European Biofuels
TECHNOLOGY PLATFORM

European Biofuels Technology Platform

Strategic Research and Innovation Agenda 2016

innovation driving
sustainable biofuels

June 2016

European Biofuels Technology Platform: innovation driving sustainable biofuels

The European Biofuels Technology Platform (EBTP) was established in 2006 to contribute to the development of cost competitive world class biofuels technologies and accelerate the deployment of sustainable biofuels in the European Union, through a process of guidance, prioritisation and promotion of research, development and demonstration activities (R&D&D).

It brings together the knowledge and expertise of stakeholders active in the biofuels value chains: biomass resources providers, biofuels and bio-energy producers, technology vendors, transportation fuels marketers, transport industry, research and technology development organisations and NGOs. It is managed by a Steering Committee and supported by a Secretariat, the European Commission being an active observer. Stakeholders can register and share access to key contacts, internal and external reports, events, opinions and expertise on biofuels R&D&D. Platform activities are carried out through four working groups (Biomass Availability and Supply; Conversion; Biofuels Distribution and End Use; Policy and Sustainability).

The initial focus of the EBTP during 2007 was to produce a Strategic Research Agenda and Strategy Deployment Document SRA/SDD identifying key R&D&D working lines for the next decades, as necessary to achieve the Vision 2030. The SRA/SDD, which was launched at the First Stakeholder Plenary Meeting in Brussels in January 2008, also aimed to provide a reliable source of information and opinion on the development of biofuels for transport in the EU. In 2010, the EBTP published an update to the Strategic Research Agenda (SRA).

In light of new legislation and an ongoing debate on the availability and sustainability of feedstocks, as well as the acceleration of novel feedstocks, advanced conversion technologies, and emerging markets (e.g. aviation, shipping) the current Strategic Research and Innovation Agenda has been produced by the EBTP Working Groups.

For more information on the European Biofuels Technology Platform please visit www.biofuelstp.eu

European Biofuels Technology Platform: Strategic Research and Innovation Agenda 2016

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List of Abbreviations

BBI	Bio-based Industries
BtL	Biomass to Liquid
DDF	Diesel Dual Fuel
DME	Dimethyl ether
EBTP	European Biofuels Technology Platform
EIBI	European Industrial Bioenergy Initiative
ERTRAC	European Road Transport Research Advisory Council
ETBE	Ethyl Tertiary Butyl Ether
EU	European Union
EV	Electric Vehicles
FAME	Fatty Acid Methyl Ester
FFV	Flex-Fuel Vehicles
FQD	Fuel Quality Directive
GHG	Green House Gas
IMO	International Maritime Organization
HD	Heavy Duty
HVO	Hydrotreated Vegetable Oil
ICE	Internal Combustion Engine
IEA	International Energy Agency
iLUC	Indirect Land Use Changes
ISO	International Organization for Standardization
LCA	Life Cycle Analysis
MS	Member States
Mtoe	Million Tonnes of Oil Equivalent
NGO	Non-Governmental Organisation
R&D	Research and Development
R&D&D	Research, Development and Deployment
RED	Renewable Energy Directive
RES	Renewable Energy Source
SDD	Strategy Deployment Document
SRIA	Strategic Research Innovation Agenda
SRA	Strategic Research Agenda
TRL	Technology Readiness Level
UCO	Used Cooking Oil
WTO	World Trade Organisation

1. Executive Summary

The aim of this update is to present most significant recent evolutions of relevance to biofuels and to highlight corresponding R&D&D priorities.

Facts

- European biofuels policy from 2012-2014 was characterized by the discussion about the Revision to the Fuel Quality Directive (FQD) and Renewable Energy Directive (RED) to address iLUC (indirect Land Use Change)
- In April 2015, the European Parliament and Council found a compromise and approved the new legislation, the so called the "iLUC Directive", which limits the way Member States can meet the target of 10% for renewables in transport fuels by 2020
- The European Commission has published the Communication on the 2030 Climate and Energy Goals in January 2014 which doesn't foresee a specific target for biofuels after 2020
- Sustainability and public awareness, already identified in 2010 SRA/SDD as critical, have growing importance
- Several industrial units for advanced biofuels have been built and started up in 2014-15 much more in America than in the EU, whose technology leadership on this topic is increasingly being challenged
- Biofuels in the concept of circular economy has gained importance
- New alternative fuels including electric vehicles are available

Observations and recommendations

The fundamentals for biofuels have not changed. As highlighted in the 2010 SRA, the winning options will be the pathways (combination of feedstock, conversion and end products) best addressing combined strategic and sustainability targets: environmental performances (green house gas reduction, biodiversity, water, local emissions); security and diversification of energy supply; economic competitiveness and public awareness.

Currently commercially deployed feedstocks and conversion technologies should provide a significant contribution to the EU 2020 targets but will probably not be sufficient. It is necessary to enlarge the feedstock basis and enhance conversion efficiency. These broad objectives were at the core of the last SRA/SDD findings and remain fully valid.

- Establish a clear, stable and policy framework for the long term (post-2020) starting with simple, meaningful, quantifiable objectives and measures
- Develop a policy framework towards 2030 that stimulates sustainable biomass strategies e.g. encouraging integrated biomass applications, taking into account the overall goals defined at the political level.
- Relevant, transparent and science based data and tools for practical implementation of sustainability requirements in the legislation and market place should be further developed
- Support resource efficient supply following a system approach (including legal and financial mechanisms and measures)
- The key priorities for commercial biofuel technologies are to improve environmental (GHG, energy balance, water, inputs…) and economic performance and bring flexibility as integrated biorefinery
- Conversion technologies targeting fuels for heavy duty road, air, and marine transport deserve priority attention because of lack of alternatives and their increasing demand
- Work to ensure a fair appreciation of CO_2 emissions of vehicles running on biofuels (well-to-wheel approach, electric vehicles and vehicles running on renewable fuel should be treated using equal criteria)

2. Introduction and State of the Art

The transport sector is supporting our economic activities and plays an important role on an individual level providing personal mobility. In Europe total energy consumption of transport accounts for 348 Mtoe (Million Tonnes of Oil Equivalent) in 2013. Road transport is responsible for the majority of energy consumption (81.7 %) followed by air (13.9 %), rail (2.0 %) and water (1.6 %). The transport sector strongly depends on fossil energy carriers and is responsible for around a quarter of EU greenhouse gas emissions (24.3 % in 2012). For road transport, alternative fuels (biofuels and natural gas) supplied around 5 % of the consumption in the EU, of which 90 % was biofuels.

The latest SRA from the EBTP was published in 2010. The 2010 update, relying heavily on Directive 2009/28/EC (RED) was written at a time when the use of biofuels was growing rapidly. Obviously, things have changed since 2010, in terms of technology, market and policy developments.

In 2014, nearly 13.9 Mtoe of biofuels were consumed in EU 28, totalling to 4.9 % of road transport fuels. This shows a downturn in comparison to 2012 when 14.6 Mtoe biofuels were consumed in the EU. Still, biofuels are expected to contribute to meeting the lion share of the EU 2020 target of 10 % renewable energies in the transport sector. Even though the EU2020 targets are far from being met, the development of advanced biofuels capacities is slowing down. The biofuels commercialization within recent years has not been as successful as envisaged and at the current state advanced biofuels have to defend their position as one of the key elements in decarbonizing transport for 2030 and beyond, next to options such as electrification, and further energy efficiency improvements. Since 2012, EU biofuels demand is decreasing. This is caused by changes of Member States policies following the public debate about biofuels and unclear directions at European level. Also less transport fuels have been used, which together with adjusted blending mandates and blending of double-counting biofuels, has reduced physical biofuel demand. To obtain a further demand increase, higher biofuels blends would need to be promoted also in the long term (10 years minimum) with a strong political interest to realize energy independence, with adaptation of technical fuel standards where necessary.

Contrary to the decreasing demand, the European biofuels production is still increasing. The rapid growth phase from 2002 till 2010 was terminated with a production decrease in 2011 by 10% (compared to 2010) but recovered with an annual growth rate of about ~10 % between 2012 and 2013. The figure below shows the European biofuels production. This contradiction, less demand on one hand and increasing production on the other can be explained by the fact that the EC imposed antidumping duties for bioethanol from the United States and for biodiesel from Argentina and Indonesia, the main countries from which the EU imports biofuels, and increasing EU biofuel exports.

In addition to the decreasing demand side, the European biofuels policy from 2012-2014 was characterized by the discussion about the Revision to the Fuel Quality Directive (FQD) and Renewable Energy Directive (RED) to address iLUC (indirect Land Use Change). The future situation of biofuels at European level was unclear and investment in the industry deterred hindering the commercialization of these technologies.

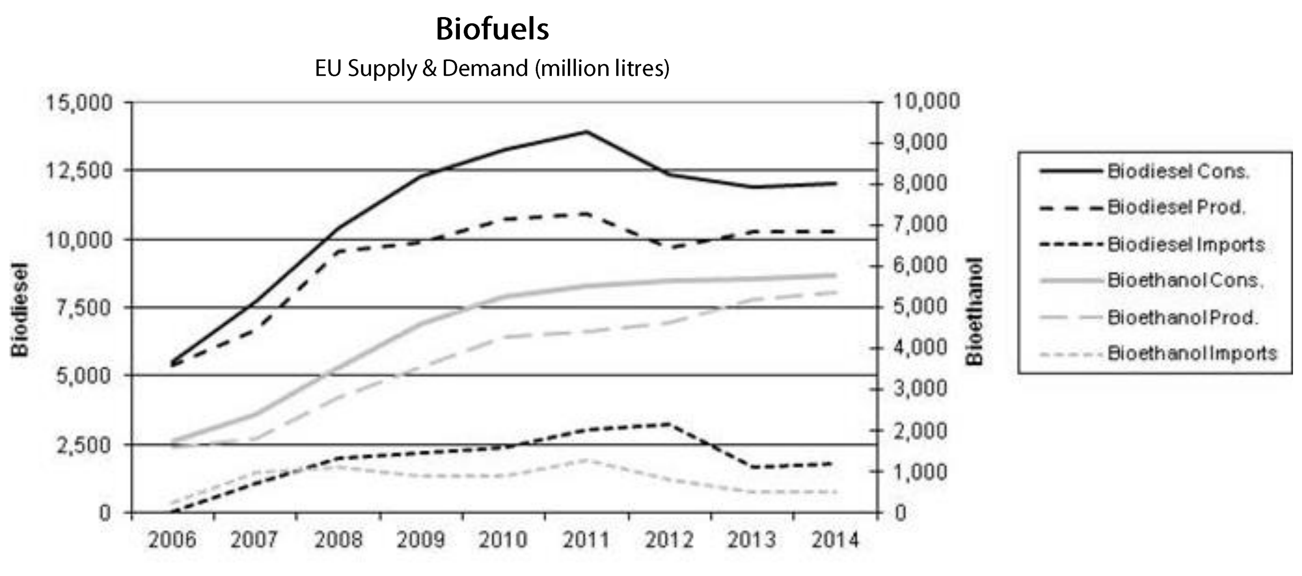

Figure 1: EU Conventional and Advanced Biofuels Supply and Demand, 2006-2014 (Source: EU FAS Posts)

In April 2015, the European Parliament and Council finally found a compromise and approved the new legislation, the so called the "iLUC Directive", which limits the way Member States can meet the target of 10% for renewables in transport fuels by 2020, bringing many months of debate to an end. There will be a cap of 7% on the RED recognisable contribution of biofuels produced from conventional crops, and a greater weight on the production of advanced biofuels from a list of eligible feedstocks. The amendments to RED and FQD were approved by the Council in July 2015 and published in the official Journal on 15 Sep 2015. Member States must then transpose the law into national legislation by September 2017. By 6 Apr 2017, they have to establish a sub-target for advanced biofuels. The reference value for this sub-target is 0.5% by 2020 and only advanced biofuels made from feedstocks listed in Annex IX part A[1] of the Directive are eligible. MS have to provide a grounded reason for establishing a lower sub-target.

