EXPERIENCES WITH POWER-TO-GAS TECHNOLOGIES IN INTERNATIONAL PROJECTS

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Agenda

1. Hydrogenics in a nutshell
2. Demonstration projects
3. EU regulatory framework: status and prospects
Hydrogenics, a leading hydrogen technology provider

Onsite Generation | Electrolysers

H₂O + electricity → H₂ + ½ O₂

Power Systems | Fuel Cell Modules

H₂ + ½ O₂ → H₂O + electricity

Industrial Hydrogen | Hydrogen Fueling

Stand-by Power | Mobility Power
Hydrogenics, a 100% global hydrogen company

**Hydrogenics Corporation**
- Headquarter
- Mississauga, Ontario, Canada
- Since 1948
- +/- 70 employees
- Areas of expertise: Fuel cells, PEM electrolysis, Power-to-Gas
- Previously: The Electrolyser Company, Stuart Energy

**Hydrogenics Europe**
- Oevel, Belgium
- Since 1987
- +/- 70 employees
- Areas of expertise: pressurized alkaline electrolysis, hydrogen refueling stations, Power-to-Gas
- Previously: Vandenborre Hydrogen Systems

**Hydrogenics GmbH**
- Gladbeck, Germany
- Since 2002
- +/- 15 employees
- Areas of expertise: Fuel cells, mobility projects, Power-to-Gas

- In total: +170 employees
- Incorporated in 2000 [NASDAQ: HYGS; TSX: HYG]
- More than 3,000 products deployed in 100 countries worldwide
- Total revenues (2017): 48.1 Mio $
- Over 65 years of electrolysis leadership

**Production facility**

**Sales office**
Our ‘Renewable Hydrogen’ vision
Selection of our key references

**Electrolysis**
- 700 bar Hydrogen Refueling Station
  Aberdeen, Scotland (UK)

**Fuel Cells**
- 1 MW stationary Fuel cell (H₂ repowering)
  Kolon, South-Korea
- Fuel cell for mobility (H₂ trains)
  Alstom Coradia iLint, Germany
- Fuel cell for mobility (H₂ buses), China
- 1,5 MW PEM P2G (direct injection), Hamburg, Germany
- 1 MW alkaline P2G (methanation)
  BIOCAT, Copenhagen, Denmark
Agenda

1. Hydrogenics in a nutshell

2. Demonstration projects

3. EU regulatory framework: status and prospects
HyLYZER® -1000-30
5 MW PEM Electrolyser

- Containerized design & compact footprint: 2 x 40 ft
- Plug&Play modular design based on 2 x 2.5 MW cell stacks
- Fully tested & certified @ Hydrogenics’s factory
European demonstration projects
Learnings from demonstration projects

• System cost is coming down faster than expected
• System energy efficiency on track to achieve MAWP objective
• System responsiveness adequate for ancillary grid services
• Maintenance cost trending towards 1% of Capex
• Footprint PEMWE system adequate for large-scale solutions
Agenda

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Expectations from EU Policy

• **Clean Energy Package**
  – Definition of Renewable H₂ requirements → cost of Renewable H₂
  – H₂ in transport (direct use, refineries) → value + market for Renewable H₂ in transport

• **Clean Mobility Package**
  – Will determine the market for Fuel Cell Electric Vehicles / Hydrogen Refueling Stations and the future demand for Renewable H₂ in transport

• **Gas Package**
  – Will determine the requirements and value of renewable hydrogen and green gases (SNG) for gas applications

• **EU Funds made available**
  – CEF, H2020, Innovation Fund (ETS), Project of Common Interest, Fuel Cell and Hydrogen Joint-Undertaking
EU PRIMES model tested with hydrogen (Prof. Capros)  
Presented at High-Level Roundtable on Sector Integration (1/03/18)

- Reference EU energy modeling tool (2050)
- New Balanced Scenario has been developed which includes hydrogen
- With hydrogen
  - CO₂ reduction potential is higher
  - CO₂ reduction cost is lower
- A more detailed analysis is ongoing
Key messages

• Hydrogen and Fuel Cell technologies are mature and ready
• Cost reduction is ongoing: from project to product manufacturing & product upscaling
• Massive CO$_2$ reduction potential: power, gas, transport and industry
• Policy makers understand now the interest of hydrogen (sector integration)

• Markets in the EU will be READY soon!
• Thanks to:
  1. Green hydrogen certification mechanism
  2. Premium value for end product / application
  3. Access to renewable electricity at low cost
  4. Grid connection to deliver balancing services
Thank you for your attention
EU Policy update - key facts
Clean Energy Package for all Europeans

• Defines renewable targets in power, heat and transport sectors (period: 2021-2030)
• Extensive discussions and lobby in 2017
• 3 draft versions: EU Commission / EU parliament / EU Council > not fully aligned on hydrogen
• Trialogue discussions started in February 2018 and are expected to end at latest in June 2018 (> official directive)
• The work continues in 2019-2020: transposition of the EU directive in EU member states
EU Policy update - key facts

**Clean Energy Package** for all Europeans

- ReFuNoBios: renewable fuels of non-biological origin (= Renewable H₂ and derivates) are in!

**Keys elements being discussed during trialogue**

- How do you prove the renewable hydrogen character: direct connection, renewable grid mix, Guarantees of Origin (GoO), Power Purchase Agreement (PPA)...
- Relationship with battery electric mobility (level playing field: PPA, multipliers)
- Renewable hydrogen in refineries ("... *intermediate products...*) and methodology
- Status of "*waste-based/recycled carbon fuels*"
- Origin of CO₂ when combined with H₂: direct air capture, biogenic, fossil?
- Energy storage definition
EU Policy update – key facts

Clean Mobility package

• Proposal launched by the EU Commission in November 2017
• 3 main elements:
  – **CO₂ standards for car manufacturers** > reduction of emission for new sold vehicles (environmental performance, clean vehicle definition and quantitative objectives)
  – **Clean vehicle directive** > public procurements with mandatory targets for clean vehicles in tendering processes
  – **Alternative fuels infrastructure** > increase the level of ambition of national plans, increase investment and improve consumer acceptance (including HRS)
• Very positive already for hydrogen
• Extensive discussions are taking place in 2018 with a final decision expected by the end of the year 2018.
EU Policy update – key facts

EU Gas package

• The gas package is being prepared now but will not be presented before the next Commission will be in office, so most probably end of 2019/beginning 2020.

• It will be a Regulation and not a Directive -> regulation of electricity and gas will be rather parallel then consecutive. This is excellent news for sectoral integration and for hydrogen.

• 1/3 of the package will be mirroring the electricity market (REDII). 2/3 of the package will mostly cover the future content of the gas grids: “green gases”.

• The Commission is neutral when it comes to green or blue hydrogen. It’s important that it is decarbonized.

• President Juncker’s Cabinet are at ease with the perspective that the gas grid will complement the power grid with regards to the energy transition and with hydrogen (and biomethane) replacing natural gas step by step.