

# MAN ES P2X

Power-to-X, un Vecteur majeur  
de la transition énergétique

# Agenda

- 1 Why P2X ?**
- 2 Applications and Use Cases**
- 3 Business cases**
- 4 MAN Energy Solutions offering**
- 5 MAN Energy Solutions references**

# 1 Why P2X ?

# The game changers

Global warming



Political measures :

- ▶ Paris Agreement to limit temperature increase to 1,5°C
- ▶ Carbon price mechanisms (EU, China)
- ▶ Renewable energy targets (67+ countries)



# The game changers

Local pollution



Political measures :

- ▶ 100+ car « Green Zones » in Europe
- ▶ ECA zones multiplication
- ▶ Low emission vehicle credits mechanisms in China, Europe, or US

# Significant changes in energy system

Strong increase in Renewable Electricity share



Source: IEA Renewables 2019 report



Renewable Energy Sources:

- ▶ 240 GW/yr add. capacity planned until 2024
- ▶ Today world mix 26%, expected 30% in 2024
- ▶ High ambitions, up to 100% in some areas



# Significant changes in energy system

Beginning of transition in transports



- ▶ 2 Million electric cars today in operation
- ▶ First H<sub>2</sub> trains in operation
- ▶ 163 LNG fuelled ships in operation, > 80 ordered



