Deliverable 7.5 Recommendations for market deployment & commercialisation

Results of a survey on current and future market status of fuel cell powered material handling vehicles

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Acronyms and Abbreviations

CGH_2	compressed gas hydrogen
DOE	US Department of Energy,
FC	fuel cell
FCH JU	Fuel Cell and Hydrogen Joint Undertaking
GHG	greenhouse gases
H_2	hydrogen
LBST	Ludwig-Bölkow-Systemtechnik GmbH
MHV	material handling vehicles
NREL	National Renewable Energy Laboratory, USA

Executive Summary

Fuel cell powered material handling vehicles (FC MHV) have been considered as attractive early market applications to demonstrate the advantages of fuel cell technology. Fuel cells to power MHV lowers operational costs, produces zero emissions and improves reliability and working conditions. In addition the need for large battery storage and charging rooms, freeing up valuable production space and removing any lead and sulphuric acid contamination from the work environment complement the technical advantages. Since battery charging is no longer required, total electricity demand is reduced and the fees associated with battery recycling and disposal are eliminated.

The HyLIFT-EUROPE project funded by the Fuel Cell and Hydrogen Joint Undertaking (FCH JU), started in 2013 and builds on the ambition of the HyLIFT-DEMO project that was concluded in 2014, to develop and test an increasing number of fuel cell powered forklift trucks and install the necessary hydrogen refuelling infrastructure.

This Deliverable 7.5 of the HyLIFT-EUROPE project is part of Task 7.5 Recommendations for market deployment & commercialisation of FC MHV) addressing two tasks:

- 7.2.1 Development of suggestions for deployment support mechanisms on European/national/regional level.
- 7.2.2 Report on recommendations for the commercialisation of fuel cells in the material handling sector.

This report includes an overview of the most recent developments in Europe and the US and the results of a dedicated survey that was sent out to the project partners as well as to HyPulsion and Colruyt, a large supermarket chain in Belgium, between November 2014 and April 2015 to inquire about current status and recommendations for market deployment support schemes that potentially can be implemented on European, national and regional level across Europe, similar to schemes in the U.S.

The report hopes to contribute to a comprehensive and evidence-based insight in the conditions that could further facilitate the uptake of European manufactured FC MHV in Europe and the rest of the world

The report will be disseminated to key stakeholders and enablers to facilitate support of regional, national and European support for FC MHV commercialisation activities.

1 Introduction – The HyLIFT-EUROPE Project Context

The HyLIFT-EUROPE project was designed to build on the learnings of its predecessor, the HyLIFT-DEMO project that started in 2010:

- Ensure appropriate fleet size; at least about 25 MHV in multiple shift operations;
- Identify a local source of hydrogen to reduce costs;
- Use existing authorisation examples of other HRS to speed up procedures;
- Essential for successful roll-out: fast and reliable authorisation procedures for construction and operation of hydrogen refuelling stations and MHV common all over Europe;
- Targets for greening local logistics operations should consider both indoor and outdoor operations;
- Ensure time for training and instruction of operators.

During the HyLIFT-DEMO project it became clear that the incentives for FC MHV in the USA, namely a subsidy to cover part of the cost of the fuel cell, ignited a significant faster uptake of FC MHV across the Atlantic than in Europe.

However several initiatives over the last two years indicate that logistic operators in Europe have become increasingly interested in low emission, flexible, time and money efficient solutions. Although the winners of the first Toyota Material Handling Europe design contest in 2014 did not include FC powered entries, this might already change in this year's competition (deadline October 18, 2015!).

This chapter is providing an overview of recent developments in the uptake of FC powered MHV in Europe and the USA.

1.1 FC MHV activities co-financed by the FCH JU

- **SHEL**: Sustainable Hydrogen Evaluation in Logistics. This project has been terminated in 2012. Its aim was to demonstrate the market readiness of Fuel Cell Hydrogen powered (FCH) materials handling vehicles, hydrogen refuelling infrastructure and end user acceptance to accelerate early market take-up of Fuel Cell Hydrogen Fork Lift Trucks (FCH FLTs) in Europe. The project planned to demonstrate 10 units of 1.5 -2.5 ton FCH FLTs and hydrogen refuelling infrastructure across 3 sites in Europe: UK, Spain and Turkey. The project also looked at examining the production of the forklift and benchmarking FCH and FLT system components. As one of the lead partners ceased to exist, the project could not be continued.

