EUROPEAN COMMISSION
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SET Plan Secretariat

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SET-Plan – Issues Paper

"Strategic Targets for bioenergy and renewable fuels needed for sustainable transport solutions in the context of an Initiative for Global Leadership in Bioenergy"

Purpose of this new document

This document[1] is intended to progress the implementation of the actions contained in the SET-Plan Communication[2], and specifically the strategic targets for the priority "Diversify and strengthen energy options for sustainable transport" for what concerns market take-up of renewable fuels and the actions concerned with the priority "Number one in renewable energy" in bioenergy. It is part of a series of Issues Papers jointly prepared by the services of the European Commission and discussed with the representatives of EU member states and countries part of the SET Plan, working together in the SET Plan Steering Group.

The Issues Papers propose to stakeholders strategic targets in different areas of the transport and energy sector. The input from, and positions of stakeholders will be used to come to an agreement on targets, "Declaration of Intent", in a dedicated meeting of the SET Plan Steering Group with a representation of key stakeholders.

Stakeholders are invited to take position on the proposed targets in accordance with the guidelines set out in the paper The SET Plan actions: implementation process and expected outcomes and submit their positions to SET-PLAN-SECRETARIAT@ec.europa.eu by **7/11/2016** at the latest.

All relevant documents and material are available on the SETIS website (https://setis.ec.europa.eu/).

[1] This document has no legally binding character, and does not prejudge the process or final form of any future decisions by the European Commission.
[2] Towards an Integrated Strategic Energy Technology (SET) Plan: Accelerating the European Energy System Transformation" (C(2015)6317)

1. Introduction

The 2030 Climate and Energy Policy Framework for the period from 2020 to 2030 has set the objectives to reach a 40 % reduction in GHG emissions by 2030 compared to 1990, a binding target of at least 27 % for the share of renewable energy in 2030 and a 27% energy efficiency indicative target. The Energy Roadmap 2050[3] investigated possible pathways for a transition towards a decarbonisation of 80% of the energy system. Bioenergy production for heating & cooling, electricity and transport is expected to play a major role in the decarbonisation in all scenarios of the Energy Roadmap 2050.

Bioenergy is currently the most widely used renewable energy source worldwide. .According to the International Energy Agency (IEA), bioenergy accounts for roughly 10% of the global energy supply. Based on Eurostat records, it contributes to Europe's energy supply almost as much as the primary energy production of indigenous gas and more than that of oil. Furthermore, it represents two-thirds of Europe's renewable energy sources with an absolute growth in the last five years as important as the growth of all other renewable sources together.

Within the current policy to achieve a RES share of 20% of final energy consumption by 2020, Member States committed in their National Renewable Energy Plans (NREAPs) to deploy bioenergy capable to deliver 140 Mtoe, which would correspond to about 56% of all RES, or in other terms, about 12% of the entire final energy consumption.

Bioenergy has the potential to grow significantly in the next decades and to become one of the foundations of a future sustainable energy system It could sustainably contribute between 25% and 33% to the future global primary energy supply (up to 250 EJ) in 2050[4].

In the EU, cconsidering a binding target of 27% by 2030 for renewable energy's share, and a decrease of Europe's final energy consumption to 950 Mtoe (2015: 1050 Mtoe), it is realistic to assume a contribution of 160 Mtoe (17%) by bioenergy. However, as of 2014, the contribution of bioenergy with 103 Mtoe has not quite reached the 2020 target of the NREAPs, even though it represents 59% of all renewable energy contribution. The final share however will depend on the cost and availability of sustainable biomass which are addressed as a whole for all biomass origins and uses including food feed and industrial uses of biomass in an on-going study of the European Commission[5]

Bioenergy is the only renewable energy source that is continuously available and versatile: on the product side, it can contribute to replace fossil fuels in all energy markets, heat, electricity with base load and flexible capabilities and fuels for transport, including for aviation.

On the supply side it may benefit from widespread availability of its directly grown feedstock such as energy crops and wooden biomass, but also from residues from both agriculture and forestry, the organic fraction of municipal and industrial solid waste, as well as algae and aquatic biomasses.

