ADVANCEFUEL

D5.3 Report on policy analysis

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ADVANCEFUEL at a glance

ADVANCEFUEL (www.ADVANCEFUEL.eu) is a market research project formed by 8 partners from Chalmers University, Imperial College London (ICL), Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Aalto University, The Agency for Renewable Resources (FNR), Energy Research Centre of the Netherlands (ECN), Utrecht University and Greenovate Europe. It aims to facilitate the commercialisation of renewable transport fuels by providing market stakeholders with new knowledge, tools, standards and recommendations to help remove barriers to their uptake. The project focuses on liquid advanced biofuels – defined as liquid fuels produced from lignocellulosic feedstocks from agriculture, forestry and waste – and liquid renewable alternative fuels produced from renewable hydrogen and CO2 streams.

To support commercial development of these fuels, the project develops a framework to monitor current status, and future perspectives, of renewable fuels in Europe in order to better understand how to overcome barriers to their market roll-out. Based on this, it investigates individual barriers through stakeholder consultations and discusses validation and potential solutions during stakeholder workshops. The project also examines the challenges of biomass availability for second-generation biofuels, looking at non-food crops and residues, and how to improve supply chains from providers to converters. New and innovative conversion technologies are explored to determine how they can be integrated into energy infrastructure.

Sustainability is a major concern for renewable fuels and ADVANCEFUEL examines socio-economic and environmental sustainability across the entire value chain, providing sustainability criteria and policy-recommendations for ensuring that renewable fuels are beyond doubt sustainable fuels. A decision support tool is created for policy-makers to enable a full value chain assessment of renewable fuels, as well as scenarios and sensitivity analysis on future uptake of these fuels.

Stakeholders are addressed throughout the project to involve them in a dialogue on the future of renewable fuels and receive feedback on ADVANCEFUEL developments to ensure applicability to the end audience, validate results and ensure successful transfer and uptake of results. For instance, the Stakeholder Platform (accessible online) contributes to this objective. ADVANCEFUEL is thus a coordinated effort to support the development of new transport fuel value chains that can contribute to the achievement of the EU's renewable energy targets and reduce carbon emissions in the transport sector to 2030 and beyond.

To stay up to date with ADVANCEFUEL's stakeholder activities, sign up at: www.ADVANCEFUEL.eu/en/stakeholders

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Contents

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Summary

Among potential RESfuel options, advanced biofuels represent the most important solution for short to medium term decarbonisation in transport and especially for aviation, marine and heavy-duty road transport sectors that lack alternatives. Their production and market uptake, however, is minor relative to conventional biofuels due to complex challenges faced in technological development, high production costs and uncertainty with regards to long-term consistency of policy.

A plausible solution would be for the EU to provide a more stable policy framework tailored to the specific requirements of the sector. Such an action would provide a clear direction for successful market uptake, increase investor confidence and help these fuels penetrate the highly competitive energy market. Developing such policy is, however, complicated. Advanced biofuel production is associated with other primary production sectors, i.e. agriculture, forestry and waste and as such many tradeoffs and complications arise.

The main aim of the work described in this report is to provide evidence on policy interventions which can be used by policymakers as tools to facilitate market uptake of advanced fuel value chains and to maintain and enhance currently installed operations.

The findings from the work suggest that there is a significant opportunity for future policy formation in EU to step back from the current perspective on RESfuel and advanced biofuel policies and explore options of steering future market uptake through a combination of policy interventions that address the complete value chain and are also interlinked with the perspectives of Sustainable Development Goals (SDGs), the Common Agricultural Policy (CAP) and the bioeconomy.

The integrated policy framework suggested in this report could provide an initial baseline for EU policy to tackle these inter-link challenges by analysing the current value chains and develop policy recommendations across all sustainability dimensions: economic, social and environment. To complement these policy recommendations, the indicators from SDGs, CAP and bioeconomy can be implemented and help measure further progress on the socio-economic targets.

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1. Introduction

1.1.Background

The world is facing severe challenges through climate change and environmental degradation caused by human activities to a rapidly growing population that demands food, energy and materials from limited natural resources (European Commission, 2018[1]). The European Union (EU) aims to tackle these challenges through sustainable concepts, a major one being "bioeconomy". This concept allows the EU to steer away from the current economy that relies heavily on fossil-based resources to an economy that uses renewable biological resources. It also enables decoupling of economic growth from energy and raw materials consumption and creates opportunities to grow the EU economy as one of the leading global leaders in sustainable resource consumption.

Energy and transport are key sectors targeted by EU policies since they produce high amounts of greenhouse gas (GHG) emissions (Figure 1). Advanced biofuels represent the most important solution for short to medium term decarbonisation among potential RESfuels options, especially for aviation, marine and heavy duty road transport sectors that lack alternatives.

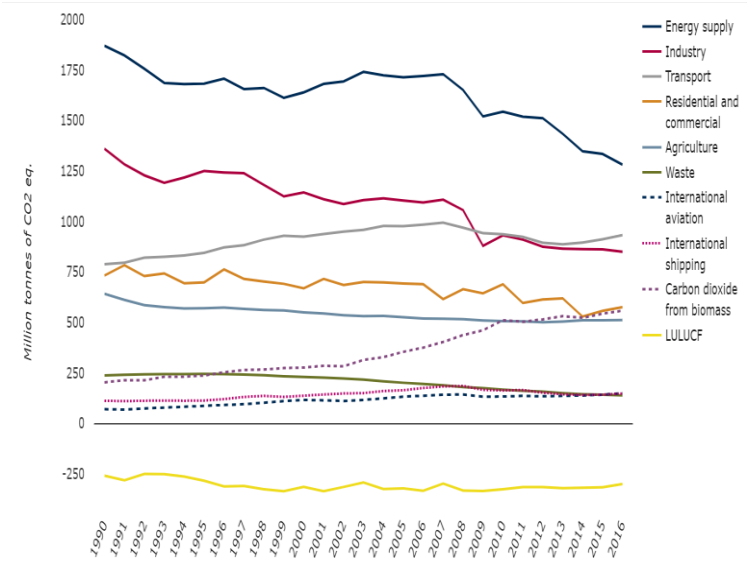

Figure 1 Graph represents the GHG emissions according to the sectors in the EU -28, from 1990 to 2016 (EEA, 2018[2])

Their use not only has the potential to reduce GHG emissions, but also provides energy security via reduced dependency on imported fossil fuels. A further benefit is employment – notably in rural

[1] European Commission. (2018) A new Bioeconomy strategy for a sustainable Europe. European Union.

[2] EEA. (2018) GHG emissions by sector in the EU-28, 1990-2016. Available from: https://www.eea.europa.eu/data-and-maps/daviz/ghg-emissions-by-sector-in#tab-chart_1 [Accessed Jan 18, 2019].

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areas - since biofuels depend on biomass production from agriculture, forestry and waste sectors (Edwards et al., 2008[3]).

Biofuels and advanced biofuels can be classified according to technological maturity, as illustrated in Figure 2. Conventional biofuels have well-established processes and are already produced on a commercial scale. The typical feedstock of these biofuels is directly from food-crops such as sugar cane or starch grains like corn. These biofuels are termed first-generation biofuels.

Advanced biofuels require research and development in their conversion technologies and are generally at the pilot or demonstration and early commercialisation phases (IEA, 2011[4]). In the European Union, the RED II proposes a sub-target of 3.6% blending for advanced biofuels (double counted, so in physical terms 1.8%) coming from the feedstocks listed in RED Annex IX, Part A, by 2030, starting with a sub-mandate for 0.5% blending in 2021. The feedstocks that can be used to achieve this sub-mandate are: algae; biowaste from households and industry; agriculture residues (e.g., straw); industrial residues (e.g., husks, nut shells); forestry residues (e.g., branches, black liquor) and; energy crops. This sub-mandate for advanced feedstocks should help to promote emerging technologies for biofuel production, such as cellulose hydrolysis and pyrolysis.
Production and market uptake of advanced biofuels is minor relative to conventional biofuels due to complex challenges faced in technological development and high production costs.

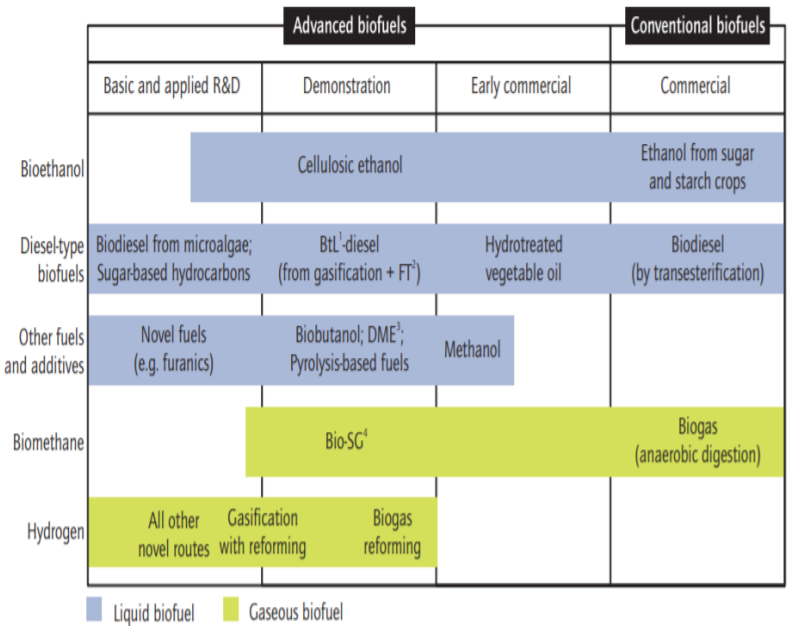

Figure 2 Commercialisation status of the different types of Biofuels categorise according to its technology maturity (IEA, 2011)

In recent years, the benefits and risks of conventional biofuels have been subject to debate. One major concern is compe-

[3] Edwards, R., Szekeres, S., Neuwahl, F. & Mahieu, V. (2008) Biofuels in the European Context: Facts and Uncertainties Petten, Netherlands, European Communities.
[4] IEA. (2011) Technology Roadmap Biofuels for Transport. Paris, France, International Energy Agency.

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tition with food. Questions have been raised on whether biofuels cause shifts in production from food to energy reducing food supply and, in turn, causing inflation of food prices (Galarza & Sassi, 2016[5]).

Another ongoing debate is the extent of the role that conventional biofuels actually play in reducing GHG emissions. Concerns were raised when studies indicated how emissions from direct and indirect land use change (ILUC) caused by biofuels production have not been taken account in the life-cycle analysis (Edwards & Marelli, 2010[6]). According to a Joint Research Centre (JRC) report, the GHG emissions from indirect land use change could potentially release enough to negate the savings from conventional EU biofuels if these have not been produced by sustainable agriculture practices (Edwards et al., 2008[7]).

These controversies on conventional biofuels have created growing interest and demand for advanced biofuels. As noted, however, advanced biofuels are currently costly and require more innovation and technological development due to their complexity in conversion, making it harder to produce them in commercial scale. A further factor preventing the market from reaching full potential is uncertainty with regards to long-term consistency of EU biofuel policy.

A solution would be for the EU to provide a more stable policy framework tailored to the specific requirements of the advance biofuels sector. A consistent policy framework with clear messages would increase investor certainty in this sector and help these fuels to penetrate the highly competitive energy market.

Developing such policy is, however, complicated due to the fact that advanced biofuel production is associated with other primary production sectors, i.e. agriculture, forestry and waste. Future advance biofuels policies will, therefore, need to deliver coherent messages amongst other sustainability targets and other market sectors objectives as well as consider potential socio-economic impacts.

[5] Galarza, M. & Sassi, M. (2016) Biofuels and Food Security: Future Challenges and Opportunities. In: Setti, M. & Zizzola, D. (eds.). Bioenergies in East Africa between challenges and opportunities., Edizioni Altravista. pp. 50-63.

[6] Edwards, R. & Marelli, L. (2010) Indirect Land Use Change From Increased Biofuels Demand - Comparison of Models and Results for Marginal Biofuels Production from Different Feedstocks. Publications Office of the European Union.

[7] Edwards, R., Szekeres, S., Neuwahl, F. & Mahieu, V. (2008) Biofuels in the European Context: Facts and Uncertainties Petten, Netherlands, European Communities.

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1.2. Aim and objectives

The main aim of the work described in this report is to provide evidence on policy interventions which can be used by policymakers as tools to facilitate market uptake of advanced fuel value chains and to maintain and enhance currently installed operations.

The work presented combines data and information from literature and stakeholder views from selected semi-structured interviews, performed during the period October 2018 to February 2019.

The focus of this deliverable is advanced biofuels in the context of the overall policy for biomass, bioenergy and biofuels in the European Union. It also provides an overview of the respective policy landscape for advanced biofuels in all Member States. The update of the deliverable (D5.4, February 2020) will also provide the respective analysis for all Member States and broaden the fuel types to all RESfuels.

This report analyses the current situation, maps the overall policy landscape for biofuels and advance fuels as well as individual market segments in road, marine and aviation, identifies gaps, suggests relevant indicators and makes initial recommendations for future policy interventions. These will be further communicated to stakeholders (through an online consultation and a dedicated workshop and the updated, validated version will be presented in the deliverable D5.4.

2. Methodology

2.1.Rationale and structure of the approach

Current policy mechanisms have been insufficient to support advanced biofuels and RESfuels market in general. Future sustainable growth and market uptake depends largely on a clear, stable and consistent policy framework that will provide investor confidence, to enable the industry to improve technical and financial performance. Designing an efficient policy for the

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sector is complex, due to its cross-sectoral nature that is determined by supply-demand interactions across the value chain and results to inevitable trade-offs between sectors (Panoutsou, 2017[8]).

The work approach in this report is based on the "integrated policy framework" [9] which has also been used in S2Biom[10] and Biomass Policies projects[11]. The framework performs a value chain analysis and is structured into two interlinked sections:

1. **Analysis and direction setting**
2. **Policy recommendations and impact assessment**

The analysis and direction setting section provides an overview of the current state of market and policies and performs a gap analysis in the policy framework along the value chain (including relevant indicators). Based on this, it explores the need for policy interventions and identifies future policy objectives. Overall, this stage provides a benchmark for the recommended policy to be evaluated against a counterfactual scenario in which no actions are proposed.