The EC has published the Communication on the 2030 Climate and Energy Goals in January 2014. This sets out the framework post 2020, includes a reduction in greenhouse gas (GHG) emissions by 40 % compared to the 1990 level, an EU-wide binding target of at least 27 % for renewable energy and further ambitions regarding the energy efficiency. For renewable energy in transport in general (including biofuels for transport) no specific targets are foreseen. According to the EC the further development within the transport sector should be based on an integrated approach and should be based on alternative, sustainable fuels. More details should be provided in the course of 2016 with new policies and legislation on the decarbonisation of transport and a new renewable energy package.

Meanwhile, the commercial production of advanced biofuel technologies proceeds and several biofuels plants have been commissioned. But for the further biofuels deployment there are still some key issues which need to be solved along the value chains. These will be presented in more detail in the following chapters. It is important to note that the deployment of biofuels can only be pursued if the research within the different areas and aspects of biofuels are linked and collaborated actions are implemented.

On the feedstock side, more information about the resource efficient supply chain and competing uses for agriculture, forestry and wastes within other renewable sectors needs to be explored focusing at ways to improve mobilisation at different regional scales and at improved projections for 2030 and beyond. Currently, many different feedstocks are used for producing different biofuels; thus various conversion technologies are utilized. Specific value chains within this regional context differ and it is not possible to identify a 'one-size-fits-all' technology. In addition to the regional context of the biofuel production it needs to be taken into account that, the solution for an alternative fuel will differ across the different end-use sectors (road, air, marine). Currently electric vehicles seem to be more attractive than biofuels to politicians and decision makers and the auto manufacturers are not that fond of biocomponents, although advanced drop-in type biofuels offer a fast-track option for decarbonizing transport. Currently EU ordinances to reduce CO2-emissions from passenger cars (333/2014 and 443/2009) are no real incentives for the auto manufacturers to produce other alternative fuel vehicles than electric vehicles. For a fair competition with Electric Vehicles (EV), EVs as well as biofuel powered internal combustion engine (ICE) vehicles should be evaluated on a well-to-wheel basis for GHG emissions as well as cost-effectiveness taking into account all the investments needed. The implementation of biofuels into the market still needs relevant incentives through demand setting i.e. blending mandates. **Moreover, some transport modes such as aviation, are relying on liquid fuels, and even if there is currently a global trend towards a "more electrical aircraft", the propulsion part will still rely on these liquid fuels for a long time. Advanced drop-in biofuels are consequently compulsory in order to meet future aviation ambitious greenhouse gases emissions reduction target.**

When progressing from research into the demonstration phase a larger focus need to be given to additional aspect besides just the development of technology. This also applies to the form of projects where "new" actors (along the value chain as well as policy) need to be involved for long term success. technology development focused on feedstock

[1] ILUC Directive ANNEX IX Part A: (a) Algae if cultivated on land in ponds or photobioreactors. (b) Biomass fraction of mixed municipal waste, but not separated household waste subject to recycling targets under point (a) of Article 11(2) of Directive 2008/98/EC. (c) Bio-waste as defined in Article 3(4) of Directive 2008/98/EC from private households subject to separate collection as defined in Article 3(11) of that Directive. (d) Biomass fraction of industrial waste not fit for use in the food or feed chain, including material from retail and wholesale and the agro-food and fish and aquaculture industry, and excluding feedstocks listed in part B of this Annex. (e) Straw. (f) Animal manure and sewage sludge. (g) Palm oil mill effluent and empty palm fruit bunches. (h) Tall oil pitch. (i) Crude glycerine. (j) Bagasse. (k) Grape marcs and wine lees. (l) Nut shells. (m) Husks. (n) Cobs cleaned of kernels of corn. (o) Biomass fraction of wastes and residues from forestry and forest-based industries, i.e. bark, branches, pre- commercial thinnings, leaves, needles, tree tops, saw dust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin and tall oil. (p) Other non-food cellulosic material as defined in point (s) of the second paragraph of Article 2. (q) Other ligno-cellulosic material as defined in point (r) of the second paragraph of Article 2 except saw logs and veneer logs. (r) Renewable liquid and gaseous transport fuels of non-biological origin. (s) Carbon capture and utilisation for transport purposes, if the energy source is renewable in accordance with point (a) of the second paragraph of Article 2. (t) Bacteria, if the energy source is renewable in accordance with point (a) of the second paragraph of Article 2.

flexibility and integration with existing industries will not be enough, it need to be coupled to research and development regarding markets, business models, novel value chain cooperation, policy instruments etc. Technology and market development need to go hand in hand. This could be addressed both by forms (supporting and collaboration actions) and focus/content in R&D projects (cross-disciplinary research projects as well as "conventional" research projects).

It is important to realise that there should not be an adversarial set-up between biofuels or any other energy carrier. The important thing is the need to increase the share of renewable energy in all energy carriers. So far, the competitor within the transport sector is fossil fuel, 88% of oil imports account for the transport sector and the European dependence on imported oil is still increasing. It should be made visible that, depending on origin, feedstock and processes used, also fossil fuel has an impact on sustainability (e.g. social impact). Therefore similar criteria and performance should be investigated and made transparent for fossil fuels to allow fair competition. Indirect cost, often referred to as externalities are brought to the society with the use of fossil energy carriers. These include human health problems caused by air pollution from the burning of coal and oil; damage to land from coal mining; environmental degradation caused by global warming, acid rain, and water pollution; and national security costs, such as protecting foreign sources of oil. The producers and the users of energy do not pay for these costs, society as a whole must pay for them.

It is also important to highlight, that the deployment of biofuels doesn't only bring challenges but it also brings opportunities e.g. to decarbonize transport, boost economic growth and jobs and achieve steps towards energy security for Europe. According to the EurObserv'ER Report[2] the 2013 EU biofuel sector sales turnover was 14.3 billion euro and work force of around 100 000 workers.

It will be necessary to identify synergies between the fuel generation and the fully established industries and to create biorefinery concepts for the optimal use of biomass. It should be kept in mind that a new biorefinery creates approximately 100 direct jobs and up to 1,000 more in ancillary services like maintenance and transport. Also towards 2030 and 2050, it is clear that biofuels will be part of an EU transport decarbonisation strategy that optimally uses its resources and technological assets[3].

[2] http://www.eurobserv-er.org/14th-annual-overview-barometer/

[3] For example, a macro-economic impact assessment for Finland shows that for this country, a high ambition for biofuels is the most cost-effective strategy for decarbonising transport. While the results of such an analysis may differ between EU Member States, the study clearly shows that biofuels have a significant role to play.

3. Markets, regulatory framework and public awareness

Main recent evolutions and facts

- The Renewable Energy and Fuel Quality Directives (RED and FQD, see box below for more details) have set the regulatory framework for biofuels up to 2020 in the EU. The compromise on iLUC finally adopted in Sep 2015 (2015/1513/EC) puts a 7% limit on biofuels from crops and sets an indicative target for advanced biofuels at 0.5% (energy content) for 2020.
- Member States' implementation of the above directives (by Sep 2017) is expected to provide greater clarity on renewable fuel and energy mix targets at national levels.
- Different regulatory frameworks including sustainability requirements and supporting advanced technologies are being developed. Some novel approaches focus on GHG performance of biofuels instead of an energy share.
- The Energy Union stresses that the EU needs to invest in advanced, sustainable alternative fuels, including biofuel production processes, and in the bio-economy more generally. It also highlights that the EU will need to take into account the impact of bioenergy on the environment, land-use and food production. The integrated SET-Plan[1] aims to accelerate the development and deployment of low-carbon technologies.
- When it comes to the decarbonisation of transport, the focus of the Energy Union is on electro-mobility, which has been granted a zero emission footprint regardless the source of electrical energy.
- The Directive on the deployment of alternative fuels infrastructure (2014/94/EC) requires Member States to develop national policy frameworks for the market development of alternative fuels and their infrastructure; and fuel labelling in order to improve the development of biofuel distribution and consumers' information.
- The complexity of biofuels issues is not yet fully understood by the public.

Recommendations

- Establish a clear, stable and consistent policy framework for the long term (post-2020) starting with simple, meaningful, quantifiable objectives and measures
- Develop a policy framework towards 2030 that stimulates sustainable biomass strategies e.g. encouraging integrated biomass applications, taking into account the overall goals defined at the political level.
- As several national energy and transport policies are being developed for the horizon 2030 – in line with the Energy Union, and the Directive on the deployment of alternative fuels infrastructure (2014/94/EC), try to harmonise these policies where necessary to avoid fragmentation and ensure reliable interconnection for transport (and fuel distribution).
- Ensure a swift transposition of European directives at Member States level.
- Develop regulatory tools to overcome the hurdles for demonstration and first-commercial plants.
- For sustainability related tools and for innovative biofuel technologies, ensure continued R&D support. Develop relevant investment schemes to allow funding of risky demonstration and reference projects via public/private partnerships (see European Industrial Bioenergy Initiative).
- Develop the appropriate, highly specialised professional skills that are required for the bio-industry[2]
- Encourage and support initiatives at all level (regional, national and EU wide) to inform and explain to the wider public the benefits and necessity of sustainable biofuels.

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[1] http://ec.europa.eu/energy/en/topics/technology-and-innovation/strategic-energy-technology-plan

[2] In line with the recommendations from the FP7 EU funded project, BIOTIC (see: http://www.industrialbiotech-europe.eu/new/wp-content/uploads/2015/06/BIO-TIC-roadmap.pdf

Main recent evolutions

Since 2005 world biofuel consumption has dramatically increased. The US, Europe and Brazil remain the biggest consumers of biofuels thanks to legislative support (see Figure 2).

Over the recent years the growth in biofuel demand has slowed down however because of the global economic crisis, and reduced increase in transport fuel consumption in several regions and changes in policy frameworks. Concerns on sustainability impact and public perception have also limited expansion of biofuels in EU.

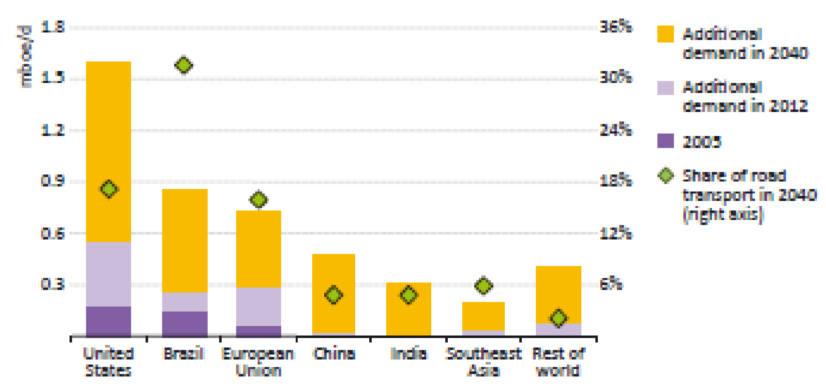


Figure 2: Biofuel consumption per region in 2005, in 2012 and projection for 2040. (Source: IEA World Energy Outlook 2014, New Policies Scenario to 2040).

In recent years, prices for both crude oil and agricultural commodities have been highly volatile (with a strong dependence of the food price index on energy prices). Thus, even though the first European countries started to introduce biofuels 15-20 years ago, biofuels are not yet ready to compete at a global scale without adequate regulatory support.

The Renewable Energy and the Fuel Quality Directives (see Table 1 next page) provide the current legal framework for biofuels in the EU. The debate and long delay in revising these directives have created market uncertainty, and reduced investors' confidence. In addition the **recent compromise** on iLUC (between the Council and the European Parliament in April 2015) with **the absence of a mandatory target for advanced biofuels (instead there is a subtarget with an indicative reference value at 0.5%) increases the challenges for the development of those innovative products.** It is worth mentioning that all EU current biofuel regulations, in particular these related to mass balancing, are dedicated to liquid fuels, such as bioethanol and biodiesel, not providing a clear guidance for biomethane.

