IEA Bioenergy
Technology Collaboration Programme

Lessons learned biofuels

Assessment of successes and lessons learned for biofuels deployment

Summary Series

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Project website: https://www.ieabioenergy.com/blog/task/lessons-learned-biofuels/#

The project in a nutshell

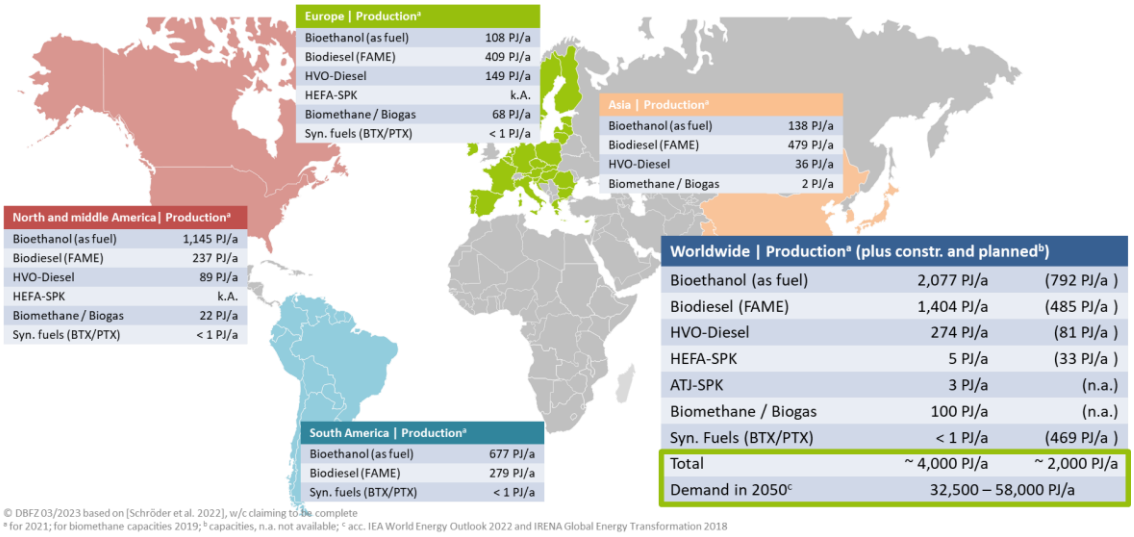
The intertask project "Lessons learned biofuels" examined the technical, economic, societal and political reasons underlying the past and ongoing booms and busts cycles of biofuel technologies development, demonstration, deployment and replication. The aim was to identify key factors for technology successes and the best policy framework conditions as well as the measures for stimulating increased future markets for production and consumption of sustainable transport biofuels.

The work was carried out from 2020 to 2023 in a collaboration between three IEA Bioenergy Tasks (Task 39 "Biofuels", Task 40 "Deployment" and Task 45 "Sustainability"), with the work organized in five work packages. In addition, workshops were held on a number of topics. The results are summarised as follows.

STATUS QUO BIOFUEL PROJECTS

Despite the relatively minor share of renewables in transport (globally about 3%), biofuels continue to be a central fuel option in most strategies to decarbonise transport. Countries that are using both types of policy instruments (technology-push and market-pull) have achieved most success in growing markets for biofuels production and use.

An overview on renewable fuels today as well as required amounts until 2050 is shown below. Bioethanol and biodiesel (FAME) are currently the renewable fuels with the highest production volumes worldwide followed by HVO/HEFA and biomethane/biogas. The total production of about 4 EJ together with fuel capacities planned and under construction of about 2 EJ needs to be multiplied by a factor of 5 to 10 to meet the estimated demand of renewable fuels (biofuels and e-fuels) worldwide by 2050.



META-ANALYSIS ON EXISTING STUDIES

Within the analysis of existing studies, parameters such as feedstocks, by-products, public policies, implementation/ replication potential, environmental aspects and contribution to SDG were analysed in a semi-quantitative method for different biofuels.

For example, Brazil and the US have a long history of improving product yields, costs and environmental indicators especially for conventional ethanol (both sugarcane and corn) and biodiesel. Mandates and appropriate other regulations were essential in achieving that. Also, the ongoing economic crisis (e.g. due to the covid pandemic and also the Ukrainian war) affects the market; so that the advances in biofuel production and setbacks in the past years will have to be recovered.

Wherever feedstock supply is limited, this leads to innovation and development of novel biofuels, currently at low TRL. Earlier innovations such as Biomass-to-liquid, Bio SNG, HVO, and straw-derived ethanol show suitable indicators of environmental impact, SDG, and feedstock diversity to be replicated in different regions. However, published indicators are seldom available which indicates that technological challenges and cost limitations are still to be overcome to reach market maturity.

CASE STUDIES TECHNOLOGIES

Seven case studies were elaborated for different biofuel technologies for selected countries, including Germany (e.g. Clariant, Choren and KIT), Sweden (e.g. Chemrec, GobiGas and SunePine) and Canada (e.g. Enerkem). The analysis has identified technology successes and the best policy framework conditions and measures for stimulating increased future markets.

