HYDROGENICS

SHIFT **POWER** | **ENERGIZE** YOUR WORLD

EXPERIENCES WITH POWER-TO-GAS TECHNOLOGIES IN INTERNATIONAL PROJECTS

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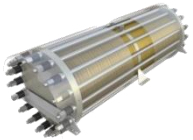
Power-to-Gas Conference, May 7th 2018, Antwerp

Agenda

1. Hydrogenics in a nutshell
2. Demonstration projects
3. EU regulatory framework : status and prospects

Hydrogenics, a leading hydrogen technology provider

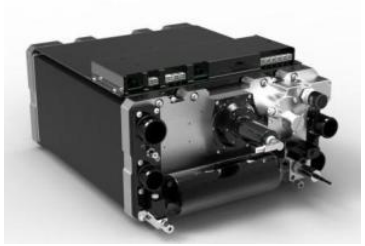


Onsite Generation | Electrolysers

H_2O + electricity → H_2 + ½ O_2

Industrial Hydrogen

Hydrogen Fueling



Power Systems | Fuel Cell Modules

H_2 + ½ O_2 → H_2O + electricity

Stand-by Power

Mobility Power

Hydrogenics, a 100% global hydrogen company

Hydrogenics Corporation

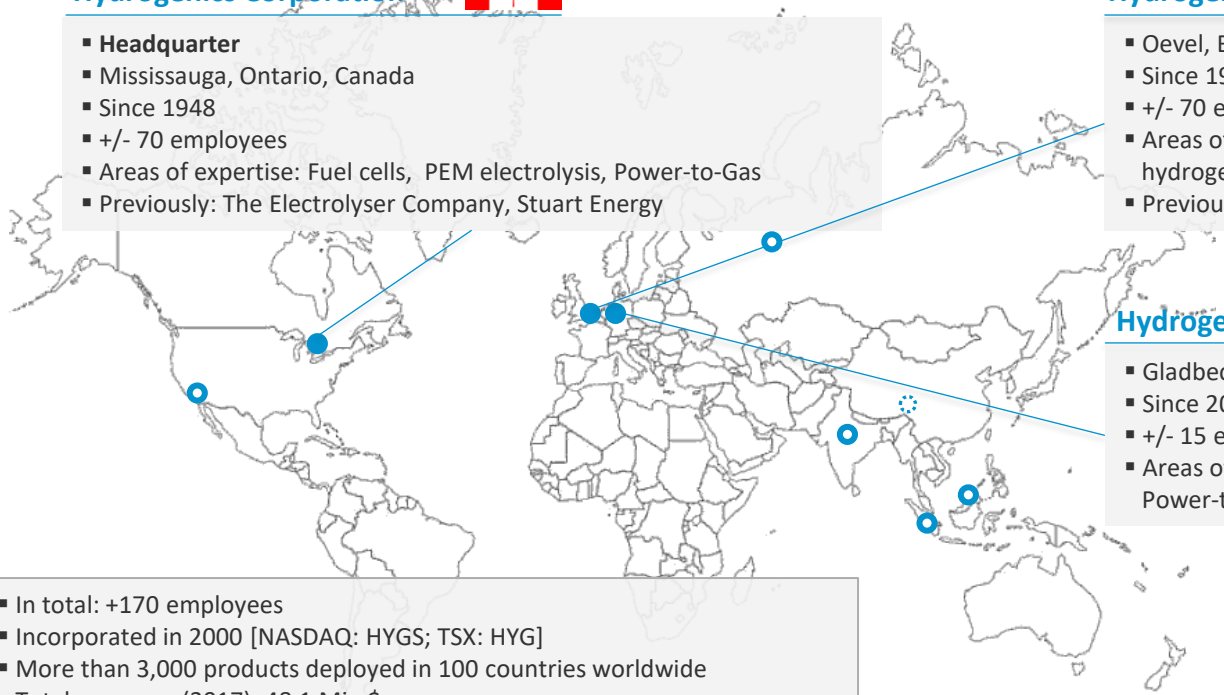
- **Headquarter**
- Mississauga, Ontario, Canada
- Since 1948
- +/- 70 employees
- Areas of expertise: Fuel cells, PEM electrolysis, Power-to-Gas
- Previously: The Electrolyser Company, Stuart Energy