Different regulatory frameworks including sustainability requirements and support for advanced technologies are being developed actively in some countries. For example, Italy and Finland established ambitious policy frameworks in support of advanced biofuels. Germany on the other hand has decided to focus on GHG performance by implementing the FQD as the main policy tool to achieve its 2020 targets (see EBTP report on *Post-2020 Visions and National Plans for Sustainable Transport*[1]). Today, low carbon requirements and market incentives focus essentially on GHG performance, with additional efforts to include other factors such as biodiversity protection. There is likelihood that the RED will not be comprehensively and uniformly implemented in the Member States. Furthermore, it is not clear whether all Member States will achieve 10% renewable in transport and 6% reduction in GHG emissions of fuels by 2020 in the absence of specific transport framework by 2030.

In addition, the Directive on the deployment of alternative fuels infrastructure (2014/91/EU of October 22, 2014) requires Member States to develop national policy frameworks for the market development of alternative fuels and their infrastructure; and fuel labelling in order to improve the development of biofuel distribution and consumers' information. There are difficulties in realizing demonstration and first-commercial plants in Europe even with financial aid. The NER300[2] funding for risk sharing of innovative flag ship projects has so far materialized in only two biofuel projects which reached final investment decision (BEST Italy, Verbiostraw Germany). Legislative stability (over timeframes of well over 10 years) is an essential requirement as a favourable investment conditions for biofuel production plants.

As part of the Energy Union Strategy presented in February 2015, (COM(2015) 80 final), the European Commission provides some hints on the role of biofuels post 2020. The Energy Union stresses that the EU needs to invest in advanced, sustainable alternative fuels, including biofuel production processes, and in the bio-economy more generally. It also highlights that the EU will need to take into account the impact of bioenergy on the environment, land-use and food production. When it comes to the decarbonisation of transport – the focus of the Energy Union is on electro-mobility, which has been deliberately granted a zero emission footprint, regardless of the impact of the source of electrical energy or the actual life cycle emissions of that transport modality. As a follow up to the Energy Union, a Communication on the decarbonisation of transport and a revision of the Renewable Energy Directive will be presented in 2016.

[1] http://www.biofuelstp.eu/downloads/ebtpreports/ecn-sustainable-transport-visions-beyond-2020.pdf

[2] http://ec.europa.eu/clima/policies/lowcarbon/ner300/index_en.htm

Table 1: Existing EU biofuels framework

The Renewable Energy Directive 2009/28/EC (RED)	**The Fuel Quality Directive 2009/30/EC (FQD)**

• Every EU Member State has to achieve a 10% energy content target of renewables in transport by 2020 using biofuels, renewable electricity or hydrogen
• Biofuels from waste, residues, cellulosic and lignocellulosic material count twice TOWARDS THE 10% target
• Bonus of 29 g CO_2/MJ for biofuels from degraded/contaminated land
	• Fuel suppliers/blenders have to reduce by 6% reduction of the GHG intensity of all fuels put in the European market by 2020, an objective that fuel distributors are expected to meet by blending biofuels and reducing upstream emissions or UERs
	• Environmental quality standards for a number of fuel parameters,
	• Standards for blending biofuels:
	  ◦ 10% ethanol in petrol (E10) with transitory regulations (protection grade E5) for older cars and derogations for petrol vapour pressure subject to EC approval
	  ◦ 7% biodiesel in diesel (B7) by volume, with an option for more than 7% with consumer info
	• Mechanism for reporting and reduction of the life cycle GHG emissions from fuel

Sustainability Criteria	**New provisions brought by the iLUC Directive (2015/1513/EC)**

To qualify for both FQD and RED targets, biofuels need to meet sustainability criteria:
• a minimum GHG emissions savings of 35% compared to fossil fuel, rising to 50% in 2017 and 60% for new installations
• restrictions on the types of land converted to the production of biofuels crops (land with high biodiversity value and high carbon stocks are no-go areas). The latter criterion covers direct land use change only
	• No ILUC factor in GHG calculation but a public reporting obligation from 2020
	• 7% cap on conventional biofuels (from crops) in energy content:
	  ◦ Every Member State (MS) can account a max of 7% of crop-based biofuels towards the 10% target of renewables in transport by 2020
	  ◦ A MS can decide to set a lower cap than 7%
	  ◦ A MS can also decide to apply the 7% cap to the FQD
	  ◦ Possibility of setting out criteria for the identification and certification of low iLUC crop-based biofuels beyond that could be eligible beyond the cap
	• 0.5% indicative sub-target for advanced biofuels:
	  ◦ Each MS should set up a national target of 0.5% advanced biofuels by 2020 within 18 months of the entry into force of the Directive, i.e. 6 Apr 2017
	  ◦ The 0,5% is double counted and would count 1% towards the 10% target
	  ◦ MSs may set a national target lower than 0.5% under certain conditions (limited potential for sustainable production or availability, more incentives to efficiency or EVs, etc)
	  ◦ UCO (Used Cooking Oils) and animal fats are double counted but not eligible within the 0.5% target

The complexity of biofuels issues is not yet fully understood by the wider public. This remains a critical issue that the sector has to deal with.

The launch of the website www.BiofuelsforEurope.eu on June 23, 2015 is one example of initiative that can provide better information to the European audience.

Recommendations

It is urgent and critical to prevent the European bioindustry and bioeconomy from losing their importance and competitiveness at the international level. Post 2020 liquid transportation fuel and combustion engines will still make up by far the majority of road transportation in both light and heavy duty vehicles as well as in aviation and marine transport. A pragmatic and long-term approach to biofuel legislation is thus vital on an EU level. Such legislation should be based on simple, meaningful, quantifiable and verifiable criteria which are based on sound science and which are implemented without delay at Member State level. In addition it should not penalise the EU biofuels industries against the other regions and continents or for that matter unfairly against other alternatives like EV.

It is important to take into account that several national energy and transport policies are being developed for the horizon 2030 – in line with the Energy Union, and the Directive on the deployment of alternative fuels infrastructure (2014/94/EC). These policies need to be harmonised where necessary to avoid fragmentation and ensure reliable interconnection for transport (and fuel distribution). Overall, the process to develop the legislative 2030 framework should be better structured than what occurred with the debate for the amendment of the RED.

The post-2020 policy framework should also take into account the possible role of biomethane in transport more explicitly. This relates to elements in the new RED II (e.g. on non-discriminatory grid access for biomethane, guarantees of origin for it and their international trade, and sustainability policy for solid and gaseous biomass) and elements in other regulations, such as a legal status for digestates.

Land use change and other sustainability criteria must still be further clarified. In addition rules for more explicit checking and for sustainability certification should be implemented and tested in Europe, and outside Europe as it is probable that imports from other regions will occur.

For innovative biofuel technologies, continued R&D support should be ensured through existing EU and national instruments. High-risk demonstration and reference plants require adequate investment schemes (grant, loans, fiscal incentives) to allow funding e.g. via public/private partnerships. Policy makers must create favourable investment conditions with clear messages for the massive industrial investments that are required for decarbonisation in Europe.

It is also necessary to increase public funding and to strengthen support of R&D on sustainability related tools and data (see chapter 2).

Importantly as well, initiatives to inform and explain to the wider public the benefits of biofuels on the economy and on the Society (and the ongoing efforts to minimise their pitfalls) shall be encouraged and supported (see specific funding or activities such as the European Sustainable Energy Week, http://www.eusew.eu).

Public awareness

Since their early introduction in the EU in the 1990's, biofuels have been presented as a green substitute for oil-derived fuels and have benefited from an overall positive image. During 2008, as food prices soared, media attention focussed on biofuels as the perceived main reason ("food vs. fuel" discussion). Developments in Life Cycle Analysis (LCA) have shown that there are no "real world" pathways in Europe that result in biofuels at least as CO_2 intensive as conventional fossil fuels. Perceived environmental and social issues related to biofuels remain high on international agendas though real world results are actually giving cause for optimism. Further examination of real world results are required so that the successful models are reinforced, lower performing models phased out and stakeholders made aware of real conditions in the field. It is clear that public awareness of biofuels is crucial to their deployment and that there can be no acceptance without sound, science based information communicated in a clear way. Improving industry openness is an easy and quick way to enhance public confidence.

The public perception of biofuels' sustainability represents an important element limiting the expansion of these technologies and needs to be addressed under a global prospective. It is critical to encourage and support communication initiatives aiming at explaining to the wider public the benefits of biofuels as well as their potential pitfalls and the efforts deployed to mitigate them. Policy makers and stakeholders should invest efforts into informing the public of the values and impacts of large scale bio-industrialisation in Europe.

4. Sustainability

Main recent evolutions and facts

- Certification schemes for sustainable biofuels have been established in several Member States, in line with the conditions given in the Renewable Energy Directive.
- In EU policy, the debate on iLUC has been settled (see the regulations chapter) and no iLUC factors were included in the RED for lack of scientific conclusiveness and general agreement on this aspect. However, several questions remain open (direct and indirect land use, definition of biodiversity, soil, water, forest carbon balances and the related sustainability of forestry materials, social criteria, etc.). All in all, it is still unclear how certification systems will develop further, and which ones will become the most adequate and consensual.
- It is increasingly recognised that sustainability requirements are not only relevant for bioenergy/biofuels applications of biomass, but also for competing usages (food, feed, fibre). Therefore, a holistic approach should be pursued.
- More research and data are still necessary to improve existing sustainability criteria and develop new land management strategies, in order to ensure the long-term availability and competitiveness of biomass.

Policy recommendations

- Greater EU regulatory clarity and coherence across member states is necessary, as is renewed commitment to the goal of a single EU market for liquid transport fuels.
- Continued dialogue at international level is needed to achieve compatible standards on actual sustainability performance of feedstocks, possibly resulting into an ISO standard.
- Work towards application of sustainability criteria across all biomass uses to allow a level playing field between energy, food and other applications of biomass.
- Similar criteria and performance should be investigated and made transparent for fossil fuels to allow fair competition.

R&D recommendations

- Biofuel sustainability should be embedded in broader efforts towards sustainable use of biomass and land, and the development of innovative land and biomass management strategies is worth pursuing, particularly for food crops.
- Relevant, transparent and science based data and tools for practical implementation of sustainability requirements in the legislation and market place should be further developed.
- Sustainability of biofuels is still a "loosely defined" topic from a scientific point of view: it is essential to accelerate the development of science based, rational and transparent:
    - Criteria, indicators, methodology (LCA and others) and data,
        - across the full value chains
        - based as much as possible on data from demonstration or industrial-scale projects
        - for EU relevant geographies, for both domestic and imported feedstocks or biofuels
        - for the three dimensions of sustainability (environmental, social and economic)
    - Models, monitoring and impact assessment tools to
        - help assess implementation of enacted legislation
        - prepare public (policy) and private (investment) decisions
        - better assess the issues around direct and indirect land use change
        - help manage the issues of competing uses of arable land and biomass
        - provide satisfactory guarantee of the sustainable use of biomass while stimulating best practice
- Develop projects to demonstrate the sustainability of full value chains[1]

[1] For example, the FP7 project S2Biom (http://www.s2biom.eu/en/) develops a toolset with databases to address these questions for the sustainable delivery of non-food biomass for the bioeconomy.

Main recent evolution and facts

Sustainability has already been identified as a key challenge for biofuels by the EBTP in the original 2008 SRA/SDD. With the Renewable Energy Directive (RED) and the Fuel Quality Directive (FQD), legal requirements for biofuel sustainability were introduced in the EU in June 2009. These directives set quantitative targets for GHG emission reductions (see chapter 3 for a more detailed introduction to RED and FQD).