[3] COM(2011) 885

[4]IEA Bioenergy Strategic Plan 2015-2020. According to IPCC–AR5 WGIII, 2014, the magnitude of the future global bioenergy potential is still uncertain.

[5] Biomass Study 2015/16 pursuant to the Mandate on the provision of data and analysis on a long-term basis on biomass supply and demand by the JRC addressing the different bioeconomy sectors

On the path from resources to the final energy product there are many technologies used for feedstock preparation on one hand and for the conversion into the final product, being electricity, heat or transport fuel.

It is due to this versatility that an integrated approach is followed here to enhance the synergies and economies of scale, to achieve economic benefits in the value chain to ultimately reduce the production costs and to optimise the greenhouse-gas performance of all bioenergy-products through technology and feedstock upgrading.

In the longer-term, the very ambitious European climate targets of carbon neutrality across all sectors beyond 2050 require a holistic look at the energy system, fully taking into account the interdependencies between various energy consuming sectors, and fully basing it on renewables. The use of renewable hydrogen and other renewable liquid and gaseous fuels derived thereof (Power-to-Gas including hydrogen/Power-to-Liquid) may enable in addition to advanced use of bioenergy to realize a fully renewable energy supply for linking the electricity, heating, transport and industrial sectors.

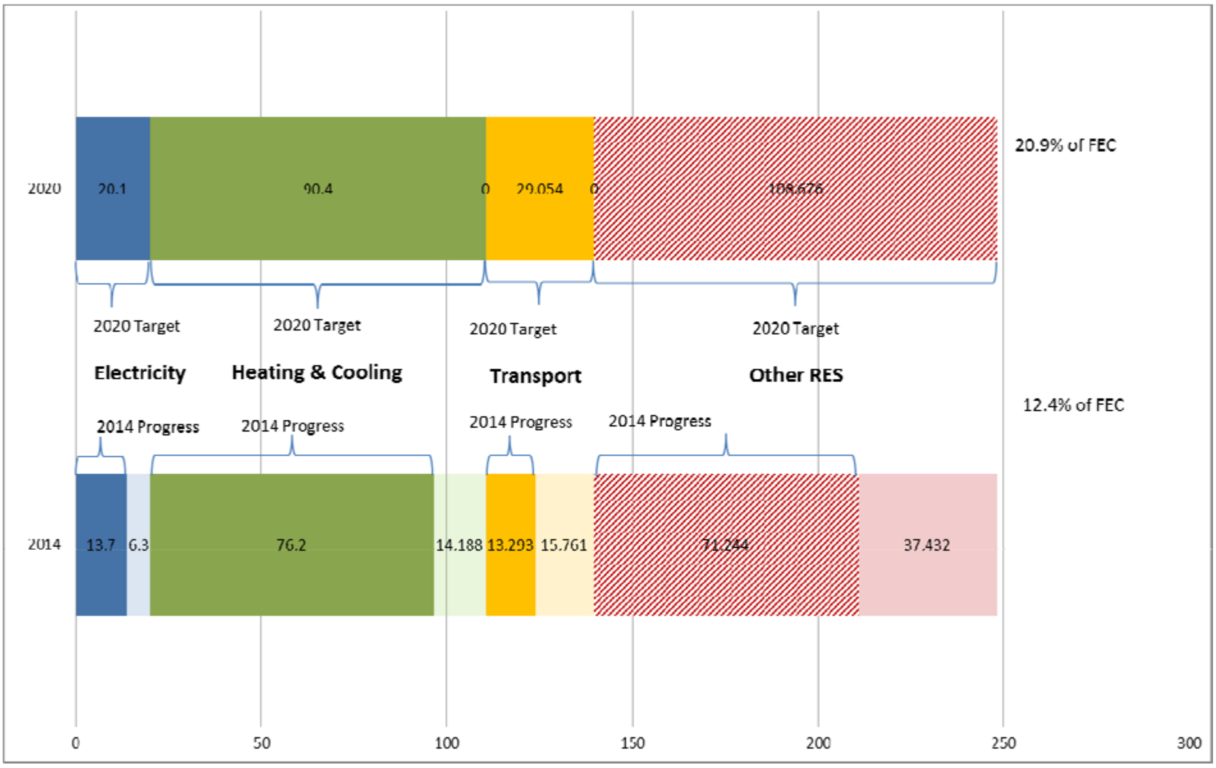

Figure 1: Shares of Bioenergy for Electricity, Heating/Cooling and Transport together with other RES. (FEC=Final Energy Consumption). All figures are Mtoe

