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Task 64

Technology Collaboration Programme
by iea

Task 64: E-fuels and End-Use Perspectives

Project Duration	May 2022–November 2024
Participants **Task sharing** **Cost sharing**	 Brazil, China, Denmark, Finland, Germany, Japan, Switzerland, USA None
Total Budget	EUR 200,000 (USD 216,900)
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Purpose, Objectives, and Key Question

The net-zero policy of most countries requires actions to reduce and replace the use of fossil fuels. These fuels are energy carriers that are currently used for mobility, industry, heating, and other purposes. There are some applications, such as aviation or international shipping and other "hard-to-abate" sectors, which cannot easily be electrified for long distances and involve difficulty to obtain low emission fuels. Therefore, demand for fuels will remain and these fuels will need to be produced from renewable energy or lower carbon intensity sources in the coming decades. The energy transition means that new technologies are tested and deployed to replace the fossil fuels. One option for fuels with low-carbon emissions could be e-fuels.

The technologies for e-fuel production and application are being developed around the world. Task 64 on e-fuels and end-use perspectives was set up in the AMF TCP to assess their significance at the international level. The aim was to gain an overview of the status of e-fuels in the various countries involved. The application of these fuels, some of which are new, is relevant for AMF TCP as they can be used for motorized processes. At the same time, there is still little experience in the use of these new fuels, as their production is still in infancy.

The focus of Task 64 was an informative exchange about the production and application of different e-fuels and the corresponding regulatory framework. The output of the task was a concise report addressing the following topics:

- Demo sites/pilot programmes
- Carbon dioxide (CO_2) and hydrogen (H_2) resources
- Application side
- Regulations and standards
- Life-cycle assessment (LCA)
- Techno-economic assessment (TEA)
- Stakeholders

Activities

The collaborating countries were Brazil, China, Denmark, Finland, Germany, Japan, Switzerland, and the USA (see list of participants). Furthermore, collaboration and exchanges with IEA Bioenergy TCP, IEA Hydrogen TCP, IEA HEV TCP, IEAGHG, and the International Transport Forum took place. The task was managed by Zoe Stadler, OST Eastern Switzerland University of Applied Sciences.

In the task, workshops around different e-fuel specific topics were organized, during which the task participants formulated key messages and joint conclusions that served as the basis for the final report. Various specific e-fuel topics were included: demo sites and pilot programmes, resources, application, regulations, life-cycle assessments, techno-economic assessments, and stakeholders.

The final task report provides an overview of ongoing activities in the participant countries, as well as past and current technical, economic, and regulatory challenges. In addition to the exchange of information, the report is intended to help raise awareness of the importance of global activities in the field of e-fuels.

The duration of the task was two years with the main findings presented at a webinar.

Key Findings

Several countries have launched strategic programs to increase the production of e-fuels. These initiatives provide incentives, support research, or enact regulations that mandate a certain percentage of e-fuel use.

Key findings of task 64 are:

- E-fuels and biofuels must be considered together in the energy strategy, as both will play a crucial role in hard-to-electrify sectors (aviation, shipping, heavy-duty road transport, and industry).
- Some e-fuels can be produced with mature technologies, but the combination of several technologies in an e-fuel production plant can have a low overall technology maturity level.
- Strategic programs to support e-fuel production have been implemented in several countries. They consist of incentives for e-fuel production, support for research projects, and/or regulations that make the proportionate use of e-fuels mandatory.
- The energy-intensive production of e-fuels leads to the discussion as to whether they should primarily be used for applications that are difficult to electrify. These hard-to-abate sectors are the aviation industry, maritime applications, and industrial processes.
- Hydrogen production via water electrolysis has the largest impact on the carbon intensity of the product. Life-cycle assessments results show that using renewable electricity is key to having low-carbon e-fuels.
- The most important cost driver in the production of e-fuels is hydrogen production by water electrolysis, and production costs depend primarily on electricity prices, which depend on the geographical location, and capital costs.