Although these directives provide a certain legal framework for biofuels, Indirect Land Use Change (iLUC) factors are **still debated so that they were not included in the compromise on the RED between the European Council and the European Parliament.** A provisional estimation of iLUC emissions from biofuel and bioliquid feedstocks (gCO2eq/MJ) has been maintained in the final text for reporting by the Commission, and not for assessing regulatory compliance. This reporting is based on ranges taken from Monte Carlo analysis by the International Food Policy Research Institute (IFPRI). This will enable the European Commission to gather data across EU to be reviewed in light of the possibility of introducing adjusted estimated indirect land-use change emissions factors into the future RED II as a sustainability criterion. Many questions e.g. regarding direct and indirect land use or the definition of biodiversity, soil, water social criteria remain open until today. So far, certification criteria have been established in several Member States, in line with the conditions given in the Renewable Energy Directive but clarity and coherence across Member States is necessary. It is important to work towards international harmonisation and/or procedures for mutual recognition of sustainability criteria at a global level. This is particularly important as transport is global, especially aviation.

Sustainable Biomass Regions

Sustainable Biomass Region is a concept that is being explored to help develop sustainability systems at a larger scale. According to the Bioeconomy Panel, a Sustainable Region would follow a series of principles on a regional level: focus on greenhouse gas reduction, prevention of soil degradation, and possibly restoration; optimisation of agricultural, forestry and aquatic production; a regional strategy to prevent environmental harm and to facilitate social and economic growth. One of its elements can be that additional biomass for energy is produced on the condition that additional regional biomass productivity increases allow this to be produced without jeopardising food and feed security or inducing land use change.

In an ideal end picture, a guarantee of origin from a Sustainable Region would be enough to prove the product is sustainable.

The Sustainable Biomass Regions could be a strategic initiative to help developing sustainability systems at a larger scale. Harmonisation of standards for sustainability at EU level represents a key driver to stabilise the sector in the long run, ensure a wider recognition of the biofuels industry and channel investments.

It is increasingly recognised that sustainability requirements for bioenergy/biofuels restrict biomass availability, as do competing usages (food, feed, fibre). As a consequence, consensus seems to emerge that biomass sustainability should be considered holistically, for all its applications, including food and feed, as should land use issues. Besides, adequate sustainability requirements are critical to ensure the long-term availability and competitiveness of biomass.

While the scientific debate on quantifying iLUC remains polarised, practical initiatives exist that aim at preventing undesired land use change impacts of biomass use, often at a regional level, such as the Sustainable Biomass Regions (see box above) concept. Developing strategies to safeguard sustainability on the ground may prove to be more relevant than a continuous discourse over system-wide analyses of (i)LUC.

Policy recommendations

Greater EU regulatory clarity and coherence across Member States are necessary (with the goal of reaching a European regulation regarding sustainability). A uniform set of sustainability criteria is desirable. In addition, continuous dialogue at international level, including NGOs, is needed to achieve compatible standards on actual sustainability performance, possibly resulting in a globally recognized ISO standard. Finally, sustainability criteria should apply to all biomass uses to allow a level playing field between energy food and other applications. Practical initiatives to deal with this should be supported as long as they do not increase market fragmentation. In the same time overly complex criteria and the related administrative burden for operators should be avoided.

It should be made visible that, depending on origin, feedstock and processes used, also fossil fuel has an impact on sustainability (e.g. social impact). Therefore similar criteria and performance should be investigated and made transparent for fossil fuels to allow fair competition.

R&D recommendations

Practical implementation of sustainability requirements in legislation and market place must be based on relevant, transparent and science-based data and tools, based as much as possible on real data (demonstration or industrial-scale projects). This applies to the full chain of biofuel production, from feedstocks to end uses and to adequately account for integrated production of multiple products, to EU domestic and imported feedstocks and fuels, and to the three dimensions of sustainability (environmental[1], social and economic). There will definitely be a trade-off between fully safeguarding sustainability and the need to avoid overly complex criteria and the related administrative burden, and innovation will be needed to reconcile these two.

The concept of Sustainable Biomass Regions has not been fully elaborated yet but deserves further RD&D support, as it can provide a basis for active prevention of ILUC effects through compensating measures at regional level. This would be particularly important for conventional biofuels, as ILUC-related sustainability concerns focus on these fuels.

It is also necessary to develop science-based, rational and transparent models, monitoring and impact assessment tools to help evaluate the implementation of legislation and to facilitate public (policy) and private (investment) decision-making. In addition, such evaluation tools must take into account the issues of direct and indirect land use change, of competing uses of arable land, and the use of degraded, abandoned and contaminated land for biomass production. How information can be verified and what rules to develop for certification bodies represent another important aspect.

Moreover, a better understanding of sustainability aspects of biofuel value chain versus other economic “value chains” as well as non-market “common goods” is needed, in particular to include systemic impacts over short versus long term time lines. Sustainability related tools and data of high quality should be a priority for public R&D funding at EU and national level.

[1] (GHG, CO_2, N_20, CH_4, water, biodiversity, local emissions, soil, etc.)

5. Biomass availability and supply

Increasing the amount of biomass available under sustainable conditions was already identified as a critical challenge for biofuels in the previous EBTP SRA/SDD.

Key issues affecting biomass mobilisation by 2020 and 2030

- Sustainable and resource efficient supply chains from agriculture, forestry and wastes
- Evaluate and identify best algal cultivation, harvesting and processing technologies to use it for bioenergy/ biorefinery production for both microalgae and macroalgae
- Competition for resources and displacement effects
- Evidence based information for policy at European, national, regional and local level

R&D recommendations

- Understand interdisciplinary issues and assumptions which frame the future biomass supply across sectors by defining sustainable & resource efficient value chains
- Best practice technology transfer between forestry and agriculture based value chains
- Create a level playing field for biomass resources regardless to their end markets
- Work on bottom up analysis and regional focus cases

Policy recommendations

- Support resource efficient supply following a system approach (including legal and financial mechanisms and measures)
- Place sustainability, smart & efficient use of resources at the heart of industrial, business & social activities
- Consider supply based strategies to complement the demand ones
- Facilitate indigenous supply but with balanced approach and with respect to World Trade Organization (WTO) and international trade procedures

Market & Industry recommendations

- Facilitate market operation with consistent support frameworks
- Build "biorefinery" steps in existing industrial capacities across Europe to support multi-uses of biomass resources

Main recent evolutions and facts

The issue of mobilising biomass feedstocks in a sustainable and resource efficient manner[1] remains an issue of vital importance for Europe. Firstly for meeting the targets in the Renewable Energy Directive[2] to a low carbon energy system for 2020 and beyond. Secondly, to foster in the same time the sustainable development of the European biobased economy and meeting the objectives of the Bio-Based Industries (BBI) Joint Undertaking[3] to contribute to a more resource efficient and sustainable low-carbon economy and to increasing economic growth and employment, in particular in rural areas, by developing sustainable and competitive bio-based industries in Europe, based on advanced biorefineries that source their biomass sustainably. The box on p. 9 describes this in more detail.

[1] According to the EU 2020 Flagship Initiative Resource efficiency is a way to deliver more with less (natural resources). It increases aggregate economic value through more productive use of resources over their life cycle. It requires using those resources in a sustainable way, within the planet's long-term boundaries. This includes minimizing impacts of one resource's use on other natural resources.

[2] Directive 2009/28/EC of the European Parliament and of the Council of 5 June 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

[3] http://www.bbi-europe.eu/about/objectives#sthash.pYSyVXdt.dpuf

The total amount of biomass used in the EU for energy and material uses in 2013 is estimated to amount to 485 million tonnes[1]. The biggest share (400 million tonnes) comes from forestry with an estimated 240 million tonnes of wood used as a "classical" bio-based material primarily used in the woodworking and pulp and paper industry.[2] 160 million tonnes of wood are used for production of energy (mainly heat and power).

The amount of biomass from agriculture, transformed in industrial material and energy is estimated to amount to 85 million tonnes, with energy use (45 million tonnes) slightly larger than material use (40 million tonnes). Obviously, a much larger share of biomass from agriculture goes into food and feed applications[3].

Biofuels are currently mainly produced from agricultural biomass, today mostly food crops. The estimated 2013 use of biomass in the EU for liquid biofuel production amounted to approximately 9 million tonnes of oil (of which 5.5 million tonnes were rapeseed oil) and approximately 18 million tonnes of starch/sugar crops (sugarbeet, wheat, corn & other cereals[4]).

However, there is growing interest within the forest industry to exploit their resources in biorefineries including advanced biofuels.

In contrast to other biomass-based renewable energy carriers, the production of biomethane/ biogas as a renewable fuel is not only aligned to one feedstock, but usually demands a substrate mix. Typically from two to five different feedstocks are used in biogas plants. A report on the current and future sustainable biomass supply for biomethane production has recently been published by the Biosurf Project[5].

In 2013, almost 10% (8 out of 79 million tonnes)[6] of the raw materials base for the chemical industries in the EU was based on renewables, with sugar and starch having the higher share (1.56 million tonnes), followed by plant oils (1.26 million tonnes), bioethanol ETBE (1 million tonnes), natural rubber (1.06 million tonnes), pure bioethanol (0.46 million tonnes), animal fats (0.43 million tonnes), glycerine (0.41 million tonnes) and several other smaller categories.

Since the 1950s microalgae have been grown commercially, to produce fish food, human food additives and pigments, in ponds or closed photo-bioreactors. It has been estimated that micro-algae could produce several times more oil than the oil palm, the most productive terrestrial plant. Most scientific literature suggests an oil production potential of between 25-30 ton ha^{-1} $year^{-1}$. However, a recent report suggests that large scale microalgal lipid production is not yet economical viable and the energy needed for microalgal biomass production for biodiesel can be six times of the energy produced in the microalgal biodiesel[7].

Most of the seaweed is harvested today, with an annual estimated 26 million tonnes (wet weight) in 2013. In the past 13 years the seaweed harvest has grown by 129%. The seaweed cultivation in Europe is still at small scale. The seaweed is used for alginate production, human consumption, fertilizers and in medical applications. For biofuel applications, high carbohydrate containing (brown) seaweed species are the most relevant as they can yield a biomass containing 10-15 tons carbohydrates per hectare.

Both micro-algae and macro-algae are considered as a potential feedstock for biofuel production in the overall biorefinery concept. Theoretical calculations show attractive potential for future algae-based biofuels, with high productivity per unit land area, but cost reduction and scale-up are critical challenges.

Key challenges for sustainable biomass supply towards 2020 and 2030 can be summarised as follows:

- **Mobilising agricultural, forestry and waste biomass through the development of sustainable supply chains and efficient technology transfer:** the issue of securing long term, sustainable and good quality feedstock remains one of the most challenging within the value chain both for energy and non-energy biobased sectors. Adding to this, the potential scale of future biorefineries and the fact that Europe has a rather diverse and fragmented biomass feedstock base dictates careful planning of both sustainable supply and logistics. The potentials in cultivating algae (micro- and macro-algae) for biomass production should also be more focused. For all types of algae, the core aim will be to achieve biorefinery technologies which enable algae to be grown for food, pharmaceuticals and biofuels at the same time.
- **Competition for resources and displacement effects:** Future research and implementation should place emphasis on the potentially negative environmental consequences of biomass supply and use (if produced and exploited in an unsustainable manner), and analyse carefully the environmental performance of biomass supply/use value chains (including algae) by means of Life Cycle Thinking and Assessment approach to avoid

[1] Sources: EuropaBio, Nova Institut, DG ENER

[2] See eg IEA Bioenergy Task 40 http://www.bioenergytrade.org/

[3] Nova-Institut 2011, FAO 2011, Kausmann et al 2008

[4] http://www.energies-renouvelables.org/observ-er/stat_baro/observ/biofuels_2011.pdf

[5] http://www.biosurf.eu/wordpress/wp-content/uploads/2015/07/BIOSURF-D4.2.pdf

[6] Sources: Cefic, VDI

[7] IEA Bioenergy Task 37 report: A perspective on algal biogas, published September, 2015

burden shifting and identify opportunities for further technological improvements.

