FUEL CELL POWERED INDUSTRIAL TRUCK APPLICATION IN THE BMW PLANT LEIPZIG. A NEW BENCHMARK? ANALYSIS AND REPORTING.

WORLD OF ENERGY SOLUTION 2014

HANNES SCHÖBEL, LINDE MATERIAL HANDLING
ROBERT MICHELI, LEHRSTUHL FML TUM
Motivation for H2Intradrive
The fuel cell technology in intralogistics

Potential advantages for customers

• No inconvenient battery change
• No investments on charger or spare batteries
• No extra space needed for charging stations
• No acids or chemicals needed
• Interesting especially for industries with high hygienic demands (e.g. food and pharmaceutical industry)
• Shows social sense of responsibility or environmentalism of customers towards the public

Requirements

• On-site H2 infrastructure
• On-site H2 production or regular H2 delivery by a hydrogen supplier
• Sufficient ventilation of warehouses (if necessary)
Project objectives

- Technological leap in the fields of operating performance, customer benefit and environmental compatibility of electric trucks
- Development of the European market
- Implementation of the whole value-added chain from research and development right up to service
- Investigation of resource expenditure, load on hydrogen-components (especially on the fuel cell system), as well as gathering of real operating conditions of industrial trucks equipped with a fuel cell in different operational scenarios
- Proof of energy efficiency, reliability, durability, sustainability and profitability
Guidelines for using fuel cell powered industrial trucks

Topics overview

General Information
- Site selection
- Industrial truck fleet
- Indoor or outdoor
- Supplier overview

Hydrogen Infrastructure
- Functionality
- Specifications
- Construction
- Security

Industrial Trucks
- Specifications
- Commissioning
- Operation
- Security

Permits and reports
- „BImSchG“ proposal
- „Erlaubnis nach BetrSichV“
- Risk assessment
- Fire protection report

© Micheli Lehrstuhl fml TUM
Guidelines for using fuel cell powered industrial trucks

Supporting instruments

Checklists

- Select location for f-cell industrial trucks
- Define eventual extensions plan
- Define number and types of trucks
- Calculate predicted hydrogen consumption
- ........

Timetables

<table>
<thead>
<tr>
<th>Aufgabe</th>
<th>Monat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erstellung und Einreichung BImSchG-Antrag</td>
<td>1</td>
</tr>
<tr>
<td>Prüfung auf Vollständigkeit des BImSchG-Antrages durch Behörde</td>
<td>2</td>
</tr>
<tr>
<td>Prüfung BImSchG-Antrag</td>
<td>3</td>
</tr>
<tr>
<td>Erstellung Antrag für Erlaubnis nach BetrSichV</td>
<td>4</td>
</tr>
<tr>
<td>Erstellung Brandschutzgutachten</td>
<td>5</td>
</tr>
<tr>
<td>Erstellung Schallschutzgutachten</td>
<td>6</td>
</tr>
<tr>
<td>Erstellung EX-Schutz-Dokument</td>
<td>7</td>
</tr>
</tbody>
</table>

FAQ

- What happens when hydrogen leaks?
- What is green certified hydrogen?
- Benefits of f-cell industrial trucks
- Disadvantages of f-cell industrial trucks
- ........
Economical part

H2IntraDrive: Invest

Notes

- Similar invest for infrastructure → currently approx. 20% of the hydrogen infrastructure capacity needed
- Higher invest for industrial trucks because of f-cell adaptation → costs will decrease with a higher production quantity
- Significant higher invest in power unit → longer lifetime and new technology, costs will decrease with higher production volume
Economical part

H2IntraDrive: Proposed lifetime of components

Notes

• Lifetime of hydrogen infrastructure is significantly higher
• Lifetime of fuel cell power units is significantly higher
### Economical part

**H2IntraDrive: Handling processes $\text{H}_2$-refueling vs. battery change**

<table>
<thead>
<tr>
<th>Forklift with cab</th>
<th>Tugger</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen refueling H2IntraDrive</td>
<td>Hydrogen refueling H2IntraDrive</td>
</tr>
<tr>
<td>Battery change. Real value with non-optimal planning&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Battery change. Real value with non-optimal planning&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Battery change. Theoretical value with optimal planning&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Battery change. Theoretical value with optimal planning&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

### Notes

- Hydrogen refueling is much faster than battery change
- No additional training for truck operator needed to refuel hydrogen tank (crane license)
- Planning of battery changing stations is often suboptimal

<sup>2</sup> Central charging station with crane & lifting beam
Economical part

Next steps

- Evaluation of operating data
  - Personal costs
  - Energy consumption of industrial trucks
  - Energy costs
  - Maintenance costs
  - .....
- Evaluation of life cycle costs in H2IntraDrive
- LCC-Model for evaluation of further applications
- Determination of requirements for economic operation of f-cell
  - Industrial truck fleet size
  - Hydrogen cost
  - Invest
  - .....

© Micheli Lehrstuhl fml TUM
Projects in Germany

BMW
11 trucks
Daimler
2 trucks (delivery in Q3/2014)
Seifert Logistic
1 truck (delivery in Q3/2014)
BASF
1 truck
Airport Hamburg
2 trucks
Airport Munich
1 truck (not operating anymore)
Linde Gas Munich
2 trucks (not operating anymore)
Projects in Europe

**Denmark:**
Kraft: 4 trucks

**Belgium:**
Colruyt: 8 - 10 trucks

**France:**
Ikea: 12 trucks

**Austria:**
Fronius: 5 trucks
DB Schenker: 10 trucks (application for project extension in process)

06.10.2014