2. Why taking action now on Bioenergy?

Bioenergy can considerably deliver energy security, combat climate change and create economic growth. Notably, it can promote energy security via flexibility in feedstock, conversion technology and end use, lead to significant GHG emissions reduction while enhancing energy sustainability, be dispatchable (ramped up and down and stored) and lastly be cost competitive. As per IEA statistics, Europe produces 37% of the global bioelectricity and 24% of the global biofuels while being the no.1 worldwide biodiesel producer. Europe is leading in most bioenergy technologies and should maintain its leadership while allowing its industry to grow and be competitive. Besides, bioenergy can and should maintain its high contribution to renewable energy development and play a key role in reaching the 2030 Energy and Climate targets.

Indeed, the role that bioenergy can play in the energy system is undoubtedly important. First, based on Eurostat data, heat alone accounts for almost half of the final energy consumption in Europe and 75% of the bioenergy consumed in Europe today is heat. According to Member States projections, the consumption of bioenergy should increase by at least 33% by 2020 with heat remaining the leading market. In addition, bioenergy is an indigenous renewable energy source with imports only 4% of Europe's gross inland consumption and its further development can continue to be based on indigenous biomass resources as currently about only 62% of annual European forest growth[6] in areas available for wood supply is harvested[7]. It can thus considerably contribute to Europe's energy security and economy by strengthening Europe's geopolitical influence and alleviating its GDP leakage of EUR 1 billion per day for importing fossil fuels as confirmed by Eurostat figures. Moreover, bioenergy offers great opportunities to all Member States through its large impact on rural economy and rural competitiveness. Biomass supply for bioenergy offers special opportunities for new jobs mostly in rural areas due to the additional elements of feedstock production, supply, handling and logistics. By creating energy decentralization effects, bioenergy brings advantages to rural areas that were deprived in the era of petro-economy, resulting in high employment potential with an added value of almost 500 000 jobs and EUR 56 billion turnover in Europe at present[8] .

3. Specific, sectorial developments

Bioenergy for Power Generation

With the increase of electricity production by solar and wind, the flexibility of power generation by biomass power plants has developed into a strategic asset for increasing further renewable electricity production, and a valid solution for compensating the variability of. Bioelectricity generated from biogas has exhibited the largest growth rate, and the current share (18.9%) of bioelectricity is already close to the 2020 target (19.3%)[9]. As very economic means to increase grid penetration of solar and wind, applicable from small to large scale, power generation from Biomass shall continue to increase significantly.

Bioenergy for Heating and Cooling

The bioenergy contribution for heating and cooling within the renewable energy has currently with 76 Mtoe the largest share (88%) of all RES used for heat and climatisation, quite close to the 2020 target of 90 Mtoe. Towards 2030 a moderate increase can be anticipated due to increased CHP deployment, together with the integration requirements of renewable electricity satisfied by bioenergy produced electricity and further energy efficiency improvements of Europe's building stock.

Biofuels for Transport

The Renewable Energy Directive[10] had established a 10% share of renewable sources for transport in 2020, and the MS NREAPs have taken this target in account. The EU decision to reduce non Trading Sector greenhouse gas emissions by 30 % by 2030 compared to 2005

[6] AEBIOM Statistical Report 2015 based on Eurostat data

[7] In accordance with the LULUCF proposal (COM(2016) 479) Article 8, forest carbon sinks will have to be evaluated against a forest management reference level; increased forest removals will thus have an impact on national GHG emissions.