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

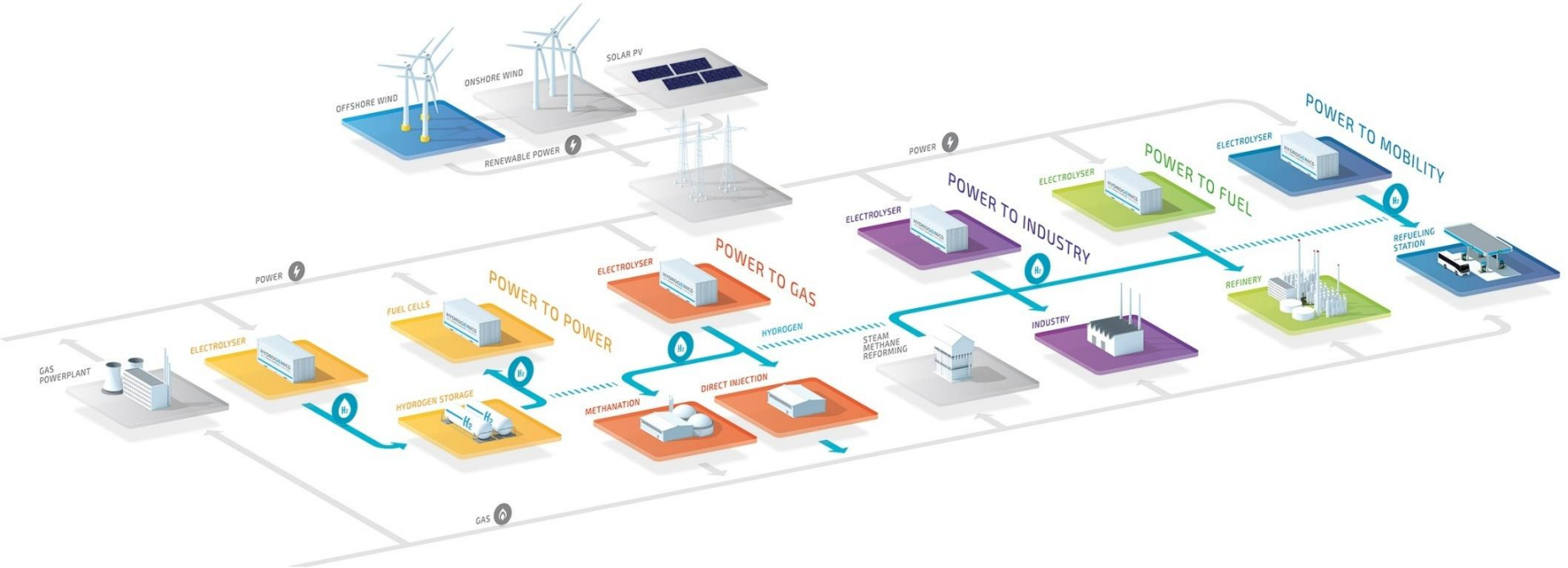


- In total: +170 employees
- Incorporated in 2000 [NASDAQ: HYGS; TSX: HYG]
- More than 3,000 products deployed in 100 countries worldwide
- Total revenues (2017): 48.1 Mio $
- Over 65 years of electrolysis leadership

● Production facility

○ Sales office

Our ‘Renewable Hydrogen’ vision



Selection of our key references

Electrolysis

700 bar Hydrogen Refueling Station
Aberdeen, Scotland (UK)

