

# HYDROG(E)NICS

SHIFT POWER | ENERGIZE YOUR WORLD



## Power to Gas

## Open Manufacturing Campus

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Sales Manager EMEA Hydrogenics OSG



Turnhout, 27 maart 2014

# Electrolysis – the path to an interconnected and clean energy future

- About Hydrogenics
- Clean Energy Future and Renewable Energy
- Power to Gas:
  - What is Power to Gas?
    - Clean Hydrogen as Energy Carrier
  - PtG Value Proposition
- The Future is NOW – Practical Realisations

# Electrolysis – the path to an interconnected and clean energy future

## ■ **About Hydrogenics**

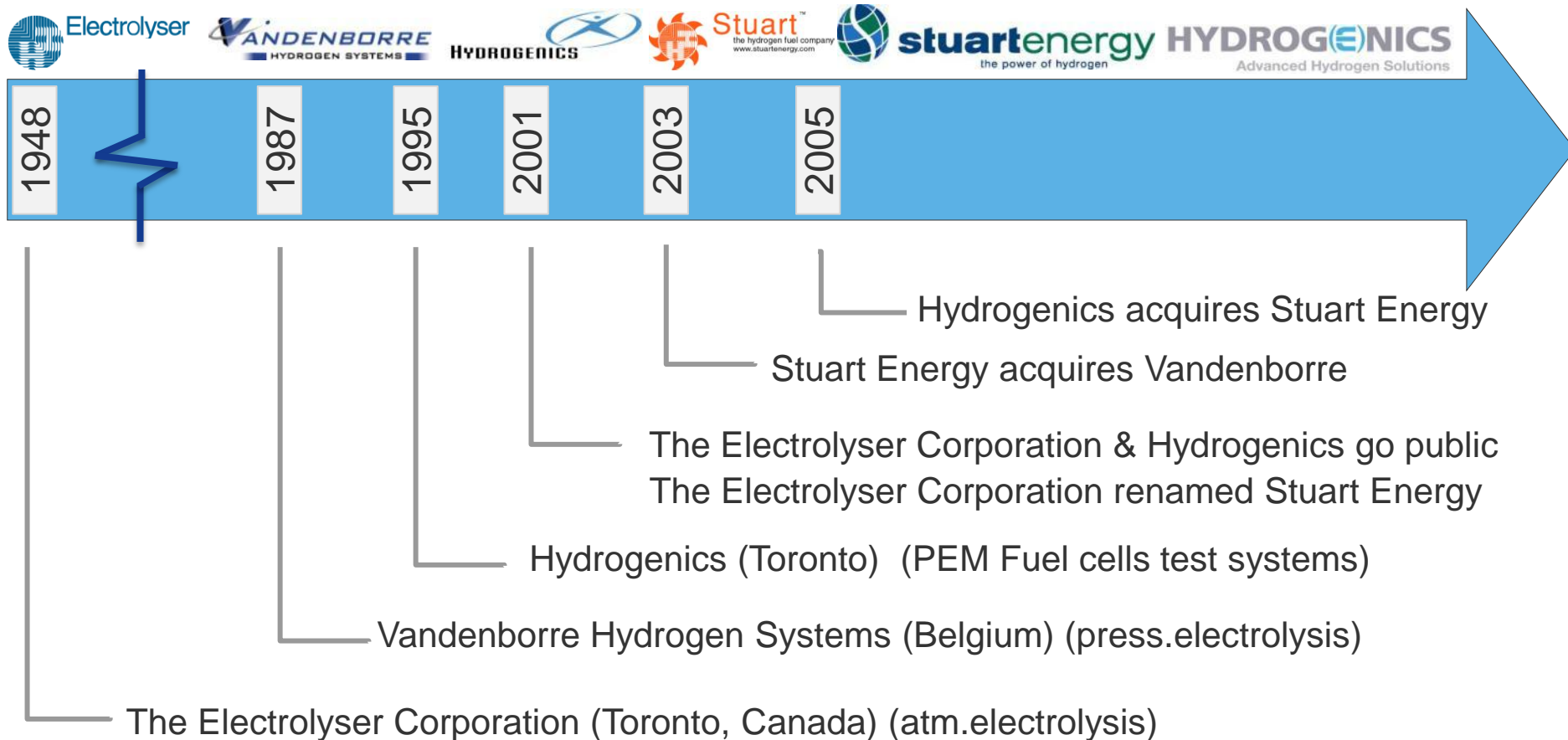
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# About Hydrogenics