# Decarbonization, new hurdles ahead

Current and coming changes raise new challenges



Electrical grid



Industrial feedstock and heating



Long range and heavy duty transportation

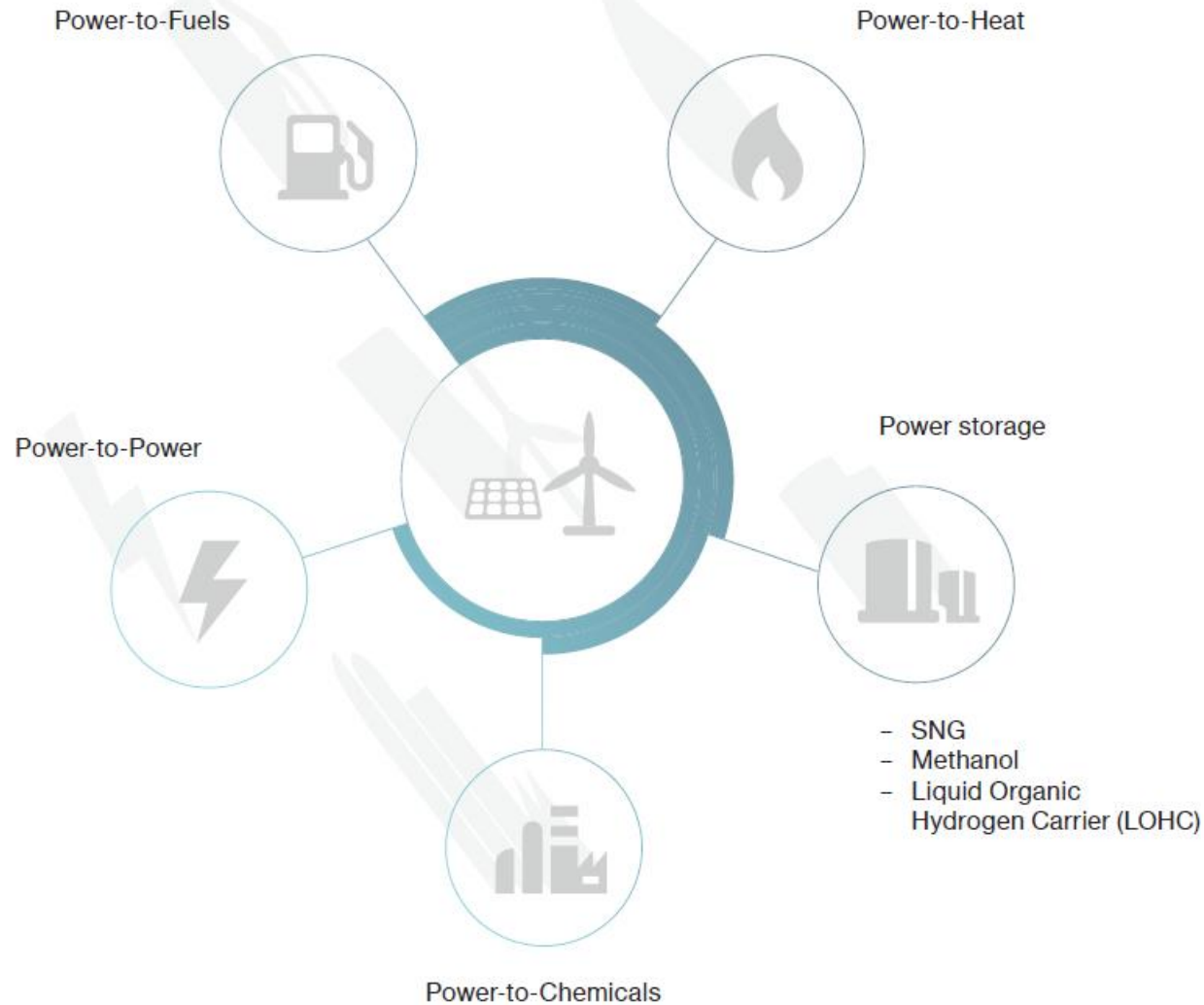


Building heating



# Power-to-X

A key to decarbonization



# Power-to-X

Key to a successful energy transition

# 2 Applications and Use Cases

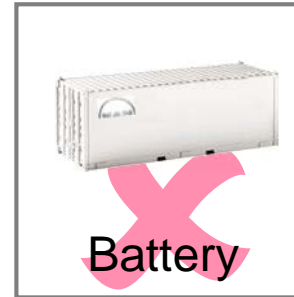
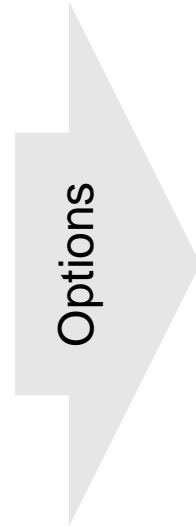
# Marine transport requires green LNG to fulfill IMO emission reduction targets



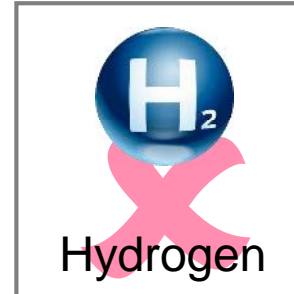
**50% reduction**

of greenhouse gases  
from 2008 to 2050<sup>1</sup>

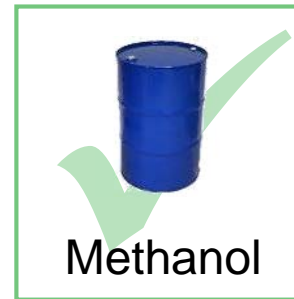
<sup>1</sup> \* Currently proposed target



Battery



Hydrogen



Methanol



- ✓ Green LNG is CO<sub>2</sub> neutral
- ✓ Uses existing infrastructure
- ✓ Allows gradual transition from fossil to renewable LNG
- ✓ Reduce carbon footprint today



# Green marine fuel

CO<sub>2</sub> neutral shipping with MAN PtX



**11,000 TEU**

Typical container vessel  
MAN ME-GI gas engine

**18,000 ton/yr LNG**

Main fuel consumption per year,  
7.5 roundtrips Dubai – Genua - Dubai

**61MW**

PtG plant operating 8000 hrs./year

**100% CO<sub>2</sub> neutrality**

Teu: Twenty-foot equivalent unit  
Source: MAN Study „11,000 teu container vessel – An ME-GI powered vessel fitted with  
fuel gas supply system and boil-off gas handling“, 2018

# Green SNG mobility

CO<sub>2</sub> neutral mobility with MAN ES PtX



or

**50 MW**

Renewable Power

**50 MW**

MAN PtG power input

Gas grid

**470**

MAN gas busses<sup>1</sup>

**28,600**

Gas cars<sup>2</sup>

- ✓ Renewable gas supply for mobility
- ✓ Using existing infrastructures and fleets

<sup>1</sup> 60000 km/a; 53 kg/100km, <sup>2</sup> 15000 km/a; 3.5 kg/100km (@ PtG = 8000h/a)



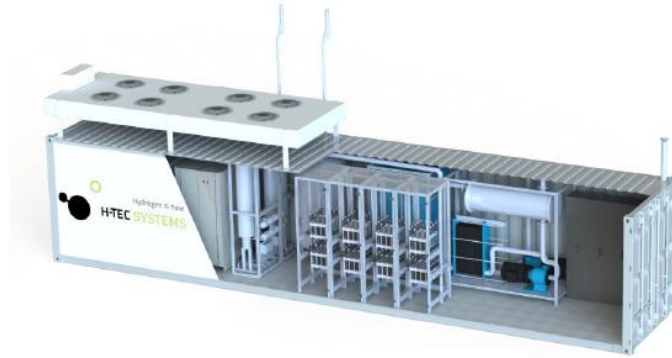
# Green Hydrogen mobility

CO<sub>2</sub> free mobility applications with MAN ES / H-TEC SYSTEMS Solutions



**1 MW**

Renewable Power



**1 MW**

H-TEC ME450/1400 Electrolyser



**1000**

AUDI h-tron quattro<sup>1</sup>

Other usages:

**2**

H<sub>2</sub> Trains



Quelle: Alstom

**20+**

H<sub>2</sub> Busses



Quelle: Van Hool

For 8000h/a PtG, 1: picture © AUDI, 15000 km/yr 1 kg/100km; trains 600km/day; busses 60000km/yr



