Development of Business Cases for Fuel Cells and Hydrogen Applications for Regions and Cities

FCH Airport ground handling equip.

Brussels, Fall 2017

This compilation of application-specific information forms part of the study ***"Development of Business Cases for Fuel Cells and Hydrogen Applications for European Regions and Cities"*** commissioned by the Fuel Cells and Hydrogen 2 Joint Undertaking (FCH2 JU), N° FCH/OP/contract 180, Reference Number FCH JU 2017 D4259 .

The study aims to **support a coalition of currently more than 90 European regions and cities** in their assessment of fuel cells and hydrogen applications to support project development. Roland Berger GmbH coordinated the study work of the coalition and provided analytical support.

All information provided within this document **is based on publically available sources** and reflects the **state of knowledge as of August 2017**.

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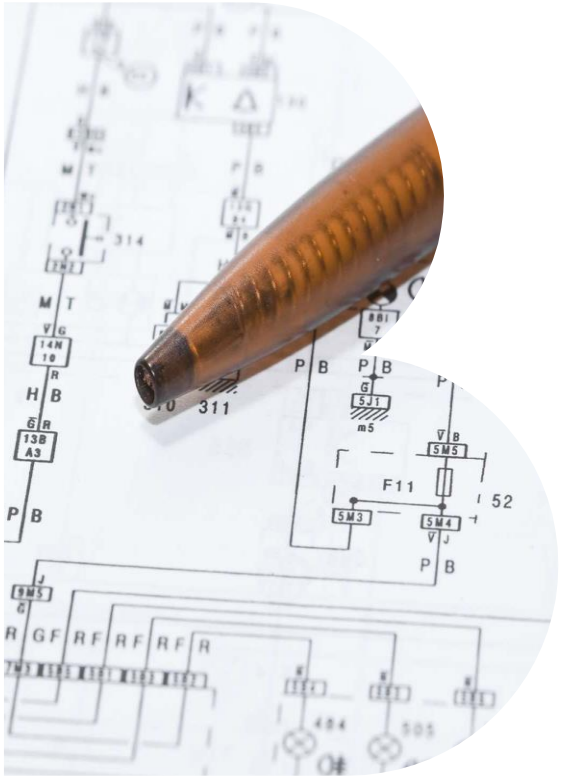
A. Technology Introduction



A

Aircraft ground support equipment constitutes an entire ecosystem with numerous potential use cases for fuel cell applications

Fuel cell powered aircraft ground support equipment (GSE) 1/4

Brief description: Fuel cell powered aircraft ground support equipment (GSE) use compressed hydrogen gas as a fuel to generate electric power via an energy converter (fuel cell); the produced electricity powers an electric motor; ***various GSE is in use at airports which constitutes an entire ecosystem – numerous potential use cases***

Use cases: Cities and regions can use/promote fuel cell aircraft ground support equipment to reduce emissions and noise pollution as well as health and working conditions for workers and travelers

Fuel cell powered ground support equipment (GSE) [1)]

Key components	Fuel cell stack and system module, hydrogen tank, battery, electric motor
Output	20kW
Max. speed	25 km/h
Fuel	Compressed hydrogen (CGH2) at 350 bar
Refuelling interval, time of charging	8 hours, 3-4 min.
Approximate capital costs	n.a.
Original equipment manufacturers	Mulag Fahrzeugwerk, Charlatte
Fuel cell suppliers	H_2 Logic, Ballard Power Systems, Plug Power
Typical customers	Airport operators, logistics companies
Competing technologies	Diesel, LPG, CNG, battery electric

1) Based on towing tractor "Comet 3 FC" by Mulag

Source: Roland Berger

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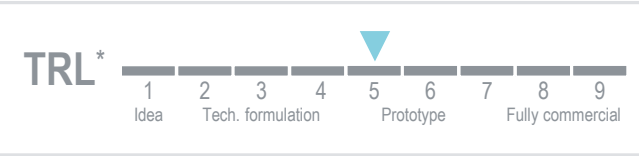
Until now, only few prototype demonstrations available – technology to be further tested to prove technological readiness

Fuel cell powered aircraft ground support equipment (GSE) 2/4

Overall technological readiness: Prototypes developed, demonstration projects in operational environment complete or ongoing (albeit mostly outside Europe)



Demonstration projects / deployment examples (selection)