- **Informing policy formation and updates at European, national, regional and local level:** resource efficient and sustainable biomass supply remains an important issue both for achieving the policy and respective targets across different sectors (energy, fuels, biomaterials, etc.) and governance levels in Europe but also for attracting new investments in biorefineries and the biobased economy. Current policies place focus on feedstocks that are already on the market leading to strong competition in terms of land, water and food/ feed. Mobilising the unused potential from residuals and waste streams alongside sustainable cropped biomass options requires thorough technical knowledge and long term policy steering to make the investments and changes in management possible.

Policy recommendations

Based on the abovementioned considerations, future policy and implementation strategies should strengthen complementarities and synergies among different sectors using arable land and/or biomass:

- Knowledge improvement to inform decision making
- Create a level playing field for biomass resources regardless to their end markets
- Improve biomass production and use within the Common Agricultural Policy
- Support for establishing cooperatives/ clusters to help mobilize potentials from small and fragmented land parcels
- Place focus on marginal land opportunities and steer biomass production systems
- Promote education and training to meet the future demands in upstream operations

Biofuels in the current and future Circular Economy

Bioenergy and biofuels will play an important and central role in the current and future Circular Economy (see Figure 3).

In the short-term bioenergy (fuels, power, heat) is expected to play an initiating role in the transition to a Bio(based) Economy by providing biomass mobilisation and certification expertise, facilities and infrastructure, and chain covering stakeholders that potentially can be used to kick-start biorefinery deployment, with the aim to use the available biomass potential in a sustainable way to co-produce both food/feed ingredients, biobased products (chemicals, materials) and energy (fuels, power, heat).

In the mid and longer-term bioenergy is expected to play a central role as part of efficient bio-cascading/biorefining approaches within the Bio(based) Economy by:

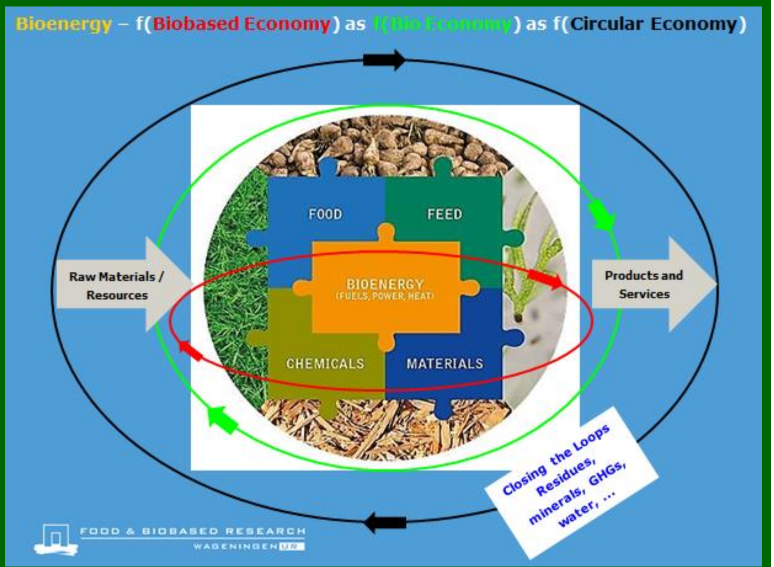


Figure 3: Bioenergy within the Circular Economy (Source: Wageningen UR, IEA Bioenergy Task 42).

- Providing sustainable biofuels – biofuels sustainably produced from non-food biomass sources – to sectors where they are the only alternative fuels to be used to reduce their GHG-emissions, i.e. aviation, shipping and heavy duty transport – **biofuel-driven biorefinery approach.**
- Valorisation of primary (agro), secondary (process) and tertiary (post-consumer) chain residues to both power/heat to be used to meet internal product-driven biorefinery-based process energy requirements or for external use, and to sustainable biofuels to meet (part of) the logistical energy requirements for biomass sourcing and product delivery purposes – **product-driven biorefinery approach.**
- Valorisation of biomass residues and non-food biomass sources to power/heat in high-efficient co-firing and stand-alone conversion facilities with upstream value-added products extraction and/or valorisation of process residues – **energy-driven biorefinery approach.**

R&D recommendations

Sustainable and reliable supply of feedstocks will be a critical success factor for the long-term perspective of biomass-based technologies on a large scale. This relates to efforts in improving productivity and resource efficiency in these sectors, in developing reliable supply chains that open up the feedstock potentials, certification issues, and prevention of excessive disturbances in agricultural and forest commodity markets. These challenges which are not specific to bioenergy use of biomass should be addressed in a coherent effort shared with the relevant stakeholders and initiatives.

A. Mobilising agricultural, forestry and waste biomass through the development of sustainable supply chains
   a. Sustainable feedstock production
      i. Cropping systems suitable to marginal, low quality, abandoned lands in Europe, including dry farming in water scarce conditions.
      ii. Ecological intensification of agriculture/ forest – matching feedstock production to the ecological and climatic zones, optimising and recycling nutrients and water, new pest and disease control techniques.
      iii. Multifunctional agro-forestry - combining agricultural and forestry best practices to create diverse, productive, profitable, healthy and sustainable land-use system.
      iv. Cost efficient algal biomass production on a larger scale. Optimisation of algal strains, that does not only refer to yield rates, but also to tolerance of contaminants, chemical composition, fouling etc.
   b. Harvesting; Collection; Storage- maintain a system perspective within the value chains
      i. Improve collection, sorting and handling of various waste streams.
      ii. Develop harvesting and collection systems (new equipment, new chains) to maximise supply by minimizing costs per unit.
      iii. Assessment of potential, collection, logistics, economics and environmental impact of crop residues, wood and wood-processing residues, and food-processing residues.
      iv. More efficient and automatized harvesting systems for micro- and macro-algae storage and stabilisation
      v. Develop feedstock quality and monitoring systems both for wet and for dry storage.
      vi. Increase the efficiency of logistics over longer distances in the future by developing and testing technology and supply chains.
      vii. Improve the process of collection hubs by assessing legal prerequisites, optimal technology and location for specific biorefinery cases.
      viii. Integrate biomass value chains with other value chains (e.g. integrated harvesting of residues and the main product(s), new alternatives for backhauling, multiple-use machines to alleviate seasonal fluctuations

B. Competition of resources and displacement effects (including land and water)
   a. Resource assessment/ forecasting
      i. Resource assessment "cross- sector" forecasts/ monitoring guidelines in relation to resource efficiency, cascading factors, competition for land use and implementation level (top down & bottom up)
      ii. Develop biomass cost- supply curves in relation to cascading factors, costs and life cycle analysis.
      iii. Integrating microalgae production with other renewable energy technologies.
      iv. Database and large datasets management
         1. Crop knowledge data base including yields, farming practices and agro-environmental impact (GHG emissions, water, biodiversity…)
         2. Feedstock quality data (physical and chemical) both for dry and wet biomass in relation to diverse end use options and post-harvest operations such as size reduction, densification, blending, etc.
      v. Locate the "hot spots" of biomass by matching supply to demand.

C. Informing policy formation and updates at European, national, regional and local level
   a. Value chain analysis
      i. Analysis and estimation of direct and indirect impacts over employment and economy at regional and national scale from specific value chains and the use/promotion of biofuels
      ii. Optimise supply tools taking into account various land use, resource efficiency, displacement effects, market interdependencies, etc.
      iii. Demonstration of a portfolio of value chains (subject to regional ecology and climate) with high potential for feedstock supply in relation to availability, infrastructure and supportive policy framework.
      iv. Supply and demand analysis and impacts for policy and financing mechanisms (local, regional level).
      v. Best practices, mobilisation, benchmarking

A good example is the S2BIOM project[1] which complements its strategies & roadmaps with bottom-up information deriving from a comprehensive set of case studies, which also enable the project partners to validate the toolset in a close-to-real-life environment. In East and South-East Europe, where biomass supply chains are less structured and data is scarce, case studies are addressing wider aspects, including policy perspectives & stakeholder engagement.

Finally, it will be necessary to optimise closed loop cycles and biorefinery concepts for the use of wastes and residues to develop advanced biomass conversion technology / systems and to identify synergies between the fuel generation and the fully established industries.

[1] http://www.s2biom.eu/en/

6. Conversion processes

Main recent evolutions

- Due to the availability of several potential feedstocks used for different biofuels, a number of processing technologies are available and needed.
- The new EU 2030 climate and energy package is not including any specific targets for decarbonisation of transport, as was the case with the 10 % share of Renewable Energy Sources (RES) in 2020
- In the "value chain dedicated tool box" of technologies for biomass conversion into biofuels, new tools have emerged
- Production of high quality drop-in renewable diesel produced from several vegetable oils, industrial wastes and residues, and forest industry by-products has greatly increased in some European countries. Its quality is such that it can be used up to 100% in current diesel engine technology.
- The NER300 funding for risk sharing of innovative flag ship projects has so far only materialized in 2 projects: BEST (Biochemtex) and Verbiostraw. Mechanisms to both stimulate the market up-take and to provide more secure revenue streams on a longer term are needed.
- Several industrial units for advanced biofuels have been built and started up in 2014-15 much more in America than in the EU, whose technology leadership on this topic is increasingly being challenged

R&D recommendations

- The key priorities for commercial biofuel technologies are to improve environmental (GHG, energy balance, water, inputs…) and economic performance and bring flexibility as integrated biorefinery.
- For advanced biofuels (not yet commercially deployed), the focus is on:
  - Verification of feedstock flexibility to process a wide range of sustainable feedstocks while ensuring an energy and carbon efficient process and the option to add higher value by-products.
  - Integration of biofuel production to existing industrial sides like in chemical, forest, food industry or in mineral oil refineries to reduce overall costs
- The target is biofuels which perform at least as well as, but preferably better than existing ones.
- Conversion technologies targeting fuels for heavy duty road, air, and marine transport deserve priority attention because of lack of alternatives and their increasing demand.
- For the previously mentioned three applications it should be noted that the quality requirement vary considerably, i.e. the aviation fuel quality is much more stringent
- For certain existing processes simple tuning allows producing biojet or marine biofuels in co-production with paraffinic diesel. First flight tests at commercial scale are ongoing.
- Value chains as identified by the European Bioenergy Initiative leveraging on industrial synergies with existing facilities deserve priority attention.
- There is growing interest to electrofuels, also integrated into biofuels production (power-to-gas and power-to-liquids) boosted by low price renewable electricity. There are first pilot units in operation.

Main recent evolutions

The key objectives for biofuel conversion technologies were already highlighted in the 2008 SRA/SDD: Developing energy and carbon efficient biomass-to-fuel processes aiming at decarbonisation of transport sector which are flexible with regard to feedstocks and which result in high-quality, sustainable end products.

Biofuels such as ethanol from sugar or starch, or fatty acid methyl ester and HVO from vegetable oils, have been produced on an industrial level for years and can, with some confidence, be called "conventional" biofuels. Hydro-treatment capacity of vegetable and other oils has increased rapidly during the last years, as well as the new capacity of cellulosic ethanol, an advanced technology, although so far in smaller volumes. However, there remain challenges related to the sustainability of some of the feedstocks as described in the "iLUC directive". The new iLUC directive (amending RED and FQD directives) approved by the Council on 13 July 2015 limits traditional food chain based biofuels (mainly ethanol and FAME) to 7 % and sets a voluntary target of advanced biofuels to 0.5 % by 2020 in Europe. The new EU 2030 climate and energy package is not including any specific targets for decarbonisation of transport, as was the case with the 10 % share of RES in 2020. To be able to contribute sufficiently to the EU 2030 biofuel targets, more sustainable large scale production capacity is needed. Therefore second generation, or advanced biofuel technologies needs to be further developed and demonstrated in several dedicated value chains in various part of Europe. The advanced alternatives are expected to offer increased GHG reduction, enlarged biomass feedstock base, higher efficiency utilisation of current feedstocks, and minimized overall costs. In order to cope with the RED GHG reduction level, conversion processes should aim for GHG reduction of more than 60% compared to fossil reference in EU directives.