- **HAWL Hydrogen And Warehouse Logistics:** aims at demonstrating competitiveness, technical maturity and user acceptance of hydrogen fuel cell powered forklift trucks fleets in a logistics warehouse environment in Europe, as an alternative to battery powered trucks operation. The particularity of this project is that the end-user has been part of the consortium since the beginning of the project. At the beginning of March 2015, the 6 months - test phase has started in a logistics facility near Orleans in France, with 10 hydrogen fuel cells powered forklift trucks in operation to demonstrate the productivity of the solution in comparison with the batteries. If the test is successful, further deployments should follow.
- **HyLIFT-DEMO**: the aim of the project, financed by the FCH JU, was to conduct a large scale demonstration of FC MHV, to enable deployment and market introduction starting no later than 2013. A 2-year demonstration included 30 units of 2.5-3.5 tons forklifts with a fully integrated 3rd generation fuel cell system, as well as a demonstration of a hydrogen refuelling infrastructure at 3 end-user sites throughout Europe. The project was finalized in 2014.

1.2 Feedback FCH MHV industry discussions in Germany

A workshop organized at the beginning of 2015 on the use of fuel cells in the automotive industry by ADV, the German airports organisation, included a discussion on FC MHV.

Participants included Daimler, BMW, VW, other materials handling vehicle suppliers, fuel cell system providers. Outcome of the discussion was that because the technology is not yet self-sustaining in the market, further promotion and subsidies are still needed. Otherwise break-even is hard to achieve.

Getting permission for the operation of hydrogen refuelling stations for materials handling vehicles is also still a burning issue, which has urgently to be solved, e.g. there is no consistent permission procedure in the different German states although it was mentioned that the ISO 20100, SAE 2601, TÜV Merkblatt might be applied.

1.3 FC MHV developments in Belgium

In November 2014 the European supermarket leader Colruyt Group announced that it will use 200 HyPulsion GenDrive units in its Halle, Belgium, facility. The units will be rolled-out in two phases: 75 units in phase one and 125 in phase two. Colruyt has operated FC MHV since 2012 and installed a H_2 refuelling station that recently has been upgraded to 70 MPa.

1.4 FC MHV status in France

In 2013, a demonstration has started at IKEA's logistic platform in Saint-Quentin Fallavier, near Lyon in France, with a couple of fuel cell powered trucks deployed. With a surface area of 100,000 m2, IKEA's distribution centre in Saint Quentin-Fallavier is a key warehouse for the upstream logistics of IKEA's stores in Southern Europe. 5 forklifts are currently operated in this building. 5 additional ones should be running onsite in autumn 2015.

FC MHV at IKEA, Saint-Quentin-Fallavier

In March 2015, FM Logistic, a French international logistics group, at the Neuville-aux-Bois logistics platform, located near the city of Orléans (France), started operating 10 forklifts, equipped with hydrogen fuel cells. Eventually, the site's 84 forklifts could switch to hydrogen, which would make it the first logistics hub in Europe to convert its entire fleet of forklift trucks to hydrogen.

In August 2015, the first European deployment of fuel cell hydrogen forklifts in a Greenfield site has started at Prelocentre premises, close to Orléans, in France. 28 forklifts are currently running on hydrogen as part of the HyLIFT-EUROPE project.

France over the last year also made significant progress in the HRS permitting process that could further support the use for FC MHV:

- The AFNOR M58-003 standard for hydrogen installations was published in 2014.
- Preliminary regulatory text for hydrogen refuelling stations circulated for information by DGPR (Risk Prevention General Directorate – regulation authority) to DREALs (Environment Regional Directorate – Permitting authority) in 2014.
- Operational information note circulated by DGSCGC (General Directorate for Civil Security and Crisis Management) to all (SDIS) (Departmental Fire Rescue Services) in 2014.
- Training sessions took place for fire brigades (using notably FCH-JU "HyResponse" material)

These developments have contributed to speed up significantly permitting process in France due to increased competency level of various stakeholders (18 months in 2012 vs. 3 months in 2014). Europe / FCH-JU should build on this basis.

1.5 FC MHV status in Austria

In March 2013, German Rail logistics operator DB Schenker saw the delivery of the first of ten pallet trucks with fuel cell hybrid drive as part of the “E-Log-BioFleet” research project coordinated by JOANNEUM RESEARCH. The project is co-funded by the Austrian Federal Minister for Transport, Innovation and Technology and was finalized in 2014.

