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M2H2: Hydrail's Fast Track to Clean Energy Fuel Cells

Leveraging mobile hydrogen generation systems to power today's trains for tomorrow's decarbonisation mandates

Diesel fuel, the standard for powering trains the world over, contains air pollutants, including CO2 – a greenhouse gas that causes global warming – as well as NOx, SOx, and particulate matter (PM), which pose health risks to passengers and train personnel.

It's an outdated approach to propulsion and a critical global challenge yet to be solved, even as addressing climate change has reached fever pitch. Governments around the world are facing mounting pressure to clean up the environment and have responded with mandates that include international net-zero carbon emissions by 2050.

Understanding the benefits of swift action, the UK's rail transportation authority has imposed its own deadline for zero emissions industrywide, culminating in the elimination of all diesel-only trains, or the transformation thereof, by 2040. This is a full ten years before the national (and international) carbon deadline; many other countries are expected to follow suit. Certainly great news for the environment and its inhabitants, but quite the conundrum for an industry that has relied heavily on diesel for nearly a century. Fuel cell technology, which uses clean hydrogen (H2) as its energy source, is poised to play a critical role in cleaning up the industry and getting trains on track for a greener, carbon-free future.

Fuel cells: From H2 to 'Where to?'

Powered by hydrogen, today's fuel cell (FC) technologies give train manufacturers and rail operators a readily available yet environmentally friendly source of propulsion, now known as hydrail. FCs generate clean, renewable energy and have been touted as key to decarbonisation and reduction of greenhouse gases.

Currently, there is a lack of infrastructure for distributing hydrogen, based on a very limited amount of hydrogen pipeline in existence. Transport by high pressure gas tube trailers and by liquified tankers is also very costly. Today, new breakthroughs in hydrogen-on-demand address these challenges and provide a clean alternative to diesel-based propulsion.

- With no moving parts and plug-in modularity, FCs are low maintenance
- Unlike diesel or liquified natural gas (LNG), hydrogen is truly zero emission
- Hydrogen refuelling is quick – with just 20 minutes of refuelling, an FC electric passenger train with multiple units can run for more than 18 hours
- An FC's range is longer, allowing hydrogen fuel cell trains to travel up to 1,000 kilometres before refuelling
- FC locomotives can be deployed on diesel locomotive service routes
- Existing locomotives can be retrofitted with hydrogen FC power

Historically, FC solutions have presented a challenge based on the potential for large-scale storage and transportation of the hydrogen required as the fuel source – no easy feat for a variety of reasons. Hydrogen has a higher energy density than diesel, and since hydrogen is the lightest element on the periodic table, it is difficult to store. For instance, 1kg of hydrogen gas at standard pressure and temperature conditions occupies over 11 cubic meters (388.5ft^3).

High-pressure compressed hydrogen solutions have been gaining popularity, but they have inherent risks and limitations and require considerations of space and cryogenic temperatures. In these systems, hydrogen is stored in either gas or liquid form. High-pressure H2 must be kept in costly composite overwrapped pressure vessels (COPVs), which may leak and need to be re-certified every five years. COPVs are generally designed to be stored on top of or within carriage, which can make passengers wary. Liquefied H2 is costly to produce (energy-intensive) and transport. For hydrogen to be economically viable, its storage density must be increased, costs reduced, and logistics improved.