# 3 Business cases

# Exemplary feasibility for SNG plant

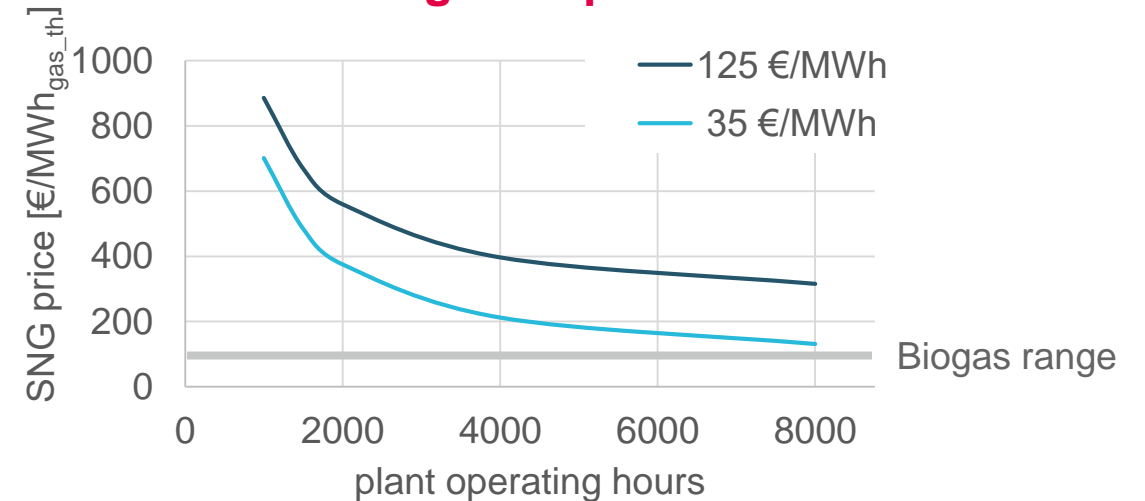
P2G shows difficult economics without CO<sub>2</sub> tax

## Assumptions:

- Plant size: 50MW electrical input to electrolysis
- Operation: 8000 h/a
- Electricity costs: 35 €/MWh<sub>el</sub>
- Amortisation time: 10 years
- CO<sub>2</sub> by amine treatment plant
- no income from CO<sub>2</sub> avoidance
- Renumeration of O<sub>2</sub>: 0.1 €/Nm<sup>3</sup>



## Resulting SNG price



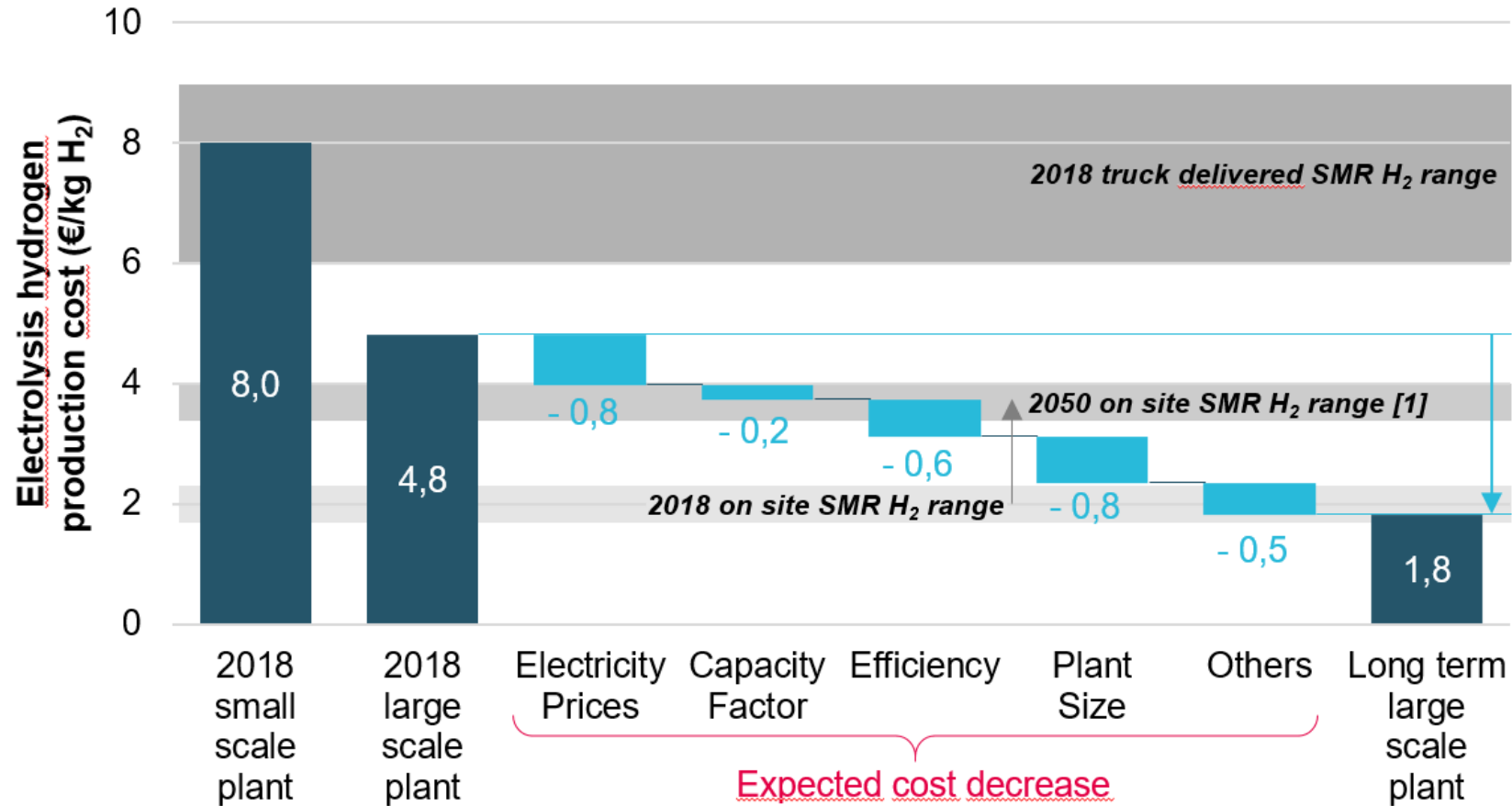
## Gas price examples in Europe:

