Elektrolyseanlagen für Multi-MW Anwendungen
An Overview of McPhy

**KEY FIGURES**

- 5 sites: France, Germany, Italy, China
- Flagship Reference:
  > 17 MW Electrolysis
  > 23 HRS in operation
- 15 years of R&D
- ~ 100 employees
- Strategic partnership with EDF
A complete range of hydrogen equipment to design turnkey projects

Electrolyzer for Industry & Energy
Hydrogen Refilling Station for Mobility

Supported by Strong Industrial assets and know-how

McPhy Italy: Manufacturing Center
McPhy Germany: Engineering Center
McPhy France: R&D, HRS Center
HRS - references

23 HRS
A DAILY POTENTIAL OF
69,000
ZERO-EMISSION KILOMETERS
#CLEANMOBILITY

Unlimited HRS designs

10,000 kg / day

4,000 kg / day

2,000 kg / day

Unique combination between our high-pressure alkaline electrolysis technology and our HRS know-how

Symbio Grenoble | 2015
McPhy LMF | 2015
City of Paris | 2015
ENGIE GNVert Lyon | 2015
Valence Romans Agglo | 2015
City of Rouen | 2017
Sarreguemines | HRS + ELY | 2017
ENGIE Lab Singapour | 2018
RiverSimple UK | 2018
Semitan Nantes | 2018
Rungis | 2018
SMT-AC (buses) | HRS + ELY | 2019
H2 Mobility Deutschland | 2019
CC Touraine Vallée de l'Indre (Sorigny) | 2019
EAS-Hymob (x7) | 2019
ENGIE GNVert Lyon | HRS + ELY | 2019
Confid. | HRS + ELY | 2019
McPhy’s references in Ely: learnings, skills & assets

<table>
<thead>
<tr>
<th>Electrolysis</th>
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<tbody>
<tr>
<td>**100 MW</td>
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<tr>
<td>A total footprint below 4,500 m²</td>
</tr>
<tr>
<td>**20 MW</td>
</tr>
<tr>
<td>Fast dynamic response time</td>
</tr>
<tr>
<td>**4 MW</td>
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<tr>
<td>High pressure production (30 bar)</td>
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<tr>
<td><strong>Breakthrough Alkaline ELY Technology</strong></td>
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<tr>
<td>Unique combination between our high-pressure alkaline electrolysis technology</td>
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**McPhy’s introduction**

McPhy has installed 17 MW of high capacity electrolyzers, more than 7 tons of clean hydrogen produced per day.

<table>
<thead>
<tr>
<th>Capacity</th>
<th>Location</th>
<th>Year</th>
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<tbody>
<tr>
<td>6 MW</td>
<td>Audi</td>
<td>2013</td>
</tr>
<tr>
<td>0.5 MW</td>
<td>Prenzlau</td>
<td>2013</td>
</tr>
<tr>
<td>0.5 MW</td>
<td>H2Ber</td>
<td>2014</td>
</tr>
<tr>
<td>4 MW</td>
<td>Hebei</td>
<td>2017</td>
</tr>
<tr>
<td>1 MW</td>
<td>EnergieDienst</td>
<td>2017</td>
</tr>
<tr>
<td>1 MW</td>
<td>Jupiter 1000</td>
<td>2018</td>
</tr>
<tr>
<td>0.5 MW</td>
<td>RAG</td>
<td>2018</td>
</tr>
<tr>
<td>0.5 MW</td>
<td>SMT-AG</td>
<td>2019</td>
</tr>
<tr>
<td>2 MW</td>
<td>Confid.</td>
<td>2019</td>
</tr>
<tr>
<td>1 MW HCD</td>
<td>Confid.</td>
<td>2019</td>
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McPhy | March 2019
By the way, how does an electrolyzer look like?

1 MW Electrolyzer (indoor installed)

Stack under erection (outdoor case)

Transformer/Rectifier

Demin water

Rule of Thumb:
200Nm³/h or 18kg/h per MW electrolyzer
McPhy in Hydrogen production units (Electrolyzers)

3 main technologies for electrolyzers:
- Solid Oxide Electrolyzer Cell
- Alkaline (atmospheric & pressurized)
- PEM (atmospheric & pressurized)

3 ranges of McPhy electrolyzers:

1. Less than 500 kW
   - Small electrolyzer “McLyzer” type
   - Delivered in containers “plug & play”

2. from 500 kW to 4 MW
   - High Current electrolyzers “McLyzer HC” type
   - Delivered in containers “plug & play”

3. 4 MW to > 100 MW
   - Multi MW units: Standard brick 4 MW, standard cluster 20 MW, up to > 100 MW platforms
## Our Core Modules

