Industrial challenges of alkaline electrolysis

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3èmes Rencontres académie-industrie du CNC
A leading low-carbon H₂ Equipment Manufacturer

**History**

- **2024**
  - Opening of the Gigafactory
  - Partnerships materialization

- **2022**
  - R&D acceleration
  - Industrial scale up

- **2020**
  - 180 M€ raised
  - Technip & Chart partnerships

- **2018**
  - EDF partnership

- **2013**
  - Refueling stations development
  - Enertrag’s electrolyzer acquisition
  - PIEL acquisition

- **2008**
  - Incubation with CEA & CNRS

**People & footprint**

- 260 employees
- 24% women
- 25 nationalities
- 50+% PhD / engineers

**Our products**

- **Electrolyzers**
- **Refueling stations**

**Key figures**

- Revenue
- Backlog
- People

**Shareholders & partners**

- Listed on Euronext Paris

**Pan-European Pure Player**
McPhy pressurized alkaline technology
Stack is at the heart of H₂ production, but needs a full industrial platform around

1. Transformer & Rectifier Unit (TRU)
   - e-
   - 20 kV AC >> 500 V >> 500 V DC
   - Transformer
   - Rectifier
   - [4-5] kWh per kgH₂

2. Stack
   - Gaseous products & liquid KOH
   - H₂O & KOH (28%)
   - H₂ (90%)
   - O₂ (2%) H₂O (8%)
   - O₂ (99%)
   - H₂ & H₂O

3. Water Demineralization Unit
   - Tap water
   - 20 liters per kgH₂
   - Demineralized water
   - 10 liters per kgH₂

4. Electrolyzer Process Unit (EPU)
   - H₂ & waste
   - (95%) & H₂O (5%) & O₂ traces
   - After cooling

5. Purification and Drying Unit (PDU)
   - Purified H₂
   - ISO 22734 purity compliant (>99.995%)

6. Client
Main market driver: Green H$_2$ industrial applications...

Estimated Cumulated Installed Electrolysis Capacity [in GW]

**Market by Region [GW]**
- Europe: 39 GW (2021), 15 GW (2025), 7 GW (2030)
- Americas: 26 GW (2021), 18 GW (2025), 9 GW (2030)
- MENA: 9 GW (2021), 15 GW (2025), 3 GW (2030)
- Asia & Oceania: 3 GW (2021), 4 GW (2025), 1 GW (2030)

**Market by Project Size [GW]**
- <100 MW: 33 GW (2021), 15 GW (2025), 4 GW (2030)
- >100 MW and <1 GW: 27 GW (2021), 10 GW (2025), 7 GW (2030)
- >1 GW: 92 GW (2021), 33 GW (2025), 15 GW (2030)

**Market by Technology [GW]**
- PEM: 29 GW (2021), 27 GW (2025), 9 GW (2030)
- SOEC: 54 GW (2021), 27 GW (2025), 15 GW (2030)
- ALK: 0 GW (2021), 7 GW (2025), 3 GW (2030)
- Other: 7 GW (2021), 4 GW (2025), 1 GW (2030)

Sources: IEA, Hydrogen Council, Desk research
... to abate 2% of worldwide CO$_2$ emissions

Grey H$_2$ production = 100 Mt/year
  = ca. 800 Mt/year of CO$_2$
  = ca. 2% of world GHG emissions

1 MW of electrolysis = 18 kg H$_2$/hour
  = 140 t H$_2$/year (at 90% average load) / Grid connected
  = 80 t H$_2$/year (at 50% average load) / Renewable Energy

50 GW = 4-7 Mt H$_2$/year
  = 25-50 Mt CO$_2$ emission saved (70-90% saved)

Sources: IEA, Hydrogen Council, Desk research
Answering large industrial needs
McPhy building blocks of 4 x 4 MW stacks with 16 MW EPUs

Our next building block: 4 x 4 MW stacks with a 16 MW EPU for large capacity industrial applications
The different challenges for large-scale deployment
| A mix of chemical, physical & engineering challenges

Chemical challenges at the cathode level

- 3 industrial technologies: (1) NiS, (2) microporous Ni, (3) Pt-based electrodes
- Many emerging technologies
- The heart of electrolysis
- The most expensive part
The different challenges for large-scale deployment
| A mix of chemical, physical & engineering challenges

Chemical challenges at the **cathode** level

Physical challenges at the **cell** level

- Flow of electrolyte as homogeneous as possible
- Ohmic losses brought by hydrogen bubbles
The different challenges for large-scale deployment

A mix of chemical, physical & engineering challenges

Chemical challenges at the **cathode** level
Physical challenges at the **cell** level
Engineering challenges at the **stack** level

- Automatization of stack production
- Polymer vs. metal frames
- Electronic conduction at the electrodes level
- Safety management of internal pressure
The different challenges for large-scale deployment
| A mix of chemical, physical & engineering challenges

Chemical challenges at the **cathode** level
Physical challenges at the **cell** level
Engineering challenges at the **stack** level
Process safety challenges at the **EPU** level
• Explosive & self-igniting mixture 4+% \( \text{O}_2 \) in \( \text{H}_2 \)
The different challenges for large-scale deployment

| A mix of chemical, physical & engineering challenges

Chemical challenges at the **cathode** level
Physical challenges at the **cell** level
Engineering challenges at the **stack** level
Process safety challenges at the **EPU** level
Digital challenges at the **multi-stack platform** level

- Optimization management of 100+ stacks to cope with constantly changing electrical load