LCRI LOW-CARBON RESOURCES INITIATIVE

EPRI GTI ENERGY

EXECUTIVE SUMMARY

Executive Summary: Synthetic Fuels Produced from Green H_2 and Captured CO_2

This study addressed electrochemical pathways for synthetic hydrocarbon fuel (synfuel or electrofuel) production using green hydrogen (H_2) and carbon dioxide (CO_2) via integration of electrolysis for H_2 or syngas (H_2+CO), as well as making fuels compatible with existing infrastructure. Electrofuels produced from CO_2 and water/steam (H_2O) with renewable electricity could facilitate storage of electricity and be useful to the transportation and power sectors. They can also reduce greenhouse gas emissions while solving intermittence of renewables and the associated effects on power grid stability.

A literature survey was conducted to compare merits and challenges of the three prime electrolysis technologies—polymer electrolyte membrane (PEM), alkaline (AEL), and solid oxide electrolysis cell (SOEC)—to generate H_2, carbon monoxide (CO), or H_2+CO from water/steam (H_2O) and CO_2 for synfuel production. Co-electrolysis was also included in the survey due to advantages such as lower electrolysis cell resistance and reduced possibility of further reduction of CO to carbon (C). Fischer–Tropsch (FT) is the most established technology for syngas conversion to synfuels. The survey identified key factors affecting synfuel costs, evaluated the potential for further cost reduction, and reviewed ongoing projects staged for electrofuel production to assess readiness to commercialization.

The study finds that the two key factors impacting synfuel production costs are electrolyzer cost and renewable electricity price. Capacity factor and electrolyzer life also affect fuel costs. Economic studies from literature for synfuel production yield a wide price range due to highly variable processes and techno-economic analysis (TEA) assumptions. The average synfuel cost of $11.00/gal is about four times the current gasoline price and could become economically appealing under a tax on CO_2 emissions or credits.

Key findings from the full report include:

- SOEC technology is attractive because of high conversion efficiencies due to favorable thermodynamics and kinetics at higher operating temperatures. SOECs can be utilized for direct electrochemical conversion of steam (H_2O), CO_2, or both into H_2, CO, or H_2+CO via co-electrolysis. Also, SOECs can be thermally integrated with a range of chemical syntheses, enabling recycling of captured CO_2 and H_2O into synthetic natural gas (SNG), gasoline, or methanol, resulting in further efficiency improvements compared with low-temperature (LT) electrolysis (AEL and PEM) technologies.
- Synfuels have the potential to reduce greenhouse gas emissions and global warming below the 2°C level.
- Synfuels are easier to handle, store, and transport compared to electricity.
- Synfuels are currently expensive (four times the cost of gasoline) due to high capital costs needed for deployment. A cost reduction can be realized by lowering renewable electricity costs, increasing efficiencies via improved production processes (e.g., SOEC co-electrolysis), and economies of scale.
- Synfuel technology is currently at a pilot/demonstration rating on the technology readiness level (TRL) scale (TRL 5–7).
- Sunfire, a German company, is aggressively pursuing the commercialization of synfuel technology after successful demonstration (kilowatt scale) of SOEC electrolysis for H_2 and syngas production to generate liquids in an FT reactor.

There is growing interest in synfuels derived from CO_2 and water as an attractive alternative to reduce fossil fuel usage, mitigate climate change, increase energy security, and find applications to decarbonize transport and power sectors, with multiple developers engaging in demonstration projects. An advantage of producing synfuels is that there is an existing market and infrastructure. The cost of synfuels generated with electrolyzers using renewable energy is a key issue that can impact new business ventures and related infrastructure investment in the power and transportation sectors. This study reviews the predictable impact of electrolysis technology development on reducing the cost of electrofuel production.

Corporate strategy and emerging technology groups can apply this research to gauge the technology, understand factors that will affect the production cost of synfuels, and apply a critical review of future cost projections for associated equipment. This may be useful when evaluating engagement with new business models involving synfuels (such as decarbonizing fuels or alternative fuels for transportation and power sectors) and associated technology investments. The description of demonstration projects illustrates the innovativeness of synfuel technology.

The Low-Carbon Resources Initiative

This report was published under the Low-Carbon Resources Initiative (LCRI), a joint effort of the EPRI and GTI Energy addressing the need to accelerate development and deployment of low- and zero-carbon energy technologies. The LCRI is targeting advances in the production, distribution, and application of low-carbon energy carriers and the cross-cutting technologies that enable their integration at scale. These energy carriers, which include hydrogen, ammonia, synthetic fuels, and biofuels, are needed to enable affordable pathways to economy-wide decarbonization by mid-century. For more information, visit www.LowCarbonLCRI.com.

Technical Contacts

H. Meyer, Senior Institute Engineer, GTI Energy
Des Plaines, IL 60018, 847.768.0955, hmeyer@gti.energy

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EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com