Case study shows what it would take for Chicago's O'Hare International Airport to run on hydrogen

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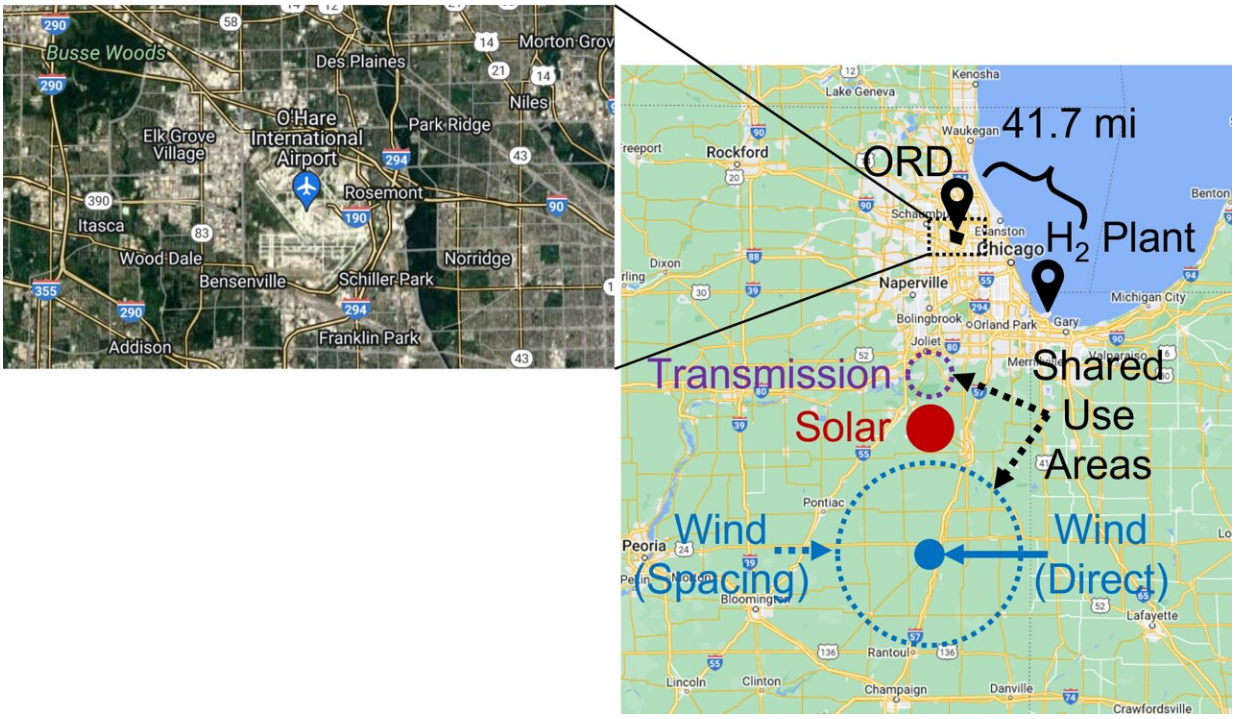

Hypothetical land area use to meet 2035 requirements for 100 percent renewable energy grid based on the needs of Chicago's O'Hare International Airport. Credit: Google Maps and the National Renewable Energy Laboratory

Hydrogen is emerging as one of the most viable carbon-free energy sources to replace fossil-derived jet fuels and meet the goal for net zero

emissions by 2050. But the production life cycle to manufacture hydrogen so it can be used in aircraft can produce significant greenhouse gas emissions.

To study the problem, Phil Ansell, aerospace engineer at the University of Illinois Urbana-Champaign, conducted a case study using the electrolyzed hydrogen fuel needs of Chicago's O'Hare International Airport with today's electric grid mix.

The study, "Electrical Grid Requirements for Sustainable Green Hydrogen Use in Aviation," was presented at the AIAA Aviation 2023 Forum and was published by Aerospace Research Central.

Ansell's findings show, its use today would be associated with approximately two and a half times the global warming potential as the direct use of fossil-derived jet fuels. However, because he believes electrolyzed hydrogen is still the best option for O'Hare and aviation, he addressed the problem with tangible solutions.

