

[Home \(/\)](#) / [Other renewables \(.../.../\)](#) / [25 November 2020 \(.../\)](#) / [Green hydrogen generation from municipal waste](#)

Green hydrogen generation from municipal waste

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Since the construction of the suspended railway in the late 1800s, Wuppertal in Germany has been pioneers in transportation, with the Schwebebahn still in operation today. Once again, Wuppertal is putting themselves on the map for their innovative approach to mobility, with the implementation of a fleet of fuel cell electric buses, powered by the green hydrogen generated from the incineration of municipal waste.

Driving towards decarbonisation in the urban transport sector

1000 buses operate in the region and it is pivotal that they make the switch from diesel to hydrogen, to preserve the environment. As of 2019, the first A330 FC fuel cell and hydrogen-powered buses arrived in Wuppertal, with more arriving in 2020. For every 10 FCEBs on the road, approximately 700 t of carbon dioxide emissions from diesel fuel combustion can be eliminated per year. With an overall project budget of €12 million, over half will be spent on purchasing FCEBs and the rest will be invested in hydrogen production, storage, and fuelling systems. The hydrogen comes from a 1.25 MW electrolyser, sourced from Hydrogenics. The PEM technology is essential to ensure that the hydrogen is free from impurities, to avoid the unnecessary degradation of the fuel cell catalysts, which would decrease performance. Also, the technology is perfect for this application where the electrolyser needs to start up and shut down frequently when the local electricity demand is low. This results in a minimised 'stress' level and ensures an environmentally and economically sustainable operation. Integral to the design is a high-pressure hydrogen gas buffer storage, with capacity of 425 kg, enabling faster fuelling of multiple buses in rapid succession and allows the electrolyser to run intermittently when the cash value of exporting electricity to the local grid is low.

Energy density for efficient mobility

The gas compression system and fuelling dispensers for the hydrogen supply have been manufactured by Maximator GmbH, which has played a leading role in this project. Maximator has interests in high-pressure testing, components, and hydraulics. Its fuelling station utilises two stages of hydrogen compression with a gas intercooler between the stages. In the past, changing out the gasket was a time-consuming process that meant the fuelling station must be taken offline for several days. For pilot stations, that has been tolerated either by the acceptance of the downtime or the use of a second fuelling station to build redundancy into the system – at a significant cost. However, as hydrogen refuelling stations become an integral part of our mobility infrastructure, they must compete with traditional gasoline pumps and offer at least 99% availability. Therefore, it holds multiple high-pressure sealing gaskets that are automatically loaded into the hydrogen fuelling station gas compressor and to fully automate

the process a sensitive hydrogen gas detection system is employed. This is to measure leakages and determine the optimal timing to change the gasket.

Green hydrogen from green electricity

The electrical power required for the PEM electrolyser will be generated from combusting approximately 100 tpd of municipal waste. Only the Restmüll – the most difficult rubbish to dispose of – is used as feedstock to the waste incinerator. This waste has a biomass content of more than 50%. Although this process releases greenhouse gases, carbon dioxide emissions trading (using a more sustainable source of electricity to power the electrolyser instead of burning fossil fuels) means that the electricity generated from the Wuppertal waste incinerator can be labelled as 'green'. Put in operation in 1976, the plant was purpose-built for power generation from the combustion of municipal solid waste. Every year, around 400 000 t of waste is burned in the AWG Wuppertal waste incineration power station. This represents a significant contribution to a positive carbon dioxide balance because the operation of the waste power plant saves immense amounts of fossil fuels and therefore reduces the overall environmental impact. The flue gas scrubber contains a bank of filters to ensure that the power plant's emissions are normally less than 10% of the legal limit.

Prize-winning innovation

Wuppertal was rewarded for its hard work, winning the North-Rhine Westfalia state competition for hydrogen mobility on 15 October 2020. In doing so, they obtained the title "Model Region for Hydrogen Mobility". During acceptance of the prize, Wuppertal Municipal Works CEO, Markus Hilkenbach said, "when implemented correctly, sustainability must represent added value for our customers and urban society as a whole. Our hydrogen buses not only run without CO₂ emissions; thanks to the electric drive they also cause hardly any noise. That is also an important factor for residents".

Contributed by Stephen B. Harrison and Daniel W. Harker, sbh4 GmbH.

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