EU Biofuels R&D: focus points for technological improvement

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European Commission

Outline

- Work conducted within European Commission in-house 'Low Carbon Energy Observatory'
- Advanced biofuels definition, legislative support in the EU
- Overview of pathways
- Results of research
  - Challenges and 'next steps' per technology
- Slide on funding details per technology

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Low Carbon Energy Observatory

- In-house Commission project by JRC for DG-RTD, in the context of the SET-Plan.
- Runs 2015 to 2020
- Provides world-class data, analysis and intelligence on developments in low carbon energy technologies

LCEO Technologies

- Wind Energy
- Photovoltaics
- Solar Thermal Electricity
- Solar Thermal Heating and Cooling
- Ocean Energy
- Geothermal Energy
- Hydropower
- Biomass for Heat and Power
- Carbon Capture, Utilisation and Storage
- Unconventional Fossil Fuels
- Sustainable advanced biofuels
- Hydrogen and Fuel Cells
- Advanced Alternative Fuels

+ related future emerging technologies

LCEO Approach

- **Where we are**
  - Technology state-of-the-art
  - Industry and market situation
- **How we got here**
  - EU Projects; H2020 and SET-Plan flagship projects
  - International R&D
- **Future directions**
  - Enablers and barriers
  - Technology cost and development outlook
  - Energy system scenarios

Advanced biofuels; definition

- Advanced biofuels **definition** varies, as advanced can refer to various attributes of value chain
- We consider advanced, technologies capable of converting:
  - lignocellulosic feedstocks (i.e. agricultural and forestry residues)
  - non-food and non-feed biomass (i.e. grasses, miscanthus, algae) and
  - biogenic waste and residues (e.g. biogenic fraction of municipal solid waste and animal manure)
- ..into transportation fuels with high GHG emissions savings, and no or low indirect land use change (ILUC) impact

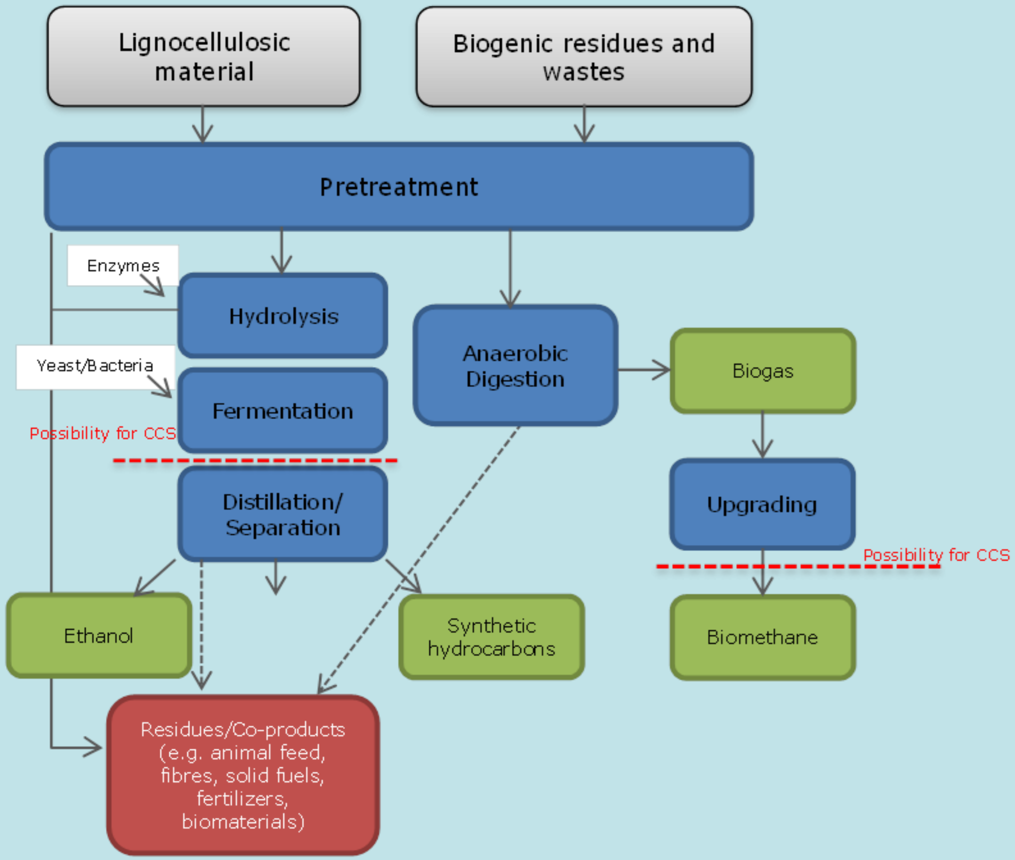
Advanced biofuels; sub-categories

- Advanced biofuels technologies were classified into three main categories namely:
  - *Biochemical*
  - *Thermochemical or*
  - *Oleochemical production routes*
- Each technology includes a number of sub-technologies that were analysed
- Significant changes to the previous (2016) version of this work include new sections looking at advances in fatty acid methyl ester (FAME) and hydro-treated vegetable oil pathways, these are increasingly expanding their use of waste and residual feedstocks