The "Potential recommendations and impact assessment" section firstly delivers a new set of recommendations of policy interventions by addressing the following questions:

- What type of policy mechanisms and why should it be introduced?
- What will they accomplish?
- To which specific gaps and challenges are they targeted?
- What is their additional value compared to current support measures?

Secondly, it performs a qualitative policy impact assessment across the value chain using specific indicators.

[8] Panoutsou, C. (2017) An integrated policy framework for the sustainable exploitation of biomass for advanced biofuels from marginal lands.
[9] Panoutsou, C. Singh., A., Uslu, A., van Stralen, J., Kwant, K., Muisers, J., Pelkmans, L. and N. Devrient. 2016. Biomass Policies project. Deliverable D4.4. Lessons and recommendations for EU and national policy frameworks.
[10] FP7 KBBE.2013. Grant Agreement n°608622. S2BIOM. Delivery of sustainable supply of non-food biomass to support a "re-source-efficient" Bioeconomy in Europe. http://www.s2biom.eu. The project refined methodologies and provided support for the sustainable delivery of non-food biomass feedstock at local, regional and pan European level through developing Strategies, and Roadmaps informed by a "computerized and easy to use" planning toolset (and respective databases) with up to date harmonized datasets for EU27, western Balkans, Turkey, Moldova and Ukraine. The spatial level of analysis both for the toolset and the databases is NUTS1 (country), NUTS2 (regional) and NUTS3 (local level).
[11] IEE/12/835/SI2.645920. Biomass Policies. Strategic Initiative for Resource Efficient Biomass Policies. The project built a consistent knowledge base both for the efficient resource mobilisation (sustainability criteria; costs, logistics, availability) and for the assessment of resource efficient biomass value chains n EU28 (with a set of consistent technical indicators).

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2.2.Indicators used to assess policy

Indicators play a vital role in policy formation. They shape the evidence base and support policy makers to monitor progress. Moreover, they provide feedback on policy outcomes through quantifying effectiveness so that new agendas and issues can be identified in the outline of new policy goals (Pinter, Swanson & Barr, 2004[12]).

Indicators, therefore, inform about relevant metrics that are required in decision-making. Their use improves transparency since they allow the public or any stakeholders to trace the policy's rationale, progress and delivery over time as well as allowing comparisons across countries and databases (Josling & Valdes, 2004[13]).

Transparency plays a significant role in sustainable development policies and indicators have often been used in this policy area due to their ability to integrate stakeholder's views and improve their understanding of one another. Improved mutual understanding enables policy decisions to be better shaped to avoid conflicts and address issues of high importance for stakeholders (Pinter et al., 2004[14]).

The work in this report, beyond the energy and transport relevant indicators, introduces two additional sets from i) Sustainable Development Goals[15] , and ii) the Common Agricultural Policy (CAP)[16].

i) indicators from the Sustainable Development Goals (SDGs)

Interest in Sustainable Development indicators has risen at all levels including global organisations such as the Organisation for Economic Co-operation and Development (OECD). OECD uses sustainable development and environmental metrics to monitor and compare the relationship between economic activity and environment pressures to support policy evaluation (Neuhoff et al., 2014[17]). Establishing a system of indicators in this policy area is complex due to

[12] Pinter, L., Swanson, D. & Barr, J. E. (2004) Use of Indicators in Policy Analysis. International Institute for Sustainable Development.
[13] Josling, T. E. & Valdes, A. (2004) Agricultural Policy Indicators. The Food and Agriculture Organization of the United Nations.
[14] Pinter, L., Swanson, D. & Barr, J. E. (2004) Use of Indicators in Policy Analysis. International Institute for Sustainable Development.
[15] https://www.un.org/sustainabledevelopment/sustainable-development-goals/
[16] https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/cap-glance_en
[17] Neuhoff, K., Laing, T., Lester, S. & Rysanek, A. (2014) The role of indicators for effective policy implementation. University of Cambridge.

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the various policies objectives, sectors, stakeholders and indicator's functions (Pinter et al., 2004).

The UN established the SDGs to provide a common set of goals and target in order to unite global efforts in tackling these seventeen goals (see Figure (3)) that are defined to be the global sustainable development priorities by 2030. The SDGs not only achieve the millennium development goals (MDGs) but address other inter-connected challenges across the three dimensions of sustainable development: economic, social and environment. The SDGs seek worldwide action from governments, organization and even efforts from businesses in private sector to have a role in contributing to these goals (UN Global Compact, 2015[18]).

Figure 3 The 17 UN Sustainable Development goals

Advanced biofuels and RESfuels in general can play a significant role in achieving the SDGs since they offer solutions to the following goals (IRENA, IEA Bioenergy & FAO, 2017):

- SDG (2): Ending hunger by ensuring food security by promoting sustainable agriculture
- SDG (7): Offers affordable and clean sustainable energy for everyone
- SDG (13): Helps contribute to climate goals with its significant impact on GHG savings when implement with best practice
- SDG (15): Promotes better land use since biofuel regulations ensure sustainable practice when dealing with ecosystem and biodiversity.

[18] UN Global Compact. (2015) Learn More About the SDGs. Available from: https://sdgcompass.org/sdgs/ [Accessed Feb 20, 2019].

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ii) indicators in the Common Agricultural Policy (CAP)

CAP impact assessments include agriculture, forestry and residual raw feedstocks that are eligible as raw material in Annex IX of REDII and as such they are included in the analysis of this report. They are based on sixteen common indicators. These provide a monitoring and evaluation framework for the EU Common Agriculture policy (ENRD, 2018[19]). Figure (4) illustrates how the sixteen indicators portray the impacts on the three sustainability pillars: economic, social and environment.

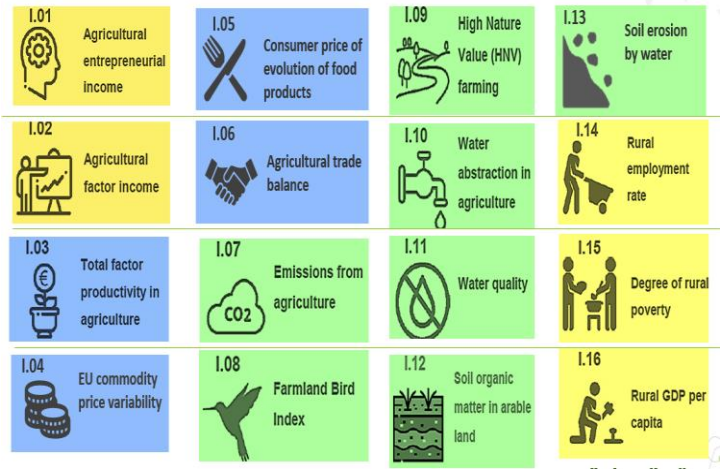

Figure 4 CAP indicators categories according to the sustainability dimensions (in green environmental measures; in blue economic and in yellow social)

This indicator system is too wide and complex to measure the biofuels sector but needs to adapted and focused.

To do this, the CAP impact indicators were assessed for relevance to the Sustainable Development Goals (SDGs) and EU Bioeconomy targets[20]. This was done based on literature and interviews with selected stakeholders. The indicators were scored according to how relevant or applicable they could be to measure the progress of the different SDGs and EU Bioeconomy targets. The EU Bioeconomy strategy established the five following goals: food security, sustainable management of natural resources, reducing dependency of fossil-based resource, mitigating Climate change and sustainable economic growth (Newton et al., 2017[21]). The indicators that cover the maximum number of goals have been selected as the indicators to be used in the project to evaluate the current biofuel policies. It is noted that recommended indicators must address the whole sustainable dimensions of economy, society and environment. Figure (5) illustrates this process.

[19] ENRD. (2018) GUIDELINES ASSESSING RDP ACHIEVEMENTS AND IMPACTS IN 2019. European Commission.
[20] https://ec.europa.eu/commission/news/new-bioeconomy-strategy-sustainable-europe-2018-oct-11-0_en
[21] Newton, A., Lescai, F., Carrez, D., Carus, M. & Jilkova, J. (2017) Expert Group Report: Review of the EU Bioeconomy Strategy and its Action Plan Brussels, European Union.

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Keys:	
	Highly Relatable
	Slightly Relatable
	Not relatable

	CAP indicators	Sustainable dimension	EU Bioeconomy Challnges (/5)	Description	SDGs																Totals			Comments
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Highly relatable	Relatables	SUM	
1	Agricultural entrepreneurial income	Social	1	Sustainable economic growth																		2	6	8	Only consider agriculture stream - doesn't cover the whole bioeconomy primary resources such as waste stream
2	Agricultural factor income	Social	1	Sustainable economic growth																		2	6	8	
3	Total factor productivity in agriculture	Economics	2	Sustainable economic growth, sustanable management of natural resources																		4	8	12	Effects the production cost of all bioeconomy products/energy and include data on competition with non-renweable resources
4	EU commodity price variability	Economics	3	Food security, sustainable economic growth, Reducing dependncy of fossil-based resource																		3	6	9	
5	Consumer price evolution of food products	Economics	2	Food security, sustainable economic growth																		3	5	8	
6	Agricultural trade balance	Economics	1	Sustainable economic growth																		1	2	3	
7	Emissions from agriculture	Environment	3	Sustainable management of natural resources, reducing dependency of fossil-based resource , mitigating climate change																		6	8	14	Threshold standards, been apply to several procedures and policies
8	Farmland bird index	Environment	2	Sustainable management of natural resources, mitigating climate change																		1	3	4	
9	High nature value (HNV) farming	Environment	2	Sustainable management of natural resources, mitigating climate change																		0	1	1	
10	Water abstraction in agriculture	Environment	2	Sustainable management of natural resources, reducing dependency of fossil-based resource																		2	4	6	
11	Water quality	Environment	2	Sustainable management of natural resources, mitigating climate change																		3	4	7	
12	Soil organic matter in arable land	Environment	4	Food security, Sustainable management of natural resources, reducing dependency of fossil-based resource , mitigating climate change																		3	5	8	Effects the productivity of bio-based resources
13	Soil erosion by water	Environment	2	Sustainable management of natural resources, mitigating climate change																		0	2	2	
14	Rural employment rate	Social	1	Sustainable economic growth																		2	6	8	Easier to obtain data
15	Degree of rural poverty	Social	1	Sustainable economic growth																		2	6	8	
16	Rural GDP per capita	Economics	1	Sustainable economic growth																		2	4	6	

Figure 5 Indicator selection process through scoring system by comparing the 16 CAP indicators with the SDGs

From Figure (5), there were many indicators that rank the top three when assessing with the SDGs. However, when combining the score with the EU Bioeconomy targets, the recommended indicators were narrowed to the following: i) EU Commodity price variability, ii) Emissions from agriculture, iii) Soil organic matter in arable land and iv) Degree of rural poverty. It is worth mentioning that degree of rural poverty did not score highest when compared to other indicators but, it is the highest amongst social indicators and is included to help fulfil the sustainability dimensions. The following section provides a short description for the recommended indicators' and its rationale for this assessment (European Commission, 2016[22]):

- **EU Commodity price variability**
  - *Description:* It measures the EU and world market commodity price variability of agricultural commodities. It is measured by calculating the commodities' coefficient of variation with the mean over the certain period (roughly 3-5 years).
  - *Rationale:* It is a helpful indicator since biomass feedstocks for advanced biofuels will be regarded as commodities once the market is developed and any volatility and uncertainty of their prices can cause barrier for investment. Also, the indicator offers the market analysis and comparison between biofuels and fossil fuels.

- **Emissions from agriculture**
  - *Description:* The indicator measures both the greenhouse gas (GHG) and ammonia emissions from agriculture activities.
  - *Rationale:* This indicator is useful since several policies from other bioeconomy sectors already account for this indicator. Additionally, the methods of measuring the indicator have been established through standards such as Environmental Impact Assessment (EIA).

- **Soil organic matter in arable land**
  - *Description:* This indicator portrays the estimation of the total organic carbon content in arable soils. There are two groups of factors that influence inherent soil organic matter content: natural factors and human-induced factors (e.g. land use, management)
  - *Rationale:* It is essential to measure the organic matter in soil since a decline of this content can cause negative impacts e.g. a decrease in fertility and loss of structure, which ultimately linked to soil degradation. In other words, it effects the productivity of the biomass resource in the future as well as food security. Hence, policy-makers, farmers and foresters must promote sustainable practices to avoid the interconnected nature of the factors causing soil degradation (ENRD, 2018).

[22] European Commission. (2016) IMPACT INDICATORS FOR THE CAP POST 2013 . European Commission DIRECTORATE-GENERAL FOR AGRICULTURE AND RURAL DEVELOPMENT.

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- **Degree of rural poverty**
  - *Description:* The indicator measures the share of population at risk of poverty or social exclusion in thinly populated areas (used as proxy for rural areas).
  - *Rationale:* The indicator highly inter-link with the upstream indicator of "employment". Additionally, this indicator is directly associate with the EU bioeconomy goals on the regional development aspect.

The following three indicators are also added to this recommended list to ensure coverage of the complete value chain: sector turnover; carbon emission along its value chain and; employment. These indicators ensure that the whole value chain of biofuel is being covered as well as the sustainability dimensions.

2.3. Barriers

Additionally, the work presented here also assessed if the recommended policies address solutions to the key barriers of RESfuels identified by stakeholder consultation within the ADVANCEFuel project. This report summarizes the key barriers into fourteen and sorts them according to their typology and the stages of the value chain they may affect (Figure 6).