[8] 14th EurObserv'er Report on the State of Renewable Energies in Europe

[9] As planned by the member states in their National Renewable Energy Plans (NREAP)

[10] Renewable Energy Directive (2009/28/EC)

level puts strong demand to reduce the emissions from transport sector as it is has the biggest share of non-Trading Sector emission. However, progress in the assessment of the sustainability of conventional biofuel production has required a more stringent application of sustainability criteria and the greenhouse-gas performance on first generation biofuels, whilst 2nd generation processes faced still a strong economic barrier. The share of biofuels with 13.3 Mtoe in 2014 remained at 5.4%, and constitutes about 13% of all bioenergy. There is a need to increase this share by using replacement fuels from lignocellulosic biomass, residues and power to gas/liquid that do not result in competition with food or land. In the absence of supporting policies and relatively low oil-prices, large-scale production of cost-competitive drop-in fuels will however be very challenging.

Other renewable fuels for Transport

There are other promising technologies under development to produce both liquid and gaseous renewable fuels. For example, renewable electricity can be used to produce renewable hydrogen (H_2) which can be used either directly to power fuel cell vehicles or can be reacted with captured carbon dioxide to give either a liquid or gaseous transport fuel (power-to-gas, or power to liquid). Renewable hydrogen to power fuel cell vehicles is currently addressed by the Fuel Cell and Hydrogen 2 Joint Undertaking (FCH 2 JU)[11] at the European level as part of Horizon2020. To be cost competitive in P2G and P2L production, low price and high annual availability of renewable electricity is needed for significant production volumes of renewable fuels.

Renewable fuel technologies could enhance energy security of Europe when using indigenous energy sources, could improve environmental sustainability as they often do not compete with food or land and could bring economic benefits by contributing to the creation of a competitive industry. In particular, renewable hydrogen generation has a very low life-cycle emissions footprint and its use can have an important environmental impact regarding air pollution as it only emits water vapour. Moreover, renewable hydrogen besides being used to power fuel cell vehicles; it could also displace fossil hydrogen used in refineries in the production process of diesel and gasoline, hence further reducing the short-term GHG emissions of the transport sector.

Renewable liquid and gaseous transport fuels of non-biological origin (e.g. power to gas including hydrogen from renewable sources and power to liquid) can be expected to make a significant contribution to the total transport fuels mix in the future.
However, the long-term availability of these technologies should be addressed with R&I actions and considerable effort is necessary at MS level to catalyse their market uptake. The barriers are mainly related to the cost for the generation of these fuels and the efficiency and robustness of the generation technologies, but their commercialization would also require upscale and important investments.

Barriers to address

The availability and cost of sustainable biomass can be a major barrier for large scale deployment of bioenergy technologies. There are significant uncertainties with regard to biomass potential for energy use due to difference in approaches, assumptions, aggregation levels that need to be addressed. The competition for biomass resources to alternative use of biomass for food, feed, fibre, heat and power and fuel applications can be important,

[11] Fuel Cell and Hydrogen Joint Undertaking Multi-Annual Work Plan 2014-2020. Adopted by the FCH2 JU Governing Board on 30/06/2014

involving traditional energy use but also large scale applications, for pulp and paper, wood processing, biobased industry, etc. It is also important to note that there is not only competition but there are also great synergies between these different uses of e.g. forest biomass where different processes use all parts of trees and share consequently the cost of logging.

A main issue regarding the viability of bioenergy plants lies in the development of a reliable, integrated biomass supply chains from cultivation, harvesting, transport, storage to conversion and by-product use. Secure, long-term supply of sustainable feedstock – often by local supply chains -is essential to the economics of bioenergy plants.

The economics of bioenergy production are one of the major barriers for the deployment of bioenergy technologies. In most cases, the energy from biomass is more expensive compared to energy from fossil fuels.

There are significant economies of scale. While higher capacity plants can be more cost-effective, their capacity is generally limited by the local feedstock availability and increasing transportation cost for large amounts of biomass, requiring the collection and transport of biomass over larger areas.