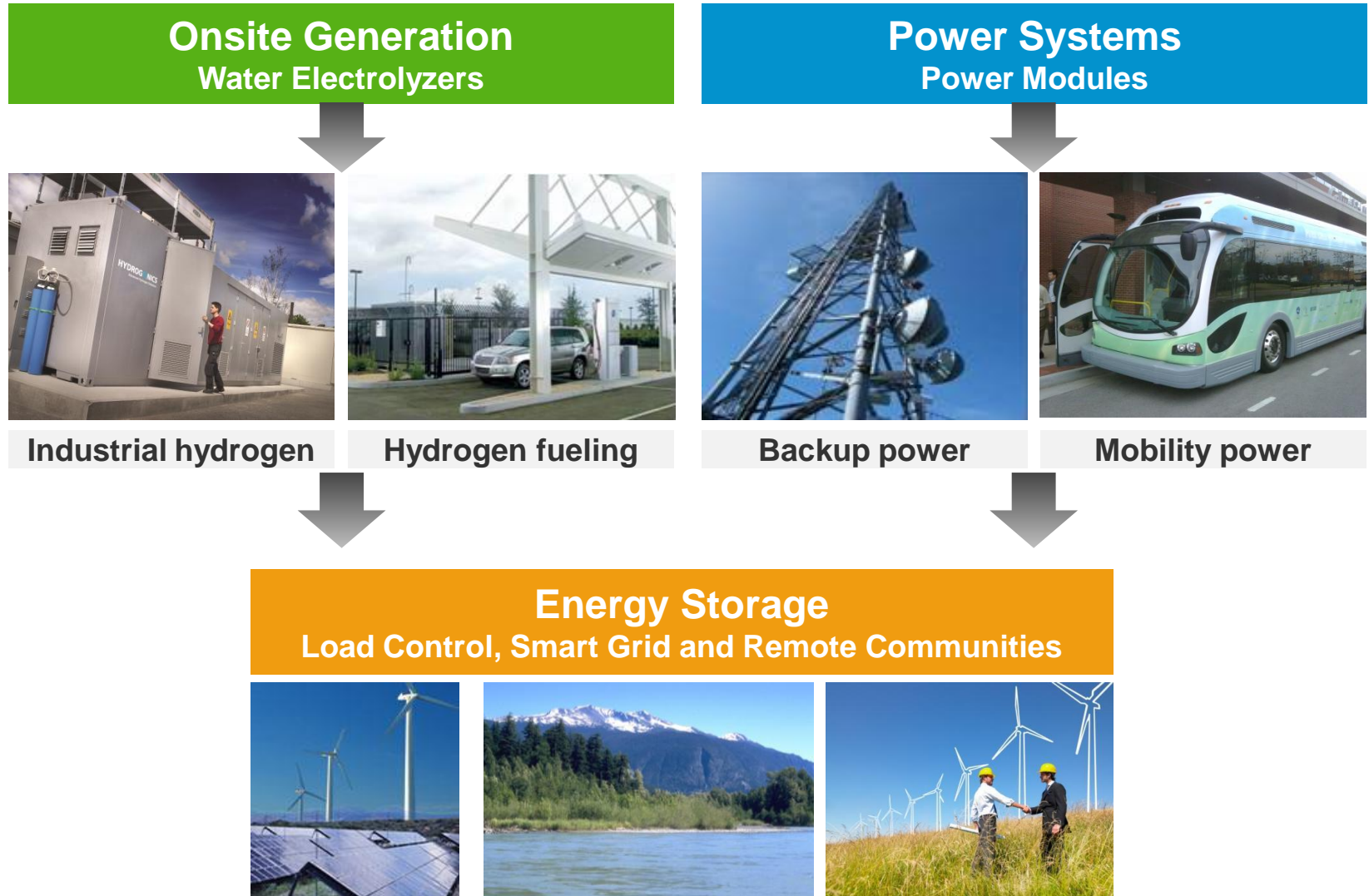
- Global provider of hydrogen fuel cells and water electrolysis products and services
- Incorporated in 1995 [NASDAQ: HYGS; TSX: HYG]
- 150 full time employees
- Headquartered in Canada with European facilities in Germany and Belgium
- 181 patents and patent applications
- More than 2,000 products deployed in 100 countries worldwide
- Manufacturing facilities are ISO 9001 audited



# Company History



# Lines of Business



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# Clean Energy Future = Renewable Energy

- Renewable Energy to
  - Reduce CO<sub>2</sub> emissions
  - Reduce use of Fossil Energy Reserves
- More Renewable Energy Sources used
  - Wind
  - Solar
  - Hydro
- Difficulties with Renewable Energy:
  - Intermittent nature (wind, solar)
  - Storage & Transportation of the electrical energy