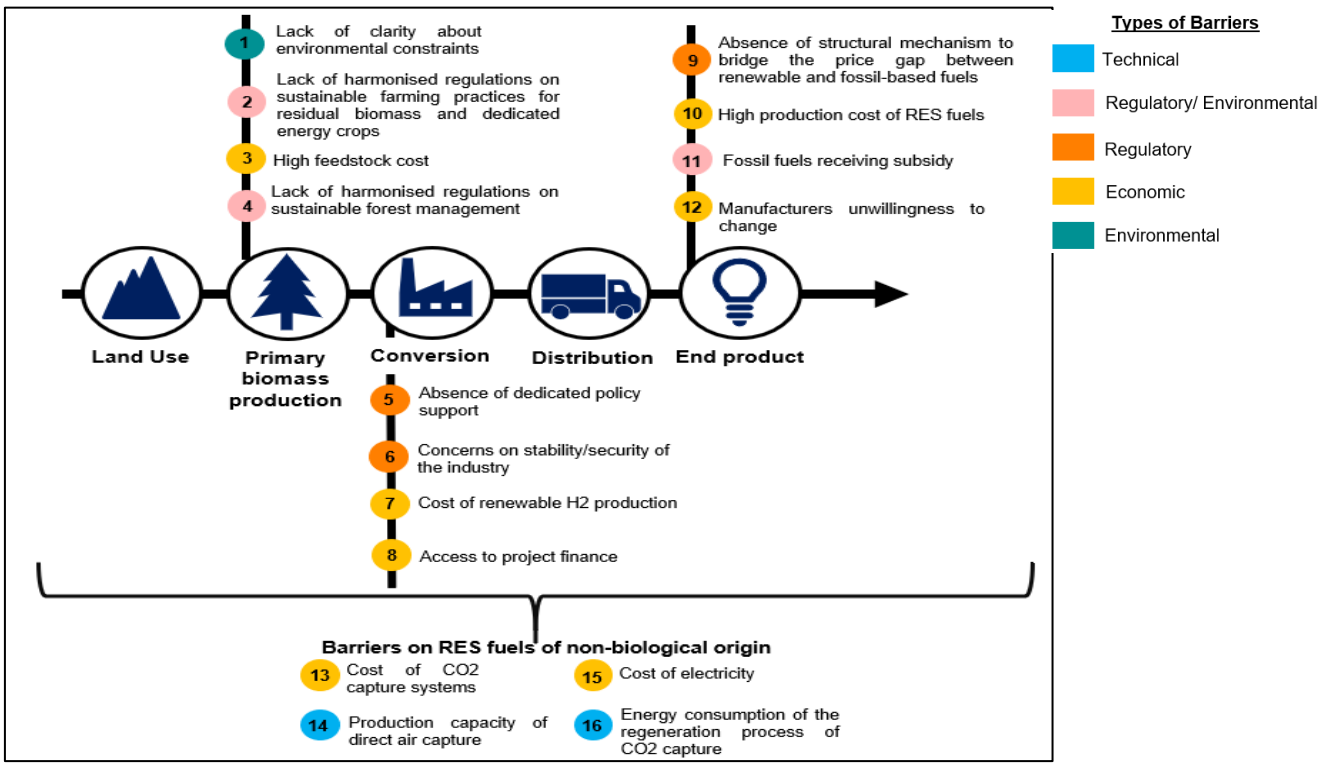

Figure 6 Key Barriers to EU advanced biofuels identified by stakeholder's consultation

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2.4.Policy impact assessment

By using impact assessments provide transparency in policymaking since decision-making can be based on evidence. They also establish a system on which policies can be prioritised.

An initial impact assessment was carried out for current biofuel policies and the recommended future policy framework for advanced biofuels. The assessment quantified each of the policies' impact on the selected indicators that cover the three dimensions of sustainability (economic, social and environmental) through a scoring rate system ranging from 1 (Significant negative impacts) to 5 (Significant Positive impact) with 3 representing no impact or the status quo. The assessment and the recommendations will be communicated to stakeholders (through an online consultation and a dedicated workshop) and the updated, validated version will be presented in the final deliverable in Month 30.

2.5.Data collection and sources

One of the main sources used in this report is the policy landscape database created by the S2biom project. The S2biom project is co-funded under the European Commission's 7th Framework Programme, where it aims to provide consistent and scientific evidence on the lignocellulosic biomass value chain. One of its aims was to collate datasets and establish a harmonised database so that future policy making could be more transparent. This database contains details of current EU biofuels policies. The nature of the work also required statistical data and trends as supporting evidence. Such information has been found in the JRC bioeconomy knowledge Centre, Eurostat and OECD or an annual government review re-port (The Organisation for Economic Co-operation and Development.

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3. Analysis and direction setting

This section provides an overview of the current state of market and policies and performs a gap analysis in the policy framework along the value chain (including relevant indicators). Based on this, it explores the need for policy interventions and identifies future policy objectives.

3.1. Current state of biofuels in EU

Opportunity I: Bioenergy represents more than 60% of the EU renewable energy

The share of renewable energy in total EU primary energy supply increased from 10.4% in 2011 to 13.6% in 2016. Bioenergy is a major contributor, with a 64.8% share, From the forecasts in National Renewable Energy Action Plans, bioenergy should reach approximately 139 Mtoe by 2020, and thus play a significant role to help EU reach its 20% share of renewable energy in gross production (Calderón et al., 2017[23]).

Challenge I: Although bioenergy continues to grow, the growth of biofuels in transport slowed down due to high uncertainty in policy
Policy barriers:
i) Absense of dedicated policy support
ii) Concerns on stability/ security of the industry

[23] Calderón, C., Gauthier, G., Jossart, J., Archambeau, P. & Gailliez, T. (2017) AEBIOM Statistical report 2017 European Bioenergy Outlook. Brussels, European Biomass Association (AEBIOM).

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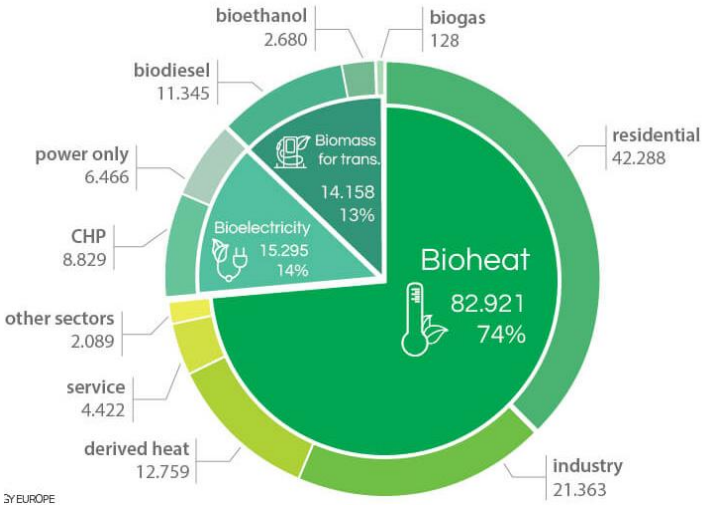

Figure (7) displays how bioenergy is distributed in these sectors, with a 74% share in bioheat, 14% in bioelectricity and 13% in transport biofuels.

Figure 7 EU-28 gross final energy consumption of bioenergy per market segment (in 2015, ktoe, %) (Calderón et al., 2017)

According to the Aebiom statistical report 2017, there has been a significant increase of bioenergy in bioheat and bioelectricity sector (approximately 6.6% increase between 2014 and 2015), but only a modest increase for transport biofuels (Calderón et al., 2017). Statistics indicate that before 2012, there was a sharp increase in biofuel consumption in the transport sector, but it levelled off in 2013 at 12.1 Mtoe. In 2014-2015, the consumption stabilized at 14.2 Mtoe (EUObserv'ER, 2017[24]).

The slow growth of transport biofuels is due both to low prices for fossil fuels during the period and political instability in the sector. There have been several signs that portray uncertainty in biofuels policies recently.

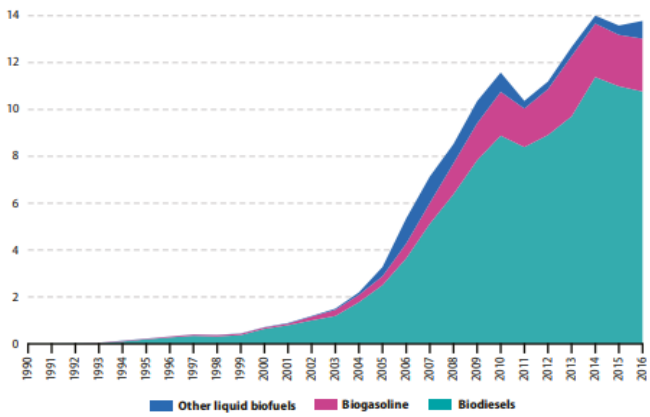

Figure 8 EU trends of Primary production of liquid biofuels from 1990-2016 (Mtoe)(Eurostats, 2019)

An important reason for the slowdown of the sector has been the long wait for amendments to be made to the relevant legislation that concerns the sustainability of certain types of biofuels especially food-crops feedstock, which cause uncertainty for expansion of first-generation biofuels (EUObserv'ER, 2017).

Another fact that confirms the slowdown is the employment in the biofuels sector. This was

[24] EUObserv'ER. (2017) THE STATE OF RENEWABLE ENERGIES IN EUROPE EDITION 2016 16th EurObserv'ER Report. Paris, Imprimerie Graphius.

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estimated to be approximately 100,000 by 2015. However, by observing the overall employment trend in Figure (9), this represents about a 1.5% drop. Diane Lescot, the Leader of the EurObserv'ER consortium, explains the cause of this trend is policy uncertainty and risks around controversies such as food security.

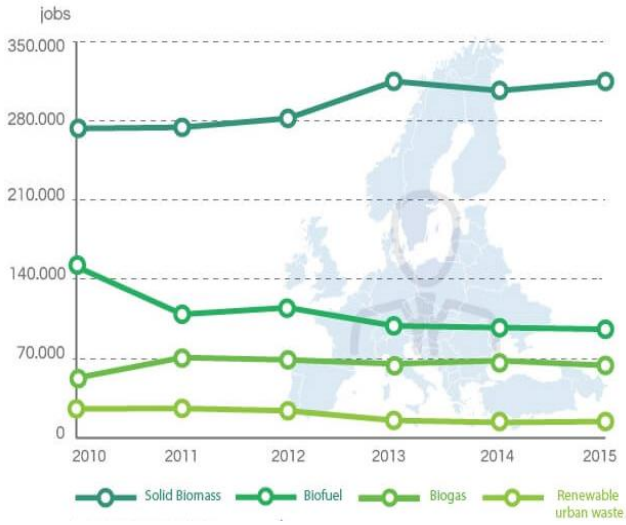

Figure 9: The evolution of the employment distribution within the EU bioenergy from 2010 to 2015 (both direct and indirect jobs) (Calderón et al., 2017)

Challenge II: Controversy over environmental benefits of biofuels and advanced biofuels
Policy barrier: Lack of harmonised regulations for farming and forest management

Several years ago, biofuels were widely considered to revolutionise the transport sector by significantly reducing the GHG emissions compared to conventional fossil fuels. Subsequent studies showed the significance of indirect use change (ILUC) emissions when calculating GHG savings of biofuel. ILUC emissions stem from the increasing demand for biofuel production that leads to higher demand for feedstocks that grows on cropland. Since cropland is essential to food production, agricultural expansion occurs if natural lands are being converted. If the expansion is on high carbon stock land (e.g. forest), then this will lead to high emissions and other environmental impacts (Searle, 2018[25]).

A report by the European Federation for Transport and Environment (T&E) aimed to quantify the ILUC impacts of EU biofuels policies by combining results from the two main models (IFPRI and GLOBIOM) used by the European Commission. The T&E analysis compares direct and indirect emissions (land-use change) of different types of biomass used for biofuel production compared to emissions from fossil fuels (see Figure (9). Both soy and palm biodiesel are worst performing, with 200-300% higher emissions than regular biodiesel. Even biodiesel produced from rapeseed emits 20% more GHG than fossil fuels when taking account of the ILUC emissions. By including the current biofuel policy of 7% cap on food-based biofuels into the model forecast, it is estimated that there will still be an increase in overall EU transport emissions by 1.4% in 2020.

[25] Searle, S. (2018) Analysis of high and low indirect land-use change definitions in European Union renewable fuel policy. INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION.

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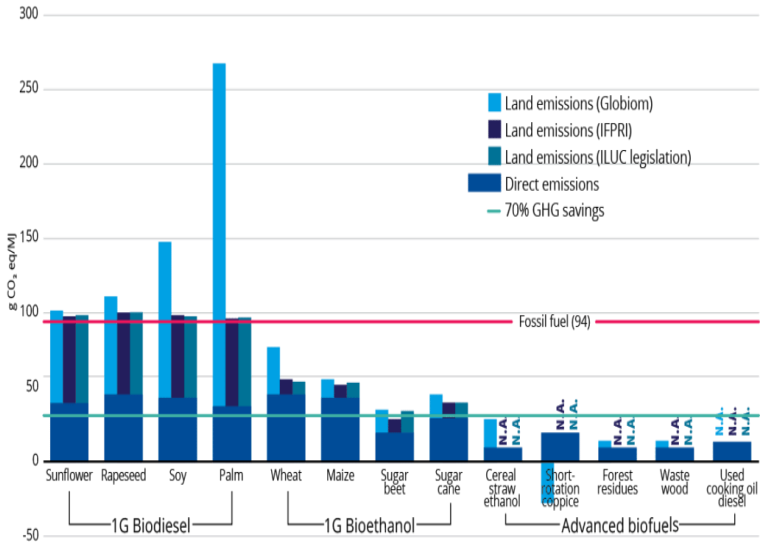

Figure 10 Direct and indirect emissions of the different types of biofuels feedstock (T&E, 2017)

As seen from the graph, advanced biofuels have significantly higher GHG emissions savings than Biodiesel and Bioethanol. Hence, the European Commission is supporting the use of advanced biofuels to help accomplish the renewable energy direction (RED II) 2030 objectives.