Consequently and for overcoming the barriers of feedstock and economics of bioenergy production vis-à-vis higher capacity plants, it is necessary to improve the performance of the biomass conversion to intermediate bioenergy carriers analogous to coal, oil and gaseous fossil energy carriers and thus create the crude energy feedstock basis that could be further refined to final bioenergy products or directly used for heat and power generation. This will positively affect the performance of further conversion to final bioenergy products and result in cost reduction and increased availability of end bioenergy uses (fuels, electricity and heat).

The further processing of intermediate bioenergy carriers to advanced biofuels for transport purposes and the development of heat and power from biomass have additional particular challenges, related to performance concerning necessary technological development for improving the conversion and energy efficiency and reduce the production cost of the end product, but also to sustainability. These challenges are equally important for both thermochemical and biochemical/biological technological pathways, as well as for bioenergy carriers by micro-organisms (e.g algae) from CO_2 and sunlight. On the other hand, sustainability in terms of environmental and social impact is essential for increasing public acceptance of bioenergy production and enabling bioenergy deployment.

Sustainability can improve when bioenergy is provided by low-cost, waste or residual streams of biological materials. The use of residual biomass allows the valorisation of waste streams for energy recovery and it generally provides environmental benefits with environmental risks that can be minimized by proper management guidelines. In addition the use of abandoned/marginal land for production of energy crops for advanced biofuels improves bioenergy sustainability, as it avoids diversion of productive land from food to energy production.

Up-scaling of many bioenergy technologies for commercial applications is still lacking but vital for proving their viability and sustainability (economic, environmental and social) and allowing their market deployment. De-risking of costly first-of-a-kind new investments and integrating bioenergy technological concepts into existing industrial sites and infrastructure to revamp them are critical aspects for bioenergy commercialization.

The economic competitiveness of bioenergy could be improved in biorefineries with the side production of high-value co-products in addition to biofuels, power and process heat. Combined Heat and Power (CHP) could improve the economic performances of bioenergy plants, but the use of heat is limited by the local heat demand, by its seasonal variation, and by capital costs of the district heating/cooling network. However, the development of district heating systems could benefit the use of heat from bioenergy plants encompassing also combined heat and power production and thus their efficiency. Within a developed smart grid, such cogeneration district heating systems would have a large potential to compensate the lower generation of solar electricity during the heating season.
Given the positive contribution to both energy security and climate mitigation goals, advanced renewable fuels can strongly justify the short-term additional economic cost that their initial production implies, with the perspective that they can prove to become viable and cost effective in the longer-term, thus returning the initial investments. Many synergies exist between biofuels and renewable fuels and there are many opportunities for process integration to optimise resource efficiency and minimizing initial investments. It is also expected that the contribution of many different types of renewable fuels will be needed to achieve fossil fuel substitution across all transport modes (e.g. a diverse range of renewable alcohols, renewable hydrocarbons, renewable hydrogen, renewable electricity, renewable synthetic fuels, etc.). It is equally understood that each Member State must make its own sustainable transport fuel implementation plan based on its own strengths and resources. It is vital however that the EU ensures a supportive and stable policy framework for fossil fuel substitution to be achieved in a sustainable manner.

5. Targets

The European Commission has set a long-term goal to develop a competitive, resource efficient and low carbon economy by 2050 and adopted the Roadmap for moving to a competitive low carbon economy in 2050 (COM(2011) 112) and Energy Roadmap 2050 (COM(2011)885 final). The European Union has set a binding target of 20 % share of renewable energies in the overall EU energy consumption by 2020 and a 10% binding minimum target to be achieved by all Member States for the share of renewable energy in transport. The aggregated data from the National Renewable Energy Action Plans (NREAPs) shows that bioenergy (electricity, heating and biofuels in transport) is expected to expand considerably, maintaining its major role as renewable energy in the energy mix in the EU until 2020. Overall, the share of bioenergy in the gross final energy consumption will increase from 5.0 % in 2005, 8.5% in 2012 to almost 12% in 2020, with a share in the renewable energy sources of almost 60%. The installed bioenergy power capacity in the EU almost doubled from 2005 to 2012, from 16 GW in 2005 to reach 29 GW in 2012. The analysis of the National Renewable Energy Action Plans shows that the bioenergy capacity is projected to increase to more than 43 GW in 2020. Solid biomass is the main contributor to biomass capacity since 2005, with more than two thirds of biomass capacity, and will remain still in the same position until 2020. In parallel with the increasing installed capacity, the electricity generation from biomass increased significantly, from 69 TWh in 2005 to 141 TWh in 2014 and it is projected to reach 233 TWh in 2020. The contribution to electricity made by bioenergy will reach 19 % of RES electricity in 2020, according to the aggregated data of the NREAPs[12].