- Natural gas for industrial consumers: 20 - 65 €/MWh
- Biogas: 50 - 80 €/MWh
- CNG Petrol Station: 1.1 €/kg → 80 €/MWh

SNG: Synthetic Natural Gas; CNG: Compressed Natural Gas

# Coming improvements of P2X economics

Massive renewable H<sub>2</sub> production achievable in the long run

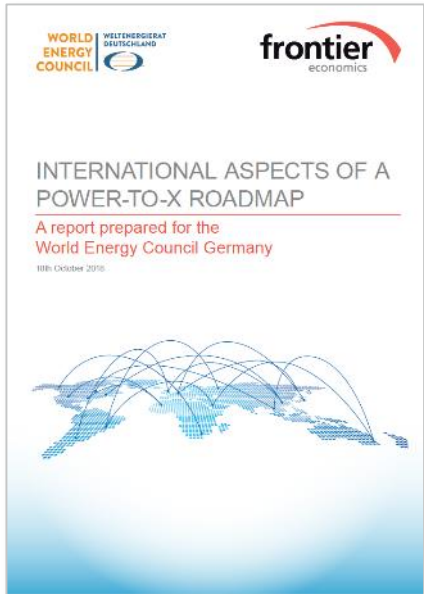


- ▶ Nascent market in small size decentralized industrial H<sub>2</sub> production ?
- ▶ Nascent hydrogen mobility most dynamic market today ?
- ▶ Cost reduction by scaling up needed for positive business cases in other applications



# There is a need for synthetic fuels policy action

“P2X is a necessary element of the global energy transition”



**200MW/a**

New PtX plants in EU  
from 2020 onwards

**3000 – 6000 GW**

Electrolysis capacity in second  
half of 21st century

**250 bln. €**

Savings until 2050 with eFuels  
compared to pure electrification

Feasible production of synthetic fuels  
requires:

- No tax loads, incentive frame
- Low cost RES for electricity supply over  
> 4000 hours per year
- Financial support to enable market  
development and subsequently cost  
reduction
- Incentives for users of carbon neutral fuels

PtX: Power to X; EEG: renewable energy law in Germany; RES: renewable energy sources

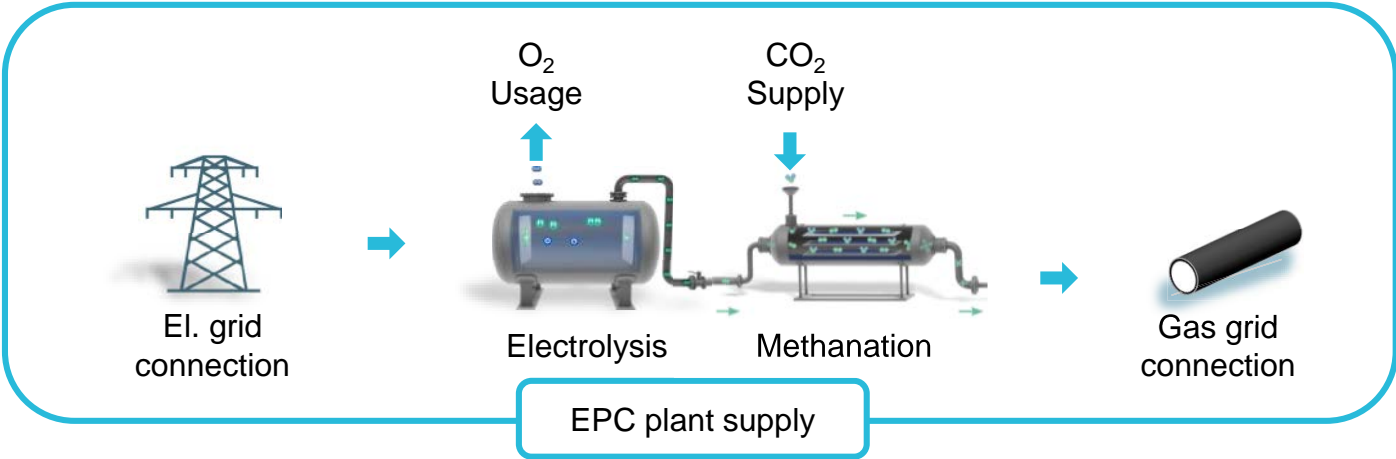
# 4 MAN ES offering

# MAN ES Power-to-X (PtX)





# MAN ES Scope of Supply and technical data



## Input

el. Power @ electrolysis:	50 MW
Carbon Dioxide (CO <sub>2</sub> ) @ CO <sub>2</sub> >95%, H <sub>2</sub> O <5%, SO <sub>2</sub> ≤0,01 ppm	5.1 t/h