3.2.Current state of advanced biofuels in EU

Opportunity II: The advanced biofuels sector is established with world leading industrial activity in EU

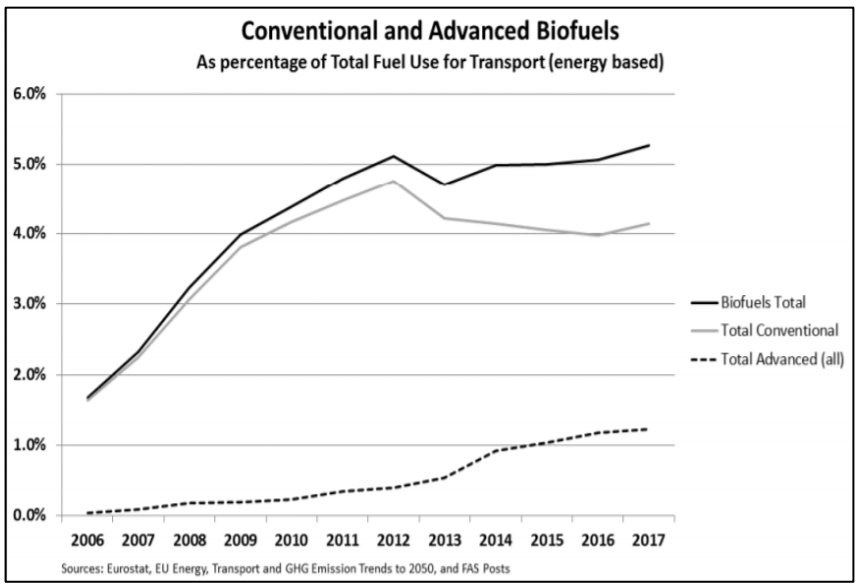

Figure 11 Graph to show the progression of Conventional and Advanced Biofuels as a percentage of Total Fuel consumption in the transport sector (Flach et al., 2017[26])

The use of advanced biofuels in the EU transport sector has increased gradually, as illustrated in Figure (11). In 2017, the blending of advanced biofuels in transport reached approximately 1.2%, surpassing the 2020 target of 0.5 % (Flach, Lieberz & Rossetti, 2017). This non-

[26] Flach, B., Lieberz, S. & Rossetti, A. (2017) EU Biofuels Annual 2017. Hague, USDA Foreign Agricultural Service.

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binding target was introduced in the amended of the EU Indirect Land-use Change (ILUC) directive to promote the use of biofuels produced from non-food feedstocks and wastes (Giuntoli, 2018[27]).

The primary feedstock that showed the highest rate of increase is hydrogenated vegetable oil, with fuel production from this source reaching 2.6 billion litres in 2017. Another type of biofuel considered to have high potential for increase is cellulosic ethanol, with current capacity roughly about 60 million litres estimated to rise to 200 million litres in 2021. Some commentators have doubts about this projection (Flach et al., 2017)

EU is a leader in development of advanced biofuels. This could be due to the advance in conversion technology, strong industrial commitment and consistent investment in R&D.

Aviation is a focus sector for support from the EC, with the EC, Airbus, and aviation and biofuel producer industry bodies jointly launching an action plan called the European Advanced Biofuels Flightpath. One objective is to establish a financial mechanism to fund the construction of "first of a kind" advanced biofuel production plants intended for aviation and commercialise biofuels for aviation. Test flights are ongoing from 2008 (European Commission, 2011[28]).

Opportunity III: Advanced biofuels market uptake will grow due to policy demand

Advanced biofuel consumption is forecast to increase due to rising demand. The recently revised renewable energy directive (RED II) established targets of advanced biofuels consumption to reach a minimum share of 3.5% by 2030 (including double counting, so in physical terms it will be 1.75%). Furthermore, the RED II capped conventional biofuels at 7% from 2021. These two measures will combine to drive a transition to advanced biofuels (Flach et al., 2017; Giuntoli, 2018).

With the market shift to advanced biofuel, EU benefits both in terms of GHG savings and energy security. It is estimated that potential CO2 savings can range from 60 -85 % which can help EU make a significant impact towards achieving its climate goals (Malins et al., 2014).

Opportunity IV: EU can achieve high market uptake and benefit from the use of domestic biomass for advanced biofuels.

[27] Giuntoli, J. (2018) ADVANCED BIOFUEL POLICIES IN SELECT EU MEMBER STATES: 2018 UPDATE. INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION.

[28] European Commission. (2011) Launch of the European Advanced Biofuels Flightpath European Commission.

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In 2014, another study by environmental NGOs and advanced biofuels companies estimated that the EU has the technical potential to supply 16% of road transport fuel by 2030 by using currently available EU wastes and residues. With this potential, it is forecast that there would be up to 15 billion euros of additional, annual revenue, especially in rural economies. It is estimated that up to 300,000 addition jobs could be created by 2030 across various sectors, as shown by Figure (12) (Bourguignon & Vandenbussche, 2017).

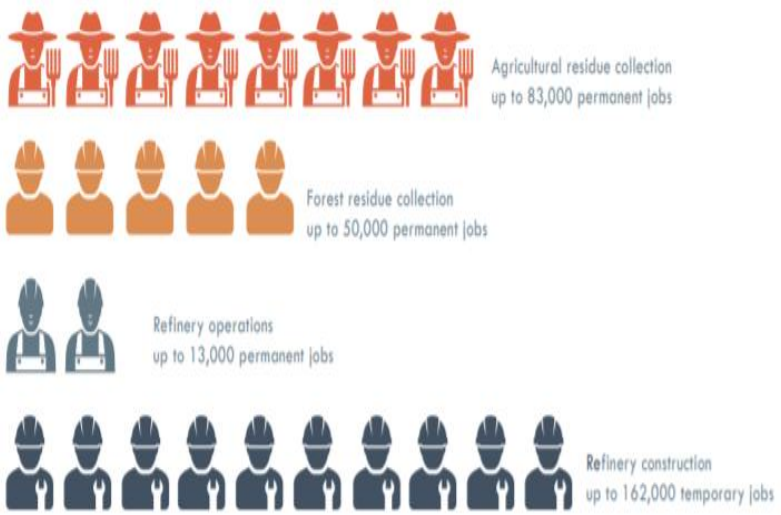

Figure 12 Diagram representing the additional employment if the entire waste and residue are used to convert to advanced biofuels (Malins et al., 2014[29])

Opportunity V: Advanced biofuels can offer solutions for the decarbonization of transport segments with limited low carbon solutions, i.e. aviation, marine and road transport.

Advanced biofuels are seen to have an important role in decarbonising aviation and water transport, which is important against the ongoing growth of the aviation sector. EC forecasts show that fossil fuel continue to dominate in this market but, by 2035, bio-kerosene will start to slowly penetrate the aviation fuel mix (Capros et al., 2013[30], Flach et al., 2017).
Advanced biofuels also impose adverse effects and pose challenges concerning sustainability. Such effects must also be considered when considering the recommendations for future policy. These include lifecycle greenhouse gas emissions as well as environmental, social and economic factors.

[29] Malins, c., Searle, S., Baral, A., Turley, D. & Hopwood, L. (2014) Wasted: Europe's untapped resource European Climate organisation.
[30] Capros, P., De Vita, A., Tasios, N., Papadopouls, D., Siskos, P. & Apostolaki, E. (2013) EU ENERGY, TRANSPORT AND GHG EMISSIONS TRENDS TO 2050 REFERENCE SCENARIO 2013. European Commission.

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Challenge III: Advanced biofuels in specific transport segments require high investment, market stability. This necessitates strong and immediate actions in policy formation
Policy barriers:
i) Absence of dedicated support
ii) Absence of structural mechanism to bridge the price gap between advance biofuels, RESfuels and fossil ones.

Another challenge is to secure investment towards R&D in these technologies in order to produce in commercial scale. Hence, it is essential for the EU to provide a stable policy environment to foster these investments.

A key challenge in this sector is to balance technology development with the costs imposed on consumers.

The innovation curve in Figure (13) should be used to help select the type of policy instruments to be used as the technology advances. Also, policies should be adapted regularly as there are changes or impacts from the economic climate, the availability of credit and new knowledge on the impacts (Biofuels for Europe, 2017).

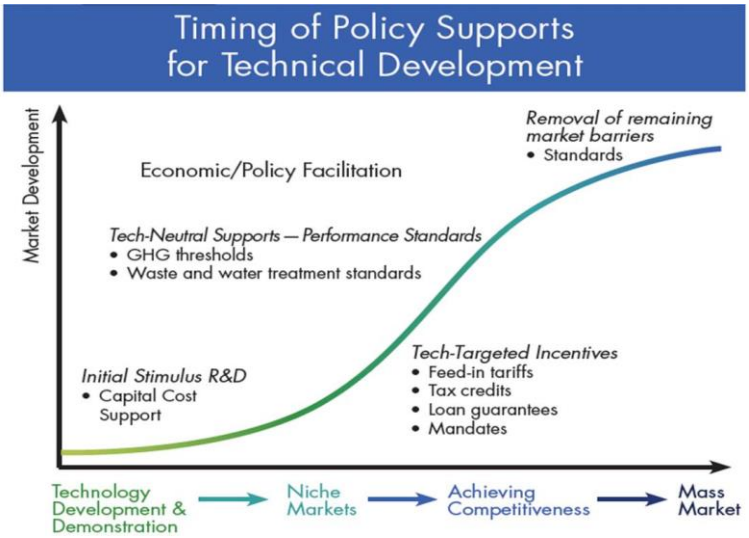

Figure 13 Diagram of policy supports according to technical development (Biofuels for Europe, 2017[31])

[31] Biofuels for Europe. (2017) Advanced Biofuels. Available from: http://www.biofuelsforeurope.eu/advanced-biofuels/ [Accessed 20 Jan, 2019].

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3.3.Policy landscape for biofuels and advanced biofuels in EU

This section provides a general overview of the EU Biofuel policy landscape structured according to stages in the value chain, as illustrated in the schematic overview in Figure (14).

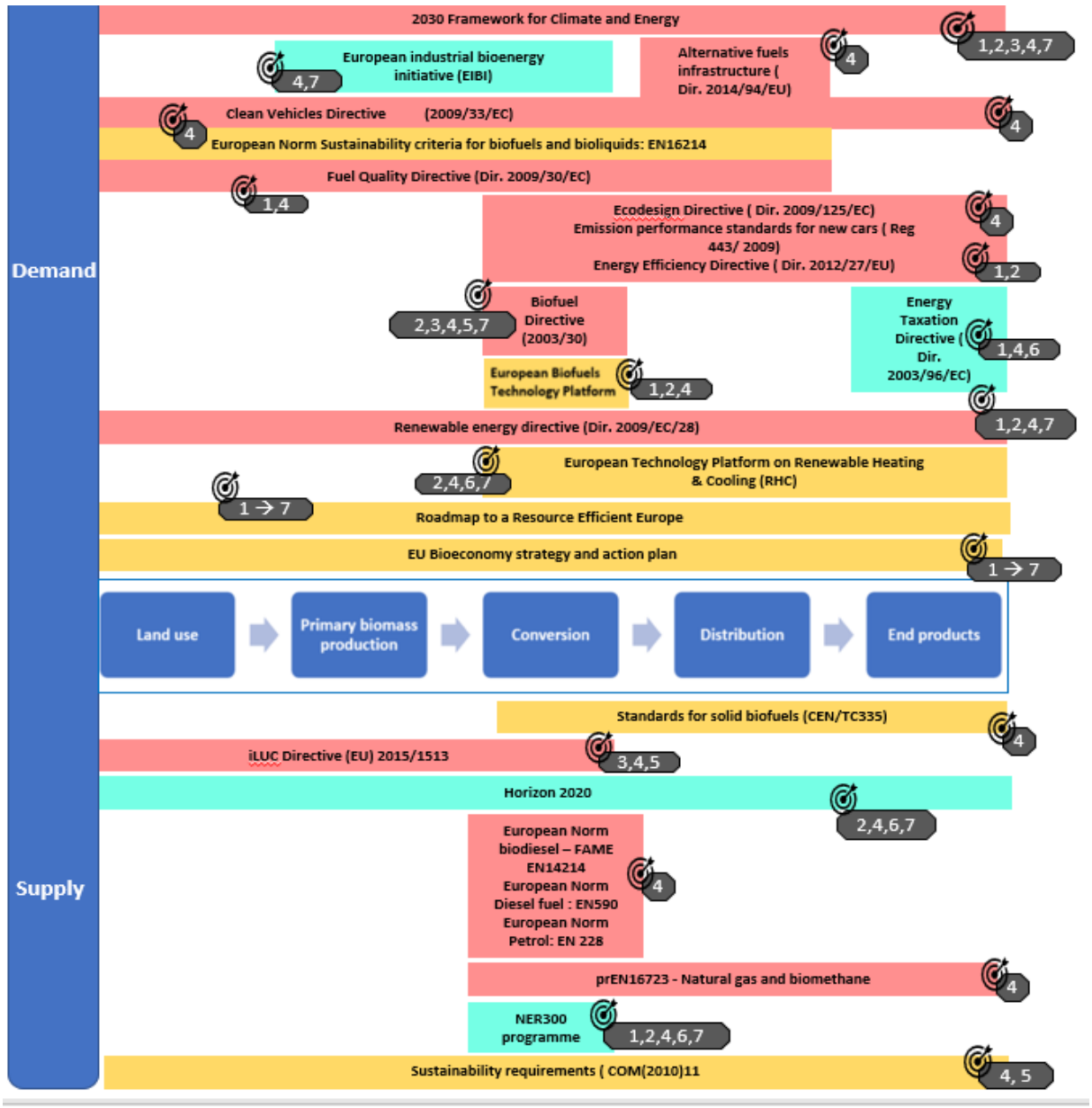

Figure 14 Schematic overview of general policies applied along the biofuel's value chain

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This report considers the following stages in the biofuel's value chain: land use; primary biomass production; conversion; distribution and; end products. The details of each stage can be found in section 2. It should be noted that Figure (14) also categorises policies according to either demand or supply.

It is also vital to consider the policies dedicated to the biomass sector since biomass plays a major role in the biofuel's value chain and could potentially play a significant role in the future of advanced biofuel. The EU biomass sector relates to sectors including agriculture, forestry and waste. Figure (15) illustrates the policies of these sectors according to the different stages of its value chains.