"We've known for decades that hydrogen is technologically feasible and becoming more economically scalable for the aviation industry to be sustainable," Ansell said. "What this study shows is that we need to make the right investments in facilities and infrastructure for that to happen, because today's electric grid won't be acceptable. This is a gut check for the aviation community."

Ansell said although the aviation ecosystem would like to look at just the emissions that are directly introduced to the atmosphere by aircraft, such an approach misses the actual sustainability goals set by the industry. Hydrogen is very attractive because it only produces water vapor emissions when utilized on an aircraft. But that perspective doesn't include all of the energy needs throughout the fuel's life cycle.

He looked at three different resources that forecast the future composition of the U.S. electrical power grid. One was from the Energy Information Administration and two separate forecasts from the National Renewable Energy Laboratory. From those, he learned of multiple plans for how the U.S. could feasibly achieve a fully renewable grid by the year 2035.

As a part of the study, Ansell assumed the adoption of one of the NREL zero emissions electric grids—one that has heavy concentrations of solar, wind, and other renewable energy sources. He calculated the amount of land needed to produce the electricity that then is leveraged for the hydrogen production via the water electrolysis process, the hydrogen liquefaction process, even shipping it to the airport.

"What we need to understand is the total environmental impacts, economic impacts, as well as other potential social impacts, like water use, and conflict of land that we might anticipate for the amount of fuel energy that aviation would need."

Without naming specific locations in Chicagoland, Ansell approximated the amount of physical land that would be needed to produce renewable electric energy to produce useable hydrogen for aviation. These might be a combination of solar arrays or wind turbines. He also investigated repurposing outdated energy-producing facilities.

"I tried to incorporate indirect land use change in a positive way," Ansell said. "If we have land that is currently allocated for infrastructure, then leveraging the area for this new related purpose is a win."

One of the reasons Ansell chose O'Hare for the case study is because it's near Lake Michigan, a large body of freshwater, making it an ideal location to consider for hydrogen.

"Many other parts of the world don't have a ready supply of freshwater and already have large desalination operations to get fresh drinking water for their populations. This process is also very energy intensive. Not having to desalinate the water first for use at O'Hare, means another step that uses energy could be avoided."

The life cycle modeling Ansell did breaks down the energy needed to process the hydrogen, but also examined various transportation scenarios. Is it more efficient to liquify the hydrogen near the large water source and pipe it or use heavy trucks to transport it to O'Hare? Or is it better to liquefy it on site at the airport? He said, those are details that all play a part in the big picture energy grid.

"One of the current gold standards people envision for the future hydrogen economy is the production of what we call green hydrogen, which is produced from water electrolysis. We split the water into hydrogen and oxygen, then use the hydrogen for energy applications. But we need to use energy to do that splitting process. We can do so electrically. However, green hydrogen is specifically produced from electricity that is sourced from renewable sources such as wind, solar, and hydroelectric. As a result, the use of modern electrical grids which feature continued use of coal and natural gas, do not meet this classification.

"Because our current grid is not fully renewable, we see negative environmental impacts if grid-sourced electrolytic hydrogen were used for aviation today. But this shouldn't stop us from the significant promise that hydrogen has for the future sustainability of aviation. Rather, this effort principally points to the need to resolve how sectors outside of the aviation ecosystem impact the progress made in the sustainability of air transportation."

According to Ansell, if only incremental increases in renewable energy

resources are introduced across the grid, electrolytic hydrogen will not be an environmentally sustainable solution. But, he says, the development of a fully renewable electrical grid in the U.S. by 2035 is technically and socially viable. The cost of renewable electricity generation has also dropped precipitously in the past two decades, such that on average it is less expensive and safer to produce electricity with wind and solar sources than it is with traditional plants that operate using fossil fuels. If a fully renewable grid becomes a reality, electrolyzed hydrogen can serve as a compelling zero-emissions solution for aviation.

"There are companies that want to make small commercial hydrogen aircraft in the next two years and bigger companies that want to develop these in the next 10 years. Are we ready from the actual lifecycle perspective? I believe we have all the technologies we need and enough money to do it," Ansell said. "It's a question of allocating and prioritizing."

More information: Phillip J. Ansell, Required Developments for Integration of Sustainable Hydrogen in Aviation, *AIAA AVIATION 2023 Forum* (2023). DOI: 10.2514/6.2023-4476

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