A large part of bioenergy deployment in Europe since 2009 has been driven by financial incentives resulting from EU regulation. Future, deployment will not only depend on the

[12] Scarlat et al, 2015

capability of bioenergy to compete with conventional sources of electricity, heat and fuels but also on the ambition of policy choices to de-carbonise the .energy system.

This can happen only through the achievement of ambitious system, cost and performance targets, as well as, regulatory and market design measures. System cost and performance are to a considerable extent interdependent and represent the actual drivers for the development of the sector. To ensure sustainable use of biomass to bioenergy, it is critical to obtain a substantial GHG reduction by replacing fossil energy (at least 100 million tons CO_2 equivalent). Together with reduction of other emissions from cogeneration[13], these performance targets are indeed necessary to enable commercial scale and competitive bioenergy supply. This requires a multidisciplinary research, development and demonstration programme involving the bioenergy production industry, the heat, electricity and transport industry, as well as certification bodies.

The achievement of the targets will depend not only on technological advances, but also on non-technological factors such as economies of scale (i.e. resulting from an increase in produced and installed capacity), risk-finance for first-of-a-kind manufacturing pilot lines and demonstration of small, commercial-scale bioenergy, biofuels and biomass co-fired CHP plants, the ability to take full advantage of the European Single Market, long-term and stable regulatory conditions, standards, etc. These non-technological issues will have to be specifically examined at the subsequent stage of defining how to achieve the agreed targets. The role of international cooperation in energy research will be also examined.

Strategic Targets in Bioenergy

Increasing the efficiency of intermediate bioenergy carriers' production paves the way for reducing costs of the final bioenergy products and allows for new industrial and market opportunities. As costs of feedstock now account for around 50% of bioenergy system costs, efforts need to be directed at reducing these costs via the use of intermediate bioenergy carriers and creating a commodity market for these carriers. Increasing the overall efficiency of the heat and power cogeneration and in particular the electrical efficiency is essential towards further reducing the cost of electricity and heat from biomass.

Building on the Integrated Roadmap (IR) of the SET Plan (see Annex A), public (European Commission and Member States/Regions) and private investment must focus on targeted R&I actions to achieve the following goals in terms of bioenergy system performance and cost reduction in bioenergy production:

1. **Improve performance in the production of bioenergy**
    - Obtain net efficiency[14] of biomass conversion to intermediate bioenergy carriers of at least 75% by 2030 with GHG emissions reduction of 60% from use of all types of bioenergy intermediate carrier products [15] resulting to a contribution to at least 4% reduction of the EU GHG emissions from the 1990 levels.
2. **Reduce cost excluding taxes and feedstock cost16 for intermediate bioenergy carriers** (before further processing to final bioenergy products)

[13] Including NOx, SOx and particle emissions

[14] Net efficiency is the percentage of useful energy output compared with the net sum of energy inputs where the energy content is based on LHV (Lower Heating Value)

[15] For bioenergy products, other than biofuels and bioliquids for which GHG savings are not yet defined in directive 2009/28/EC, the Commission has indicated the targets set for biofuels and bioliquids should be used. Otherwise the reference will be the displaced fossil fuel use

[16] The purpose of this target is to give a rating for different technologies concerning their cost competitiveness. Hence this includes production plus profit margin and relevant costs to point of sale to a customer where applicable, and excludes product related taxes applied (e.g. VAT) and feedstock cost

- Liquid and gaseous intermediate bioenergy carriers by thermochemical or biochemical processing: <20 €/MWh in 2020 and <10 €/MWh in 2030 for e.g. pyrolysis oil; <40 €/MWh in 2020 and <30 €/MWh in 2030 for higher quality, e.g. microbial oils
- Solid intermediate bioenergy carriers by thermochemical or biochemical processing (e.g., bio-char, torrefied biomass, lignin pellets): <10 €/MWh in 2020 and <5 €/MWh in 2030

