Freedom Flight

Expert Opinion:

On Airport Generation of Liquid Hydrogen is Key to Sustainable Aviation

Karl Young is one of **Freedom Flight Prize**'s technical panelists who worked on MW electromagnetic coil systems for experimental Tokamak fusion reactors at the Princeton Plasma Physics Laboratory.

He believes the availability of liquid hydrogen (LH_2) at commercial airports will ensure an accelerated development of LH_2 airliners, especially supersonic and hypersonic platforms.

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Since the late 1950s, the U.S. and Russians have demonstrated jet engines operating on H_2 to be very effective. At that time, there were no concerns about Jet-A fuel costs and CO_2 emissions, and an LH_2 infrastructure was too daunting.

With digital fuel control, today's turbofan engines (with some redesign) will operate very efficiently on H_2. 99.9% of the jet engine exhaust from burning hydrogen will be water vapor with a very small component of NO_x.

Although the water vapor produced from hydrogen-fueled airplanes will be about 3 times more than today's airliners using Jet-A, but will not affect climate in any way. It is an insignificant addition to the atmosphere compared to the moisture from ocean evaporation each day, which is 1.2×10^{15} liters (12,000,000,000,000 tons) per day on average.

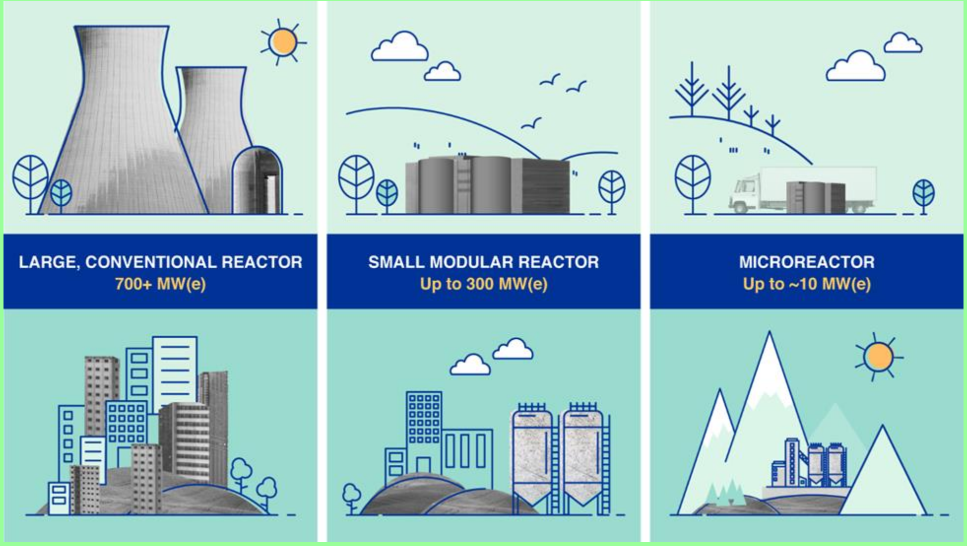
Producing hydrogen from freshwater may seem to be a potential issue, but a hydrogen economy will eliminate the water needed for fossil fuel production and power generation, which is 6.7 times more than producing hydrogen. Agriculture uses 91 times more water than that required for hydrogen production each year.

Also, around 2.56×10^{11} kg (256,000,000 tons) of CO_2 would not have been formed in 2023 if all airliners had used hydrogen instead of Jet-A. Burning H_2 will also reduce total air pollution (8 million early deaths/year from air pollution).

LH_2 must be produced at the airport to make economic sense and eliminate high-risk delivery accidents by truck, rail, or pipelines. The daily quantity of LH_2 required at a large commercial airport will mean an endless stream of LH_2 tankards 24/7.

Let's do a worst-case scenario by using the Atlanta Airport (ATL) which averages 2,700 takeoffs and landings per day, which represents around 350 million kg of Jet-A/day or around 15GWh of energy needed to produce the necessary LH_2 for 1-day's use at ATL. 625MW of power will be needed if all the airliners switch to LH_2 at Atlanta airport.

Alkaline electrolyzers are more than 95% efficient and will be the most practical on-site hydrogen production method. The oxygen can be sold for many other applications to reduce operating costs. However, we'll still need significant amounts of energy to liquefy the gas. It is preferred that we use renewable energy here, but the substantial on-site electric power requirements make renewable energy very difficult for airports without a giant desert or small ocean for solar panels or wind turbines, respectively.



Small Modular Nuclear Reactors (SMRs) could provide a great solution for airports like ATL

The risks of SMRs in pollution and radioactive residuals are much lower than today's fission reactors – there is no risk of 'thermal runaway'. Perhaps we should always remind ourselves that conventional coal and natural gas power plants produce CO_2, acid rain, and other particulate air pollutants that regularly cause health issues. To add to the positive picture for SMRs, new science is already finding ways to treat radioactive fission wastes for re-use. The excess amount of energy that can be produced by SMRs can be put to use to power airport facilities, charge electric ground vehicles, etc. These SMRs are relatively small, so they will likely fit on the existing airport premises and could even be installed below ground level. This will reduce grid stress by eliminating the airport's load demand off the grid, especially preferred as the EV population is growing.

Eventually fusion reactors will be ideal but are probably still more than 40-50 years away before they can produce LH_2 for the 1,200 international airports around the world. By then, the SMRs can use some refreshing work or replaced with SMFRs.

Conclusions

- Safe & cost-effective H_2 generation and liquefaction are central to achieving effective hydrogen-powered flight to help decarbonize air travel.
- On-site electrolysis of H_2 can be sufficiently scalable to meet large airport needs to provide a viable solution.
- Building a pipeline to an airport for H_2 will involve huge capex and still necessitates large energy needs for gas liquefaction (if not already cryogenic).
- New SMRs may provide a compelling solution to supply airports with all their energy needs and the production of LH_2 using these may provide an ideal solution. They may also provide supplementary energy that can be used by the adjacent neighborhoods.

Karl Young is a co-founder of Precision Energy Technologies, LLC (PET) in the U.S. PET provides all the technical innovations for the Essence Global Group of companies (https://essensceglobalgroup.com).

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