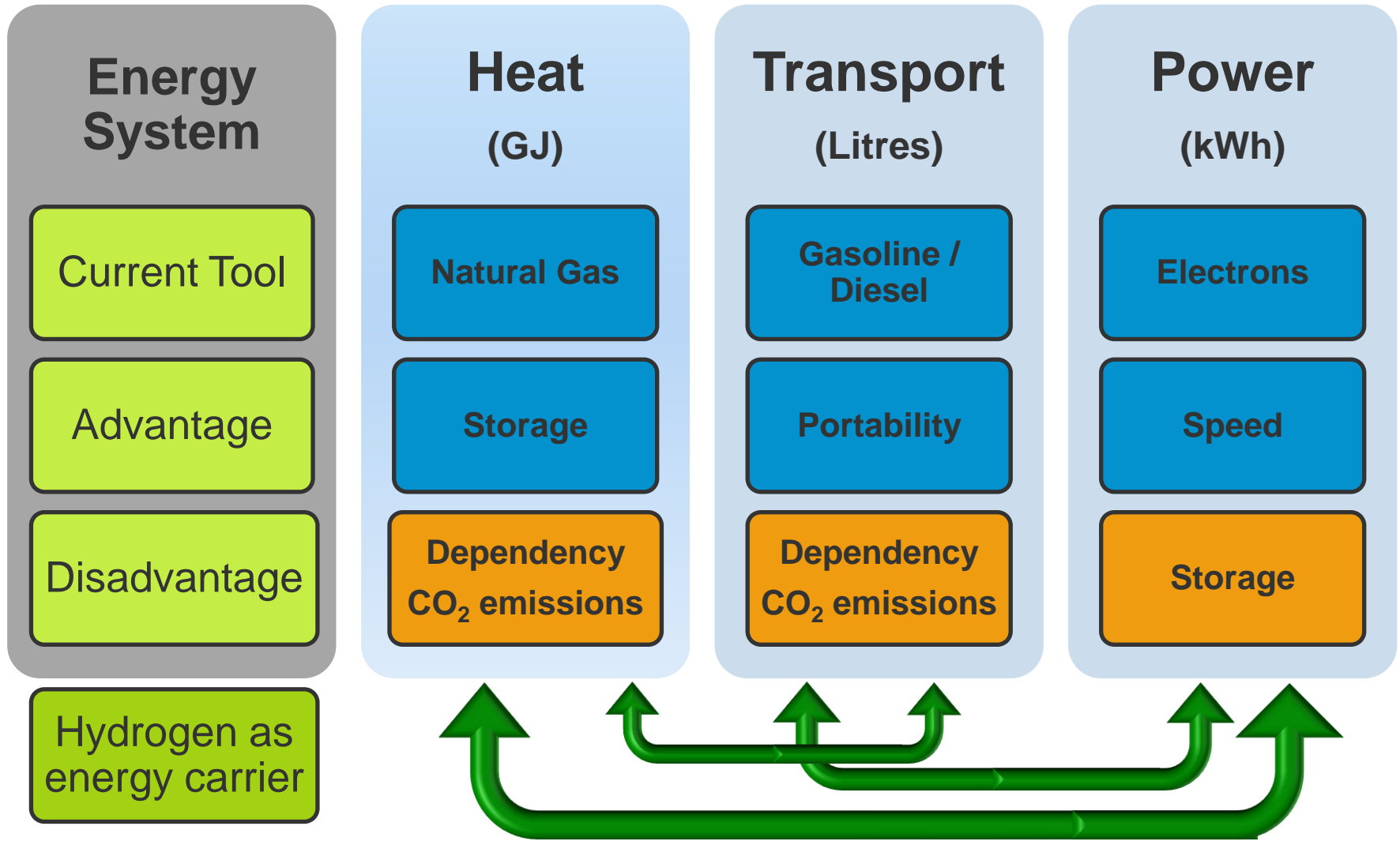
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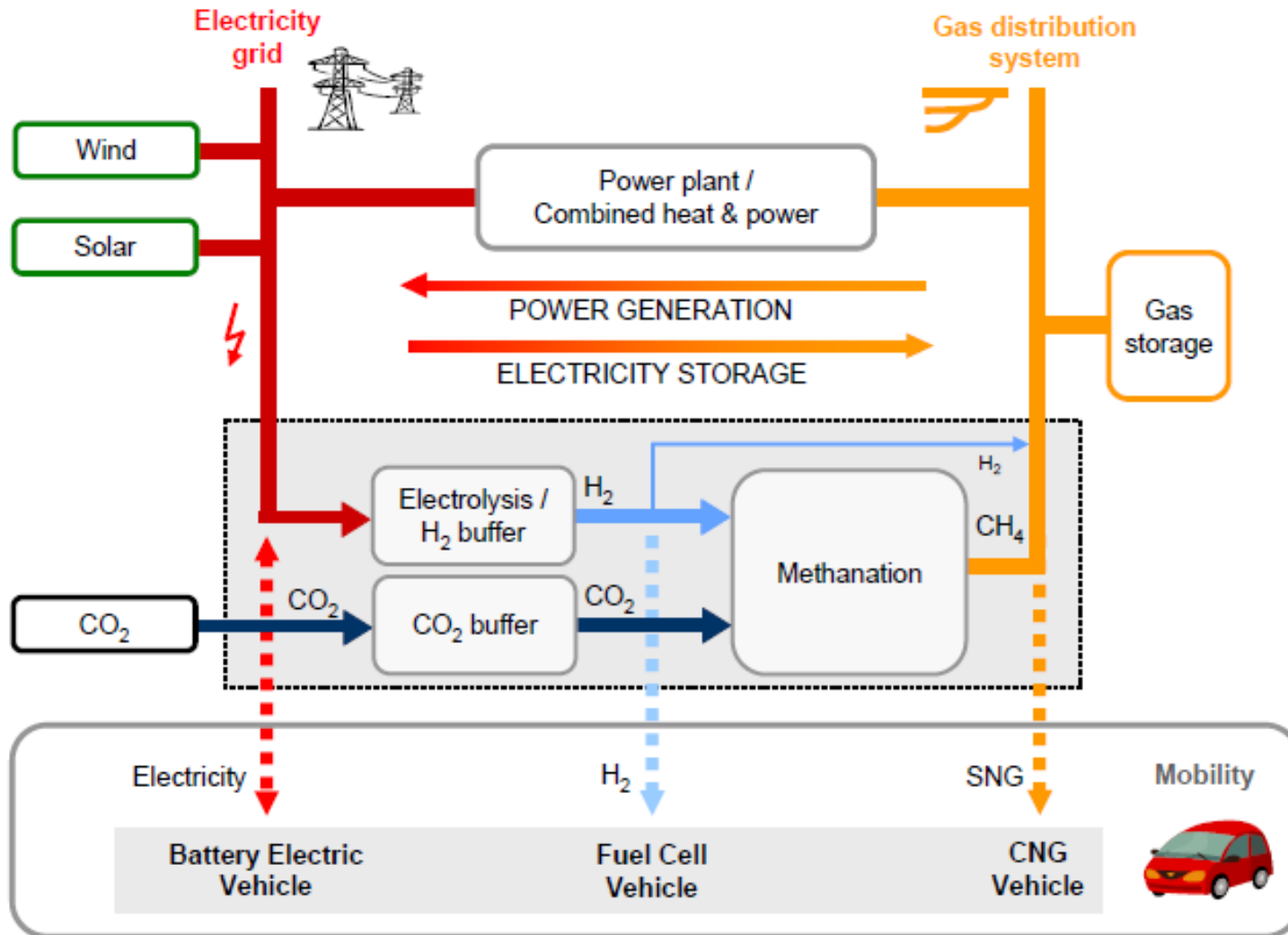
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# From Energy Silos to Energy Bridges



