BALLARD™

CASE STUDY

Fuel Cell Zero-Emission Buses for Pau, France

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Situation

France has recognized the importance of zero-emission transportation as mobility continues to be a key contributor to air pollution and increasing CO_2-emissions. In order to meet the goals of the Paris Agreement, governments in France are including hydrogen in their energy transition plans, emphasizing hydrogen mobility in a number of regions. The French government has also set a mandate for French cities to replace polluting diesel buses with cleaner alternatives.

The Pau-Béarn-Pyrénées urban community in France has been carrying out an Air Energy Climate Plan for its territory since 2016, which among other elements, focuses on transforming the city's public space by promoting and implementing zero-emission public transport opportunities.

Solution

In January 2017, the city of Pau issued a public tender for the procurement of eight 18 meter articulated buses to provide zero-emission sustainable transportation on its BHNS ('high level of service') bus routes. Both BEB (battery electric buses) and FCEB (fuel cell electric buses) solutions were evaluated. A customer analysis found that a BEB solution would have required the purchase of more vehicles to service the same routes. In fact, to meet the operational requirements, 10 BEBs with on route charging and 14 BEB with overnight depot charging, In comparison, the same service could be provided by just 8 FCEBs with depot refueling. Considering the number of vehicles and the overall infrastructure cost, the BEB and FCEB solution cost estimates were very similar for both capital expenditure and operating expenses.

In the end, Pau selected 8 FCEBs based on their ability to satisfy the city's operational requirements such as flexibility to extend the route at certain periods, resilience to potential energy infrastructure failures and securing range margin while under additional energy-demanding constraints such as a particularly cold winter/hot summer.

Site	**Pau-Béarn-Pyrénées, France**
Application	**The world's first 18 metre 100% hydrogen BRT service**
System	**100 kW FCveloCity®-HD fuel cell integrated into Van Hool tram-buses**
Fuel	**Green hydrogen provided by GENVERT (ENGIE subsidiary) using ITM electrolyzer**
Objectives	**Replace diesel buses with a zero-emission alternative**

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Fueling

To launch the innovative bus line, the city built a station to produce and distribute hydrogen fuel. GNVERT, a subsidiary of ENGIE, constructed and operates the hydrogen refueling station for the tram-buses, which produces 174 to 268 kg of hydrogen a day. The station has a distribution system which allows for eight buses to be automatically supplied with hydrogen at the same time, a world first for that kind of installation.

Hydrogen fuel offers a future-proof, scalable refueling solution well adapted to transit bus operators requirements, and in accordance with the energy strategy of France.

The hydrogen is generated onsite from water using an electrolyzer. In the near future, the power for the electrolyzer will be provided by nearby solar panels. With no emissions generated by the production of hydrogen or produced by the buses, this is a truly zero-emission transportation solution.

Distance Travelled	**>200,000 km. since December 2019**
Refueling time	**Night refueling 30 minutes**
Availability	**The tram buses ran with a 97% availability on a 6km route**

Result

Van Hool was selected to supply eight ExquiCity tram-buses (Fébus), powered by Ballard's FCveloCity®-HD 100-kilowatt fuel cell modules. These first ever fuel cell-powered tram-buses were delivered to Pau in 2019 and are being operated by the STAP (Société de Transport de l'Agglomération Paloise). The hybrid tram-buses use fuel cells for primary power and lithium batteries for additional power when needed, with the only emission being water vapour. To meet operational requirement and budget constraints, simultaneous refueling infrastructure has been selected. It takes approximately 30 minutes. This is slightly longer than the standard fuel cell bus refueling time of 10 to 12 minutes, but much shorter duration that overnight charging of battery electric buses.

The Fébus has been specially created for the city of Pau by Van Hool and haute-couture art director, Julian Gaubert, who used to work for Maison Courréges. Each tram-bus is over 18 meters (60 feet) long and has a capacity for 145 passengers. The hydrogen fuel cell technology enables each Fébus to cover more than 300 km between hydrogen refuelings.

As of January 2021, the fleet had already travelled more than 200,000 km. The buses operate 7 days a week at 97 percent availability (fuel cell modules 98%) on a 6 km long dedicated route.

Pau's FCEB fleet will benefit from the proximity of Van Hool and Ballard's European Service Center which provides service, training, onsite support, diagnostics and spare parts in order to ensure increased availability of the buses.

