2023 – IP12

Building blocks for e-fuel production

In March 2023, the IEA Technology Collaboration Programmes (TCPs) on Greenhouse Gas Research and Development (IEAGHG), Advanced Motor Fuels (AMF)[1], and Hydrogen[2] joined forces (as part of the strategic partnership within the IEA's TCPs) to host a virtual workshop with a focus on e-fuels (synthetic hydrocarbons refined from a power-to-liquid (PtL) process).

The aim of the workshop titled "Building Blocks for e-Fuel Production" was to explore and discuss the essential components and technologies involved in the production of e-fuels. The workshop sought to identify key building blocks, advancements, challenges, and potential solutions in the field of e-fuel production, fostering collaboration and knowledge exchange among experts and stakeholders to accelerate the development and deployment of sustainable e-fuel technologies.

The workshop commenced with welcoming remarks from Zoe Stadler, Task Manager for AMF Task 64; Abdul´Aziz Aliyu, Technology Analyst HICC, IEAGHG; and Marina Holgado, Technical Secretariat Coordinator, IEA Hydrogen TCP. Following that, Dr. Marcel Weeda, Hydrogen TCP Vice Chair, delivered a presentation on hydrogen production, transport and storage (T&S) for e-fuel production. Subsequently, Dr. Emanuele Moioli, R&D engineer at Hitachi-Zosen Inova, presented on the Power-to-Methane plant in Austria. Finally, Karl Hauptmeier, Managing Director of Norsk e-Fuel, spoke about the E-fuel project development and accelerating the transition to renewable aviation.

Excerpts from Marcel Weeda's presentation on Hydrogen production, T&S for e-fuel production:

Marcel started off by presenting briefs on hydrogen demand and the different renewable hydrogen pathways. **As of May 2022, there were 680 large-scale hydrogen project proposals worth USD 240 billion, representing an increase of 160 projects from the previous year**. However, only less than 10% of these hydrogen projects, valued at USD 22 billion, have reached the final investment decision (FID) stage[3]. This substantial investment gap underscores the need to prioritize mature hydrogen projects more urgently than ever.

To be on track for achieving net zero emissions by 2050, approximately USD 700 billion in hydrogen investments are required through 2030. However, to date, only 3% of this capital has been committed.[3]

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[1] AMF, founded in 1984, boasts a robust global network aimed at promoting collaborative research, development, and deployment (RD&D) efforts while delivering impartial information on clean, energy-efficient, and sustainable fuels, as well as related engine and vehicle technologies.
[2] Hydrogen TCP was established in 1977 under the IEA's umbrella to promote cooperative research and development of hydrogen technologies and facilitate information exchange among its member countries.
[3] Hydrogen Council and McKinsey & Company. Hydrogen Insights 2022. An updated perspective on hydrogen market development and actions required to unlock hydrogen at scale. September 2022.

It is crucial to recognize that aspirations and proposals alone cannot bring about the desired impact on climate change; what is needed is actual investments and implementation on the ground.

Marcel discussed some of the ongoing work within the Hydrogen TCP, which includes Task 40 and Task 42. **Task 40 focuses on energy storage and conversion using hydrogen, aiming to develop reversible or regenerative hydrogen storage materials.** These materials must meet specific targets for hydrogen storage capacities and operation temperatures, tailored to various application objectives, such as mobile systems, transport and distribution, or stationary storage systems. To achieve breakthroughs in material development, a deep understanding of hydrogen storage mechanisms is crucial. Currently, the impact of catalysts on hydrides remains unclear, despite their significance in hydrogenation/dehydrogenation processes. The successful implementation of technical applications requires a comprehensive understanding of both fundamental and engineering aspects. To foster progress, Task 40 actively engages in international collaborations, facilitating the development of new materials and systems for energy storage and conversion, encompassing hydrogen, electrochemical, and heat storage technologies.[4] Whereas **Task 42 is focused on investigating and addressing research and innovation challenges related to underground hydrogen storage (UHS) to demonstrate its technical, and economic viability.** This includes exploring storage options in porous reservoirs, salt caverns, and other manmade spaces. While salt caverns are already utilized for static hydrogen storage, there is a need to assess their technical feasibility for fast cyclic and high-performance injection and production, as well as efficient management of dense clusters of these caverns. On the other hand, hydrogen storage in porous reservoirs is relatively less developed, and it is currently undergoing more fundamental scientific and technological investigations to establish its technical viability.[5]

