, *Low Carbon Fuel Standard Re-Adoption Concept Paper*, (July 3, 2014) [hereinafter LCFS Concept Paper] at A-1, available at: http://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/030714lcfsconceptpaper.pdf.
179 LCFS Concept Paper at A-4-5 (emphasis added).
180 The following example is given in the Concept Paper: "An example is molasses from sugar production in Indonesia. This substance has traditionally been used as a low-value poultry feed supplement. Its value is too low to allow it to be profitably exported. When this substance is diverted into ethanol production, it must come into that process with a non-zero CI. Given its low-value byproduct status, however, it should not inherit its full share of the GHG emissions from the production of sugar. It should, instead, receive the CI of the product that replaces it in the poultry feed market after it is diverted into ethanol production." Concept Paper at A-5.
181 *See also* E4tech and ECOFYS, Novel Low Carbon Transport Fuels and the RTFO: Sustainability Implications: Scoping Paper for the UK Department for Transport (March 2015), Section 4.
182 *Compare* BlmSchG at Section 37a(3) (imposing a renewable fuels volume mandate from 2011-2014) *with* BlmSchG at Section 37a(4) (imposing a decarbonisation standards on transport fuels from 2015).
183 See Ecofys (2015), How to advance advanced biofuels: Assessment of costs, investment options and policy support
184 *See e.g.* BlmSchG at Section 37a(4); RFS2 Regulation at §95482.
185 *See e.g.* BlmSchG at Section 37a(6)-(7); LCFS at §95485.
186 *See* FQD, Annex IV.

[187] Proposed LCFS Regulation at §95488(b)(2)(F).

[188] *See e.g.* RFS2 Regulation at 14681 ("Other current or emerging fuel pathways may require significant new analysis and/or modeling or EPA to conduct an adequate evaluation for a compliance determination (*e.g.,* feedstocks or fuel types not yet included in EPA's assessments for this regulation). For these pathways, EPA would give notice and seek public comment on a compliance determination under the annual rulemaking process established in today's regulations.").

[189] *See* LCFS Final Regulation at § 95481(a)(38) (defining "lifecycle GHG emissions" as "the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes)… related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential."); EISA at §201(1)(H) (same).

[190] *See* LCFS Final Regulation at §95486(e).

[191] *See* Energy Act of 2004 at ¶126(2)-(4).

[192] *See* Energy Act of 2004 at ¶126(3)-(4).