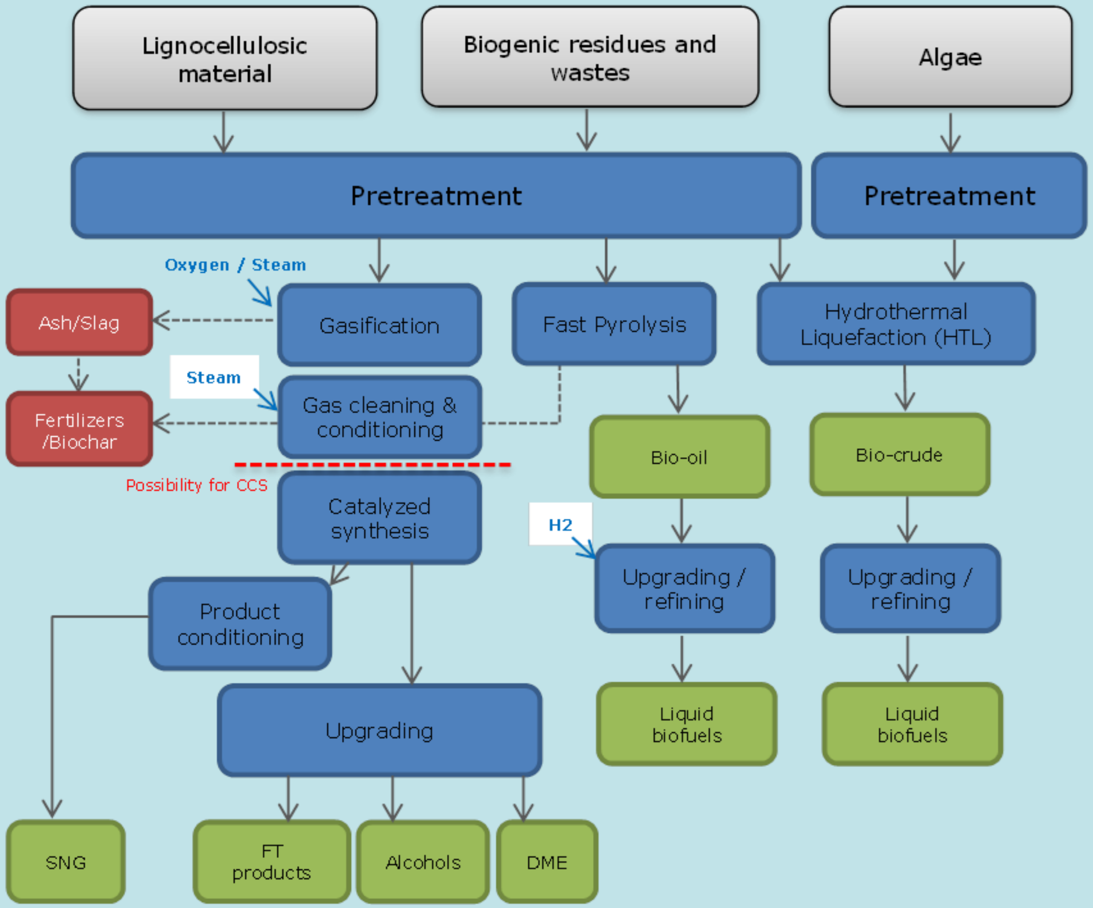
Advanced biofuels; legislative support

- Latest work updates a 2016 study
- Since 2016, new draft Renewable Energy Directive (RED) has been agreed upon, shortly to be adopted
- RED2 contains a 14% target for ren. energy in transport
- New advanced biofuels sub-target of 3.5%
- Advanced biofuels count double towards target, biofuels in Annex IX, Part B will be counted only up to 1.7%
- Production of conventional biofuels must not go beyond the 7% level
- *More focus coming on advanced biofuels*