Excerpts from Emanuele Moioli on Power-to-Methane plant in Austria

Hitachi-Zosen Inova (HZI) is running a biogas methanation plant in Gabersdorf, Austria. The methanation plant is part of “Renewable Gasfield”, a research project aimed at achieving a carbon-neutral Austria. This innovative facility adopts a comprehensive power-to-gas approach, integrating renewable energy technologies. The plant's primary goal is to facilitate the storage of green power effectively.[6]

Solar power generates renewable electricity, which is employed to service a 1 MW Proton exchange membrane (PEM) electrolyser to produce green hydrogen. The green hydrogen (40 Nm3/h) is then utilized in a ground-breaking approach for the direct methanation of raw biogas, resulting in the production of renewable natural gas (>90% Methane content). **The integrated catalytic methanation system implemented by HZI facilitates the reaction between CO2 from the biogas and hydrogen, leading to the creation of synthetic methane—a viable substitute for renewable natural gas.**

Excerpts from Karl Hauptmeier, on the Norsk e-fuel: Developing e-fuel projects

Karl started off by quoting extracts from the IPCC Sixth Assessment Report (AR6) which states that the adoption of synthetic fuels will likely focus on the aviation, shipping, and long-distance road transport

[4] Hydrogen TCP. Task 40: Energy Storage and conversion based on hydrogen. 2019-2021(extended until 2024)
[5] Hydrogen TCP. Task 42: Underground Hydrogen Storage. 2022-2024
[6] Hitachi Zosen INOVA. Gabersdorf, AUT. Methanation.

segments, where decarbonisation by electrification is more challenging. New Emission Trading Scheme (ETS) regulations for aviation have a positive impact on e-fuel development. It was agreed that:

- Free ETS allowances for aviation will be fully phased out by 2026.
- 20 million ETS allowances to be dedicated to support the uptake of synthetic aviation fuel (SAF) for commercial flights from 2024 to 2030. About 1.8 billion EUR at today's ETS prices.

Today, SAF fuels represent only 0.05% of total jet fuel consumption. The ReFuelEU Aviation initiative aims to boost the supply and demand for sustainable aviation fuels in the EU.[7] Current draft proposes a blending mandate for hydrogen-based aviation fuels of 0.7 % (2030); potentially up to 2 %. Up to 1Mt of jet e-fuel is required by 2030, based on total EU Jet Fuel demand of around 56 Mt p.a. National implementation of SAF strategies might very well exceed the targets as set out within the ReFuelEU Aviation.

Norsk e-fuel is actively involved in securing and participating in various project sites. **The Norsk e-fuel Alpha Plant, located in Mosjøen, Norway, will become the world's first full-scale e-fuels production facility.** The area boasts some of the lowest electricity prices in Europe, as well as stable access to renewable energy from hydropower. The Alpha plant is projected to have an annual production volume of 25 to 50 million litres (40,000 tons) by 2026, estimated to secure approximately 20 percent of Norway's total demand for SAF until 2030. Scaling up from the Alpha plant, the Norsk e-fuel Beta plant is projected to have an annual production volume of 100 million litres by 2028.

Discussion:

E-petrol and e-diesel are climate neutral fuels that will reduce pollution if renewable electricity is utilised, and CO_2 captured from the air. **So, the argument goes: instead of decarbonising engines, why do not we decarbonise the fuel itself.** Transport & Environment (a European clean transport campaign group) commissioned IFP Energies Nouvelles, France to run a series of lab-based tests simulating real-world driving conditions (Worldwide Harmonised Light Vehicle Test Procedure (WLTP) and Real Driving Emissions (RDE)) to measure the emissions of different e-petrol blends in an A-class (A180) Mercedes.[8]

The testing program reveals that e-petrol used in cars will continue to contribute to Europe's air pollution issues and, due to some unaccounted-for greenhouse gas emissions, cannot be considered entirely climate neutral. While the process of producing e-fuels may seem like green, capable of making engines emission-free, a closer examination reveals that utilizing renewable electricity to produce green hydrogen (both clean technologies) and incorporating CO_2 captured from the air (thereby reducing atmospheric CO2) results in a fuel that still emits toxic pollution. The findings from the Transport and Environment study can be accessed HERE.

[7] European Commission. Sustainable aviation fuels – ReFuelEU Aviation.
[8] Transport and Environment. Magic green fuels. Why synthetic fuels in cars would not solve Europe's pollution problems. 2021.

As the world moves towards decarbonizing its energy and transportation sectors, e-fuels could play a role in the mix of sustainable energy solutions. However, it is essential to evaluate each specific use case and the overall energy transition strategy to determine the most suitable and effective approach.

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