The most critical factors for keeping risks low is to demonstrate secured biomass supply with esp. local feedstock availability at competitive prices, as well as product offtake at guaranteed biofuels prices and taxes (e.g. for CO_2). Although a stable and foreseeable policy frame is definitely needed, biofuels quotas alone clearly cannot support new technology development and large first of its kind plants. Moreover, biofuels that comply with the existing infrastructure are less challenging to be implemented, since less additional costly infrastructure is required.

CASE STUDIES SUPPLY CHAINS

Different case studies for feedstock supply chains were evaluated from multiple viewpoints, including biorefineries, pulp mills, torrefied woody biomass and conceptual depots producing conversion-ready feedstock and co-products like biomass hubs.

Feedstock quality (e.g. impurities, contaminants, moisture content) is important, yet mitigation methods such as blending are effective in deploying advanced feedstock processing systems. Biomass harvesting and processing can be accomplished with a wide array of equipment and collection systems. Modified foragers and/or in-field chopping can be applied effectively across different feedstock systems. Torrefied biomass does behave superior to untreated densified biomass, saves energy and costs along the supply chain, and will open up new markets for biomass to substitute hydrocarbons and coal.

Moreover, it is important to develop sustainability certification schemes and benchmark them. Of particular importance is transparency and verification of the auditing process by qualified professionals, as to ensure quality and robustness of certification schemes.

NOTES FOR A GUIDELINE STIMULATING BIOFUELS DEVELOPMENT

Different other projects have investigated experiences and possible drivers and barriers for biofuels and tried to provide guidelines for decision makers. Merging these results with the results of this lessons learned study, a summary of "good to know" aspects for decision makers from policy and industry are summarised below.

Value chain aspect	Recommendations esp. relevant for industry	Recommendations esp. relevant for policy
Resource mobilisation | Cropping incl. soil quality and soil carbon as well as improving degraded land, mobilise residues and organic waste	Roll out of new innovations Show multi-purpose benefits arising from resource mobilisation for a (circular) bioeconomy Develop residual biomass supply chain and efficient mobilisation Support technology transfer and knowledge exchange with other biomass sectors	Define uniform definitions and classifications in relevant regulations Monitor land / resource ownership and land / resource management Promote knowledge transfer Support initiatives for domestic resources, innovative crop rotation schemes, rural land use planning (incl. financial) Clarify sustainability requirements and certificates Map local potentials and promote rural areas valorisation
Resource logistics | Infrastructure for efficient and timely mobilisation of resources	Improve/develop technologies for dedicated domestic resources acc. to their specific properties Build up regional hubs for resource logistics	Support for R&D&D to improve/develop technologies for dedicated domestic resources acc. to their specific properties Promote regional infrastructures for resource hubs
Biofuel production technologies | General	Support appropriate feasibility studies for biofuel projects including e.g. technical aspects (plant design, resource and product markets and their development as well as impacting factors), relevant norms, standards, certification schemes, permitting strategy, the timeline, costs and environmental issues, risk management aspects, communication strategy around sensitive issues Be open for capacity building,	Provide research and innovation grants to ensure continuity in funding to overcome technical barriers and improve innovations Set a frame for funding schemes and financial institutions to increase budget shares in their investment portfolios Set tailored financing mechanisms (e.g. quotas, premiums, penalties) to develop a secure framework to reduce capital investment (CAPEX) and uncertainties of production

Value chain aspect	Recommendations esp. relevant for industry	Recommendations esp. relevant for policy
	knowledge sharing and public-private partnerships to accelerate progress in TRL/FRL Share knowledge along the whole value chain and esp. considering also respective (life)time frames of the different fuel-infrastructure-powertrain routes	costs (OPEX) Support R&D&D networks of industry and academia allowing to accelerate progress in TRL/FRL for both WTT and TTW
Infrastructure and trade | Broader fuel portfolio	Support an active role of traders to promote different biofuel options for different applications Work on awareness, investments in and operation of different fuel infrastructures (e.g. gaseous fuels like methane and hydrogen as well as drop-in fuels)	Support to increase acceptance (e.g. public knowledge transfer of fuel-powertrain routes incl. sustainability aspects)
Appropriate norms and standards for innovative technologies	Start normalization and standardization activities in parallel to TRL/FRL for pilot and demonstration in order to be ready for the market	Support of accompanying projects to support normalization and standardization activities as well aspects with regard to methodologies, analytical requirements etc.

Conclusions

The project´s most important key messages include:

- Ambitious strategies and targets do not automatically create a frame that allows increasing or building up innovative technologies along the well-to-wheel/wake chain. The case studies for advanced biofuels have showed technical success however not the required commercial success. To achieve this, harmonised technology push and market-pull policies and a comprehensive monitoring of their impacts are necessary as well. This also include steering instruments to secure financing in order to lower the risk of investments and plant operation.

- Moreover, decarbonisation of the transport sector needs a transition process that allow starting with promising technology options, allows gaining experience and learning lessons for continuous improvement. We don´t have time to wait for optimized options that might fulfil all SDGs from a very early beginning.

- Therefore, it is necessary to continuously work on harmonised clear long-term policies that allow improvement of established biofuel options as ground base for decarbonisation in transport. At the same time R&D&D on innovations of advanced biofuels including hybrids with other renewables that are more complex and thus (usually) more cost demanding (e.g. with regard to GHG mitigation) is urgently needed for a sustainable carbon neutral world.