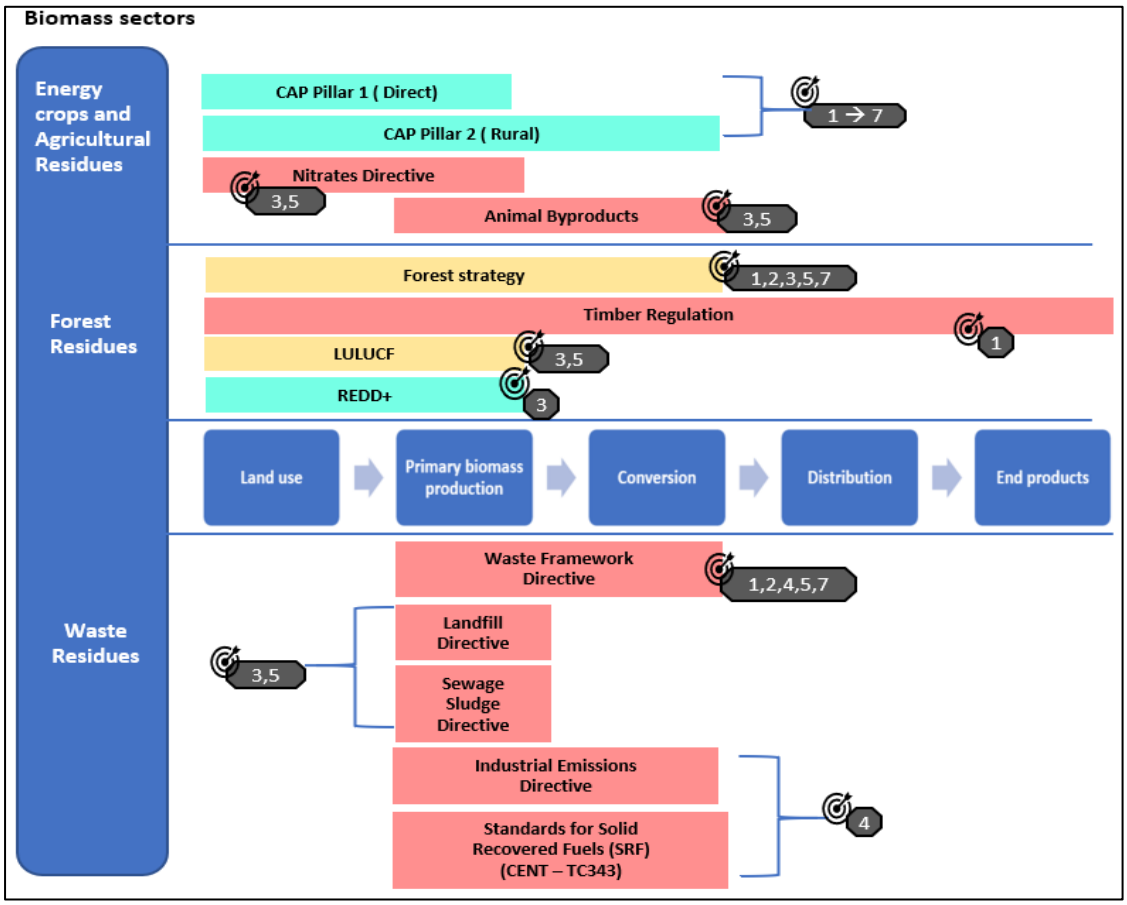

Figure 15 Schematic overview of biomass policies along with its value chain that should be considered in the biofuel's policy landscape

As illustrated in Figures (14) and (15), the schematic overview includes other elements of each policy: 1) the policy mechanism and 2) the key indicators that are used to monitor and evaluate the policy's effectiveness.

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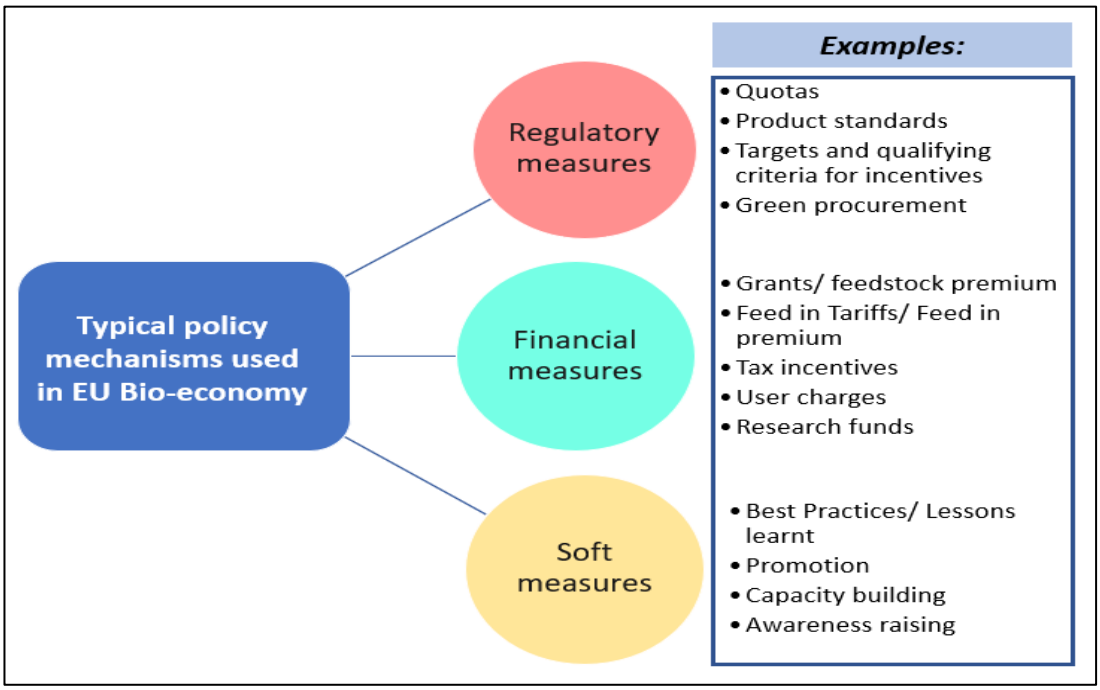

Figure 16 Diagram illustrating the policy measures included in the analysis

Each policy is colour coded according to the three types of policy measures: financial, regulatory and soft measures. Typical examples of these policy measures that are used in the EU Bioeconomy are demonstrated in Figure (16).

The numbers attached on each policy as displayed in the schematic overview represent the different key indicators that are selected to be used to monitor and evaluate the policy's effectiveness. Figure (16) represents the definition of the numbers. It should be noted that some policies will contain more than one indicator due to the cross-cutting nature of biofuel's policies that allows several EU's objectives to be met. The selection of these key indicators can be view in detail in the methodology section, but generally, the key indicators are selected to cover the three sustainability dimensions: economic, social and environmental.

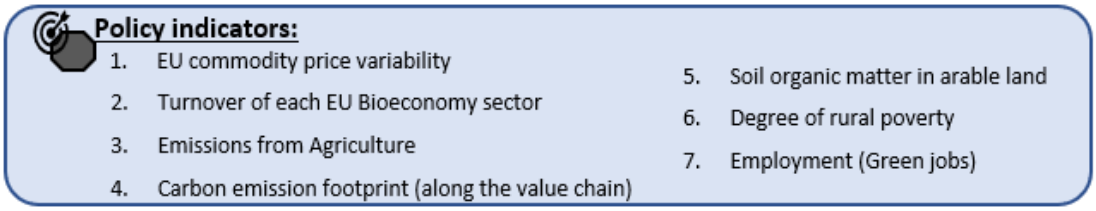

Figure 17 Key indicators selected to assess the policies

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3.4. Policy gap analysis

This section considers the main gaps and issues that the policy has not yet fully addressed. Identified gaps are grouped by challenge and are based on similar analysis conducted by EBTP[32] (REF) and complemented by a set of interviews conducted within the ADVANCEFuel project. They will be used in this analysis as a baseline to define needs, aims and objectives of new recommended policy interventions for advanced biofuels.

Challenge I: Although bioenergy continues to grow, the growth of biofuels in transport slowed down due to high uncertainty in policy
Policy barriers:
i) Absence of dedicated policy support
ii) Concerns on stability/ security of the industry

EU policies perceived as incoherent (e.g. supporting diverse solutions for transport or alternative uses of biomass). Current policies tend to support any type of solutions that reduces GHG emissions in transport. Hence, this creates competition within the renewable energy sources used in the transport sector.

One of the major competitors to advanced biofuels is the use of electric vehicles which offer the EU a way to achieve CO2 emissions goals albeit electricity generation in some member states in the EU is still quite carbon intensive. Even though there is no cap set for electric vehicles, the figure portrays the multiplication factor of the electric road vehicles to be five times the energy content of the input of renewable electricity when accounting towards the RED target (Grinsven & Kampman, 2015[33]).

No policy was addressing the competition for sustainable feedstocks between bioenergy and bioproducts sectors. Feedstocks from forest-based and agricultural residues do not directly compete with food security but may compete with other bioeconomy sectors such as biomaterials. This competition could lead to issue such as creating uncertainty for investors.

[32] http://www.etipbioenergy.eu/images/papers/draft-ebtp-position-paper-post-2020-transport-strategies.pdf and http://www.etipbioenergy.eu/images/ebtpreports/ecn-sustainable-transport-visions-beyond-2020.pdf
[33] Grinsven, A. v. & Kampman, B. (2015) Assessing progress towards implementation of the ILUC Directive. CE DELFT.

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Challenge II: Controversy over environmental benefits of biofuels and advanced biofuels
Policy barrier: Lack of harmonised regulations for farming and forest management

Current policies are oriented at low carbon - climate change and not on other sustainability dimensions of social and economic aspects. RED is an example of a policy that focuses on reducing GHG emissions but does not directly address issues such as employment, rural development and resource competition.

No policy support towards consumer and investor awareness on advanced biofuel or even conventional biofuel. Knowledge and awareness amongst investors, policymakers and the public are insufficient and should be provided with unbiased information in order to promote development of advanced biofuels. Studies show that the public has little awareness of the difference between conventional and advanced biofuel due to lack of communications and education. Moreover, there is confusion amongst consumers regarding sustainability of biofuels due to different media outlets being aligned with different stakeholders. Consumers perceive waste stream feedstocks negatively due to lack of reassurance regarding safety and quality, which is a significant obstacle for increasing demand for advanced biofuel. Advanced biofuels are based on technical development and investors with little understanding of the technology favour other, lower risk sectors. (EBTP, 2015).

Challenge III: Advanced biofuels in specific transport segments require high investment, market stability. This necessitates strong and immediate actions in policy formation.
Policy barriers:
i) Absence of dedicated support
ii) Absence of structural mechanism to bridge the price gap between advance biofuels, RESfuels and fossil ones.

Lack of policy support in funding advanced biofuel demonstration plant. As mentioned in the analysis and direction setting stage, commercialising advanced biofuel requires significant investment. Limited priority has been give to support demonstration plants by public support schemes and there has been limited access to national funds.

Low effort of policy support on using advanced biofuels in other transport sectors (except road transport). One of the policy mechanisms that are seen to address other transport sectors directly is the "multiplication factor" measure. By using advanced biofuels in aviation and water transport sectors, they will contribute to the counting for more than 20% of their

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actual energy content (Bourguignon & Vandenbussche, 2017[34]). However, the multiplication factor does not guarantee incentives for investment since its value might not overcome the cost challenges of producing advanced biofuels (Bitnere & Searle, 2017[35]).

Lack of financial instruments that support the whole value chain for advanced biofuel. Most funding instruments support the conversion stage and there is little or no support in the production cost which is also a critical to overall financial viability and performance. It is recommended that additional financial support should be provided to production (Bitnere & Searle, 2017).

Lack of harmonisation of national mandates and non-compliance penalties
Most member states give a low mandate for advanced biofuels for 2020 and 2030 compared to the overall EU mandate of 3.5%. However, the cap on conventional biofuels is comparable among all member states. This means that, to meet the EU mandate of 14% of biofuels in RES-T by 2030, member states will need to go beyond their respective national mandate. There is also huge disparity in the price of non-compliance among member states for biofuels with no harmonised penalty.

3.5.Policy aim and justification

This section highlights the key issues under consideration for EU and identifies reasons why further policy interventions are needed to increase the growth of advanced biofuel in the transport sector.

Which are the key issues under consideration for the future of advanced biofuels?

- **Technology to produce advanced biofuel is not in a mature phase**. Technical challenges need to be overcome, such as finding energy-cost efficient ways of converting waste residues to fuels.

- **Lack of investment**: Advanced biofuels have high production costs and requires large capital investment in conversion. Technology is largely in the demonstration phase and requires investment to be developed to commercial scale, with consequent unit cost reductions. Policy uncertainty combined with relatively high-risks make the sector unpromising for investors.

[34] Bourguignon, D. & Vandenbussche, T. (2017) Advanced biofuels Technologies and EU policy. European Parliamentary Research Service.
[35] Bitnere, K. & Searle, S. (2017) EFFECTIVE POLICY DESIGN FOR PROMOTING INVESTMENT IN ADVANCED ALTERNATIVE FUELS. The international council on clean trasport.

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- **Low awareness and misunderstanding knowledge on advanced biofuels amongst consumers as well as investors resulting in less demand in the market.** With lack of awareness and accurate knowledge, of advanced biofuel, consumers do not fully understand the benefits of replacing conventional fuels.

- **There is no policy to promote and measure social and economic aspects of advanced biofuels.** Several studies forecast significant benefits of advanced biofuels, in term of employment and increased turnover in the rural economy. However, there is no current policy support to promote these benefits.

- **Current policies for biofuel and advanced biofuels are incoherent, resulting in conflicts (e.g. the different solutions proposed in the transport sector).** Current policies tend to support any types of solutions that reduce GHG emissions in transport. This creates competition among renewable energy sources used in the transport sector, e.g. competition with electric vehicles. Additionally, there are conflicts between other sectors due to shared feedstocks.

Why is government intervention necessary?

The concept of advanced biofuel was initially introduced by the EC to help the EU achieve its GHG targets without competing with food sector. Advanced biofuels also provide an opportunity to shift the EU to a circular economy; feedstocks used for advanced biofuels are residues from human activities and can be converted back into consumption as energy. These benefits will only be realized with substantial investment which will not be forthcoming without a supportive policy framework.

Advanced biofuels can be considered "public goods", with benefits for society in terms of better environment and cleaner air. Investors need to be incentivised to deliver those benefits and without incentives there will be market failure (Ahlheim, 2017).