It is not possible to identify overall "best" technology. This is because of several feedstocks requiring specific conversions; targeted products have different values, and often biofuel production call for case specific integration to already existing industries. There is a large number of different feedstocks available for the production of biofuels. This calls for innovative technical approaches, although one of the remaining key requirements for biofuel technologies is their ability to use several feeds. There are several conversion routes to produce current and advanced biofuels as biofuel components or drop-in biofuels blended in traditional fossil transportation fuels. In the "value chain dedicated tool box" of technologies for biomass conversion into biofuels, new tools (previously developed for other applications in the pharmaceutical, chemical, energy and forest industries) have emerged such as synthetic biology[1], new catalytic processes, high-pressure conversion, and fast pyrolysis targeting refinery integration. They target biofuels with either lower production cost or improved technical properties (for instance aiming Biojet).

Since the publication of the 2008 SRA/SDD, a number of different advanced technologies (e.g. cellulosic ethanol and HVO based on tall oil or other industrial by-products) have been scaled-up to pilot or demonstration level during the recent past in Europe and other places. The EU's technology leadership in this area is increasingly being challenged much more plants have been built in America. More than the technology leadership itself, the issue at stake is the development of that technology in Europe. European companies are investing in USA because of its regulatory stability and the existence of financial incentives. However, for example due to the large industrial scale required from these systems, only a few have reached industrial demonstration so far. The NER300 funding for risk sharing of innovative flag ship projects has so far only materialized in two projects: BEST (cellulosic ethanol, Biochemtex Italy) and Verbiostraw (biomethane, Germany). Long term (> 10 years) relevant incentives are necessary for introduction of biofuels into the market. Such incentives should target the early stage market introduction of technologies (TRL7, TRL8[2]). However, biofuels cannot compete head to head with cost of fossil fuels even if the cost of the latter increases significantly from the low level in 2015. Thus, to have an impact of by a more widespread deployment (i.e. to go from TRL8 to TRL9[3]) of biofuels production, it also requires mechanisms to both stimulate the market up-take and to provide more secure revenue streams on a longer term. One important opportunity to reduce the cost of advanced biofuels is to integrate production to existing industries in food, forest, oil and energy industries. It is natural for example to integrate biomass conversion to industries, where biomass residues are available. Examples of such industries are power, forest, food, and pulp and paper industries. Similarly it can be

[1] Synthetic biology: rational design of the metabolism of a micro organism to produce a desired molecule using modern biotechnology tools.

[2] Demonstration plants are considered the last non-economic step to demonstrate the performance and technical reliability of a complete conversion concept in a value chain so that the the first-of-a-kind, commercial-scale industrial unit can be designed with sufficient confidence for the investment (TRL 6-7).

Flagship plants are the first-of-a-kind, commercial-scale industrial demonstration units aiming at validating operational sustainability and financial viability of a complete conversion concept defined by one of the value chains (TRL 8).

[3] Actual system proven in operational environment (TRL 9)

advantageous to integrate final fuel production to mineral oil or bio-refineries, where for example final upgrading may be carried out at large scale. In such cases drop-in biofuels may be produced in a cost efficient way and very low carbon and environmental conversion foot print.

R&D recommendations

Research and improvements in the value chains up to the 7 % level on conventional biofuels will primarily aim to strengthen their sustainability with regard to both economic and environmental performance. Environmental issues to be taken into consideration include GHG emissions, energy balances, water balance and management as well as material inputs. Research priorities for advanced biofuels will be focused on the concept and process development in specific value chains and proceeding from innovative laboratory pilots to industrial demonstration, and commercialisation. Currently there are less than 10 industrial plants in operation in Europe, if in 2030 e.q. 5 % share of advanced biofuels are needed on the EU market, more than 150-200 new plants should be built. Solutions need to be found in several dedicated value chains in various parts of European regions for cost-effectively processing a wide range of sustainable feedstocks while ensuring energy and carbon efficiency as well as selectivity towards higher-value products. Conversion technologies to distillates (diesel+jet) deserve priority attention because of increasing demand especially from heavy duty road transport as well as air and marine transportation. Oxygenates such as methanol and DME can play an important role in this segment.

Value chains which make use of synergies with existing raw materials logistics and industrial facilities offer the best economic and industrial framework to manage the high risk/high cost of deploying promising new technologies, and can thus help the transition from conventional to advanced biofuels. Such value chains deserve priority attention. For example, investing into high-quality drop-in renewable diesel allows synergies for biojet fuel production in a twofold way. Drop-in renewable diesel itself is currently undergoing certification as a sustainable jet fuel component in moderate blend percentages and the production process of renewable jet fuel is very similar to that of renewable diesel, and both products can be co-produced.

Advanced biofuels have been shown to perform in various vehicle fleets at least as well as, but often better than, existing ones from an overall tail pipe emission and sustainability point of view. A preferred route is that the advanced biofuels are fully compatible with conventional options, to allow for different blend ratios without a need for drastic changes to existing infrastructure. The concept of "drop-in fuels" has been demonstrated in cases where fuels corresponding to global standards are crucial, e.g. in aviation. For some applications new type of fuels can be more cost and energy efficient and also an overall more attractive alternative. Examples can be methanol as marine fuel and pure ethanol in dedicated bus fleets.

In the case of overproduction in energy systems with a high share of renewable generation renewable electricity with a very low carbon footprint can be seen as a valuable co-feed[1] in many biofuel production processes. Technologies that enable the utilization of electricity are in the early commercialisation phase (e.g. electrolysis) or in the research and development phase (e.g. plasma-assisted conversion, electro-catalytic conversion). Electricity can generate hydrogen through electrolysis which together with a carbon source (e.g. CO2) can be reacted to methane or liquids. The production price is dominantly depending of a continued low/negative price of electricity. Yet another way to make use of cheap power is to let the hydrogen produced from electrolysis be bled into synthesis gas from a biomass gasification plants. For several conversion routes energy in the hydrogen becomes product energy with an efficiency of about 90%. Fuel generation increases between 50 and 100% due to that the green carbon in the feedstock becomes carbon in the product instead of being vented.

[1] Renewable fuels can also be based on electricity only as the energy containing feedstock and are then called electrofuels. This process chain is based on electrolysis (production of hydrogen) and a subsequent chemical/biological synthesis to produce a gaseous (e.g. Synthetic Natural Gas) or liquid fuel (e.g. methanol, Fischer-Tropsch-Diesel).

7. Product distribution and use

Recent evolutions

General

- The growth in the use of biofuels has stagnated, biofuels use peaked in 2012 (Biofuels Barometer 2015)
- Currently electric vehicles seem to be more attractive than biofuels to politicians and decision makers (limit on 1st generation biofuels, increased calculation factors for electricity in transport, appraisal of CO2 emissions)
- The new Directive 2014/94/EU on the deployment of alternative fuels infrastructure very much focuses on electricity and gaseous fuels, with less focus on liquid biofuels
- The Directive doesn't really differentiate between fossil and renewable energy

Road vehicles

- Fuels standards:
- Process to increase ethanol content in petrol and FAME concentration in diesel under way
- EN standards for E85 and paraffinic diesel to be expected soon
- ISO and ASTM standards for DME as a diesel fuel are approved
- Impacts of new emission regulations:
- The new emission regulations (Euro 6 for passenger cars and Euro VI for heavy-duty vehicles) pose some challenges to the use of alternative fuels (e.g. low-temperature performance of FFVs, methane emissions of gas engines)

Marine

- The new IMO sulphur oxide limits in emission control areas (Baltic Sea, North Sea) will require low-sulphur fuels (0.10 % m/m as of 1.1.2015) or alternatively the use of exhaust scrubbers

Aviation

- Sustainable biofuels are a critical building block of the aviation industry's climate strategy, contrary to the automotive sector aviation will totally depend on liquid hydrocarbon fuels for the next decades

New fuels on the agenda

- Increased interest in methanol as a fuel, mainly in the marine sector and in captive fleets
- DME research and development projects are still going on, significant interest in electrofuels (power-to-gas, power-to-liquids)

R&D recommendations

- Deepen the understanding of fuel, engine and exhaust interactions through modelling and experimental work, e.g., models for combustion and emission formation, fuel oxidation stability, physical properties (e.g. viscosity in extreme conditions), lubricity, material compatibility, performance of multicomponent blends etc.
- Engine performance optimization for high quality biofuels making use of fuel detection
- Make high quality advanced biofuels attractive to vehicle manufacturers by demonstrating emission and/or engine efficiency benefits, increase cooperation with ERTRAC
- Demonstrate the cost effectiveness of biofuels for GHG emission reductions in in various sectors of transport (road, marine, aviation) to keep biofuels on the EU 2030 climate and energy agenda
- Work to ensure that high concentration biofuels are taken into account in the national implementation plans on Directive 2014/94/EU
- Work to ensure a fair appreciation of CO_2 emissions of vehicles running on biofuels (well-to-wheel approach, electric vehicles and vehicles running on renewable fuel should be treated using equal criteria)
- Further work on fuel standardisation and harmonised practises throughout Europe
- Understanding of "best fit" of alternative energies in the various sectors of transport, biofuels, electricity, synergies and disparities in fuels for different sectors

Recent evolutions

EBTP's Strategic Research Agenda was first published in 2008, and then updated in 2010. The 2010 update states, among other things:

- *"Biofuel share of the EU market for road transport fuel is rising, with increasing appetite for distillates to serve markets for transport fuels (road, aviation, marine)"*
- *"Requirements concerning fuel distribution systems and end use vehicles have remained stable over the past years and thus have not changed since the 2008 SRA/SDD was published"*

The 2010 update, relying heavily on Directive 2009/28/EC (RED) was written at a time when the use of biofuels was growing rapidly. Obviously, things have changed since 2010. Biofuels use in Europe peaked in 2012 (Biofuels Barometer 2015[1]). Within the End-Use sector the rising interest in and offering of electric vehicles in combination with the debate on biofuel sustainability have affected the attractiveness of biofuels. The "iLUC Directive" resulted in limitations on 1st generation biofuels, but also in increased calculation factors for renewable electricity in transport (now factor of 5 for road vehicles and 2.5 for trains) when fulfilling the 2020 renewable energy target for transport.

Now advanced biofuels have to defend their position as one of the elements in decarbonizing transport for 2030 and beyond. When economy picks up again in Europe, transport volumes can be predicted to increase. Electric vehicles are entering the market, but their share in the vehicle fleet and their contribution to GHG emission reductions in 2030 will still be rather limited. Therefore it is obvious that there will be a huge need for sustainable biofuels in all sectors of transport. Natural gas in transport can only deliver limited GHG benefits, especially when all methane leaks are accounted for.

Directive 2009/28/EC includes a provision for double counting of certain biofuels, meaning that they are calculated with a factor of two into the share of renewable energy. However, if the target is to reduce GHG emissions, only "actual", not "calculatory" tons of biofuels contribute to emission reductions. Calculations should be carried out how much biofuels will be needed in Europe in 2030 to achieve a 30% GHG emission reduction from transport, in addition to improvements in energy efficiency, electric vehicles, modal shift and so on, and what is the cost effectiveness of various approaches for emission reductions.

In 2013, the Commission launched its European alternative fuels strategy. The Communication[2] sets out a comprehensive alternative fuels strategy and the road to its implementation covering all modes of transport. It aims at establishing a long-term policy framework to guide technological development and investments in the deployment of these fuels and give confidence to consumers. The strategy states, among other things:

- *"For certain modes of transport, in particular long-distance road freight and aviation, limited alternatives are available. There is no single fuel solution for the future of mobility and all main alternative fuel options must be pursued, with a focus on the needs of each transport mode. A strategic approach for the Union to meet the long-term needs of all transport modes must therefore build on a comprehensive mix of alternative fuels. All options need to be included in the strategy without giving preference to any particular fuel, thereby keeping technology neutrality. "*

Figure 4 shows the hierarchy of fuels. Advanced biofuels are the only renewable alternative for aviation, whereas electrification is best suited for light-duty and urban vehicles. The current focus on electric vehicles might lead to a shift away from biofuel use in light road vehicles, which would make biomass available for use in aviation and other sectors dependent on liquid drop-in fuels. This should be considered in a holistic transport energy policy. Aviation fuels are highly constrained by some very critical properties such as energy content, cold flow properties and oxidation stability. Thus, the only possibilities are drop-in -type, oxygen-free fuels. These fuels have to comply with a very strict certification procedure before being authorized in any commercial flight. Some pathways are already certified: hydrotreated vegetable oils (with a blending ratio up to 50%), BtL (up to 50%), SIP (the Total / Amyris pathway, up to 10%, AtJ (Alcohol to Jet, based on the oligomerization of dehydrated isobutanol, up to 30%)). Other pathways are currently in the process of development and certification. Harmonisation of standards should not be limited to Europe, but should occur globally for international transport applications such as aviation.