1,5 MW PEM P2G (direct injection), Hamburg, Germany

1 MW alkaline P2G (methanation)
BIOCAT, Copenhagen, Denmark

Fuel cells

1 MW stationary Fuel cell (H_2 repowering)
Kolon, South-Korea

Fuel cell for mobility (H_2 trains)
Alstom Coradia iLint , Germany

Fuel cell for mobility (H_2 buses), China

Agenda

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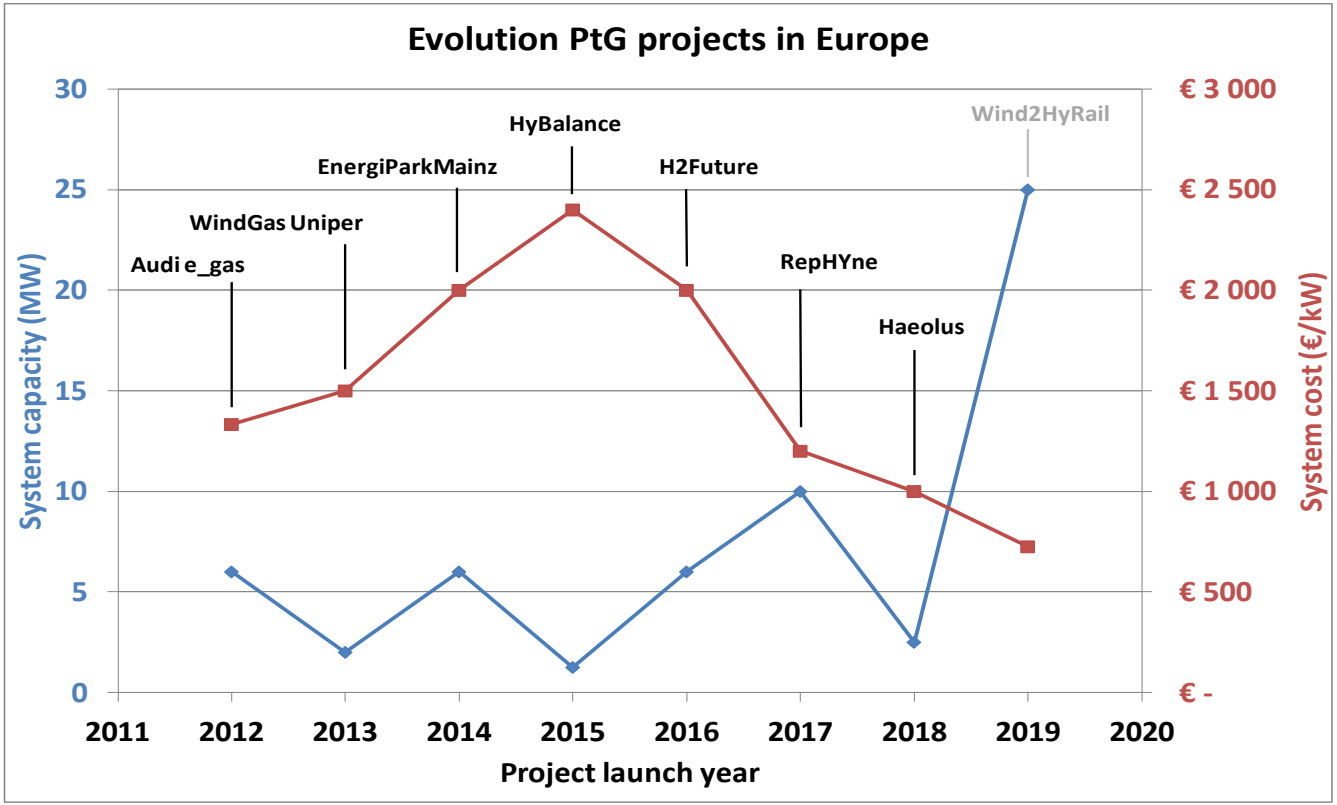
2. **Demonstration projects**
3. EU regulatory framework : status and prospects

