Potential Impact and exploitation of results

During the course of this project new areas have been identified, where additional R&D activities are needed to secure a successful commercialization of the individual applications. The three applications in this project are each at very different maturity levels at the end of the Liquid Power project. Whereas Back-up Power products are closest to a commercial market , the Material Handling platform still has ways to go, and the Fuel Processing System is still quite far from the commercial market.

On-site hydrogen production can be one important step in the transition to a hydrogen-based infrastructure. Presently, the most cost-efficient way to produce hydrogen is via large-scale natural gas steam reforming plants. There is a large interest in the future for local production near to the end-users and with various feed stocks including methanol. The capacity of small-scale production unit's range from about 25 to 500 Nm^3/h of pure hydrogen. Capacities above 500 Nm^3/h can be met by conventional available systems.

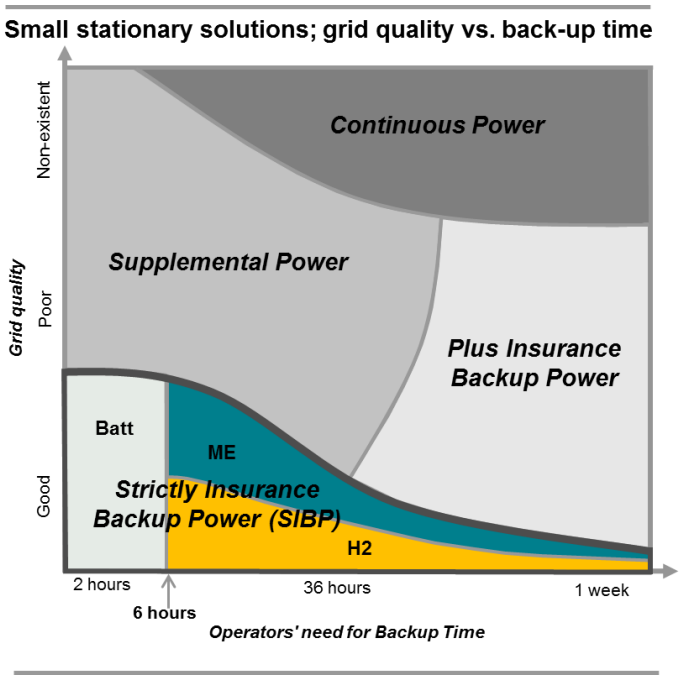
The functionality of the developed and evaluated methanol fuel processor system has been demonstrated successfully. The evaluation of the results shows plausibility with theory. The technology readiness level of the reformer system has been rated to TRL5 and for the PSA system to TRL 4, respectively. The full potential of the developed technology can be reached after further optimization of the system. The system can in the future fill the present technology gap between laboratory-scale systems and commercial available large-scale systems. This can be of the important steps for introduction of hydrogen-based infrastructure near to local end-users.

No patents are applied for the developed technologies in the project. PSA technology is a commercial available technology but mainly used in large-scale applications. The development and challenge in this project have been to design a small compact unit. We can't see any possibilities to apply a patent for the developed PSA unit. The pressurized reformer system is based on an atmospheric reformer concept. The main challenge has been to redesign the system from an atmospheric system to a pressurized system and to use methanol as a fuel. Catator already have some patents covering the use of mesh-based catalysts. These patents indirectly prevent competitors to use similar design solutions in the reformer and burner.

Patenting opportunities have been investigated in this project for the developed technologies in WP3, WP4 and WP5. All technologies have been found to be commercially available technologies. The development and challenge in this project have been to design or re-design a more robust, more reliable, more customer specific unit or product. No patenting opportunities have been identified.

Fuel cell based back-up power products are commercially up against current mature back-up power products on batteries or diesel generators. In certain market segments these current technologies used today have their shortcomings – batteries on short backup availability, short lifetime and environmental concerns regarding lead pollution and diesel generators being unreliable, requiring significant maintenance and generating both noise and heat and polluting emissions.

The following figure illustrates the commercial field where small stationary fuel cell systems are playing a competitive role, when these are used from backup power up to continuous power.