Project	Country	Start	Scope	Project volume
Department of Energy (DOE) ground support equipment demonstration		2013	Phase 1: Development of fuel cell system for cargo tractor application Phase 2: Demonstration of 15 fuel cell powered cargo tractors in airport operation Partners: FedEx, Plug Power, Charlatte, Memphis-Shelby County International Airport	EUR 4.2 m
HyLIFT-DEMO and HyLIFT-EUROPE		2012	Large scale demonstration of material handling/GSE with the participation of Mulag towing tractors with a Comet 3 FC prototype. Trials at Hamburg and Cologne/Bonn airports and performance testing at Mulag's premises in Oppenau, Germany	EUR 22.3 m[1)]
Department of Energy (DOE) Small Business Innovation Research Program		2011	Department of Energy has selected InnovaTek to receive a Phase I award under its Small Business Innovation Research Program for development of a fuel cell range extender for battery-powered airport ground support equipment. InnovaTek will collaborate with EnerFuel, a fuel cell developer, and JBT AeroTech, a GSE manufacturer	EUR 130,000

1) Also includes other material handling equipment than towing tractors
*) Technology Readiness Level ▼ ≤ 5 ▼ 6-7 ▼ 8-9

Source: Roland Berger

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Significant environmental benefit potential – synergies between the various GSE could contribute to cost-effective hydrogen supply

Fuel cell powered aircraft ground support equipment (GSE) 3/4

Use case characteristics

Stakeholders involved

> Airport operators and specialized ground handling companies
> Airport authorities
> OEM s

Demand and user profile

> Range, performance and refueling service offerings ideally similar to conventional GSE
> 24/7 operations in 3 shifts

Deployment requirements

> Hydrogen storage and refuelling infrastructure
> High safety standards for hydrogen storage and transportation

Key other aspects

> Fuel cells automatically shut off when not needed, no idling required

Benefit potential for regions and cities

Environmental

> Zero carbon and greenhouse gas (GHG) emissions
> Low noise pollution
> Reducing overall environmental footprint of airports

Social

> Higher standard of living in areas near airports which are significantly polluted by noise and emissions
> Improved public consent for airport infrastructure
> Health benefits for workers and passengers through reduced noise and pollution

Economic

> Fuel Cells are twice as efficient as diesel engines
> No investment into electric infrastructure needed compared to battery electric fleets
> As airports comprise an entire ecosystem, it is easier to generate a critical mass of hydrogen vehicles and applications for efficient and cost-effective hydrogen supply

Other

> Depending on the production type of hydrogen, reduction of dependency on fossil fuels or energy imports

Source: Roland Berger

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Technological readiness, product cost as well as hydrogen supply as critical issues to increase fuel cell applications in airports

Fuel cell powered aircraft ground support equipment (GSE) 4/4

Hot topics / critical issues / key challenges:

> **Technological readiness and system/product definition** (until now, only proof of concepts and prototype demonstration projects; very specific operational requirements regarding the various potential use cases of fuel cells for ground support equipment)

> **Product cost** (capital expenditures expected to be significantly higher than for equipment powered by diesel and other fuels; business case highly dependent on fuel prices with airport operators requiring a positive return on investment)

> **Hydrogen infrastructure** (availability of distribution logistics, local storage and refuelling stations must be ensured; adequate location inside or outside the airport must be found)

> **Environmental sustainability** (well-to-wheel emissions largely depend on resources used in hydrogen production)

> **Training of workers** (usage as well as storage of hydrogen; behaviour in case of emergencies)

Further recommended reading:

N/A

Key contacts in the coalition:

Please refer to working group clustering in stakeholder list on the share folder

https://sharefolder.rolandberger.com/project/P005

Source: Roland Berger

B. Preliminary Business Case

Airport services are a complex ecosystem with multiple types of equipment – Potential for FCH applications in transport and energy

Snapshot of airport ground service ecosystem and FCH opportunities (selection)