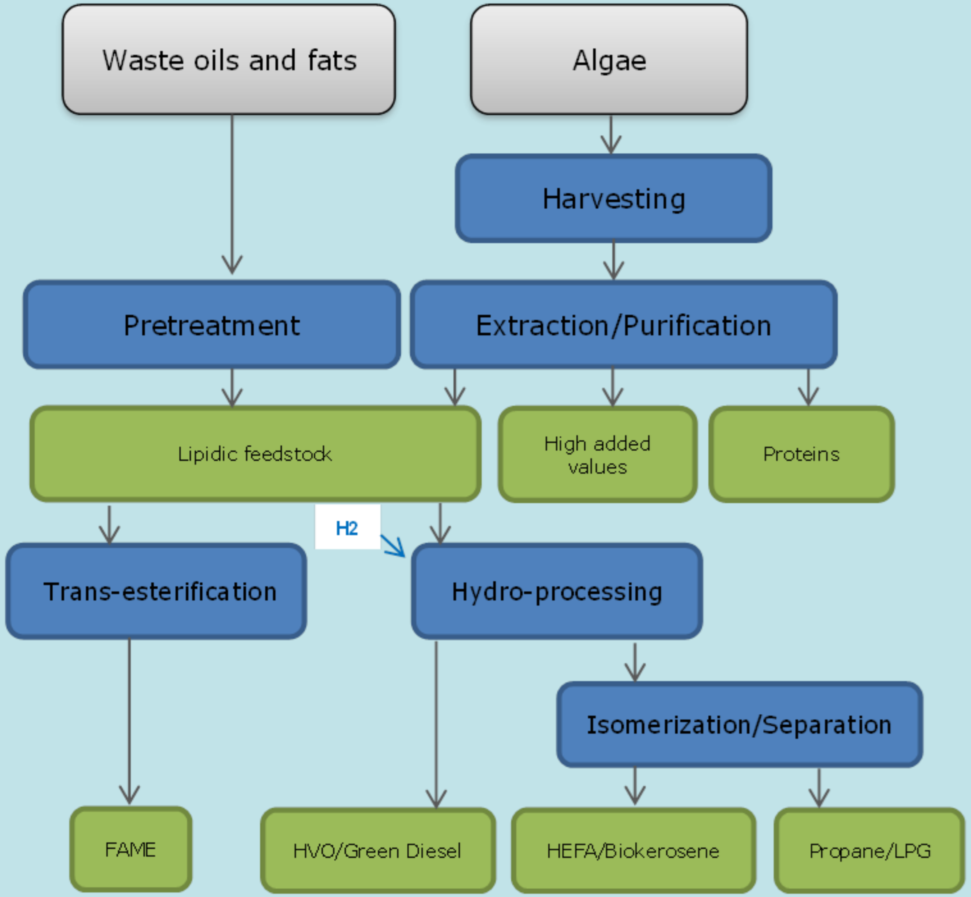
Bio-chemical technologies



Thermo-chemical technologies



Oleo-chemical technologies



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Results of research

- Overview considering the main challenges per technology
- Likely ‘next steps’ per technology

Fermentation; challenges and next steps

- A lot of H2020 fermentation projects, aim at **proving robustness** of the entire cellulosic ethanol production chain; interesting to see results and progress of these key projects
  - Even if steady and reliable production is not achieved, it will be important to understand any remaining weak-points and to focus further research efforts on these
- Basic developmental needs and future trends broadly remain the same as in 2016’s report
  - Further **optimising the performance** of new processes and saccharification/fermentation yields, and improving economic and environmental performance (& reduce costs) remain critical
  - Focus has been on ethanol production, but we see large investigations taking place on **butanol**
- **Increased scale** of projects over time (also outside EU) suggests technological progress from intensive R&D. However, better details on cellulosic ethanol production costs may still be higher than recent estimates indicate, both because of high enzyme costs, or high feedstock costs
- Further R&D showing reasonable economics and/or **systems running reliably for prolonged periods**, with detailed verifiable results will be highly beneficial to all parties; it is understood results can be commercially sensitive, but without such clarity, the risk is that future investments in R&D are not targeted as efficiently as possible

Anaerobic digestion; challenges and next steps

- European AD sector is oriented to **improve digestion of lignocellulosic feedstocks** (mainly ag. residues such as straws) and other complex waste streams (e.g. wastewater sludges), to tackle issues of feedstock availability and sustainability. Technological improvements needed to show the possibility to economically use such feedstocks
- Improving **digestate valorisation** also emerging as a target for the sector. Recovering nutrients, by producing market-ready products instead of spreading digestate on fields. Other projects place AD plants in biorefineries
- Biogas **upgrading to biomethane** is the goal of much new investment in AD, current separation technologies still have to prove competitiveness.
- The lack of public awareness, about potential benefits of AD, is still limiting the technical efforts ongoing in scaling down the technologies; interesting possibilities to enlarge feedstock choices, by improving the recovery of waste streams at urban and peri-urban levels, appear not fully exploited.
- Several projects are promoting actions to fill the gap but a constant effort is needed to obtain positive support to valuable initiatives