<table>
<thead>
<tr>
<th>McLyzer 200-30</th>
<th>McLyzer 400-30</th>
<th>McLyzer 800-30</th>
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<tbody>
<tr>
<td>Capacity:</td>
<td>Capacity:</td>
<td>Capacity:</td>
</tr>
<tr>
<td>200 Nm³/h</td>
<td>400 Nm³/h</td>
<td>800 Nm³/h</td>
</tr>
<tr>
<td>&gt; 430 kg/d</td>
<td>&gt; 860 kg/d</td>
<td>&gt; 1.720 kg/d</td>
</tr>
<tr>
<td>Containerized solution: 1 x 30’ + 2 x 20’</td>
<td>Containerized solution: 2 x 20’ + 1 x 40’</td>
<td>Base for Multi-MW plants</td>
</tr>
<tr>
<td>Solution for HRS up to 400kg/d , PTG and PTP</td>
<td>Solution for large HRS, PTG and PTP</td>
<td></td>
</tr>
<tr>
<td>Spec. Energy consumption: 5 kWh/Nm³</td>
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</tr>
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</table>
Example of a 2MW unit
(similar principle as for 0.5 or 1MW)

Layout of a McLyzer 400-30 – not contractual / for reference only – actualization of layout will be provided with basic design informations.
Example of a 0.5MW unit (valid up to 2MW)
Exemple of a 0,5MW unit (valid up to 2MW)
PtG | References under operation: Audi (Werlte) - 2013

Industrial hydrogen & Power-to-Gas: Audi, One of the first PtG project in Europe

• Operated by Audi
• 6 MW atm Hydrogen production
• In operation since October 2013
H₂BER | the First Multi-Energy-Refueling Station in Europe

KEY FIGURES

- Electrolyzer connected to both the grid and the wind park
- World first Multi Energy refueling Station operated by Total
- Located at the airport of Berlin
- Commissioning: May 2014

McLyzer 250 kg/day
42 bar system Electrolyzer
H₂BER | the First Multi-Energy-Refueling Station in Europe

Concept:
H₂BER | the First Multi-Energy-Refueling Station in Europe

Proven:
✓ Overall Stack efficiency of 83%
✓ Utilization of electricity from wind by 99% despite high load changes during the energy supply
✓ Production of hydrogen with a stable, high quality fit for Fuel Cell Electric Vehicles like Toyota, Hyundai, Mercedes Benz etc.
✓ Gas is produced with 30bar pressure, optimized for industrial solutions and direct injection into the gas grid.

Red: Energy Input
Blue: Energy conversion by electrolyser
Green: deviation in %
H₂BER | the First Multi-Energy-Refueling Station in Europe

Red: Energy Input
Blue: Energy conversion by electrolyser
Green: deviation in %

5 sec (measuring step 1 sec)
PtG | EnergieDienst, ENBW Group (Germany) 1 MW at 30 bar

- First hydrogen project in partnership with Center For Solar Energy
- 2 McLyzer 100 : 200 Nm3/h – 1 MW at 30 bar
- Inauguration November 2018, commissioning in May
- H₂ application : mobility, Industry, Storage
HEBEI I 4-10W Platform

- Realistic outlook to a 10MW-platform today (HEBEI):
  - Currently the shown layout is equipped with 4 Module of 2 MW with stacks of 0,5 MW
  - Complete showcase for a wind power driven hydrogen plant incl. truck-out infrastructure and future HRS (400 kg)
McPhy to set up its first station for 6 hydrogen buses in the Hauts de France region

KEY FIGURES

• Deployment scheduled in the summer of 2019
• The future Bulle 6 line will be the first in France exclusively operated with hydrogen buses
20 MW Cluster – General Architecture & Key Systems

MCC/Control cabinets
Designed by McPhy, Manufactured by approved sub-suppliers

Electrolyzer modules (4MW)
Key component: manufactured in-house and by single source suppliers

KOH Handling station
Manufactured by sub-suppliers (volume capacity depends on plant size)

Instrument air system
Manufactured by sub-suppliers

Transformer/Rectifier
Supplied by 2 approved sub-suppliers

Purification & Drying unit
Manufactured by sub-suppliers (Designed in cooperation for McLyzer products)

Demin water plant
Manufactured by approved sub-suppliers

Cooling system
Manufactured by approved sub-suppliers
Industrial Design:

from 100 MW Platform to **GW ELY Plant**

**STEP II** > 20 MW Cluster and 100 MW ELY Plant
2019: 20 MW Cluster
2020: 100 MW Plant

**STEP III** > 100 MW Cluster and GW ELY plant
2021: 100 MW Cluster "New Design"
2025: 1 GW Plant

**100 MW Plant**: 20 MW Cluster X 5

**GW ELY Plant**: 100 MW Cluster X 10
McPhy’s 20MW cluster, containerized/skidded
Electrolysers, Hydrogen storage systems, Refueling Stations, Combined Heat and Power Plants are all System designed, engineered and manufactured in Europe.
The Business Case for Green Hydrogen in Germany

**Targets for Hydrogen Price**
- 2 €/kg for industrial used Hydrogen (SMR is state-of-the-art)
- 4-6 €/kg for mobility

**1 MW electrolyser**
- 8,000 hrs of operation at nominal load per year
- 150 €/MWh
- ~11 €/kg production cost

**10 MW electrolyser**
- 8,000 hrs of operation at nominal load per year
- 40 €/MWh (energy intensive)
- ~3 €/kg production cost

**Conclusion**
- For small scale systems the electricity price prohibits any viable business case
- For large scale systems we come close to conventional hydrogen production methods. In order to be competitive to grey hydrogen sources today, subsidies or CO₂ taxes are necessary.
Thank you!

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