Government intervention is necessary in the form of a long term stable policy framework (see challenge I and opportunities I, III) that will facilitate sustainability and smooth market operation (see challenge II and opportunities III, IV) as well as encourage private investment (see challenge III and opportunity V).

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What are the policy objectives and the intended effects?

Recommended policies will from an integrated policy framework that will enable more sustainable market uptake of advanced biofuels within the transport sector. To achieve this, policy objectives are as follows:

- To ensure policy coherence amongst the biomass sectors to prevent any competition or conflicts between them.
- To facilitate funding for innovation across the advanced biofuels value chain in order to produce cost-effective biofuels to compete in the market.
- To promote the concept of advanced biofuel and raise awareness amongst consumers.
- To assist in maintaining operations of currently installed capacities as well as planning strategies for future capacity.
- To encourage the use of advanced biofuels in individual market segments especially in heavy road transport, marine and aviation sectors.

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4. Policy recommendations and impact assessment

4.1. Policy recommendations

This section delivers a set of recommended policy interventions, linked to the identified challenges and barriers, aimed at increased growth of advanced biofuels while ensuring sustainability.

Policy interventions	Type of policy mechanism	The rationale for the recommended policy interventions	Which barrier does it address?	Expected added value of the recommended policy interventions
Challenge I: Long term, consistent framework **Opportunity I: Bioenergy is one of the main sectors contributing to the increased renewable energy shares in the EU.** **Opportunity III: Advanced biofuels market uptake will grow due to policy demand**				
Set a sub-target of GHG emissions savings for the main transport sector that lack of other low carbon options (road, shipping and aviation sector)	Regulatory measures	Creates demand for advanced biofuel since these transport sectors have the technical limitation on their options to help them achieve these targets	Absence of dedicated policy support Concerns on stability/ security of the industry	The significant increase in GHG savings in overall transport sector which helps EU achieve its new targets proposed in RED II.
Develop strategies for advanced biofuels that integrate rural land-use planning and agricultural incentive schemes	Soft measures	To maintain sustainable development as well as to involve more certainty and investment of advanced biofuels in rural areas	Absence of dedicated policy support Lack of harmonised regulations for farming and forest management	Increase employment and development in rural areas. Additionally, planning allows time to ensure that the land uses to produce feedstock comply with EU sustainability criteria for biofuels.

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Promote information campaigns for farmers on the positive impacts of biofuels on rural development and sustainable agriculture practices	Soft measures	Increase incentives for farmers to diversify their activities towards supplying sustainable raw materials for advanced biofuels.	Lack of harmonised regulations for farming and forest management	More investment and capacity for advanced biofuel feedstock. This result in less competition with other bioeconomy sectors since there is an increase in the supply of feedstock.
Set up a framework that allows advanced biofuels to integrate other bioeconomy sectors objectives to avoid any conflicts.	Soft measure	To ensure policy coherence amongst the biomass sectors so that competition can be avoided.	Absence of dedicated policy support Concerns on stability/ security of the industry	All bioeconomy sectors can provide the capacity to its full potential since there is no competition between feedstocks.
Challenge II: Controversy over environmental benefits of biofuels and advanced biofuels **Opportunity III: Advanced biofuels market uptake will grow due to policy demand** **Opportunity IV: EU can achieve high shares and benefit from the use of domestic bio-mass for advanced biofuels.**				
Establish a certification-labelling scheme for advanced biofuel on its sustainability by assessing across its whole value chain.	Soft measure	To reassure the public that advanced biofuels are being produced sustainably. This creates certainty and reliability of advanced biofuels towards consumers.	Lack of harmonised regulations for farming and forest management	This result in creating a positive image on the sustainability of biofuels. Hence, it has the potential of increasing the demand for advanced biofuel.
Proposed stricter regulations on the sustainability criteria of electric vehicles by implementing Life cycle analysis	Regulatory measure	To reduce competition of advanced biofuels in the transport sector. This measure is used because even though electric vehicles does save GHG emissions in the end use, but several studies show that the upstream of this value chain shows many signs of negative impacts on the environment.	Lack of harmonised regulations for farming and forest management Concerns on stability/ security of the industry	To increase the demand for advanced biofuels by eliminating a key competitor.

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Challenge III: Advanced biofuels in specific transport segments require high investment, market stability. This necessitates strong and immediate actions in policy formation. **Opportunity IV: EU can achieve high shares and benefit from the use of domestic bio-mass for advanced biofuels.**				
To establish a funding programme based on the European Industrial Bioenergy Initiative and diverse sources of funds from a public-private partnership to invest in the demonstration plant	Financial	Significant investment is needed to launch demonstration plants for advanced biofuel in order to develop the technology for commercial-scale production. By using this measure, this decreases the government's pressure to supply all this capital.	Absence of structural mechanism to bridge the price gap between advance biofuels, RESfuels and fossil ones. Concerns on stability/ security of the industry	Since most of the advanced biofuel is currently at the demonstration phase, this investment can help accelerate these biofuels deployment into the market. Also, most demonstration plant is set in rural areas. This provides temporary employment and development in these areas.
Lessening costs to consumers by introducing a buy-out price, however still maintaining costs that are high enough in order to cause incentive of the uptake of advanced biofuels	Financial	To create incentives for fuel supplier to supply the amount of advanced biofuel that must meet the EU obligation. However, the fuel supplier has the option to pay a penalty fee instead if fail to supply this amount where the fee is then used to assist other fuel suppliers that able to achieve this target.	Absence of structural mechanism to bridge the price gap between advance biofuels, RESfuels and fossil ones. Concerns on stability/ security of the industry	To maintain or increase the share of advanced biofuels in the transport sector. Additionally, this measure assists advanced biofuels in penetrating the market.

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4.2.Policy impact assessment

Policy assessment is required to provide evidence-based knowledge and help policymakers make decisions on whether and how to implement policies. Impact assessment is selected as a form of quantitative method to predict and assess the potential economic, social and environmental impacts of the policy options (Adelle & Weiland, 2012).

In this section, recommended policies are evaluated for their impact using the selected key indicators documented above. The overall impact score for each policy option is calculated by multiplying level of impact and the likelihood that the EC will agree with the policy being implemented. Tables (1) and (2) define the scale of the score for impact level and likelihood.

Table 1 Scale definition of the likelihood of the policy being implemented in the future by 2030 and the impact level

Likelihood of the policy being implemented by 2030	
Score	Definition
5	Almost certain that the policy will be implemented
4	Highly likely that the policy may be implemented
3	Possible chance that the policy could be implemented
2	Highly unlikely policy will be implemented
1	Almost certain that the policy will not be implemented by 2030.

Table 2 Scale definition of the impact level of policy towards the key indicators

Impact of policy towards the key indicators	
Score	Definition
5	Positive significant impact
4	Positive minor effect
3	Negligible or unsure impact
2	Negative minor effect
1	Negative significant impact

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To evaluate whether policy is effective for deployment of advanced biofuels, the overall impact score that is calculated for each policy option is matched with the impact scoring matrix in Figure (17). Overall impact scores are colour-coded and are categorized as low, medium and high effectiveness. The impacts score and commentary are provided in Figures () and () respectively.

Figure 17 Overall impact scoring matrix

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Table (3): Impact assessment of recommended policies according to the indicators and it's key barriers

	Policy options	Likelihood	Indicators														Barriers															
			EU commodity price variability		Turnover of each Bioeconomy sector		Emissions from agriculture		Carbon emission along the value chain		Soil organic matter in arable land		Degree of rural poverty		Employment		Lignocellulosic Feedstock supply step				Conversion step				End-use step				RES fuels of non-biological origin				Total
			Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total	Impact	Total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	To establish a funding programme based on European Industrial Bioenergy Initiative and diverse sources of funds from public-private partnership to invest in demonstration plant	4	5	20	4	16	3	12	5	20	3	12	4	16	4	16			✓			✓	✓	✓		✓							5
2	Set a sub-target of GHG emissions savings for the main transport sector that lack of other low carbon options (road, shipping and aviation sector)	4	4	16	2	8	3	12	5	20	3	12	3	12	3	12	✓																1
3	Develop strategies for advanced biofuels that integrates rural land-use planning and agricultural incentive schemes	4	2	8	4	16	5	20	4	16	5	20	4	16	4	16	✓	✓	✓														3
4	Lessening costs to consumers by introducing a buy-out price, however still maintaining costs that are high enough in order to cause incentive of the uptake of advanced biofuels	2	4	8	3	6	3	6	2	4	3	6	3	6	3	6										✓		✓					2
5	Promote information campaigns for farmers on the positive impacts of biofuels on rural development and sustainable agriculture practices	5	4	20	3	15	4	20	3	15	5	25	5	25	4	20	✓	✓	✓				✓					✓					5
6	Establish a certification-labelling scheme for advanced biofuel on its sustainability by assessing across its whole value chain.	3	3	9	3	9	5	15	5	15	5	15	3	9	3	9	✓	✓		✓													3
7	Set up a framework that allows advanced biofuels to integrate other bioeconomy sectors objectives to avoid any conflicts.	2	4	8	5	10	3	6	4	8	3	6	4	8	4	8		✓		✓	✓	✓			✓			✓					6
8	Proposed stricter regulations on the sustainability criteria of electric vehicles by implementing Life cycle analysis	2	3	6	3	6	2	4	3	6	3	6	3	6	3	6	✓						✓								✓		3
Total:			95		86		95		104		102		98		93		14				7				6				1				

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Table (4) Justification comments on the impact scores assigned in the impact assessment

Recommend Policy		Likelihood	Indicators						
			EU commodity price variability	Turnover of each Bioeconomy sector	Emissions from agriculture	Carbon emission along the value chain	Soil organic matter in arable land	Degree of rural poverty	Employment
(1)	Score:	4	5	4	3	5	3	4	4
	Justification comment:	Sine there is already existing established initiative from the EU to find these funds	The successful result of these demonstration plant should provide a cost-effective conversion technology, lowering the use of food-crops feedstock.	Improved conversion technology offers opportunity for advanced biofuels to play a significant role in other bioeconomy sector.	No effect since the policy focuses on conversion stage, no impacts on the upper stream.	A well-developed conversion technology can save up to 60-85% GHG emissions depending on the feedstock (Malins, Searle, Baral, Turley, & Hopwood, 2014)	No effect since the policy focuses on conversion stage, no impacts on the upper stream.	Usually demonstration plants are located in rural areas, hence this produce more employment and increase in economic activities in rural areas	
(2)	Score:	4	4	2	3	5	3	3	3
	Justification Comment:	Help contribute to the new RED II target for GHG savings for transport sector	Higher demand for advanced biofuel feedstock will influence in food-crop feedstock demand	If advanced biofuel price is still this high, then this will increase in transportation cost. This will affect all other businesses.	Not sure of impacts since it depends on the sector to use which alternative of RES.	The policy is intended to reduce GHG emissions along the value chain.	Not sure of impacts since it depends on the sector to use which alternative of RES	Not sure of impacts	Not sure of outcome due to the uncertainty of demand
(3)	Score:	4	2	4	5	4	5	4	4
	Justification Comment:	There are existing common CAP measures that can help support in developing the strategies	Agricultural incentive schemes will increase the supply, lowering the commodity price on food-crop. Could increase the demand on 1st generation biofuels.	These strategies can complement with goals from other biomass feedstock sectors e.g. agriculture, forestry and waste	The strategies offer opportunity to introduce agriculture' best practices into the schemes	By focusing on agriculture practices can significantly reduce the GHG savings of the biofuel's life cycle	Rural planning allows time to assess the land to minimise environment impacts.	The strategies focused on rural areas, hence these plans and investments will directly have positive impacts to these community. Agriculture incentive schemes can offer employment since more farmers are needed to supply these feedstocks.	
(4)	Score:	2	4	3	3	2	3	3	3
	Justification Comment:	Difficult in this stage because the technologies are not mature enough yet to be deployed in commercial scale	Reducing pressure for consumers to pay high price on advance biofuel	Not sure of impacts	No impact	This measure offers an escape option for firms and government to pay the way out instead of meeting their share target	No impact	No impact	No impact

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(5)	Score:	5	4	3	4	3	5	5	4
	Justification Comment:	Easy to implement since no large capital is needed	Sustainable agriculture practices help maintain the environment condition for future generation, resulting in securing food and feedstock	Not sure of impacts	These practices can prevent pollutions from agriculture activities. However, these practices are not compulsory.	Not covering the whole value chain, just focusing on the land use and feedstock production stage.	Sustainable agricultural practices focus on maintaining soil organic matter to preserve soil functioning and mitigate atmospheric CO2(Brodt, Six, Feenstra, & Ingels, 2011)	Rural developme nt and agriculture activities have direct positive impacts to this indicator	Employments increase as rural development increases
(6)	Score:	3	3	3	5	5	5	3	3
	Justification Comment:	Possible but need to establish common standards for sustainability of advanced biofuel first	Applying standards usually makes price of fuels goes up since fuel produces needs to comply with	No impact	The measure will take account the sustainability of whole value chain, meaning that there should be positive impacts on these indicators			Not sure on impact	No impact
(7)	Score:	2	4	5	3	4	3	4	4
	Justification Comment:	Stakeholders still need better understanding and need to study the true impacts of the sector on other sectors	Can potentially avoid conflicts with other fuel feedstocks	the potential impacts of advanced biofuel can help contribute other bioeconomy sectors objectives e.g. maximizing profits.	Not sure on impact	Using advanced biofuel can reduce GHG savings across the whole value chain of other sectors	Not sure of impact	Other bioeconomy sectors objectives do aim to increase rural development and employment in their sectors. The framework aligns these common targets, to support each other	
(8)	Score:	2	3	3	2	3	3	3	3
	Justification Comment:	The measure will upset large number of stakeholders	Unsure about the impact	Unsure about the impact	By making stricter regulation on EV, this can increase competition on GHG savings with advanced biofuels in the future	No impact on GHG savings of advanced biofuel	No impact	With the increase cost of electricity production due to stricter regulation, Deschenes' study finds that employment rates are weakly linked to electricity prices. Also, no evidence on links with rural poverty (Dechezleprêtre & Sato, 2014).	