3. Reduce conversion system costs for high efficiency (>90% based on net calorific value of which >30% electrical) large scale biomass cogeneration of heat and power by 20% in 2020 and 50% in 2030 compared to present levels

Strategic Targets in Renewable Fuels for Transport

Immediate action is needed to support development of technologies and their exploitation for the production of all advanced renewable fuels at commercial scale in what are currently the diesel and petrol/gasoline markets. Dedicated action is needed to facilitate and bring to scale production of renewable hydrogen production for the transport sector, the roll-out of which is expected to accelerate post-2025 in the European markets.

Renewables are targeted to contribute 10% of the energy requirement for fuels for all forms of transport in the EU by 2020 as a way of reducing fossil emissions from the transport sector. In 2015, the Council and Parliament (Directive 2015/1513 Article 3d) set a limit of 7% for the contribution of biofuels produced from food crops (e.g. cereal and other starch-rich crops, sugars and oil crops) and established an indicative target of 0.5 % for advanced renewable fuels in transport by 2020. Member States shall set their national targets by April 2017, keeping in mind the reference target.

Taking the 7% limit into account, the aim to achieve 0.5 percentage points of the 10% renewables target by 2020 for advanced biofuels and to make a significant contribution to the 27% target for renewable energy by 2030, there is clearly a need to dramatically increase the production of all advanced renewable transport fuels. These fuels should be based on non-food biomass feedstocks, residues and wastes and of non-biological origin like renewable power to gas and power to liquid fuels (feedstocks listed in Annex IX of Directive 2015/1513). Legislation in force and approved voluntary certification systems provide for the foundation for a sustainability regime in the EU. However, there is still a need to extend the GHG savings methodology to the full range of renewable fuels and a definition and scheme for guarantees of origin (GoO) for low carbon hydrogen. Moreover, the urgent need for greenhouse-gas emission reduction in transport sector as part of non-trading sector reduction of 30 % by 2030 compared to 2005 calls for advanced renewable fuels.

1. Improve production performance

1.1. Advanced Biofuels

- By 2030, improve net process efficiency of conversion to end biofuels products of at least 30% compared to present levels, with simultaneously reducing the conversion process costs.
- By 2020, obtain total production of 25 TWh (2.15 Mtoe) advanced biofuels[17].

[17]This corresponds to the non-binding target of 0.5% of the approximately 5000 TWh (430 Mtoe) total transport fuel consumption and to 3 GW installed production capacity.

1.2. Other renewable liquid and gaseous fuels

- By 2030, improve net process efficiency of various production pathways of advanced renewable liquid and gaseous fuels[18] of at least 30% compared to present levels.
- By 2030, for renewable hydrogen production by electrolysis improve net process efficiency to reach 70%[19].

2. Improve GHG savings

Total GHG savings through use of advanced biofuels and renewable fuels will be at least that required in Directive (EU) 2015/1513 where Article 7b (amended) states that greenhouse gas emissions saving from the use of advanced renewable fuels shall be at least 60%. The greenhouse gas emission saving from the use of biofuels in transport shall be calculated in accordance with Article 7d(1) of the same directive and should be at least x% of the 40% target in 2030.

3. Reduce Costs

In conclusion, the target price in 2020 and 2030 for advanced biofuels and renewable fuels should be within a reasonable margin from parity with the fossil based fuels. Nevertheless, when policy incentives for CO_2 reduction are taken into account, they should aim to be in parity with fossil fuel prices in 2030. This will require in particular improvements in process efficiency and energy balance through the application of innovative practices[20].

3.1. Reduce cost (excluding taxes and feedstock cost) for end biofuel products

- Liquid or gaseous advanced biofuels by thermochemical or biochemical processing: <50 €/MWh in 2020 and <35 €/MWh in 2030 e.g. at least by 30% from 2020 levels
- Algae based advanced biofuels <70 €/MWh in 2020 and <35 €/MWh in 2030 e.g. at least by 50% from 2020 levels

3.2. Reduce cost for renewable liquid and gaseous fuels

- Other renewable liquid and gaseous fuels excluding renewable hydrogen: at least by 50% from 2020 levels
- Renewable hydrogen: by electrolysis <4 €/kg.