## Output

Methane (CH <sub>4</sub> ) @ CH <sub>4</sub> >95%, H <sub>2</sub> + CO <sub>2</sub> <5%	1.8 t/h
Oxygen (O <sub>2</sub> ) @ 99.95% purity	7.3 t/h
Saturated Steam @ 270°C, 55barg	5 t/h

## Technology

Electrolysis type	Alkaline or PEM
Methanation type	Catalytic
CO <sub>2</sub> separation	Amine gas treating

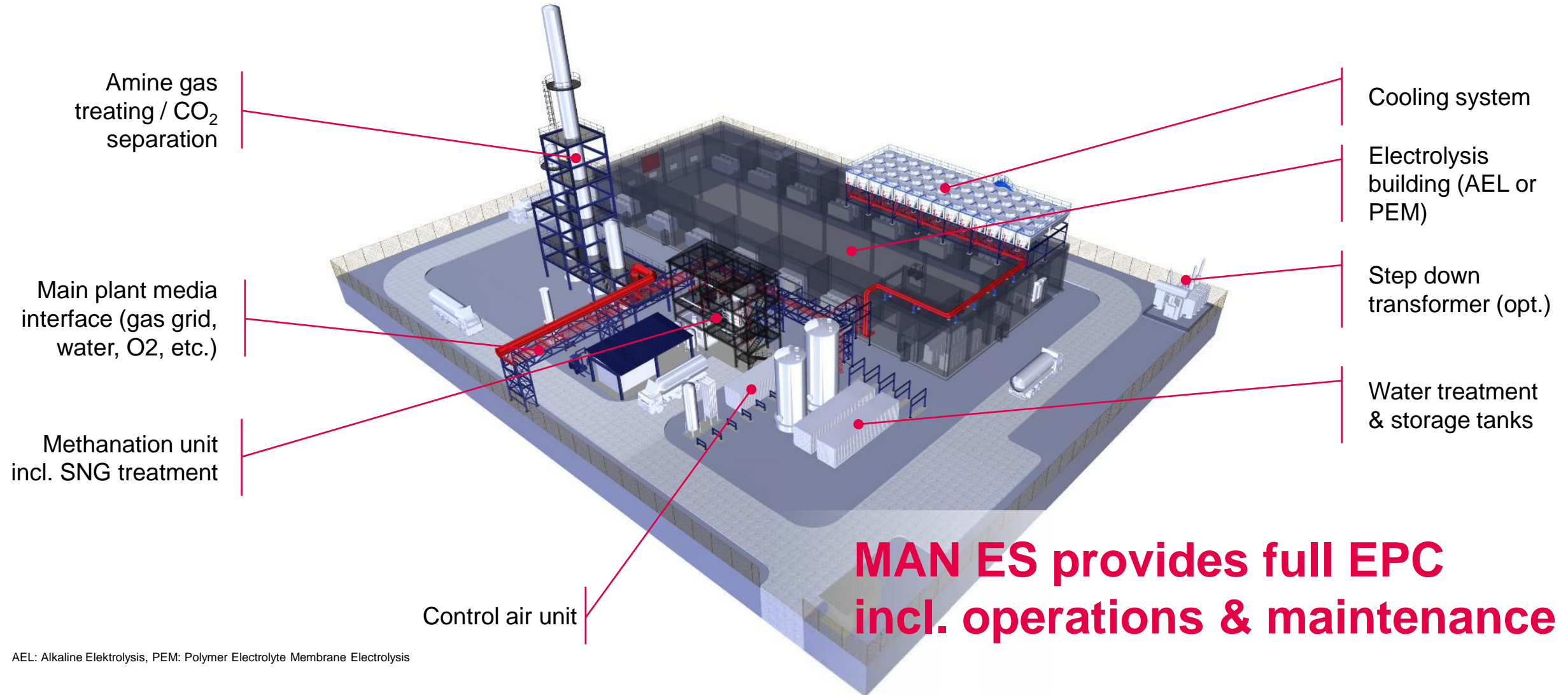
## Footprint

Plant space requirements	85 x 100 m
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Picture Source PtG Plant: Audi

# MAN ES Power-to-Gas reference plant

MAN ES 50 MW PtG plant layout - preliminary



AEL: Alkaline Elektrolysis, PEM: Polymer Electrolyte Membrane Electrolysis

# MAN ES / H-TEC SYSTEMS Electrolysers solutions

H-TEC-SYSTEMS, privileged MAN Energy Solutions partner (40% shareholder)