# Concept PtG – Interconnection of Power-Heat-Transportation



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# PtG Value Proposition

## *Integrate Renewables*

### **Capacity Value**

- Fast dynamic response to load follow profile of intermittent renewables
- Alleviates need for renewable capacity at peak demand levels

### **Infrastructure Value**

- Capital deferral of T&D upgrades
- Reduced ramping of non-peak generators

Conversion by  
Electrolysis

## *Renewable Gas*

### **Energy Value**

- Hydrogen
- SNG

### **Climate Value**

- Socio-economic costs
- Healthcare costs related to fine particles, etc.

### **Strategic Value**

- EU energy independence
- Military and political cost to secure conventional fossil-rich supplies

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Electrolyser

Compression

Pipeline connexion & metering

Control & Power Supply

# Falkenhagen, Germany

## 2MW Power to Gas Solution

### OBJECTIVES

- Convert excess wind power into hydrogen to store surplus energy.
- The hydrogen will be injected into ONTRAS/VNG's high-pressure transmission natural gas pipeline at 55bar.

### SOLUTION:

- 6 x HySTAT® 60 Outdoor with all peripherals in 20Ft. Housings to produce 360Nm³/h H<sub>2</sub>.
- A 40 Ft container including 2 compressors to compress the hydrogen to 55bar to inject it into the natural gas network.



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22.05.2013

# Meckl.-Vorpommern, Germany

## RH<sub>2</sub> - WKA Grid Stabilisation

### OBJECTIVES

- Provide electricity from a 140MW onshore wind farm at any time and when needed using hydrogen as energy storage. Some turbine are rated at 7.5 MW and CO<sub>2</sub> savings are estimated at +- 250.000 t/year.
- Use the H<sub>2</sub> in an internal combustion engine to produce electricity and retrieve the heat from the system for the building.
- In a next stage, use H<sub>2</sub> for transport and demonstrate the PtG (Power to Gas) solution by injecting the produced H<sub>2</sub> in the nearby pipeline.

### SOLUTION:

- 1MW HySTAT® indoor solution with all peripherals to produce 210Nm<sup>3</sup>/h H<sub>2</sub>.
- H<sub>2</sub> compression and storage system to store 27MWh (+-810kg) H<sub>2</sub> at 310bar
- One HICE.