The full potential of biofuels may be obtained through a thorough optimization of the engine / fuel combination. The development of new fuels may bring additional potential in terms of engine optimization but also pollutant emission reduction. As a consequence, further R&D is needed in order to fully understand the impact of fuel chemical composition, including contaminants, on the behaviour of each part of the total system (fuel line, injection, combustion, pollutant formation, after-treatment systems…). This understanding is especially critical for aviation, where a stringent certification procedure is in place, requiring a perfect understanding of fuel / system interaction in order to be able to quickly certify new drop-in type advanced biofuels.

[1] http://www.eurobserv-er.org/biofuels-barometer-2015/

[2] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52013PC0017&from=EN

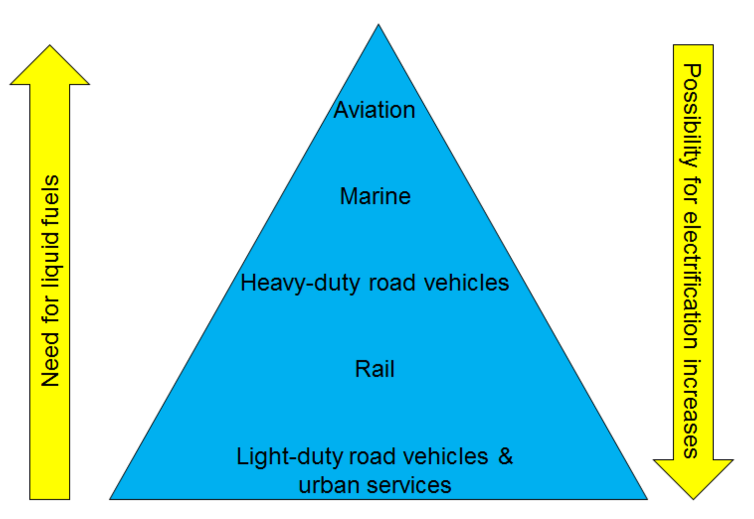


Figure 4: Hierarchy of fuels. (Source: Ministry of Transport and Communications, Finland 2013[1]) "Possibility for electrification" should be understood as "possibility for electrification of the propulsion system".

As a follow-up to the alternative fuels strategy, the Directive 2014/94/EU on the deployment of alternative fuels infrastructure. The Directive is, in principle, technology neutral, but notwithstanding has a focus on gaseous fuels and charging facilities for electric vehicles. EU member states are obliged to create national implementation plans. In this process the member states, should be alert to keep infrastructure for high concentration biofuels, when relevant.

DG ENER, Clima and MOVE have formed a working group named Sustainable Transport Forum which had its first meeting in June 2015. The group is meant to support the Commission in the implementation of the Directive. A subgroup on biofuels was initiated at the meeting.

The newest emission regulations pose some challenges to the use of alternative fuels. The Euro 6 regulation for passenger cars requires certification of flexible fuel vehicles (FFVs) at -7°C, resulting in fewer vehicle types on the market.

Testing has shown that new heavy-duty Euro VI vehicles are extremely clean, diminishing the fuel effects (e.g. conventional diesel vs. paraffinic diesel and methane) on regulated emissions. In addition, the Euro VI regulations require the vehicles to be certified on the fuel which they are going to use. Some engines have already been certified for 100 % FAME or 100 % HVO. In e.g., Sweden and Finland, there is a demand for 100 % biofuels in captive fleets such as buses.

Diesel dual fuel (DDF) engines (diesel and methane in parallel) using simple intake manifold injection of gas cannot meet the Euro VI regulation due to excessive methane emissions. New engines using direct injection of gas (high pressure direct injection HPDI) are under development. DDF engines are needed because spark-ignited gas engines cannot cater for the power and efficiency needs of the heaviest truck segment.

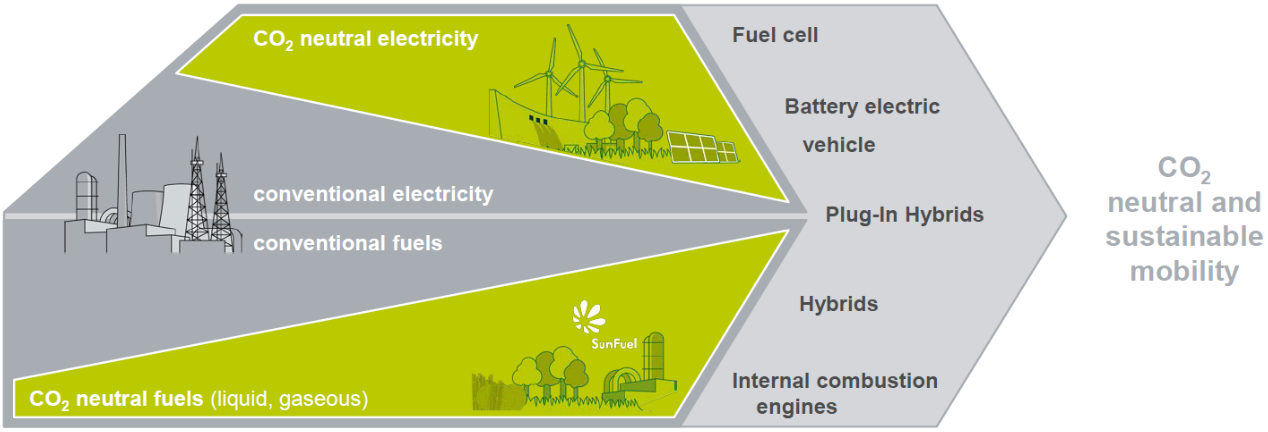
One of the reasons why heavy-duty Euro VI diesel engines perform so well is that real driving emission (RDE) testing is required, meaning that the emission limit values have to be met independent on how the vehicle is driven. RDE testing will be implemented on passenger cars only at a later stage, and the lack of RDE requirements have resulted in some issues especially regarding NO_x emission from diesel passenger cars. The use of 100 % biofuels in diesel passenger cars might increase NO_x emissions, and this is an issue that has to be tackled.

As for heavy-duty vehicles, the next step in exhaust emission regulations will most probably focus on limiting CO_2 emissions, not tightening the limits for regulated emissions.

Currently the appreciation of vehicle carbon dioxide (CO_2) emissions is currently based on tailpipe emissions only. Battery electric vehicles are calculated as zero emission vehicles into the manufacturer's average CO_2 value, which regulated. Still in 2015, low emitting vehicles (below 50 g CO_2/km) receive so-called super credits. Vehicles running on renewable fuels get little or no benefits compared to electric vehicles, making it more attractive for the vehicle manufacturers to produce electric vehicles instead of, e.g., flexible fuel ethanol vehicles. Vehicles running on renewable fuels and electricity should be treated on an equal basis, and this could be achieved using, e.g., a well-to-wheel approach to CO_2 emissions.

It is important to realise that there should not be an adversarial set-up between electricity and biofuels or biofuels or any other energy carrier. The important thing is the need to increase the share of renewable energy in all energy carriers. Figure 5 shows Volkswagen's powertrain and fuel strategy. It is also good to keep in mind that electricity is not an option for long-haul truck, ships or airplanes (Figure 4), so there will always be certain modes of transport calling for low-carbon liquid fuels.

[1] https://www.lvm.fi/docs/fi/2497123_DLFE-19513.pdf (In Finnish with English abstract)



- Coexistence of conventional powertrains and electrified mobility
- Decarbonisation of the energy carrier and higher powertrain efficiency
- A portfolio of various drivetrains will fulfil the customer expectations

Figure 5: Volkswagen's powertrain and fuels strategies - coexistence of propulsion systems. (S. Schmerbeck 2014)

Some new fuel options have appeared on the agenda, and some well know alternatives receive renewed interest. Methanol receives interest as a fuel for captive fleets and especially as a marine fuel. Methanol can offer an energy efficient biomass-to-liquids route. The first step could be to use natural gas based methanol, which is one of the largest bulk chemicals. So-called GEM (gasoline-ethanol-methanol) fuels delivering constant heat value have also been discussed. DME research and development projects are going on in Japan, Sweden and the U.S., but market introduction is not set yet. Electrofuels combining electricity and CO_2 to produce fuels (power-to-gas, power-to-liquids) have reached the demonstration stage.

Currently "advanced" or "second/third generation" biofuels refers to the feedstock and sustainability of biofuels. End-use performance also should be included in the criteria for advanced biofuels. This is accentuated especially in the aviation sector, in which only high quality, drop-in type pure hydrocarbon fuels can be used. From an end-use point of view, drop-in fuels would also be the preferred option in road vehicles. However, for reasons of cost effectiveness, there is also a need to incorporate higher amounts of "conventional" biocomponents into traditional fuels, especially ethanol in petrol.

Clean burning, high octane or high cetane biofuels can, in addition to delivering reduced GHG emissions, also deliver lower regulated emissions for older vehicles and energy efficiency improvements in new engines. The auto manufacturers should be made aware of the possibility to enhance performance using the best of biofuels. In Finland, two companies are currently selling HVO containing diesel fuel as premium quality fuel.

It is evident that the share of plug-in vehicles will increase over time. In some operational cases these vehicles will use very little fuel. For such cases fuel stability will become increasingly important. Some of the chemical reactions and interactions between fuel components leading to fuel degradation are not fully understood.

European fuels standards are constantly updated. A final EN standard for paraffinic diesel (covering hydrotreated vegetable oil as well as Fischer-Tropsch renewable diesel from solid biomass) is to be expected soon, as well as a standard for high concentration ethanol E85. In addition, discussions to increase the ethanol content of petrol and the FAME biodiesel content of diesel fuels for captive fleets are under way. With increasingly stringent requirements for low emissions and emission stability over time, maintaining high fuel quality and low levels of contaminants becomes increasingly important. ISO and ASTM standards for DME as a diesel fuel have been approved, thus eliminating one of the obstacles for the implementation of DME.

8. Deployment and recommendations

The preparation of this revision of the EBTP Strategic Research and Innovation Agenda has shown that EBTP's long-term vision is still valid, confirming the important role of biofuels for the sustainable transport sector in the EU and one of the most cost effective ways to decarbonize transport.

The biofuels sector has struggled with an unclear political framework within the recent years, and currently different biofuels pathways are at various stages of maturity. For many advanced and innovative technologies, the most pressing issue is to demonstrate the technology at the appropriate scale – pilot plants, pre-commercial demonstration or full industrial scale. For a full industrial scale two main issues remain, the feedstock base needs to be broadened and delivered fuel qualities has to meet all expectations of the automotive industry. The European Industrial Bioenergy Initiative (EIBI) estimates that up to 30 such plants will be needed across Europe for the most promising technologies to take full account of differing geographical and climatic conditions and logistical constraints. Many plants, using biochemical or thermochemical conversion technologies, are in the pipeline around Europe. Technologies for the conversion of biomass are evolving rapidly, and their deployment on commercial scale is crucial for triggering a sustainable advanced biofuels industry that would bring substantial environmental and socio-economic gains. Notwithstanding the many (potential) benefits, the implementation of commercial scale projects is slowed down by factors that are not only directly connected with the global crisis or national economic trends. At the same time when technological barriers are removed or significantly mitigated, new obstacles are jeopardizing the deployment of advanced biofuels industries. The main weaknesses are a frail biomass market where value chains needs to be strengthened in the context of a growing competition between different end-uses and resulting variability of prices as well as an uncertain political framework, with a lack of coherent strategies and action plans on European and national level. Both factors are deterring investors, so that the whole sector is facing a go-slow. Investment in biofuels projects, including serving debt over 10-12 years from start of production is not possible without guarantees of regulatory stability. Appropriate legislation is key to reduce these non-technological barriers, but also soft measures in the financial sector and coordinated actions.