## ELECTROLYSIS STACKS



**Series-S30 stacks (1 to 5 kW)**

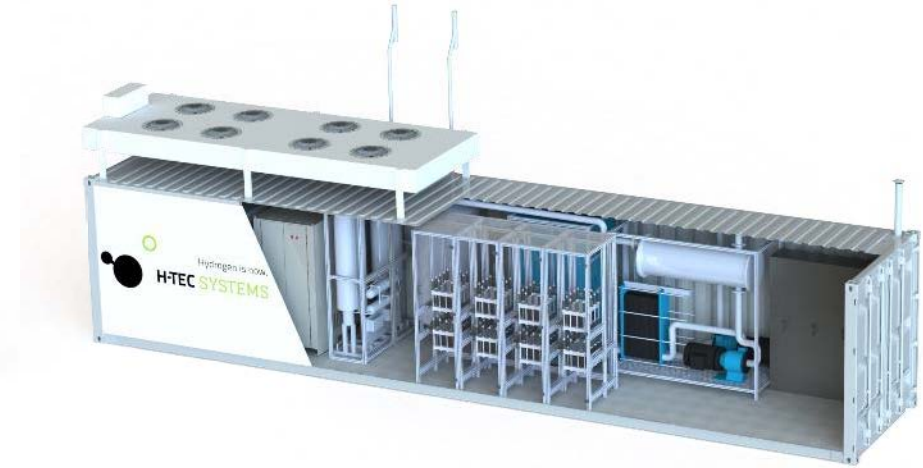
### H-TEC SYSTEMS Series-S electrolyser stacks

- Nominal power from 1 kW to 100kW
- High power density
- Low transformation costs
- High efficiency
- Suited for integrated solutions

## ELECTROLYSERS - READY. SET. SUPPLY.



**ME 100/350 (225kW, 100kg H<sub>2</sub>/day)**



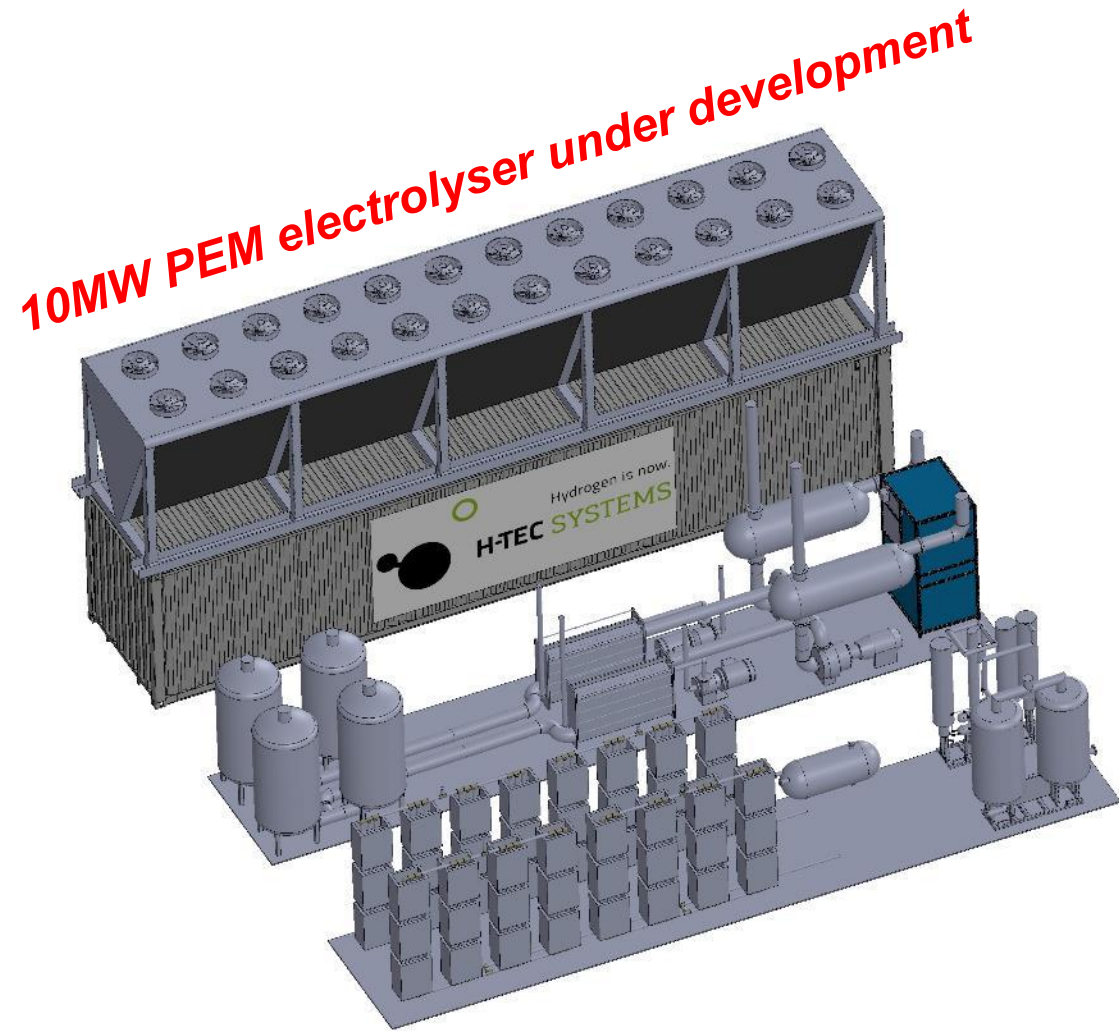
**ME450/1400 (1 MW, 450kg H<sub>2</sub>/day)**