1.6 FC MHV status in the USA

Already a leader in FC powered MHV, according to the 2014 edition of Business Case for Fuel Cells, the USA saw its first and largest customers of fuel cell powered MHV putting in the first repeat orders last year:

In July 2014, Walmart expanded on an already impressive order in February 2014 of 1174 fuel cells to power its fleet, to 2000 fuel cell powered trucks;

ACE Hardware is operating now 74 FC powered class-2 and class-3 lift and reach trucks in the US and Canada;

Central Grocers replaced a 234 fuel cell powered fleet of reach trucks, stand-up counterbalanced units and 31 sit-down counterbalanced units and center control pallet trucks, with 182 fuel cell trucks;

Kroger is replacing its 174 FC forklift trucks.

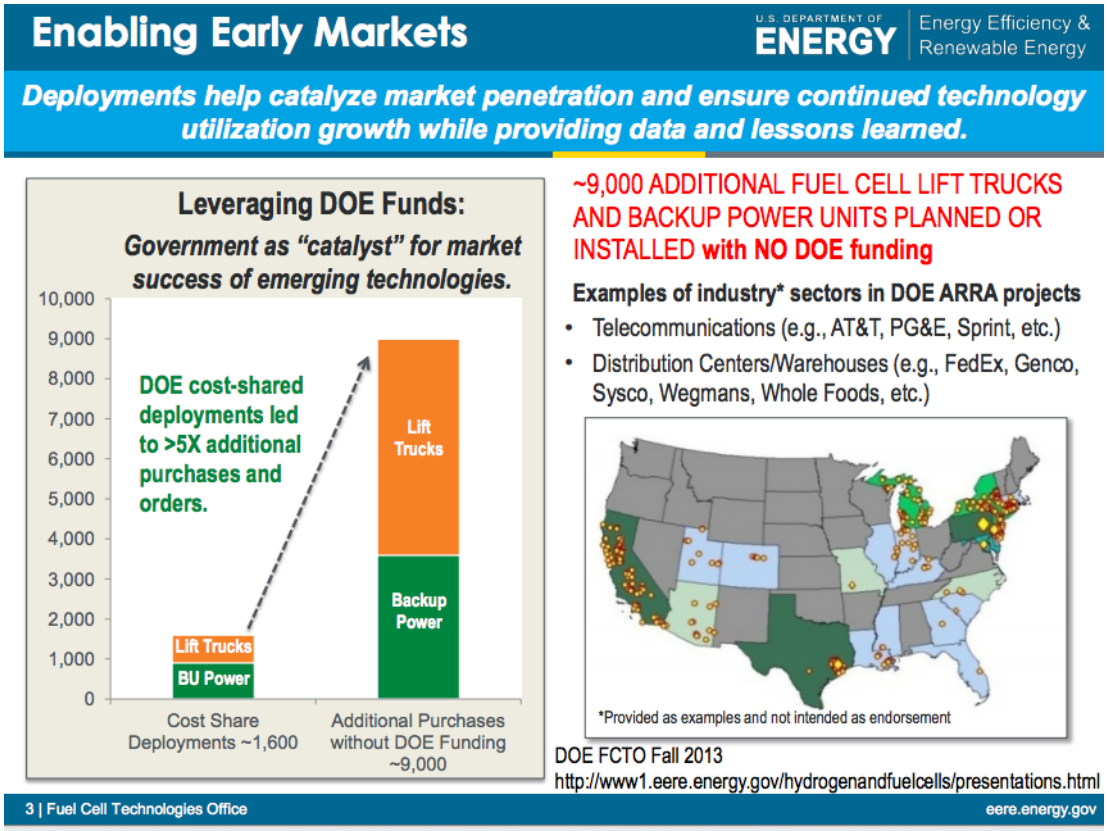
BMW has doubled its FC powered trucks in its US facility already in 2013 to 230 units.

In many of these locations hydrogen is produced using different sustainable energy sources; Walmart is using hydropower in Canada and BMW completed a landfill gas-to-hydrogen facility while using hydrogen as by-product of a sodium chlorate plant as well.

BMW USA, FC MHV

The US National Renewable Energy Laboratory, NREL, last FC MHV report of 2013 included as main conclusions:

1. The Department of Energy, DOE, cost-shared deployments led to five additional FC MHV purchases.
2. Compared to conventional fuelled MHV, FC MHV have
   - 1,5 times lower maintenance costs
   - 8 times lower fuelling labour costs
   - 2 times lower net present value of total system costs
3. See excerpt of the report on the next page.