6. Next steps

Stakeholders are requested to provide their feedback and take position on the proposed targets in accordance with the guidelines set out in the paper "The SET Plan actions: implementation process and expected outcomes". Stakeholders should submit their positions to SET-PLAN-SECRETARIAT@ec.europa.eu by **7/11/2016** at the latest. Stakeholders' positions will be used to come to an agreement on targets in a dedicated meeting of the SET Plan Steering Group with a representation of key stakeholders.

Subsequently the parties involved will undertake to agree on an Implementation Plan for the delivery of the agreed R&I targets. In doing so, factors of a technological, socio-economic, regulatory, financial, or other nature, which may be of relevance in achieving these targets, have to be considered. For developing his work, the Temporary Working Group (TWG) will consider the relevant R&I actions from the Integrated Roadmap as adopted in December 2014 (see Annex A), and will clarify the targets limitations, boundaries etc.

[18]For example using renewable electricity to produce gaseous or liquid fuels, including the capture and reuse of CO2, as well as synthetic fuels made by other innovative processes

[19]50-47kWh/kg H2

[20]To determine the price margin, input from stakeholders and Member States will be needed for developing the Implementation Plan.

Annex A: Relevant actions of the 'Towards an Integrated Roadmap' document of the SET Plan

Concrete targeted R&I actions for the long, medium and short term for bioenergy development in general are proposed in the Annex I: Part II of the 'Towards an Integrated Roadmap' document[21]. In particular the following actions are found of relevance:

Heading 1 and Challenge 7:

Action 4 of the Industrial Research and Demonstration Programme

- ***Development of high efficient large-scale or industrial steam CHP with enhanced availability and increased high temperature heat potential (up to 600°C)***

and Action 2,

- ***Demonstration of thermally treated biomass fuel to replace coal and other fossil fuels in CHP***

and Action 4 of the Innovative and Market-uptake Programme

- ***Industrial demonstration and market up-take of high efficient large-scale or industrial steam CHP with enhanced availability and increased high temperature heat potential (up to 600°C)***

Heading 3 and Challenge 1:

Action 2 of the Advanced Research Programme,

- ***Develop innovative biological, chemical and thermochemical routes for biomass conversion to obtain biofuels and bioproducts from all fractions of biomass***

Action 1 from the Industrial Research and Demonstration Programme,

- ***Demonstrate processes at TRL6-7 that decrease Capex and/or Opex and increase the overall sustainability of advanced biofuels processes to various end-use applications (road transport, aviation, etc.)***

and Action 1 of the Innovative and Market-uptake Programme are the more relevant ones.

- ***Implement advanced conversion technologies at large scale energy-driven biorefineries and implement sustainable, reliable and efficient value chains at large scale (TRL=8)***

Heading 3 and Challenge 2:

Action 1 of the Advanced Research Programme,

- ***Development of sustainable catalysts and process technologies for CO2 to methanol and fuels***

and Action 2 of the Industrial Research and Demonstration Programme

- ***Demonstration of selective conversion of CO2 to methanol, ethanol, or other fuel molecules using renewable energy***

Heading 3 and Challenge 3,

Action 1, 2 & 3 of the Advanced Research Programme

- ***Development of sustainable catalysts and process technologies for CO2 to methanol and fuels***
- ***Development of electrodes and membranes for direct selective conversion of CO2 to methanol, ethanol, or other fuel molecules using renewable energy***
- ***Development of gasoline and Diesel from CO2***

and Action 1 &2 of the of the Industrial Research and Demonstration Programme

- ***Pilot plants for CO2-based fuels***
- ***Demonstration of selective conversion of CO2 to methanol, ethanol, or other fuel molecules using renewable energy***

[21] https://setis.ec.europa.eu/set-plan-process/integrated-roadmap-and-action-plan