2018

HyLYZER® -1000-30
5 MW PEM Electrolyser

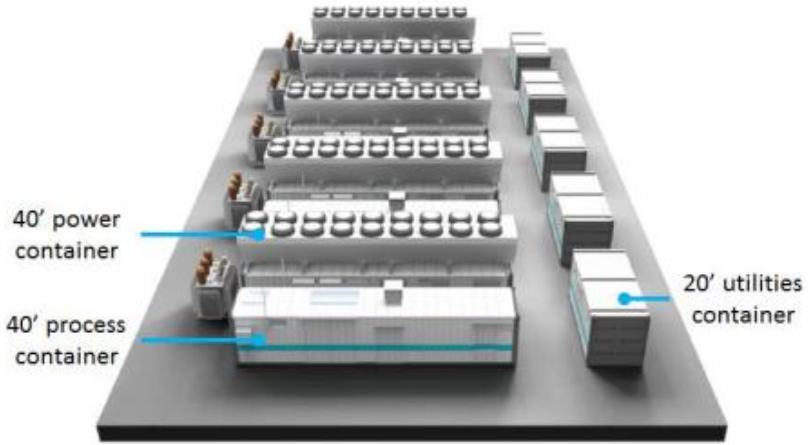
- **Containerized design & compact footprint: 2 x 40 ft**
- **Plug&Play modular design based on 2 x 2,5 MW cell stacks**
- **Fully tested & certified @ Hydrogenics's factory**

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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2. Demonstration projects
3. **EU regulatory framework**

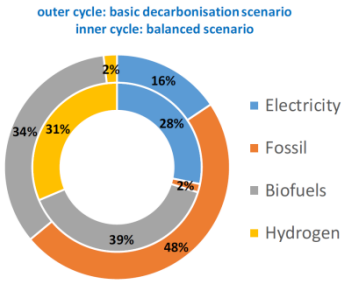
Expectations from EU Policy

- **Clean Energy Package**
  - Definition of Renewable H_2 requirements → cost of Renewable H_2
  - H_2 in transport (direct use, refineries) → value + market for Renewable H_2 in transport
- **Clean Mobility Package**
  - Will determine the market for Fuel Cell Electric Vehicles / Hydrogen Refueling Stations and the future demand for Renewable H_2 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)

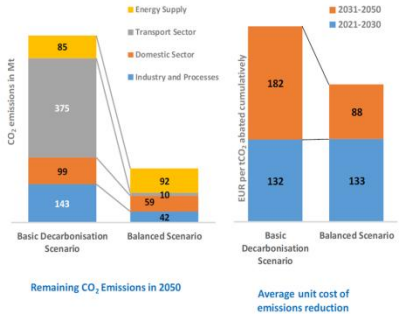
Fuel mix in Transport in 2050

PRIMES projections



Emissions and costs in the Balanced Scenario

PRIMES projections



- Reference EU energy modeling tool (2050)
- New Balanced Scenario has been developed which includes hydrogen
- With hydrogen
  - CO_2 reduction potential is **higher**
  - CO_2 reduction cost is **lower**
- PPT: http://bit.ly/2Fqlnbe
- A more detailed analysis is ongoing

Key messages

- Hydrogen and Fuel Cell **technologies are** mature and **ready**
- **Cost reduction** is ongoing : form project to product manufacturing & product up scaling
- 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

We're Ready.

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 H_2 and derivates) are in !

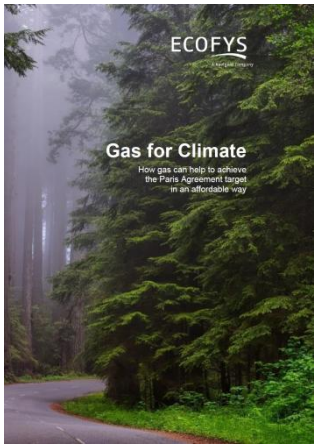
- Keys elements being discussed during trialogue
  - How do you prove the renewable hydrogen character: direct connection, renewable grid mix, Guarantees of Origin (GoO), Power Purchase Agreement (PPA)…
  - Relationship with battery electric mobility (level playing field: PPA, multipliers)
  - Renewable hydrogen in refineries *(“… intermediate products…”)* and methodology
  - Status of *“waste-based/recycled carbon fuels”*
  - Origin of CO_2 when combined with H_2: 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 :
  - **CO_2 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**.



GAS FOR CLIMATE
A path to 2050

www.gasforclimate2050.eu