Result cont'd

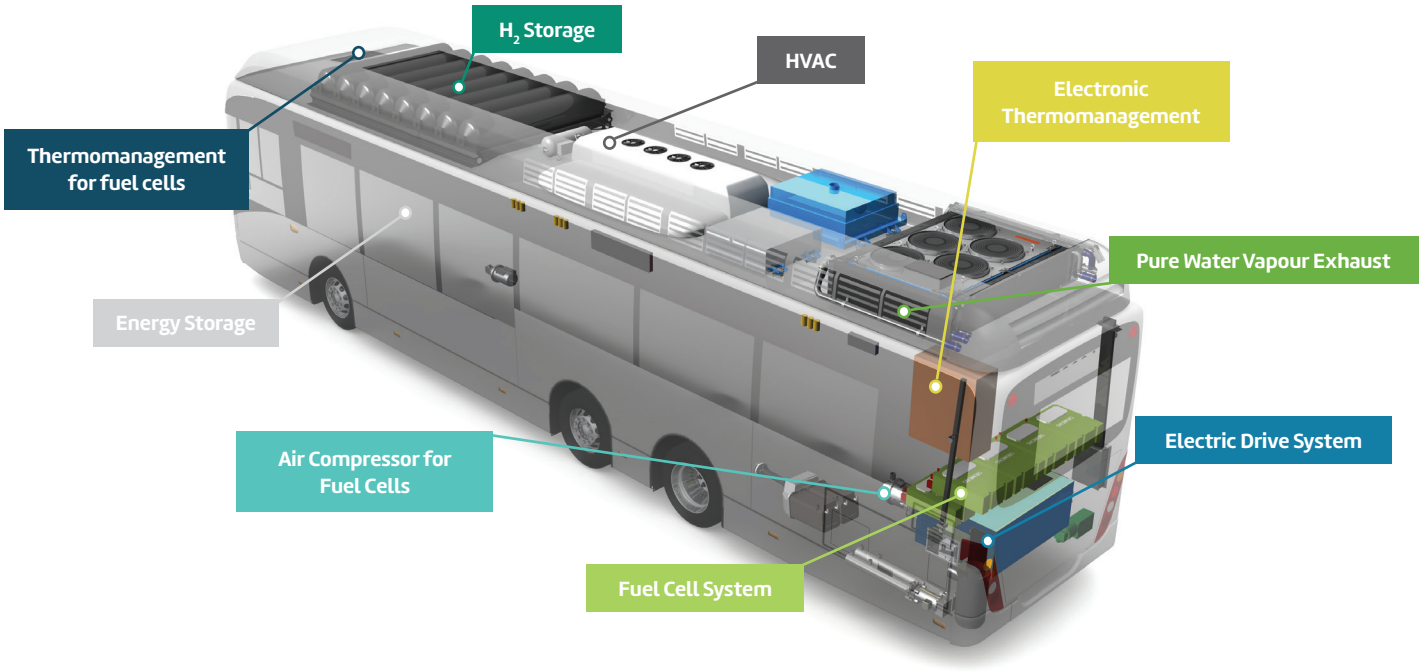
Fébus has received accolades commending the success of the project and has already won a number of prizes including: "The Energy Transition Trophy" in the "Sustainable Transport" category in 2018, the "Grand Award Bus" in 2019 and recently the Fébus was awarded the "Prix du Service de transport aux voyageurs" which goes to a project or community having developed an innovative solution in the field of hydrogen.

The 8 buses are all co-financed by the Fuel Cells and Hydrogen Joint Undertaking (FCHJU), 3 in the framework of the 3Emotion project and 5 in the framework of the Jive 2 project.

Zero Emission Bus Technology

A fuel cell bus is an electric vehicle that uses compressed hydrogen as the fuel, rather than storing energy in large batteries. Fuel cell power modules onboard the bus generate electricity through an electro-chemical process, producing only water and heat as by-products. The electricity generated by the fuel cells powers the hybrid electric motors and charges the energy storage system. Regenerative braking on the buses increases the fuel economy. High pressure tanks located on the roof of the bus store hydrogen fuel, providing sufficient range for a full day of operation.

Fuel cell power modules onboard the bus generate electricity through an electro-chemical process



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