5. Conclusions and recommendations

The work presented in this report followed a value chain approach and used a method of matching the objective of CAP indicators towards the SDGs as well as incorporating bioeconomy indicators to sensibly narrow down to seven key indicators to be used in the policy impact assessment.

What policy options can be introduced to promote the sustainable market uptake for advanced biofuels?

Future policy for advanced biofuels should address the following three main challenges faced by the sector:

- Challenge I: Although bioenergy continues to grow, the rate of growth of biofuels in transport is limited due to high uncertainty in policy
- Challenge II: Controversies with respect to the actual environmental benefits of biofuels and advanced biofuels
- Challenge III: Advanced biofuels in specific transport segments require high investment, which requires market stability.

Table (5) below provides an outlook of the assessment conducted in this report, in consultation with interviewed stakeholders.

It further relates the recommended policy measures with indicators used so far for their impact assessment, suggesting how appropriate they are and recommending new ones for future policy formation.

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Table 5 outlook of the assessment conducted in this report, in consultation with interviewed stakeholders

Policy options		Types of policy mechanism	Stage of the value chain that policy impacted the most	Current indicators that inform policy now	Based on analysis from the impact assessment	
					Appropriate?	Identify other complimentary indicators
Challenge I: Long term, consistent framework						
	Set a sub-target of GHG emissions savings for the main transport sector that lack of other low carbon options (road, shipping and aviation sector)	Regulatory measures	End-Use	Carbon emission footprint	No	- EU commodity price variability - Emissions from Agriculture
	Develop strategies for advanced biofuels that integrate rural land-use planning and agricultural incentive schemes	Soft measures	Land Use	Soil organic matter & Carbon emission footprint	No	- Turnover of each Bioeconomy sector - Emissions from Agriculture - Soil Organic matter - Degree of rural poverty - Employment
	Promote information campaigns for farmers on the positive impacts of biofuels on rural development and sustainable agriculture practices	Soft measures	Primary Biomass production	Carbon emission footprint	No	- EU commodity price variability - Turnover of each Bioeconomy sector - Emissions from Agriculture - Soil Organic matter - Degree of rural poverty - Employment

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	Set up a framework that allows advanced biofuels to integrate other bioeconomy sectors objectives to avoid any conflicts.	Soft measures	End-Use	Carbon emission footprint	Yes	N/A
Challenge II: Controversy over environmental benefits of biofuels and advanced biofuels						
	Establish a certification-labelling scheme for advanced biofuel on its sustainability by assessing across its whole value chain.	Soft measures	End-Use	Carbon emission footprint	No	- Emissions from Agriculture - Soil Organic matter
	Proposed stricter regulations on the sustainability criteria of electric vehicles by implementing Life cycle analysis	Regulatory measure	End-Use	Carbon emission footprint	Yes	N/A
Challenge III: Advanced biofuels in specific transport segments require high investment, market stability. This necessitates strong and immediate actions in policy formation.						
	To establish a funding programme based on the European Industrial Bioenergy Initiative and diverse sources of funds from a public-private partnership to invest in the demonstration plant	Financial measures	Conversion stage	Carbon emission footprint	No	- EU commodity price variability - Turnover of each Bioeconomy sector - Degree of rural poverty - Employment
	Lessening costs to consumers by introducing a buy-out price, however still maintaining costs that are high enough in order to cause incentive of the uptake of advanced biofuels	Financial measures	End-Use	Carbon emission footprint	Yes	N/A

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As anticipated, the carbon emissions indicator scores highest in measuring the policy effectiveness of the recommended policies for RESfuels. This can be justified by the fact that most current EU policies in the transport sector directly target the reduction of GHG emissions savings (including carbon footprint). Hence, the policy outcome is oriented towards this target since the anticipated role of RESfuels is to help EU meet the GHG emission savings and mitigate climate change.

Based on the analysis conducted in this report, the use of advanced biofuels offers more opportunities and potential of tackling other impacts beyond just GHG emission savings. For instance, by looking at recommended policy option 2 that is dedicated to GHG savings of transport sub-sector, only three indicators received positive impacts, and only one barrier that was identified by stakeholders were addressed.

The recommended policy option 5 that aims to provide information to promote rural development and sustainable agriculture practices for RESfuels' feedstock production not only has high impact in GHG savings but also offers positive impacts towards the other six socioeconomic indicators as well as addressing up to five key barriers to advanced biofuels.

This fact raises questions if the current EU policy is narrowing down its opportunities and restricting market uptake of domestic feedstock by targeting and measuring only one key indicator.

There is a significant opportunity for future policy formation in EU to step back from the current perspective on RESfuel policies and explore options of introducing other indicators that address the complete value chain from different perspectives such as SDGs, CAP and bioeconomy.

This study highlights the importance of these perspectives since it suggests that the policy's objectives place attention to more challenges alongside climate change. An example can be the use of marginal land. It is believed that alleviating poverty can help avoid environmental degradation since the main activities are caused by poor people whom involuntary forced to degrade the landscapes in response to population growth and economic marginalisation. However, with better information and practices, these people can adopt a protective mechanism in countering environmental degradation[36].

[36] Forsyth T, Leach M, Scoones I. Poverty and environment: priorities for research and policy; an overview study. Brighton: United Nations Development Programme and the European Commission. 1998

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The integrated policy framework suggested in this report could provide an initial baseline for EU policy to tackle these inter-link challenges by analysing the current value chains and develop policy recommendations regarding the sustainability dimensions: economic, social and environment. To complement these policy recommendations, the indicators from SDGs, CAP and bioeconomy can be implemented and help measure further progress on the socio-economic targets.

What mechanisms can be introduced to improve market uptake in aviation, marine and heavy road transport?

The entire transport sector cannot depend on a single renewable fuel source. Therefore, available alternative sources need to be strategically exploited. Road and freight sectors can run on different renewable sources, however, for the decarbonization of aviation, marine and heavy duty liquid biofuels are the most realistic options available.

Looking at the member states and EU level biofuels policies we can see that aviation, marine and freight sectors are excluded from the obligatory quotas, GHG emission reduction targets, national targets and have no specific provisions in place in to promote the use of advanced biofuels. Some member states like the Netherlands are prioritising the use of advanced biofuels for these sectors and green electricity and hydrogen fuel for road transport. In some of the member states these sectors are not even eligible for the renewable certificates while in United Kingdom they are qualified for Renewable Transport Fuel Certificate (RTFC).

Therefore, to bridge this gap and to improve the market uptake, EU and Member States can at least start with non-financial incentives and provide information provisions to keep the consumers and market players informed. Then follow up with financial incentives and investment grants to promote the new innovation technologies which can make these sector carbon efficient and finally regulate market with regulatory instruments like feed-in premiums, certification and standardization.

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Table 6 Suggested policy interventions for advanced biofuel types and value chains where biomass is expected to play major role from 2020 to 2030

Market segment	Suggested policy interventions		Barrier/ gap/ specific challenge the intervention will address		Added value compared to the existing support measures	
Aviation	Early markets	Mature markets	Early markets	Mature markets	Early markets	Mature markets
Marine Heavy duty	Strategy Action plan Investment grants	Feed in premiums for electricity Technology and/ or innovation bonus	Market is not developed Technologies have low efficiencies	Improve efficiencies in existing plants Add new capacities in existing plants Diversify feedstock	Inform and steer demand Certification/ Standardisation Premiums targeting specific indigenous feedstocks	Increase mobilisation of unused resources streams and reduce competition with non-energy markets

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ANNEX I: Current EU policy and relevant indicators for future impact assessment

This section provides a short description and links with relevant indicators for each of the policies presented. The description of these policies is based on the Biomass Policies and S2BIOM databases (mentioned earlier in the methodology section). Further reference is added if additional information is provided.

Table (1): Display of the symbol and definitions of each stage in the Biofuel's value chain

The stages of the value chain	Symbol	Definition
Land Use		Since the current biofuels require crop-stock, agricultural land is needed. This stage, therefore, takes account of the expansion and conversion of agricultural land as an indirect consequence of increased land use for the production of biofuel feedstock.
Primary biomass production		This stage covers the cultivation of these feedstocks and the conversion to a commercial biomass form.
Conversion		This stage involves transforming these biomass feedstocks into different types of biofuels through the three main types of conversion: Biochemical conversion, Thermochemical Conversion and chemical conversion.
Distribution		After the biofuel is made, it is distributed in 3 ways. This includes transportation via truck vehicles or pipeline as well through dispensing via pumps. Some biofuels that are not needed in the market yet, can be stored through Blending terminals.
End product/ consumption		This stage involves all biofuel consumption whether it will be for transportation, electricity, or even to generate heating and cooling.

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The policies are structured according to the stages of the value chain that they impact. However, as seen in the schematic diagram, some policies impacted more than just one stage of the value chain. Hence, for simpler understanding, the policy will be assigned to a stage of the value chain that it impacted or are relevant the most. For clarification, the stages of the value chain are described in Table (1).

For General Biofuel policies including specific biomass feedstock policies:

Stage 1: Land use

iLUC Directive (EU) 2015/1513

With the growing demand of biofuels in EU, iLUC or "Indirect land use change" Directive was introduced to limit the global land conversion used for biofuel production. Due to the limited cropland used in existing agriculture production, biofuel suppliers have been converting grasslands and forest into cropland for their own crops production. Consequently, instead of reducing greenhouse gas by using biofuels, this action may raise the atmospheric CO2 level since these non-croplands typically absorb a high CO2 level. Hence, this directive encourages and introduce the transition towards the use of Advance biofuels.

Other Stages of Value chain that is impacted:	

Possible Indicators: Emissions from Agriculture, Carbon emission footprint (along with the value chain), Soil organic matter in arable land

European Norm Sustainability criteria for biofuels and bioliquids: EN16214

This EU standard was a further elaboration of the sustainability criteria that was introduced in the revised RED by setting out technical specifications, principles, indicators, verification and auditing schemes to avoid any reconcile diverse interpretations between member states. EU will only accept biofuel to be "sustainably" produced if it follows these criteria:

- The biofuels must achieve at least 50% of GHG savings when compared to fossil fuels by 2017 and 60% by 2018 (only if the production plants are new)
- Crops that are used for Biofuels are not allowed to be grown in land areas that are converted from high carbon stock, e.g. wetlands and forests

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- Raw materials extracted from land with high biodiversity, e.g. primary forest cannot be used in the biofuels production.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

Stage 2: Primary Biomass production

Sustainability requirements (COM(2010)11)

With the revised RED already contain elements of sustainability scheme for i) transport's biofuels and ii) bioliquids used in electric, heating and cooling application; sustainability scheme for energy use from other types of biomass is required. Hence, the report fulfils this obligation by proposing recommendations to be put in place in member state's national level on the sustainability scheme for the use of solid biomass and biogas in the electricity, heating and cooling sectors. These recommendations intend to encourage sustainable biomass production and consumption, promotes bio-energy development as well as facilitate the biomass trading in the EU internal market.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain), Soil organic matter in arable land

Specific biomass feedstock policies:

Biomass Feedstock 1: Agriculture

The policy mechanism that is used in this sector is a combination of financial and regulatory measures. All the policies in this sector only impacted the upstream of its value chain, which are from Land use stage until the conversion stage.

CAP, pillar 1 – Direct payments

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Framework for financial support to farmers, with (environmental) requirements on agricultural practices (cross-compliance rules). Since 2015 part of the budget goes to 'Green Direct Payments', including obligatory practices on maintenance of permanent grassland, ecological focus areas and crop diversification.

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector, Emissions from Agriculture, Carbon emission footprint (along with the value chain), Soil organic matter in arable land, Degree of rural poverty, Employment (Green jobs)

CAP, pillar 2 – Rural development

Framework (incl. budget) for national and/or regional rural development programmes, defining common EU priorities, including ecosystem enhancement in agriculture and forestry, and shift to a low-carbon economy (including on-farm renewable energy production). New CAP 2014-2020 in force since 2014.

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector, Emissions from Agriculture, Carbon emission footprint (along with the value chain), Soil organic matter in arable land, Degree of rural poverty, Employment (Green jobs)

Nitrates Directive (91/676/EEC)

Restrictions on fertilisation in agriculture (focus on nitrogen) to protect water quality, to be included in Member States' programmes. All of them include a limit of 170 kg/ha/year of livestock manure.

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Other Stages of Value chain that is impacted:	

Possible Indicators: Emissions from Agriculture, Soil organic matter in arable land

Animal by-products regulation

Rules for movement, processing and disposal of animal by-products not intended for human consumption.

Other Stages of Value chain that is impacted:	

Possible Indicators: Emissions from Agriculture, Soil organic matter in arable land

Biomass Feedstock 2: Forestry

There is no common EU forest policy, so EU instruments for forestry are mainly soft measures, i.e. strategies, voluntary agreements and accounting rules. An exception is the recent Timber Regulation.

EU Forest Strategy

Strategy document (2013) defining key principles for sustainable forest management. The cascading principle for forest products (prioritise higher added value) is also mentioned.

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector, Emissions from Agriculture, Soil organic matter in arable land, Employment (Green jobs)

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EU Timber Regulation

Obligations of operators who place timber and timber products on the market to counter the trade in illegally harvested timber. In force since 2013.

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability

LULUCF – Land Use, Land-Use Change and Forestry

Accounting rules applicable to emissions and removals of greenhouse gases resulting from land use, land- use change and forestry ('LULUCF') activities, as a first step towards the inclusion of those activities in the EU's emission reduction commitment, when appropriate. The LULUCF decision requires the Member States to report on their actions to increase removals of carbon and decrease emissions of greenhouse gases from forests and soils.

Other Stages of Value chain that is impacted:	

Possible Indicators Emissions from Agriculture, Soil organic matter in arable land

REDD+

"Reducing Emissions from Deforestation and forest Degradation, conservation of forest carbon stocks, sustainable management of forests, and enhancement of forest carbon stocks." Developed countries provide financial support to developing countries which demonstrate reduced emissions from forests at a national level, as measured against a business as usual scenario (or reference level). Guide to implementation of phytosanitary standards in forestry.