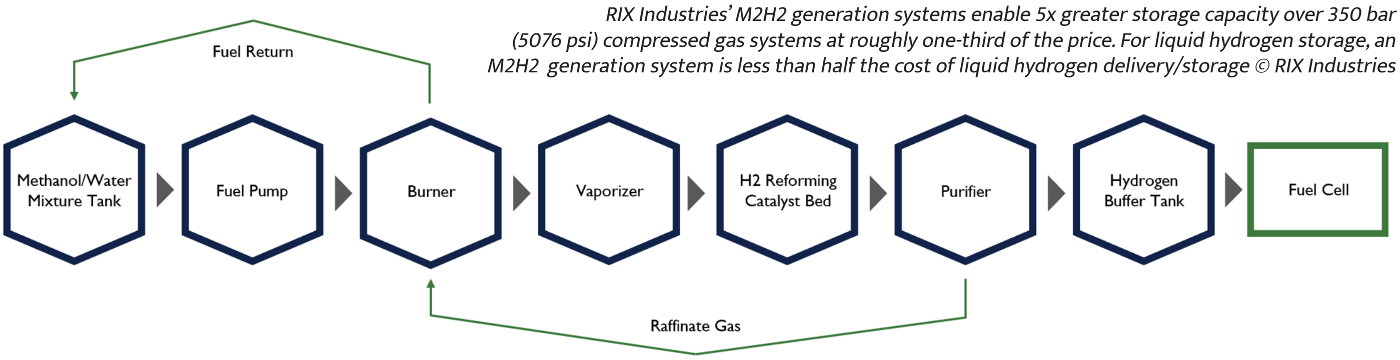
The Infrastructure Impediment

Unfortunately, there are not enough hydrogen producers in existence today to fill the needs of the burgeoning hydrogen fuel cell industry at scale. Even if there were, there are significant costs and ecological difficulties in producing and transporting the gas.

There is also a lack of hydrogen infrastructure for distributing hydrogen onboard trains and even at depots, stations and rail yards. And although the US, EU, and China each have proposals on the docket or initiatives in place, mass deployment of hydrogen fuel cells as a clean energy source could be adversely affected by the execution of said proposals and initiatives.

Methanol, on the other hand, is already widely produced and accessible for transport to wherever it is required, making hydrogen production – and subsequent FC refuelling – simple, quick, and cost-effective.

RIX Industries' M2H2 generation systems enable 5x greater storage capacity over 350 bar (5076 psi) compressed gas systems at roughly one-third of the price. For liquid hydrogen storage, an M2H2 generation system is less than half the cost of liquid hydrogen delivery/storage © RIX Industries



The Golden Ticket

Methanol-to-hydrogen (M2H2) reforming technology addresses the hydrogen storage issue by offering the highest volumetric density while providing the lowest cost-generation and best logistic storage solution compared to high-pressure gas or liquid hydrogen options. M2H2 generation systems enable 5x greater storage capacity over 350 bar (5076 psi) compressed gas systems at roughly one-third of the price. For liquid hydrogen storage, an M2H2 generation system is less than half the cost of liquid hydrogen delivery/storage.

With the capability to generate pure hydrogen (99.97%) onboard and on-demand, these systems offer users a safer and smaller onboard volume requirement as compared to high-pressure compressed hydrogen solutions. They also eliminate the heavy and costly footprint of cryogenic liquid hydrogen storage.

The M2H2 methodology incorporates proven methanol fuel reforming technology to generate hydrogen. As self-contained containerised power systems, methanol-to-hydrogen generation technology is integral to the proton exchange membrane (PEM) fuel cell – providing a high-efficiency, minimal vibration and noise, low-emission solution for power-critical applications including rail and other transport applications such as marine and air. With container-based systems for hydrogen generation, manufacturers have the means to address design challenges that can vary based on type of vehicle, routing, geographic conditions, and availability of technology and infrastructure.

The M2H2 power system is also scalable and supports 30kW up to MW fuel cell solutions. Deployment does not require major retrofit of station-based rail infrastructure; existing diesel tanks can instead store liquid methanol at ambient conditions as a feedstock. This removes the complexities and trepidations of onboard hydrogen management, which have long been a roadblock for the rail industry. These highly efficient power systems provide train manufacturers and rail operators with a path to next-generation performance – eliminating the impact of environmentally damaging diesel-based engine systems.

Diesel Is Out – Hydrogen Is In

While diesel fuel has powered the rail industry for nearly one hundred years, its days are numbered. Steam reforming of methanol to fuel cell grade hydrogen via M2H2 provides a low-emission solution meeting strict environmental fuel regulations – no NOx, SOx, or PM. Additionally, the M2H2 emits 30 to 50 percent less CO2 than diesel engines. (The M2H2 can achieve net-zero emissions using renewable methanol.) Methanol is relatively less harmful to the environment than diesel fuel. A clear, colourless liquid, methanol is fully miscible in water. If the train were to leak methanol on a bridge over a river, for example, the fuel would completely dissolve and biodegrade in the water. In contrast, a diesel engine in a similar scenario would set off an environmental crisis.

Mobile hydrogen generation gives train manufacturers the edge in meeting green initiatives ahead of schedule. It simplifies the transportation, storage, management, and deployment of onboard hydrogen – a breakthrough in the quest for clean power and one that can be implemented in existing rail vehicles and those built in the future.

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