BtL and SNG; challenges and next steps

- For the time being, **no large-scale** gasification plants producing BtL biofuels in operation. A number of opportunities for improving gasification, syngas cleaning and FT synthesis identified in IRENA 2016 to decrease production costs (up to 15% of current costs) and result in process efficiency gains.
- Possible future improvements on which R&D activities may concentrate efforts include:
  - Optimization of the process at **smaller scales**, developing new concepts suitable to smaller size range resulting in lower capital and operational costs.
  - **Process integration** within the whole plant in order to improve the overall energy balance of the plant reducing need for external energy imports.
  - Development of **biomass handling** and reliable gasification systems with greater feedstocks tolerance also able to produce a high-quality syngas.
  - Development of **novel clean-up systems** to reduce impurities from syngas and to limit the energy requirements for its upgrading.
  - Development of **new catalysts** less susceptible to impurities with longer lifetimes.
- Co-processing of FT products at existing crude oil refinery sites in order to achieve greater economies of scale and efficiencies as well as tailoring the product portfolio according to the market needs.
- For SNG, with the exception of the AMBIGO initiative, the sector is showing a lack of confidence about the possibility to profitably produce SNG via biomass gasification

Fast Pyrolysis; challenges and next steps

- There are opportunities to improve pyrolysis through development of processes able to **maximise bio-oil yields**, and the use of **catalysts able to promote higher selectivity** and productivity of desirable products.
  - Catalyst improvements are an opportunity in upgrading. More dedicated research is required to reduce hydrogen consumption during hydro-treatment. Past projects such as the FP7-CASCATBEL as well as on-going project such as 4REFINERY have already published or are investigating several technical developments using catalytic fast pyrolysis and up-grading via refining processes but they need to be scaled up.
- **Co-feeding** pyrolysis oil in oil refinery units using existing infrastructure and commercial technologies is another promising opportunity investigated by current H2020 projects.
- According to IRENA, the majority of cost reductions are expected to occur in **upgrading**, and innovations could ultimately lead to a 10%-30% fuel cost reduction.
- Another important area of investigation is to produce pyrolysis liquids from **cheaper residual resources**, while maintaining a product quality meeting the specifications for bio-liquid.
- Investigations on other processes combining different routes, such as Thermo-Catalytic Reforming that combines intermediate pyrolysis with post catalytic reforming of the pyrolysis products