Other Stages of Value chain that is impacted:	

Possible Indicators Emissions from Agriculture

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Biomass Feedstock 3: Waste

In this sector, the only policy instrument that is used is the regulatory measure. This is due to the sector's volatility to health and hazard risks that is a major concern when using waste as a biomass feedstock. Hence, policies in this sector are concentrated in the primary biomass production and conversion stage.

Waste Framework Directive (2008/98/EC)

Framework for national legislation, including waste management principles, definitions, end-of-waste criteria. The following waste hierarchy shall apply as a priority order in waste prevention and management legislation and policy: (a) prevention; (b) preparing for re-use; (c) recycling; (d) other recovery, e.g. energy recovery; and (e) disposal.

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector, Carbon emission footprint (along with the value chain), Soil organic matter in arable land, Employment (Green jobs)

Landfill Directive (1999/31/EC)

Operational and technical requirements on waste and landfills, to prevent or reduce negative effects on the environment, from landfilling of waste. It defines the different categories of waste and requires the Member States to reduce biodegradable waste going to landfills.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain), Soil organic matter in arable land

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Sewage Sludge Directive (86/278/EEC)

The directive seeks to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to prevent harmful effects on soil, vegetation, animals and man. To this end, it prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. The Directive also lays down limit values for concentrations of heavy metals in the soil, in sludge and for the maximum annual quantities of heavy metals which may be introduced into the soil.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain), Soil organic matter in arable land

Industrial Emissions Directive

The Directive defines operational conditions, technical requirements, and emission limit values for incineration and co-incineration plants within the EU. This Directive replaced the Waste Incineration Directive (2000/76/EC).

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

Standards for Solid Recovered Fuels (SRF) (CEN-TC343)

This standard provides technical Specifications and Technical Reports on solid recovered fuels, prepared from non-hazardous waste to be utilised for energy recovery in waste-incineration or co-incineration plants.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain

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Stage 3: Conversion

Horizon 2020

Horizon 2020 was launch as a financial instrument to help funds innovation and research that could lead to groundbreaking discoveries and innovations that could potentially develop sustainable economic growth whilst tackling the societal challenges in the EU. This programme, therefore, brings together the public and private sectors to collaborate and generate a single market of knowledge and innovation. The budget for this programme has a total of 79 billion euros and its funding period is until 2020.

Other Stages of Value chain that is impacted:	

Possible Indicators: Turnover of each EU Bioeconomy sector, Carbon emission footprint (along with the value chain), Degree of rural poverty, Employment (Green jobs)

SET plan: Action 8: Renewable Fuels and Bioenergy

In May 2016, the public consultation process was dedicated to the 4th Energy Union Research, Innovation and Competitiveness common priority, for "more sustainable transport systems that develop and deploy at large scale innovative technologies and services to increase energy efficiency and reduce greenhouse gas emissions". This time, it focused on Action 8 of the SET Plan Communication (C(2015)6317):

Action 8: Strengthen market take-up of renewable fuels needed for sustainable transport solutions, and bioenergy cost reductions aspects

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain), Employment (Green jobs)

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European Technology Platform on Bioenergy (ETIP Bioenergy)

ETIP Bioenergy was launched in 2016. It aims to bring together stakeholders from the EU energy industry, biomass producer, private organisation in the research and technology field, NGOs and the representative from the European Commission to gather their knowledge and resolve the current challenges for bioenergy.

Other Stages of Value chain that is impacted:	N/A

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector, Carbon emission footprint (along with the value chain)

European Norm biodiesel-FAME (Fatty acid methyl esters): EN14214

This EU legislation is a binding standard that establishes the requirements and tests methods for commercial and delivered fatty acid methyl esters (FAME), commonly used as the main biodiesel in the market. This standard helps facilitate the EU internal market for FAME biodiesel by eliminating trade barriers and is used to promote safety and common technical understanding amongst the EU stakeholder.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

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European Norm Diesel fuel: EN590

This binding standard sets the requirements and test methods that all diesel fuel being sold within the EU must comply with. This standard is relevant to biofuels since it allows conventional diesel fuels to blend with Fatty Acid Methyl Ester up to 7%, due to technical reasons.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

European Norm Petrol: EN228

This standard sets specification and test methods for all unleaded petrol sold within the EU, as well as specifying the maximum ethanol content blended in gasoline up to 5%.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

prEN16723 - Natural gas and biomethane

To support and facilitate the market penetration of the use of biogas in the EU, this standard was introduced to provide quality specifications and test methods for the updated biogas and biomethane used in 1) the injection in the natural gas grid and 2) transportation fuel.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

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NER300 programme

This funding programme is aiming to support innovative low-carbon energy demonstration projects that require investment to convert into commercial-scale within the EU. The sales revenue from the EU emissions trading system (ETS) is used to fund this programme, with currently 39 projects selected that boost technologies towards carbon capture and storage (CCS) and renewable energy (RES).

Other Stages of Value chain that is impacted:	N/A

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector, Carbon emission footprint (along with the value chain), Degree of rural poverty, Employment (Green jobs)

Stage 4: Distribution

Alternative fuels infrastructure (Dir. 2014/94/EU)

This directive aims to reduce the dependency of fossil fuels and mitigate environmental impact in EU transport by stimulating the use of alternative fuels through establishing a standard framework of measures.

Other Stages of Value chain that is impacted:	N/A

Possible Indicators: Carbon emission footprint (along with the value chain)

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EN ISO 17225 Standards for solid biofuels (CEN/TC335)

This EU standard is used to established specification and fuel classes of solid biofuel by setting out clear classification principles. This act as a tool to allow efficient trading and create a mutual understanding between the EU biofuel stakeholders. The standard covers the whole biofuel's value chain, starting from raw material supply till the end-user consumption.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

Stage 5: End products/ Consumption

Fuel quality directive (Dir. 2009/30/EC)

In 2009, several elements in this Directive had been amended including the petrol and diesel specifications. Other amendment includes establishing Article 7a, which enforce fuel production used in energy supplied for road transport to reduce its greenhouse gas intensity. The Directive also introduces sustainability criteria for biofuels to comply with, to help contribute to the greenhouse gas intensity reduction requirement.

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability, Carbon emission footprint (along with the value chain)

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Energy Taxation Directive (Dir. 2003/96/EC)

The Directive was first adopted to avoid competitive distortions and regulate the EU's energy sectors within its internal market. However, with the EU initiative to tackle climate change and energy efficiency, the directive was revised. As a result, the proposed rules promote environmentally-friendly consumption by introducing taxes on products and companies' CO2 emissions and energy content. Hence, this produces incentives for companies to invest in alternative energy sources such as biofuels since there are less CO2 emissions produced.

Other Stages of Value chain that is impacted:	N/A

Possible Indicators: EU commodity price variability, Carbon emission footprint (along with the value chain), Degree of rural poverty

2030 Framework for climate and energy

This framework establishes targets and measures for the EU to tackle climate change issues by securing the energy sector to be more competitive and sustainable. These targets include long-term aims such as reducing greenhouse gas emissions as well as increasing the use of renewable energy. For these targets to be achieved, the framework suggests a new governance system that includes performance indicators to measure these progresses.

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector, Emissions from Agriculture, Carbon emission footprint (along with the value chain), Employment (Green jobs)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N.º764799.

Clean Vehicles Directive (Dir.2009/33/EC)

This directive aims at introducing environmentally-friendly vehicles to the EU market in order to achieve a Clean and Energy efficient in road transport vehicles. This is done through public procurement tenders and public services contract that requires all road transport vehicles purchases to take into account the energy and environmental impacts associated with the vehicle's operation. The European Commission has launched several projects that developed tools to calculate the vehicle's lifetime cost according to its impacts, which later on could be used to monetise these impacts for inclusion in the purchasing decision.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

Ecodesign Directive (Dir. 2009/125/EC)

This EU directive is designed to improve the environmental performance of energy-related products (ERPs) by setting out the minimum requirements on the energy efficiency of these products. This enables the least performing or under-quality products to be eliminated off the market without creating any trade-barriers within the EU. Furthermore, this measure not only contributes to the EU's target on the 2020 energy efficiency objective, but it also promotes innovation through eco-design and encourages the industrial competitiveness for a better-quality product.

Other Stages of Value chain that is impacted:	

Possible Indicators: Carbon emission footprint (along with the value chain)

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Emission performance standards for new passenger cars (Reg 443/2009)

This regulation aims to reduce CO2 emissions polluted from light-duty vehicles. This is by establishing emission performance standards for new passengers' cars for car manufacturers to comply, with the current target of reducing the average annual of CO2 emissions to 95g/km by the year 2020.

Other Stages of Value chain that is impacted:	

Possible Indicators: *Carbon emission footprint (along with the value chain)*

Energy Efficiency Directive (Dir. 2012/27/EU)

This Directive is a binding framework that aims to support all EU member states to achieve its 20% energy efficiency target by 2020 and 30% energy efficiency target by 2030. This is by setting out measures that include legal obligations or policy schemes that will encourage member states to improve their energy efficiency consumption throughout their energy chain, starting from the initial stage of energy production till final consumption. The framework also proposed measures that involved public sector in playing as an exemplary role on this notion as well as increasing consumers awareness on their energy consumption.

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector

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Renewable energy directive (Dir, 2009/EC/28)

This directive promotes the use of renewable energy in the EU by establishing a common framework and sets binding targets for all member states to achieve, with the ultimate goal of achieving 20% share of renewable energy in the energy sector by 2020. Furthermore, the directive explicitly specified how the transport sector must achieve at least a 10% share of renewable energy from its final energy consumption by 2020.

The directive also specifies all member states to establish their national actions plans to demonstrate how they will achieve their 2020 binding target, thus promoting the use of renewable electricity and bioenergy through improving their legal framework and provide co-operation mechanisms.

In June 2018, the directive is recast to RED II by introducing new targets for 2030 as stated below:

- 14% RES transportation energy target
- Sub-target of 3.5% of advanced biofuel
- 7% Cap on conventional food-based biofuels

Other Stages of Value chain that is impacted:	

Possible Indicators: EU commodity price variability, Turnover of each EU Bioeconomy sector, Carbon emission footprint (along with the value chain), Employment (Green jobs)

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ANNEX II: Overview for policy land-scape for biofuels and ad-vanced biofuels in EU Member States

Member States	Overall Percentage Biofuel mandate (%cal)	Advanced biofuels (%cal)	Cap on crop-based biofuel (% cal)	Double counting	Obligation to reduce total GHG emissions (%)	Source
Austria	8.75% (2020)	0.5 (2020)	7 (2020)	Yes	-	(Lieberz, 2018)
Belgium	Diesel and petrol (combined) to 8,5 % (2020)	0.1(2020)	7 (2020)	Possible upon approval	-	(Lieberz, 2018) (IEA, 2018)
Bulgaria	-	0.05 (2020)	7* (2020)	No	-	(Lieberz, 2018)
Croatia	**7.85 (2019)** 8.81 (2020)	0.1 (2018)	7 (2020)	Yes, for 2nd generation and waste-based biofuels	**3 (2019)** 4 (2020)	(Sapp, 2018) (Lieberz, 2018)
Czech Republic	10% (include renewable electricty) (2020)	N/A	N/A	No	**3.5 (2019)** 6 (2020)	(UPEI, 2018)
Denmark	5.75 (2020)	0.9 (2020)	7 (2020)	-	N/A	(Lieberz, 2018)
Finland	**18 (2019)** 20 (2020)	0.5 (2020)	7 (2020)	Yes, for biofuels made from waste, residues, non-food cellulosic material, ligno-cellulosic material	-	(UPEI, 2018) (Lieberz, 2018)

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France	For Diesel: 0.35% of bio-diesel For Gasoline: 0.30% of Biogaso-line (2018)	0.6** (2020)	7 (2020)	Yes, Cellulosic and waste biofuels up to the maximum values of 0.35% for bio-diesel and 0.3% for bioethanol	-	(ePURE, 2018) (Lieberz, 2018)
Germany	N/A	0.05 (2020) 0.1 (2021) 0.2 (2023) 0.5 (2025 onwards)	6.5 (2020)	No	4 % GHG savings from 2018 and 6% GHG savings (BIMSchG) from 2020 onwards	
Greece	10 (2020)	0.2* (2020)	7 (2020)	No	-	
Hungary	RES used in transport must be: 56.8% bioethanol and 37.8 % bio-diesel (2020)	N/A	7 (2020)	Yes, for biofuel com-ponents made from waste in-cluding from non-food cellulosic and ligno-cellulosic ma-terials		
Ireland	11.11 (2020)	0.25* (2020)	7% (2020)	Yes, UCO and CAT 1 Tallow	-	
Italy	**8 (2019)** 9 (2020) 10 (2021)	0.2 (2020) 1.85 (2022)	6.7% (2020)	No	-	(Giuntoli, 2018)
Netherlands	**9.25% (2019)** 10% (2020)	1.0% (2020)	5.0% (2020)	Yes	49% (2030)	(IEA Bioen-ergy, 2018) (Lieberz, 2018)
Poland	8.5 (2020)	7% (2020)	0.1 (2020)	Yes	-	(ePURE, 2018) (Lieberz, 2018)
Portugal	**10 (2019-2020)**	-	-	Yes	-	
Romania	10 (2020)	-	-	No	4 (2018)	
Slovak Republic	7.6 (2020) 8.2(2022 till 2030)	**0.1% (2019)** 0.5% (2020-2024)	7 (2020)	Yes	3 (2018)	

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Slovenia	**7.5 (since 2015)**	-	-	Yes	4 (2018)	
Spain	8.5 (2020)	0.1% (2020)	7 (2020)		-	
Sweden	N/A	N/A	7 (2020)		21% diesel (2020) 4.2% gasoline (2020) 40% both (2030)	(Giuntoli, 2018) (ePURE, 2018)
United Kingdom	10.637 (2020), 10.679 (2021), 10.714 (2022); Beyond 2022 there is Increased each year in 0.025 percent increments by volume until 2032	0.2% (2020) 2.8% (2032)	4.0% (2020) 2.0% (2032)	Since 2017 - Certain waste or residue feedstocks determined by scheme Administrator; plus energy crops and renewable fuels of non-biological origin; also development fuels	N/A	(ePURE, 2018) (Lieberz, 2018) (UPEI, 2018)

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