# Stuttgart, Germany

## Methanation process

### OBJECTIVES

- Demonstrate the PtG (Power to Gas) solution using methane.
- Produce H<sub>2</sub> from the surplus of electricity and combine it with CO<sub>2</sub> from a biogas plant to produce methane → 4H<sub>2</sub> + CO<sub>2</sub> → CH<sub>4</sub> + H<sub>2</sub>O.

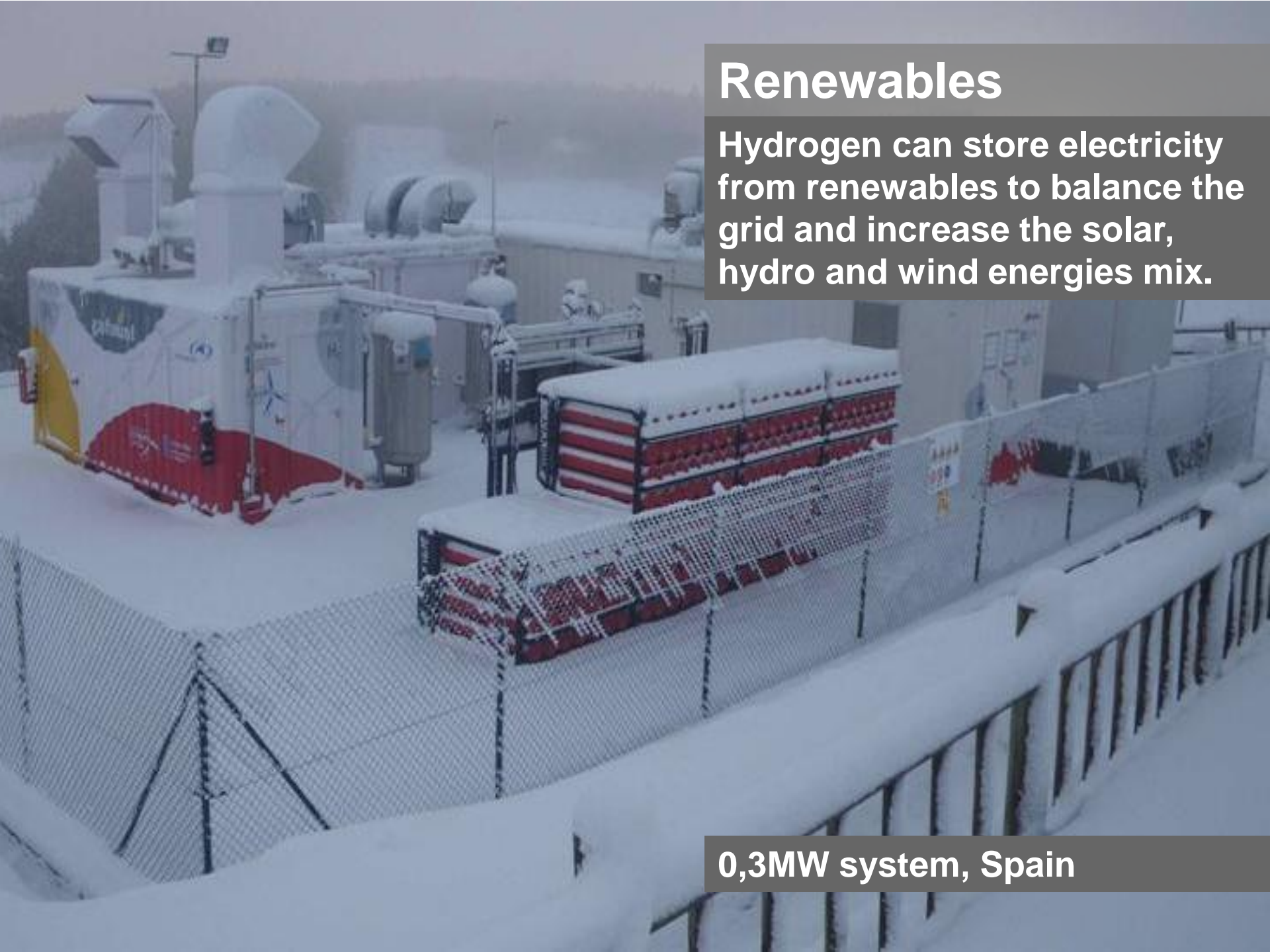
### SOLUTION:

- HySTAT® 60 Outdoor with all peripherals to produce 60Nm<sup>3</sup>/h H<sub>2</sub>.
- The electrolyser combined with a methanation process produces bio-methane.
- Bio-methane is injected in the gas grid, leading to a carbon neutral process.

# Renewables

Hydrogen can store electricity from renewables to balance the grid and increase the solar, hydro and wind energies mix.

0,3MW system, Spain



# Remote Communities

Hydrogen can store electricity from renewables to forego the use of diesel generators.