### H-TEC SYSTEMS Series-ME electrolysers

- Compact design in an ISO container
- Capable of dynamic part load operation to enable grid balancing services
- High conversion efficiency (74%), additional heat integration
- 5.0 hydrogen quality suitable for refuelling applications
- Readily available product for effective sector integration solutions

# MAN ES / H-TEC SYSTEMS Electrolysers solutions

H-TEC-SYSTEMS, privileged MAN Energy Solutions partner (40% shareholder)



## Key parameter of the 10 MW Electrolyser

- ▶ Based on proprietary stack technology
- ▶ Nominal energy consumption: 10 MW
- ▶ H<sub>2</sub> production: 2100 Nm<sup>3</sup>/h resp. 4500kg/day
- ▶ Very high efficiency of 74%
- ▶ Perfectly suited for the integration into industrial PtX plants
- ▶ Available for commissioning in 2023



# 5 MAN ES references

# MAN ES power-to-SNG reference in Werlte

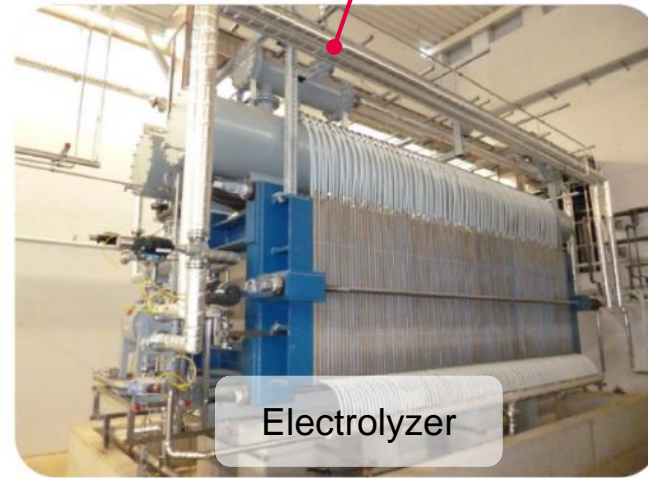
A demonstrator in operation since 2013



Methanation System



Biogas plant



Electrolyzer

## Key facts:

- 6 MW power input for alkaline Electrolysis
- SNG used as e-fuel for Audi customers
- Methanation reactor by MAN ES Deggendorf

➔ Plant In commercial operation since 2013

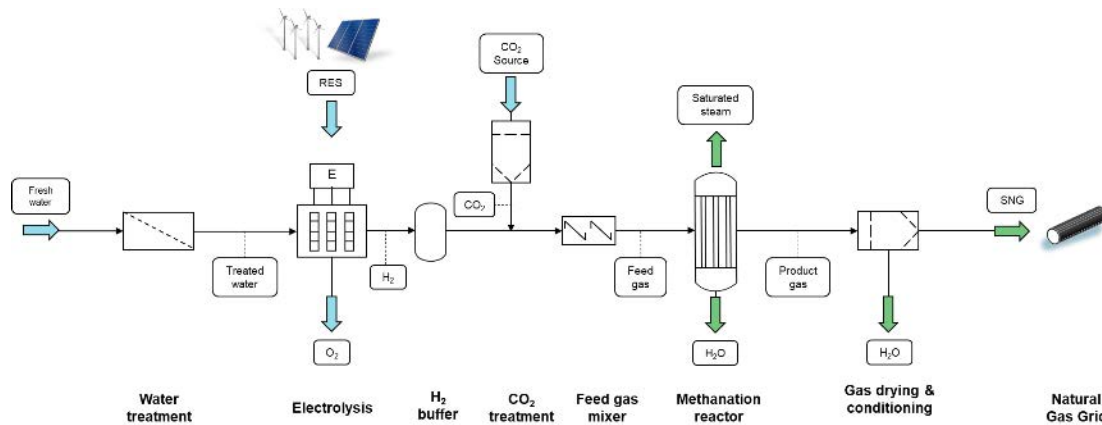
Picture source: Audi

# HySynGas Project

Cornerstone for the North German Power-to-Gas-Hub



- ▶ Industrial scale gas plant in Brunsbüttel industrial park (State of Schleswig-Holstein in the North of Germany)
- ▶ Regional purchase of CO<sub>2</sub> from combustion processes of local industry.
- ▶ Production of green hydrogen and SNG.
- ▶ Feed-in of SNG into the gas grid enables usage all over Germany. Additional off-take by local industry.
- ▶ Potential LNG terminal opens perspective for additional applications in maritime sector.