The customer segments with immediate relevance for fuel cell back-up power are:

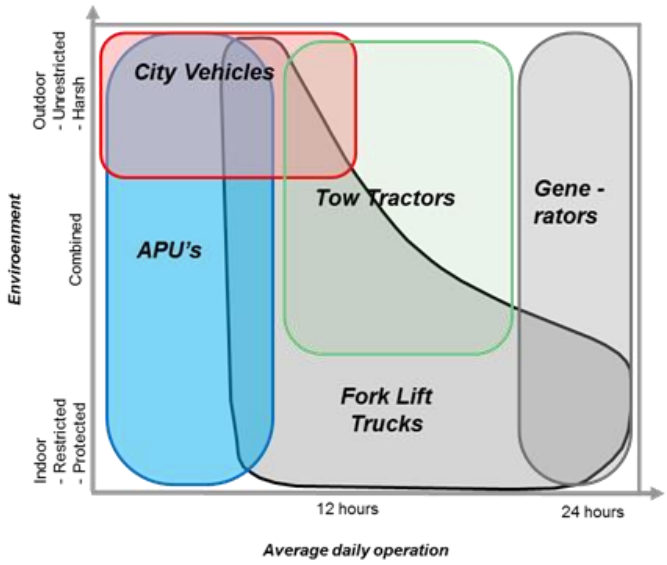
• Telecommunication – the need for reliable communication, especially for segments with users having special requirements (government, hospitals, banks etc.)
• Fiber broadband – the Fiber to The Home (FTTH) and Fiber to The Business (FTTB) segment where demands from the users can be very high
• Tetra – the special encrypted networks usually used by police, ambulance services, fire departments etc.
• Railways – the communication network along railways which is backbone for both data, cell phone network and lately also signaling

With marketing plans at hand for these early customers and the production facilities in place, the Scandinavian market is the first area, where the back-up power products of this project are introduced to customers and demonstrated in smaller trial projects for customer testing.

The material handling platform is targeting the following applications, where more and more electrified transport solutions for specialized services, reliable, robust and cost-efficient solutions are needed:

• Indoor material handling
• Urban material vehicles
• Underground vehicles
• Range extension to battery electric vehicles
• Airport vehicles

For these purposes the current technologies used today have their shortcomings – batteries on availability, short lifetime and environmental concerns regarding lead pollution and diesel engines generating both noise and polluting emissions, along with high temperatures.
The Small Motive segment is broken down into daily “Drive cycle”. The daily drive cycle tells about the hydrogen logistics challenge – the higher the use gets, the more critical the hydrogen logistics gets. On the other hand, the higher the use of hydrogen, the higher is the potential for CO2 savings.



For fork lift trucks and tow tractors, the main focus is cost savings, and as such the most relevant applications are high daily use in areas with restricted exhaust emissions, where batteries have challenges. For city vehicles and APU's, the main driver is often CO2 and in general emission reductions that are in focus, so these applications can be just as relevant for low and for high usage applications.

The first segment, where sales expectations are getting clear and concrete, is within the fork lift truck segment, where there is a good foothold with prototypes since 2010. Due to the need for technology improvements and cost reductions, and due to long sales cycles within this segment, the sales are expected to take off around in early 2018. This timeline also allows for more cost reductions also in the fueling infrastructure, which are of vital importance for the success of this product.

In Scandinavia meetings have been held with the biggest telecom and broadband industrial players, where the back-up power product and project results have been presented. These industrial customers are large and the decision process to change to a new technology of such strategic importance as back-up power supply takes a long time. Therefore, several visits are needed and products are offered for customer testing.

Similar activities have been conducted for Material handling systems. However, the target group is vehicle manufacturers and not end users, as is with back-up power products. The most relevant European based material handling manufacturing companies have been approached. The project results have been presented and good contacts have been established for further dialogue on how to proceed towards further cost reduction and optimization of fueling infrastructure. The cost challenges of the latter seem to constitute a general barrier for customers interested in fuel cell based material handling technologies. This is reflected in the vehicle manufacturer's interest in the technology only, if the fueling infrastructure can be solved cost effectively for the end customer.

Dissemination

The dissemination activity in the Liquid Power project was pursued through scientific publications in the form of articles, presentation, posters and brochures and through market focused networking and commercial customer oriented business meetings.