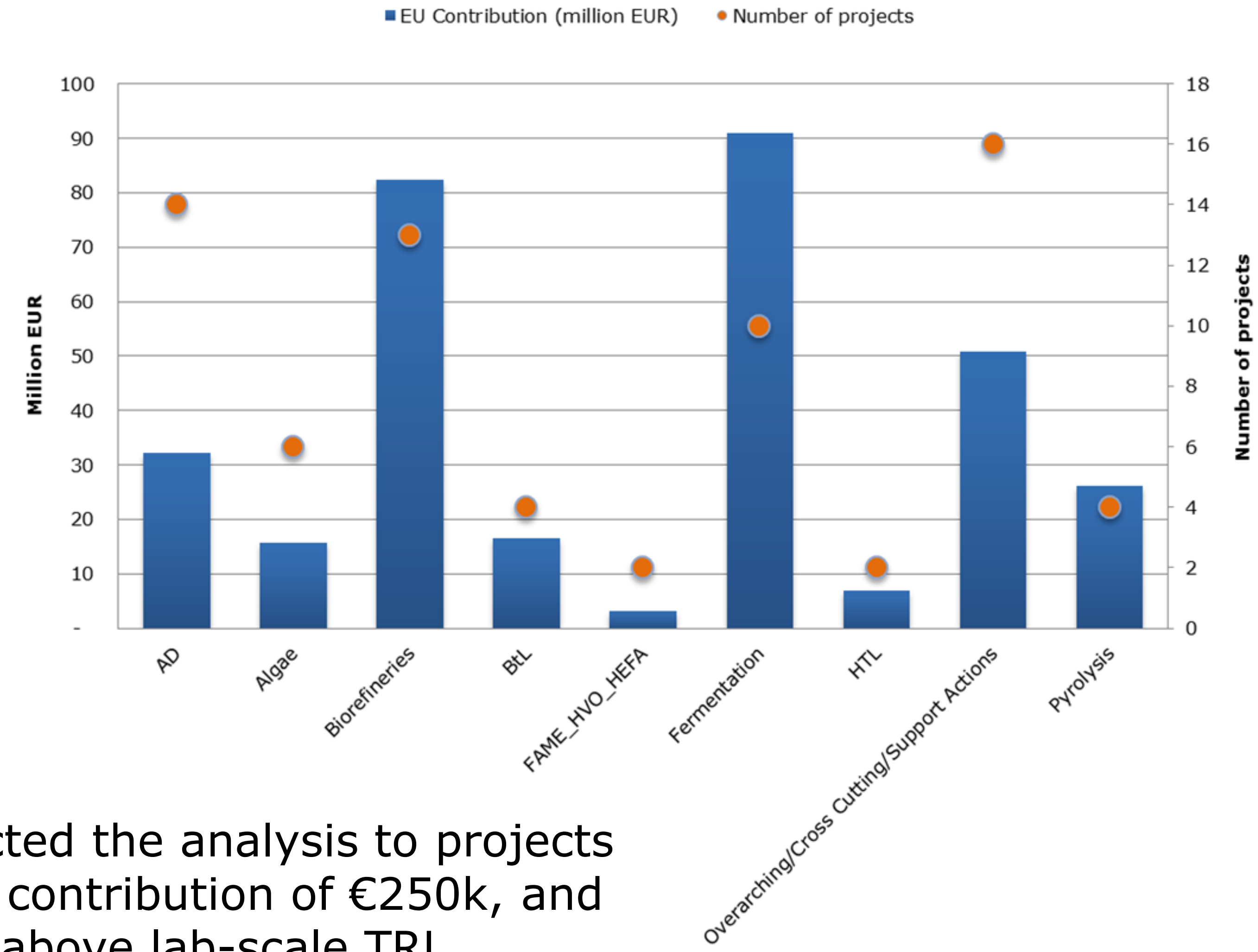
HTL; challenges and next steps

- HTL, proven at laboratory and/or pilot units, appears promising for the production of bio-crude oil that can be blended with traditional fossil crude with a view to being **upgraded** at oil refineries.
- The challenge of ongoing projects led by Steeper Energy Aps (SEA) industry in Denmark and by Licella Pty Ltd company in Australia is to **move TRL** from 5-6 (pilot) to 7-8 (nearly commercial) via testing, scale-up and demonstration.
- In both cases, R&D involves testing feedstock types to determine optimal operating parameters for development and demonstration of HTL platform and upgrading reactor configuration.
- The key objective is to validate current process assumptions, on large-scale, outdoor, year-round operation. Most recently, Licella appear to be moving closer to this point through the integration of their technology into a paper mill
- Better understanding of HTL technology needed to identify specific challenges and promote cost-effective conversion pathways. Techno-economic analyses will have to be conducted as research and development progresses over the next few years.
- An interesting development which may be a solution to the relatively limited progress on upgrading of bio-oils are initiatives of NesteOil (Neste Oil-2, 2018) and Repsol (REPSOL, 2016) are now performing tests at scale to **co-process HTL with crude** oil, but at very low blend levels.

FAME & HVO; challenges and next steps

- For FAME & HVO work to find **more sustainable feedstocks** will be necessary especially given the move away from food-based feedstocks for biofuels.
- For FAME, heterogeneous **catalysts** may improve process efficiencies, reduce waste water volumes and improve glycerine purity. Focussing on proving the industrial reliability of such technologies will likely increase the likelihood of industry take-up.
- Using **ethanol** as the reaction alcohol may improve sustainability. May be difficult as methanol is a cheaper alcohol and therefore the first choice of FAME factories. **Expanding the uses of the glycerol** co-product or improving its valorisation would be beneficial, as there is considerable over supply of this FAME process by-product already.
- The possibility to be **more flexible with feedstocks** is key, currently driving the sector technological development. Use of a wider variety of waste streams (not necessarily only derived from lipid materials) is requiring, at plant level, the adoption of complex pretreatment sections.
- In parallel to the input flexibility issue, plants are also required to be more and more flexible with respect to the outputs. As the use of biofuels is spreading from road to other transport sectors, namely air and waterborne, the relative **shares of diesel, kerosene and naphtha** (from HVO production) need to be constantly tuned, according to the specific market demand.

Overview of EU funding by tech. type*



* Note: we restricted the analysis to projects granted a min EU contribution of €250k, and fuel focused, and above lab-scale TRL

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Any questions?

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