Bella Coola Community, Canada

# Ramea Island, Newfoundland, Canada

## Remote Community

Goal of this project was to insure the continuous delivery of electrical power, to solve the issue of the intermittent availability of renewable power (wind energy) as well as the goal to replace polluting diesel generators by clean fuel (Hydrogen) powered GenSets. One HySTAT30 outdoor solution and compressor were installed for Newfoundland and Labrador Hydro (NLH).





# Basin Electric Minot, North Dakota USA (2008)

## Fueling Station using RE

Basin Electric uses electricity coming from a 75MW Windpark to drive the HySTAT30/10 indoor electrolyser to produce Hydrogen for fueling the local H2-ICE vehicles.

Outdoors you can find the compression station, storage and dispenser for this fueling station.

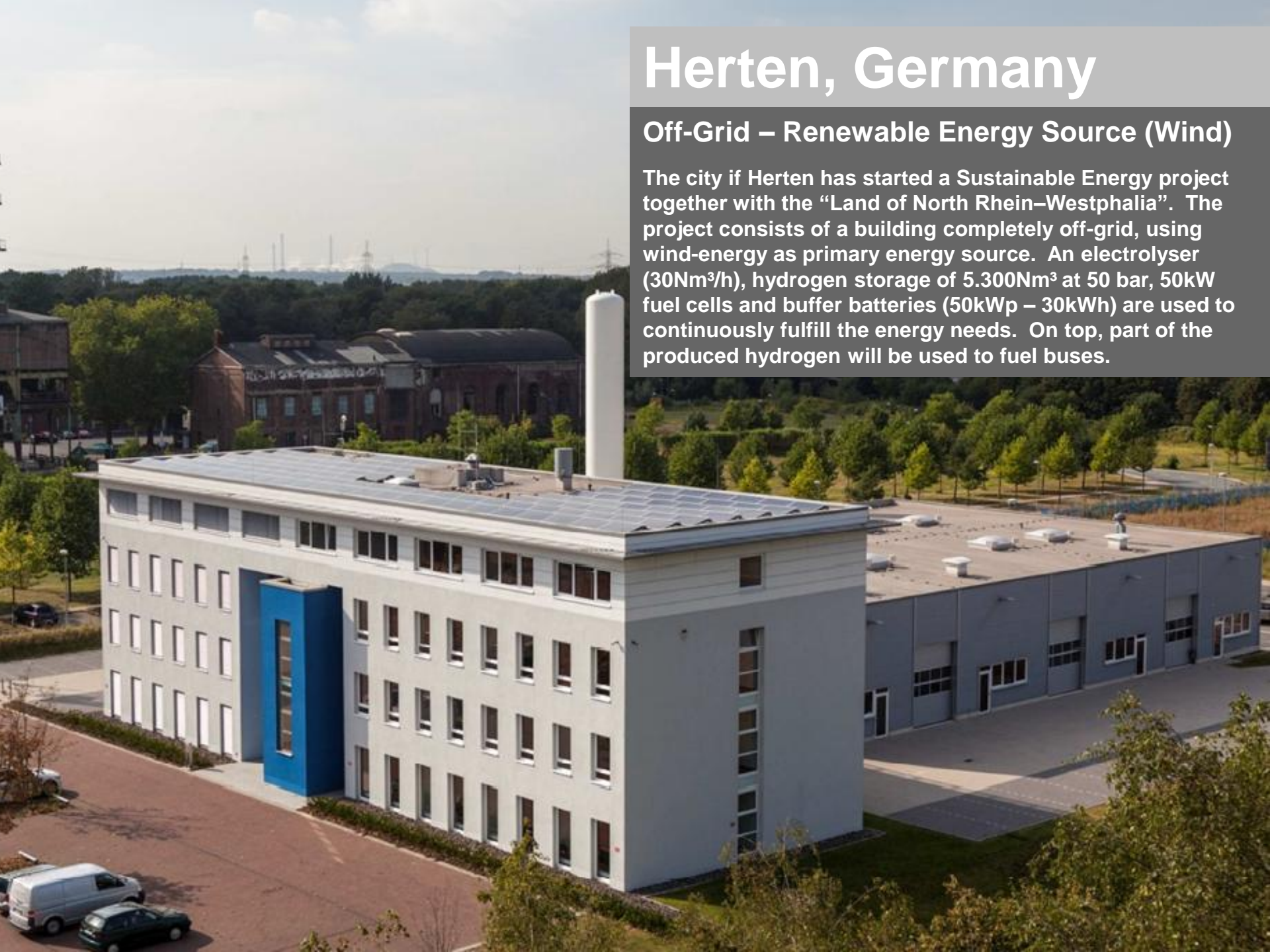
With this project, Basin Electric wanted to learn more about the way to produce Hydrogen as a fuel from Wind Energy.