	Description	Selected independent players
1 Ground handling	> **Ramp handling:** aircraft loading & unloading, marshaling, pushback, towing and repositioning, aircraft cleaning, toilet/water, … > **Passenger handling:** passenger check-in, ticketing, boarding, security and pre-board screening, … > **Cargo handling**	swissport, WFS Worldwide Flight Services, Menzies Aviation, ASIG BBA Aviation, dnata, AVIAPARTNER
2 Catering	> **Food design and production** > **Food handling:** supply logistics, loading, backflow management, … > **Inventory management:** food, tableware, …	LSG Sky Chefs, gategroup, SERVAIR, sats, DO&CO, dnata, newrest
3 Others	> **Other handling services:** de-icing, fuelling, … > **Other passenger services:** lounge management, limo services, … > **Facility management:** e.g. distributed energy supply – stationary applications…	WFS Worldwide Flight Services, Skytanking, Shell

XXX = Potential for FC applications

Source: Roland Berger

Towing tractors are one of the most advanced airport ground handling equipment with fuel cell technology so far

Use case and application characteristics

INDICATIVE

Description

> Fuel cell powered airport ground handling equipment use **compressed hydrogen gas as a fuel to generate electric power** via an energy converter (fuel cell); the produced electricity powers an electric motor

Technical characteristics

> **Technical characteristics vary greatly** according to type, size and function of the specific equipment

> **Smaller vehicles** like luggage trucks, ACU, baggage loaders, water trucks and small fuel tank trucks **with energy requirements of less than 20 kW are most suitable** for FC applications in the medium-term

> FC towing tractors are currently one of the furthest developed FC ground handling equipment (towing capacity ~1,700 -2,200 kg, driving speed ~20-27 km/h) and require a ~17-22 kW engine, they need to be refuelled for 3 to 4 min once per working shift

Competing technologies

> Diesel, Battery-Electric, Diesel-battery hybrid, CNG/LPG

Sources: Industry publications, Mulag, Eurocontrol, Roland Berger

Airports have high security standards and are very cost-sensitive – the implementation of demonstration projects is a major challenge

Business case and performance overview – PRELIMINARY & INDICATIVE

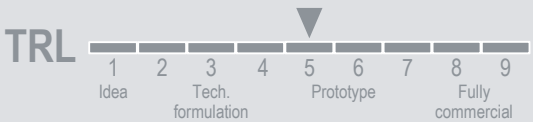
Technical/operational

> **Prototypes have been developed** for selected ground handling equipment

> Demonstration projects in operational environment are either completed or ongoing (albeit mostly outside Europe)

> **FC ground handling equipment is not commercialized yet**, successful demonstration projects in Europe need to be accelerated first

> **Challenges**: high airport security standards possibly impede the initiation of demonstration projects and the successful granting of regulatory permits, esp. for refuelling infrastructure



Economic

> **FC ground handling equipment demonstrates high system efficiency** and is low in maintenance- and operating costs

> **High CAPEX costs** are a big challenge to the cost-sensitive aviation industry

> **Key business case drivers**:
  - Cost of hydrogen vs. cost of diesel or electricity (in case of BEV competition)
  - System CAPEX
  - Infrastructure costs (esp. considering potential permitting challenges of implementing hydrogen refuelling and storage infrastructure in airports)

Environmental

> **Zero tailpipe (i.e. tank-to-wheel) emissions** of CO_2, pollutants such as NO_X and fine dust particles as well as significant noise reduction for FCH airport ground handling equipment – key benefit for workers and passengers as well as outside environment

> Well-to-wheel CO_2 emissions depend on fuel source, use case characteristics and efficiency (i.e. fuel consumption) – **potential for zero well-to-wheel emissions for FCH airport ground handling equipment with "green hydrogen"**

Source: Roland Berger

Hence, governmental authorities need to path the way by supporting permits for hydrogen applications

Key considerations concerning fuel cell airport ground handling equipment

> **Authorities place increasing importance on decarbonisation and emissions reduction** and hence stimulate the development of zero-emission engines for airport ground handling equipment; additionally, **supranational regulations** from EU-level will require CO_2 monitoring and 'cap and trade' policies might be introduced in a second step

> **Necessary size/power ranges, capital cost and fuel supply** are among the major **hurdles** faced by airport operators wanting to adopt fuel cell ground handling equipment

> When **calculating total cost of ownership** for airport ground handling equipment, the **entire ecosystem should be taken into consideration** since hydrogen refuelling stations can be shared among multiple application cases

> Further **demonstration projects in Europe** will be necessary to **increase technological readiness and hence commercial availability** – governmental support will be necessary to bring technological changes to the highly regulated and security-focused industry

Source: Roland Berger

Please do not hesitate to get in touch with us

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Source: FCH2 JU, Roland Berger