## HySynGas in short :

- ▶ 50MW Electrolysis, >20 t H<sub>2</sub>/day
- ▶ Production of > 40 t SNG/day
- ▶ CO<sub>2</sub>-saving > 110 t CO<sub>2</sub>/day



# H-TEC SYSTEMS references

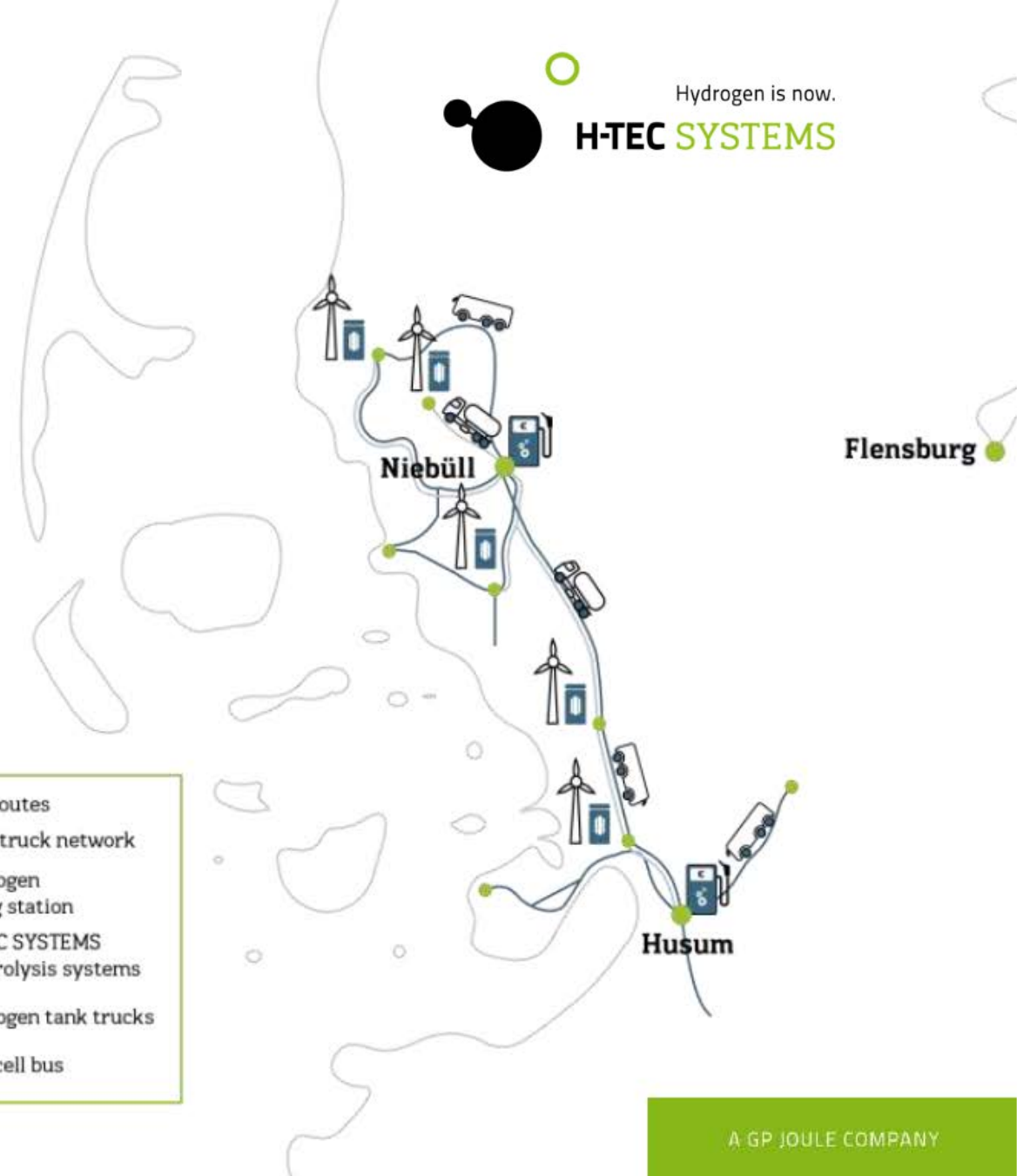
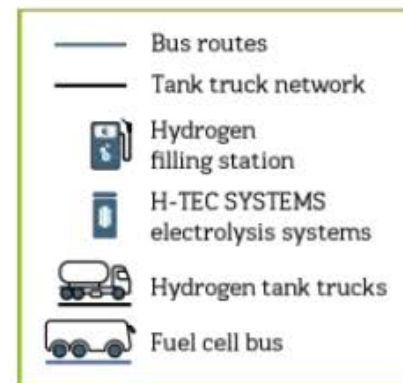
## Hydrogen mobility : eFarm concept in Schleswig-Holstein

**Excess electricity from local renewables is converted into emission-free mobility**

- Production: 5 ME100/350 Electrolysers
- Public Transport: 2 Hydrogen busses
- Fuelling: Hydrogen trailer truck to refuelling station

- Proof of reduction in CO2 emissions
- Annual CO2 saving of 322 tonnes per bus plus 800 tonnes by utilising the waste heat
- Electrolyser's full load hours can be doubled

**Complete system to be installed in 2019**



A GP JOULE COMPANY



# H-TEC SYSTEMS references

Key elements of the eFarm concept



225 kW electrolysis systems



Hydrogen refueling station (Linde AG, 2018)



Hydrogen swap body concept



Fuel cell buses (Solaris, 2018)

**Complete system to be installed in 2019**

A GP JOULE COMPANY

# Summary : environment needed to develop P2G

- Cheap green electricity
- High power factor > 4000hrs/yr
- CO<sub>2</sub> incentive Feed-in Tarif frame
- Multi MW industrial scale
- By-product valuation (O<sub>2</sub>, heat)
- H<sub>2</sub> direct sales (can be a plus)



# Thank you very much!

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October 2019



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