# Herten, Germany

## Off-Grid – Renewable Energy Source (Wind)

The city of Herten has started a Sustainable Energy project together with the “Land of North Rhein–Westphalia”. The project consists of a building completely off-grid, using wind-energy as primary energy source. An electrolyser (30Nm<sup>3</sup>/h), hydrogen storage of 5.300Nm<sup>3</sup> at 50 bar, 50kW fuel cells and buffer batteries (50kWp – 30kWh) are used to continuously fulfill the energy needs. On top, part of the produced hydrogen will be used to fuel buses.





## Hamburg, Germany

**780kg/day, 350/700 bar dispensing**

Located in the center of Hamburg in front of “Der Spiegel” newspaper offices, the station is the biggest worldwide, capable to refill busses and passenger cars. The station has 120Nm<sup>3</sup>/h electrolyzers, 430kg 45bar storage and 250kg 830bar storage and follows the SAEJ 2601refueling protocol.

# EnBW, Stuttgart, Germany

## Fueling Station

130kg per day fueling station for Fuel Cell cars  
1 Hydrogenics HySTAT-60 electrolyser integrated  
by LINDE/BOC



# Shell, Santa Monica, USA

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## Fueling Station - California

65kg per day fueling station for Fuel Cell cars and buses  
1 Hydrogenics HySTAT-60 electrolyser and 350bar dispenser



# Colruyt, Halle (Brussels)

Hydrogen is used to fill fork lift trucks at the Colruyt Distribution Center in Halle/Brussels



Currently 65kg/day, 350bar dispensing,  
Extension to come - 30Nm<sup>3</sup>/h PEM  
electrolyser and chemical compressor  
EU Project TB finalized in 2015  
Colruyt, Belgium, Halle

# Oslo, Norway

## 260kg/day, 350bar dispensing

The station is part of the CHIC project and is installed at the Ruter bus station near Oslo. Five Van Hool H<sub>2</sub> busses are being operated and can be refueled in the same time as traditional busses. The station has A 120Nm<sup>3</sup>/h electrolysers and ...kg high pressure storage. A 700bar refueling module can be added in a further stage.



# Brügg, Switzerland

## 130kg/day, 350bar dispensing

The station is part of the CHIC project and is installed at the Postauto bus station near Brügg. Five Daimler Citaro H<sub>2</sub> buses are being operated and can be refueled in the same time as traditional busses. The station has a 60Nm<sup>3</sup>/h electrolyser and ...kg high pressure storage.





# Unido-Ichet project Istanbul, Turkey

## Fueling Station

65kg/day, 220bar/350bar dispenser for boats & buses  
HySTAT30/10 Outdoor electrolyser , 135kg of Storage



# More Worldwide Fueling Projects

## Europe



Sydkraft,  
Malmö, Sweden, 2003



CUTE Program,  
Amsterdam, Netherlands, 2005



CUTE Program  
Stockholm, Sweden, 2005



CUTE Program  
Barcelona, Spain, 2005



Vattenfall, Hafen City  
Hamburg, Germany, 2014



Gaz de France  
Dunquerke, France, 2008

# More Worldwide Fueling Projects

## America's



DTE, Michigan  
2004



Exhibition Place  
Toronto, 2004



Toyota HQ  
California, 2005



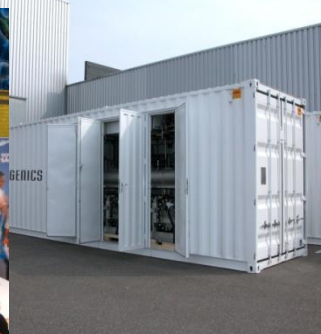
Chevron Tech. Venture  
Oakland Station, 2006



Cal State University,  
Los Angeles, CA, (in construction)



EMTU  
Sao Paulo, Brazil (in construction)



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# ANNEX: Some Numbers on Hydrogen