2 Survey Methodology

As in Europe securing contracts for FC MHV proofed challenging in comparison to the US, it was decided to conduct a survey among the project partners and affiliated companies (HyPulsion) as well as first customers (Colruyt), to inquire about their perception of current market potential, necessary support mechanisms and other recommendations.

The survey questions were developed in close cooperation with the project's coordinator and partners and the following areas were selected:

1. Sales / use figures of relevant MHV market segments;
2. Specific market conditions that favour introduction of clean MHV;
3. View on current status/efforts in the market of MHV and more specifically FC powered ones in Europe and rest of the world;
4. Feedback (potential) first customers/ on introduction of FC powered MHV (quotes?);
5. View on current and future role/ support of FCH JU, useful outcome of previous FCH JU's FC MHV projects;
6. Feedback on support of pooling customers for MHV at national and EU level (joint procurement);
7. Specific recommendations for EU, national, local support for FC MHV deployment;
8. Other comments.

The survey questions were sent to individual project partners, HyPulsion and Colruyt and were followed up by a phone interview to ensure that questions were understood.

The responses were put into a power point presentation and sent first to the individual responder to confirm the correct transcript of their input.

A compilation of all responses was sent to all participants in power point with a request to comment on the final result. A compiled version in Word format was sent in August 2015 and sent to all partners for final review.

The following chapter includes the approved version of all responses by the project partners.

3 Results of the Survey

This chapter includes the integral responses of the participants to the survey questions, no selection has been made. The text has been adapted but only to make it more readable. The responses are anonymous.

3.1 Sales/ use figures of relevant MHV: number/ type of MHV

- Tow tractors: 2013 estimate: 200 – 300 units in Europe; total market: unknown (statistical figures are not publicly available). For tow tractors batteries are not the best option as loads and hauling distances are too large;
- Class 3 trucks: 260.000 units/a worldwide. Class 3 trucks are typically operated in larger fleets which enables viable H_2 refuelling station operation;
- Class 1 trucks: ~150.000 units/a worldwide. These trucks face often either emission limitations (ICE trucks) or performance limitations (battery trucks).

3.2 Specific market conditions that favour the introduction of clean MHV

1. Companies with intensive and efficient use of MHV, frequent battery change, high labour costs are predestinated to take benefit of the FC MHV solution;
2. Large fleets, in “demanding” 3-shift operation with high energy consumption are required for viable H_2 refuelling station operation;
3. Cold store operation (bad battery performance) and high ambient temperatures (high battery degradation) could be favourable conditions for FC MHV uptake;
4. Acceptable CAPEX / OPEX is defined by truck operating conditions; lower limit of MHV fleet size is defined by hydrogen fuel price at the nozzle;
5. Airports are forced by EU regulations to reduce emissions of their fleet, depending on the size of diesel vehicles; filters are difficult, some are changing to gas vehicles;
6. Plug and play solution of potential FC MHV suppliers would favour FC over batteries;
7. Competitiveness of the FC solution through optimal use of the subsidies;
8. Broader choice of FC suppliers is desirable;
9. Set up of FC MHV user platform is necessary: (foreseen in HyLIFT-EUROPE).

3.3 View on current status / efforts in market for MHV and more specifically FC powered ones in Europe and rest of the world

1. There is a delay in manufacturing of FC powered MHV in Europe;
2. FC MHV costs need not to be more than 10% that of diesel (MHV+FC</= diesel + 10%);
3. In some countries airports' procurement requirements favour low emission solutions;
4. H_2 Infrastructure remains a challenge and there is no business case yet for H_2 refuelling operations; outside financial support is needed to enhance deployments;
5. FC MHV meet technical requirements, thanks to important efforts of FC suppliers, financial requirements could be met by economies of scale;
6. The market is lacking equipment for small scale (=10 to 30kg/d) and cost competitive H_2 refuelling; US market is advancing over the one in Europe due to easy funding schemes and large MHV fleets;
7. With current status of development of FC and H_2 technology 10-15% of market of nearly all type of MHV can be equipped;
8. Customer feedback: there is lot of efforts on the FC supplier side, same efforts are needed form hydrogen supply and MHV supply industry.

The technology to deploy H_2 refuelling stations is ready!