It is difficult to point out the perfect strategy for the biofuels deployment but it is important to highlight that technology development and integration with existing industries will not be enough; it will need to be coupled to research and development regarding markets, business models, novel value chain cooperation, policy instruments etc. The development of technology and market needs to go hand in hand. This could be addressed both by forms (supporting and collaboration actions) and focus/content in R&D projects (cross-disciplinary research projects as well as "conventional" research projects). On a long-term view, all topics described in previous chapters like biomass availability, conversion process, end users and the markets and regulations need to be taken into a holistic approach.

Figure 6 illustrates the idea of the future biofuels deployment. At the current stage commercial biofuels technologies (1st generation) are existent and first units of advanced biofuels (2nd generation) technologies are being built. The conversion towards advanced biofuels needs to connect to the current biofuels industry and its ambition to improve the economic and environmental performance from existing plants and technologies. In parallel existing and new players will be involved in the introduction of advanced biofuels to the market.

Advanced biofuels technologies have just started to enter the market and are thus at their beginning of the learning curve. These new technologies need to explore the potential of feedstock flexibility, possible co-productions and possibility to combine process schemes with the emerging biochemical industry into so called bioeconomy. This lengthy process will be dependent on long term incentives and political frameworks. The goal is that society develops general scenarios where emission of fossil carbon comes with a cost and thus helps to even out the difference between carbon neutral fuels and their fossil counterpart. Long term introduction of advanced biofuels will also be dependent on other costs, such as investments in new vehicles or alternative logistic systems. In the long term there will be considerable cost reductions associated with the fuel production due to things like advancement in technology, economy-of-scale effect, development of more advanced primary energy production etc. Figure 6 indicates that the gap between production cost of fossil and renewable fuels over time will decrease but it is of course not possible to foresee when and to which extent this will develop.

Long term incentives bridging the gap illustrated in Figure 6 need to be revisited on a regular basis and the incentives need to be adapted to the commercialisation process of the advanced biofuels but also to reflect the factual reality of the GHG issue.

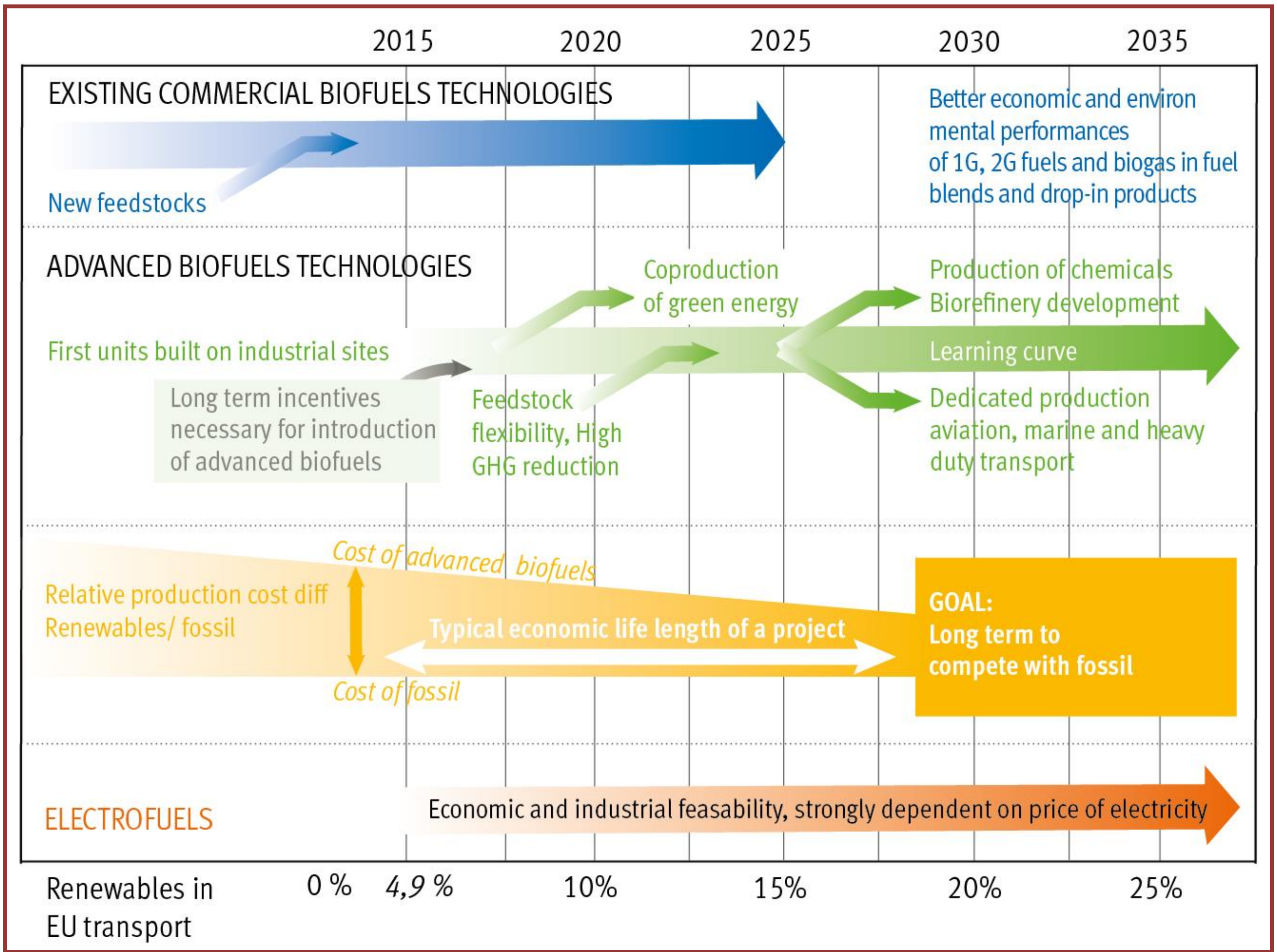
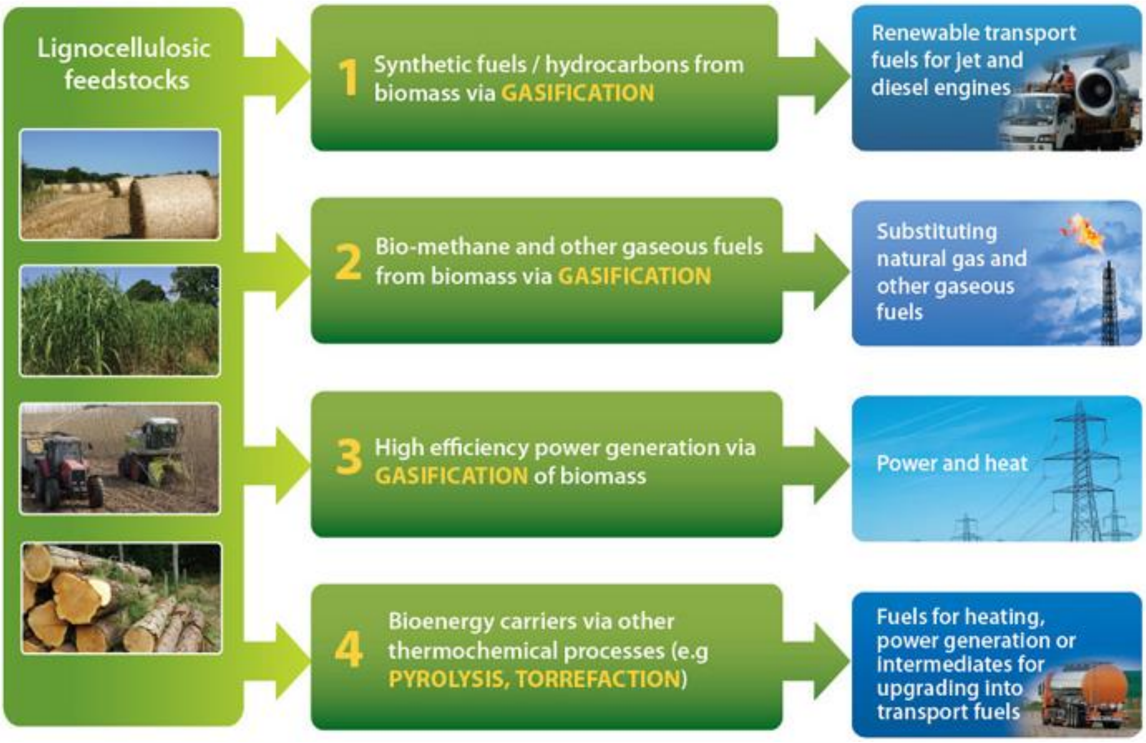
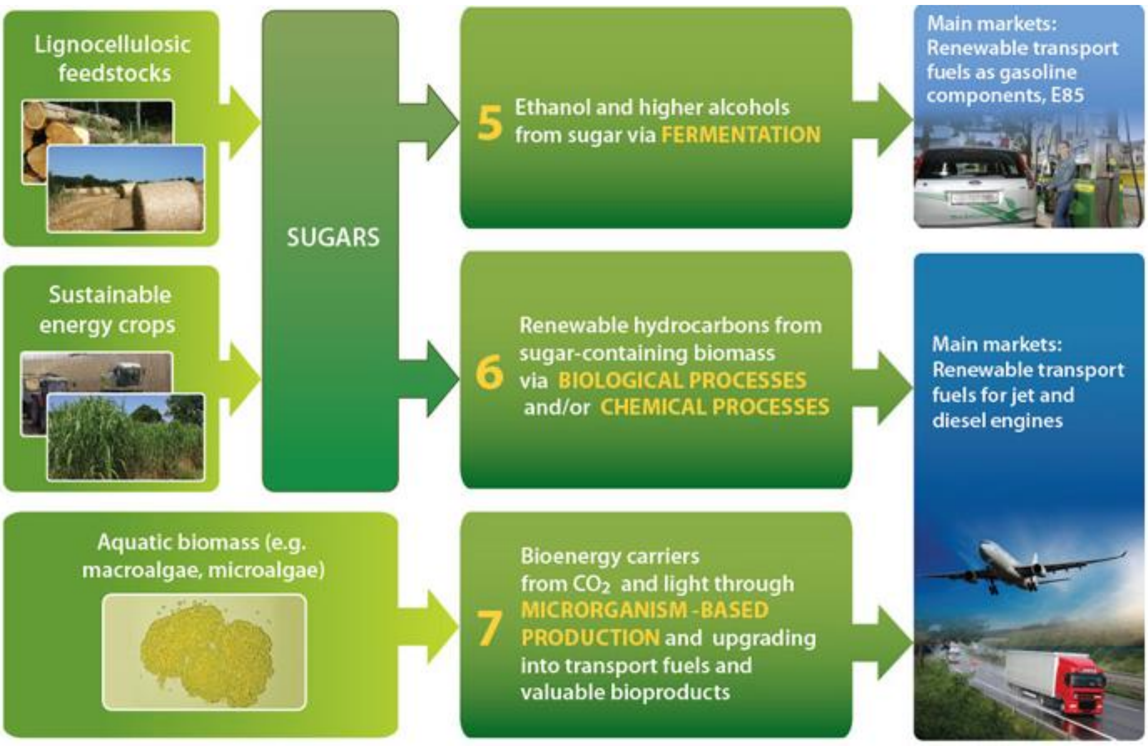


Figure 6: Biofuels deployment

Annex 1: EIBI Thermochemical Value Chains[1]



Annex 2: EIBI Biochemical Value Chains[1]



[1] http://www.biofuelstp.eu/eibi.html