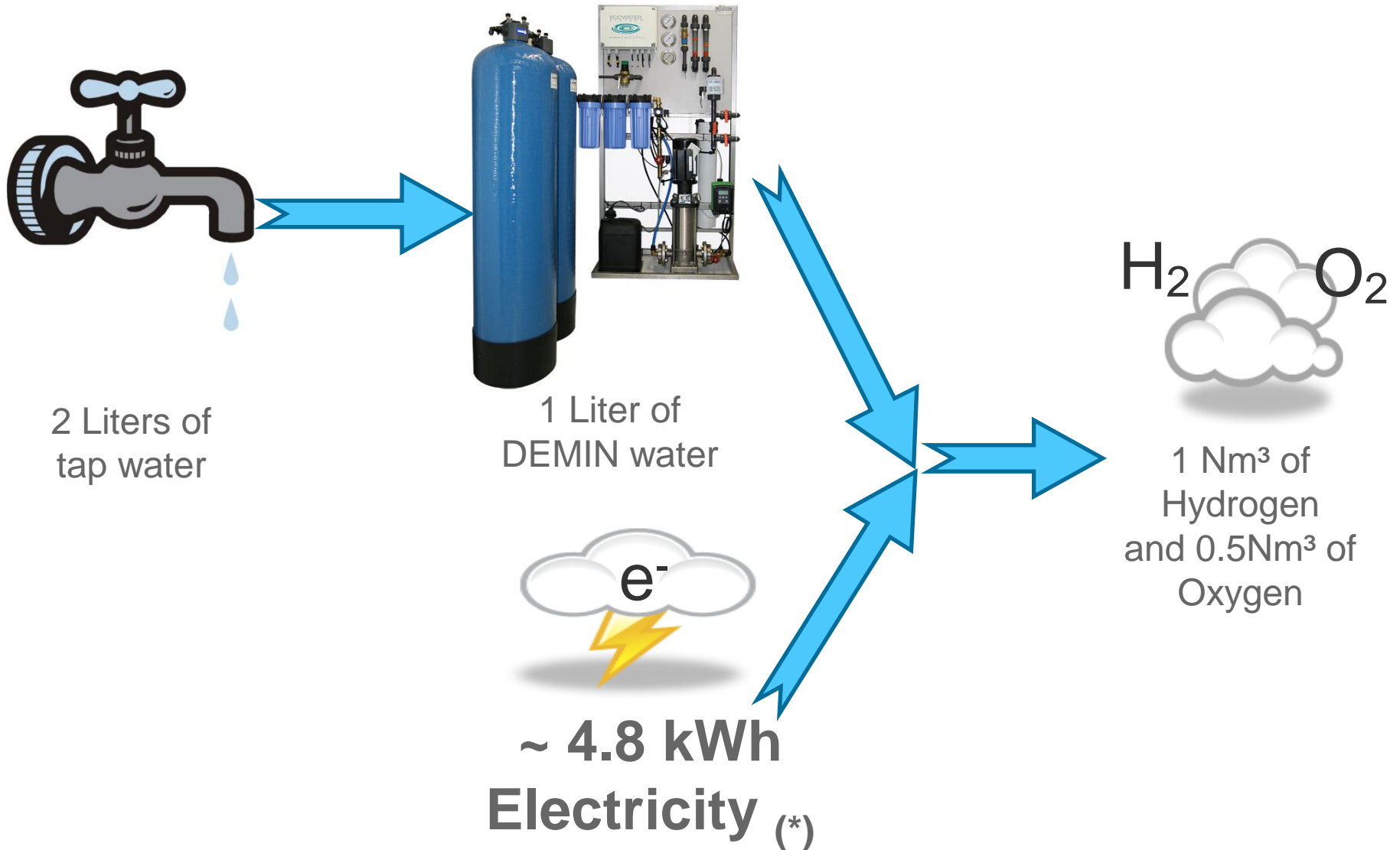


➤ **90% of all atoms in the universe are  
HYDROGEN**

**~ 75% of all mass in the universe is  
HYDROGEN**

**History of Hydrogen:**

[https://www.youtube.com/watch?v=J9C8MKnju\\_c](https://www.youtube.com/watch?v=J9C8MKnju_c)



(\*) : Electrolysis only: 4.8kWh.  
Full System (containerized) incl. all peripherals about 5.2kWh/Nm<sup>3</sup>





10 Liters of  
demin water

Require



~ **53 kWh**  
**Electricity**

To  
produce



1 kg Hydrogen

1 l H<sub>2</sub>O + 4,8kWh results in 1 Nm<sup>3</sup> of Hydrogen

11.1 Nm<sup>3</sup> of Hydrogen weighs 1 kg

# Fuel Cell Cars



1 Car uses approximately 1kg (11.1Nm<sup>3</sup>) of hydrogen for 100km  
Typical a car has about 5kg of hydrogen on board at 700bar, so  
today a driving range of about 500km  
*(buses fill up at 350bar, have a higher specific use of hydrogen/km, but have a much larger storage on the roof, so alike driving ranges in the end)*

## Hydrogen features and safety

- Can only be liquefied by lowering temperature ( $-253^{\circ}\text{C}$ ), so under normal conditions hydrogen is a gas
- Most light element in universe – 14,5 x lighter than air and rises at a speed of almost 20m/s, so rapidly diluted
- Hydrogen is one of the 3 exceptions ( $\text{H}_2$ , Ne, He) for the Joule-Thompson effect, meaning that the gas will heat-up when expanded at room temperature – all other gases will cool down at room temperature
- Hydrogen is highly flammable (4 -75% VS 1.4 – 7.6% for gasoline), but hydrogen flames have low radiant heat

## Hydrogen features and safety

- Combustion can not occur in a tank that contains only hydrogen
- Non toxic
- Colorless
- Odorless
- Tasteless