3.4 Feedback (potential) first customers / on introduction of FC powered MHV (quotes)

1. FC trucks are advantageous due to avoidance of battery swap; time savings, health & safety;
2. FC MHV increase flexibility in operation due to fast refuelling;
3. High acceptance by truck drivers (improvement of the working conditions) who need however to be instructed on hydrogen safety;
4. Theoretical knowledge about FC technology exists in general, but less or no awareness exists inside logistic industry about availability of ready FC solutions for industrial use;
5. FC MHV are easy to handle;
6. Full performance over full cycle;
7. Cologne and Hamburg prototype testing received positive feedback: customers were happy, drivers experience no big difference in operation.

3.5 Your view on current and future role / support of FCH JU, useful outcome of previous FCH JU MHV projects

1. An enlargement / expansion of the industrial development and demonstration activities incl. H_2 infrastructure is required in order to identify and qualify application specific and competitive requirements such as lifetime, safety and maintenance criteria; FCH-JU should broaden the supplier basis for FC technologies in order to prevent a single suppliers situation on the market. Some large end customers aren`t allowed to use technologies with just a single source situation on the market;
2. FCH-JU should take care about the technology related portion and quality of value-added by Europe based funding beneficiaries;
3. FCH JU Demo projects are difficult to handle: administration is a burden;
4. Additional lobby for tax reductions is needed (as in the US) to have a better impact;
5. FCH JU subsidies should be spent to support the customer, i.e. facilitate the authorisation process (fund personnel hours needed for long authorization processes, even for bigger customers!);
6. Ensure that FC MHV suppliers provide plug and play trucks or retrofit of existing trucks;
7. During product development phases technology providers need funding to limit their financial risks as market does not yet exist; current FCH-JU consortium/call architecture fits with these phases;
8. Now that the technology is ready and the first large scale deployments should start, public funding has a key role to play to launch the market. FCH-JU financing does not allow to reach quickly the commercial phase for FC and H_2 deployment in the material handling market; during deployment phases, until mass production and densified H_2 infrastructure is in place, fuel cells and hydrogen compete with cheaper technologies; incentives are necessary to bridge the cost of ownership gap for end-users and to make the final solution attractive.

3.6 Your view on support of pooling customers for FC MHV at national and EU level (joint procurement)

1. Consortia with end users have not yet reached the market:
   - Focus has remained on technology development (HyLIFT-EUROPE);
   - Rigidity of FCH JU's Description of Work (DOW) blocks coping with real (unforeseen) material handling customers (HyLIFT-EUROPE);
2. Joint procurement adds additional complexity to already complex customer projects:

- End-users schedules do not match “calls” calendars; end users are requested to commit to the technology years before starting their project (HAWL).
- Commercial offers are complicated: as technology providers are not sure to succeed in the selection process, solution pricing is uncertain.
- Competing private end-users are not willing to be part of the same consortium.
- Administrative burden and English-only are a real issue for end-users.
- Mixing end-users and technology providers in the same consortium limits competition.

3.7 Specific recommendations for EU, national, local support for FC MHV deployment

1. Funding:
   - Direct end-user funding for fuel cell purchases (€/kW for instance) is needed;
   - Direct funding of infrastructure needs to go to end-user or H_2 supplier (fixed € amount or fixed € amount by size of infrastructure for instance);
   - Cash incentive (tax credit not possible at European level) could facilitate uptake;
   - Funding offices should be open all year long. No call for proposals and no selection based on scientific quality only;
   - Distribution at European and/or National levels; end users should organize competition.
2. Develop Europe-wide state of the art safety requirements for indoor-refuelling and FC MHV operation; communicate application specific state of the art of safety requirements for MHV (e.g. EN62282-4-101: 2014, etc.).
3. Promote turn-key solution, incl. permission process, for H_2 and FC MHV systems and link to OEM.

3.8 Other comments

No other comments were made.

4 Conclusions

- The overall business case for user of FC-technology must be positive and all operational cost must be less than using battery technology instead of FC-technology.
- The refuelling station must be able to refill at least 15 trucks per hour on each dispenser.
- Design of the fuel cell must be in line with a standard to ensure the replacement of batteries with FC and enable user to switch from FC supplier “A” to supplier “B”. That is why this/these standard(s) is/are very important for future success of FC technology in MHV as bigger industrial user do not accept to be depending on one supplier.
- Acceptable CAPEX / OPEX does need to include maintenance effort for fuel cell and refuelling station as well.