Main Conclusions

To reach a net zero target in the energy and mobility system, e-fuels will play an important role together with biofuels. Both types of renewable fuels have their advantages and challenges, and both are needed for a successful energy transition. E-fuels are an important complement to biofuels, and countries can combine the synergies and benefits of e-fuels and biofuels. The opportunities that arise with the energy transition will lead to an increase in the global technology diversity. Several new technologies are being developed and there is a global technological race, with several routes and alternatives capable of assuming a relevant role in the energy transition. In the near future, there will be several emerging industries coexisting and eventually replacing the traditional technologies. Energy systems will follow a process of carbon intensity reduction, as the climate agenda will increasingly influence international trade and international relations.

In general, biofuels production technologies have a higher technology readiness level (TRL) than e-fuels. Some e-fuels, such as FT fuels or methanol, can be produced as well from high TRL or mature technologies. However, it needs to be pointed out that although some single technologies might have a high TRL, the overall TRL in the combination of several technologies in an overall plant can be lower.

In the strategies of most countries, e-fuels are regarded as important for different applications in the future. To support technology development and to increase e-fuel production, strategic programmes in several countries were implemented. Depending on the country, they consist of incentives for e-fuel production, of support for research projects or of regulations that make a certain percentage of the use of e-fuel mandatory, or a combination of these three. Next to political programmes, companies are also enforcing the use of sustainable fuels in order to reduce their carbon footprint.

The production of e-fuels is very energy-intensive if based on water electrolysis, which is why it is being discussed whether these processes should be used primarily for applications that are difficult to electrify. These so-called hard-to-abate sectors are the aviation industry, maritime applications, and industrial processes. For international aviation, fuels need to be ASTM certified. According to ASTM D7566, the following routes are suitable for SAF production: hydroprocessed esters and fatty acids (HEFA), hydroprocessed HEFA (HC-HEFA), catalytic hydrothermolysis jet (CHJ), synthetic isoparaffins (SIP), alcohol to jet (ATJ), synthetic paraffinic kerosene (SPK-A), and synthetic paraffinic kerosene – Fischer-Tropsch (SPK-FT). In the shipping industry, e-methanol, e-ammonia, e-methane, and hydrogen are considered interesting for the use. Regulations for onboard use of methanol and liquefied methane exist today and thus gives their implementation an advantage over the implementation of ammonia or hydrogen.

When producing e-fuels, water electrolysis is a key technology. It is necessary for all e-fuel production pathways and has the largest impact on e-fuel production cost as well as the carbon intensity of the product. LCA results show that using renewable electricity and hydrogen is key to having low-carbon e-fuels. Usually, using electricity grid mix for producing e-fuels does not provide greenhouse gas (GHG) emission reduction benefits compared to the fossil baseline fuels. It is therefore crucial to use low-emission electricity sources to obtain an ecological benefit. The analysis shows that e-FT fuels and e-methanol present significant GHG reduction benefit coupled with renewable electricity and/or H_2 compared to their fossil counterparts. Regional distribution of CO_2 sources and the available freshwater need to be considered further. As the amount of freshwater needed as a renewable source of hydrogen for e-fuel production is significant, regional and seasonal variations in water availability and scarcity should be considered when siting carbon capture and utilisation (CCU) facilities to avoid water-scarce areas.

The key cost driver of e-fuel production is hydrogen, of which the production cost mainly depends on electricity prices and capital cost. Since electricity costs depend on the geographical area, the location of a production facility has a major influence. To achieve low-cost hydrogen for economical e-fuels production, both electricity cost and electrolyser capital cost needs to decrease greatly. There are ambitious learning curves assumed, and high operating capacities are needed (and a challenge). The costs of e-fuel production can additionally be lowered by increasing the efficiencies of e-fuel production technologies, increasing the size of production plants, and lowering costs for other resources like CO_2 and nitrogen. The price for the CO_2 is mainly defined by post-combustion technologies like capture, purification, compression, and cooling. Point sources are more economical, as capture costs increase with decreasing concentrations. However, e-fuels are generally more expensive than biofuels. Appropriate carbon pricing and low renewable power cost are critical to enhance the economic competitiveness of e-fuels.

Despite economic challenges, projects aimed at production of e-fuels are announced frequently and across the globe. Political programmes and customer demand are the main drivers of this development, and a major expansion of production facilities is expected. It remains to be seen which technologies will prevail and which countries will be the main producers and exporters.