For the commercially most mature products of Back-up Power and early Material Handling systems, the results of this project have been disseminated through the product marketing material (data-sheet) and presented at national at international fairs targeting these particular applications (telecom and material handling).

BALLARD
PUTTING FUEL CELLS TO WORK

FCgen®-H2PM

Hydrogen-fuelled, Stationary Backup Power
1.7 kW - 5 kW

Description

Ballard Power Systems offers complete direct hydrogen backup power solutions designed for telecom and related networks applications. FCgen®-H2PM systems are clean, reliable, quiet, economical and have been deployed worldwide for critical backup power applications.

Ballard's FCgen®-H2PM systems use hydrogen fuel cell technology with a fully integrated power management system and can be configured as either integrated or standalone modules. These systems are best suited for short duration runtime applications, requiring infrequent backup power for short periods of time (relatively lower total kW hours), or for temporary use, providing continuous power over a range of kW hour requirements.

Features

Low operating cost - High efficiency and optional external hydrogen storage for extended run backup power solutions requiring inspection only once per year and maintenance only every 3rd year (two air filters)

Reliable backup - Simple modular system design with few moving parts and optional UltraCaps for 'Battery Free' solution

Modular and flexible solutions - Indoor and outdoor installation - 19" rack mountable (telecom standard) with backup and UPS configuration, multiple systems can be connected in parallel for higher power applications up to 30 kW

Temperature range - Suitable for operation in extreme climates

Environmental - Zero emissions, with low noise and no vibrations

Ease of use - Remote monitoring allows the customer to monitor fuel volume, performance data and control system operation and hydrogen cylinders permit easy swap for refueling

Compact footprint – small imprint, quiet operation and low weight allows for flexible installation, scalable, modular systems for network growth

Introducing the new product and the new characteristics of cold climate endurance to existing and new commercial customers of back-up power products in cold climate areas targeted the Scandianvian market for Telecom Back-up power products. In this context several meetings in the form of networking were held with major Scandinavian stakeholder in the Telecom infrastructure segment with different commercial focus areas:

- Raising awareness of fuel cell performance in cold climate
- Pro-moting the new features in the product
- Sharing early customer experience with basic products through field demonstration in DK Networking

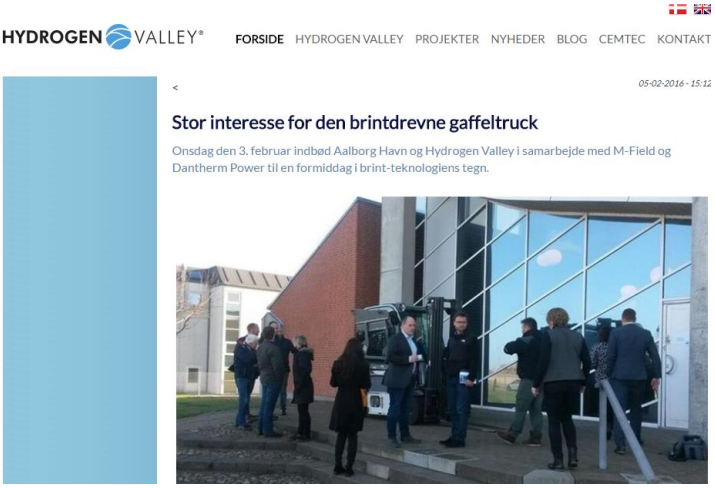
In the FCH-JU Programme review days 2013, 2014, 2015 and 2016 the projects activities were presented in the poster sessions. Below is the poster from 2015.

Towards the end of the project, the results and early commercialization activities drawing special attention also from the Danish Minister of Energy and Climate Mr. Lars Christian Lilholt, who visited the project with a delegation in april 2016.

Project results were presented during the following national and international events:

- Hydrogen Transportation Day 2016, September 2016, Copenhagen
- Danish Conference on Renewables and Energy storage, October 2016, Aalborg

Danish conference on Fuel cell MH vehicles for Harbors, Aalborg Habour, February 2016.



To disseminate the scientific knowledge along the project, one article has been published: