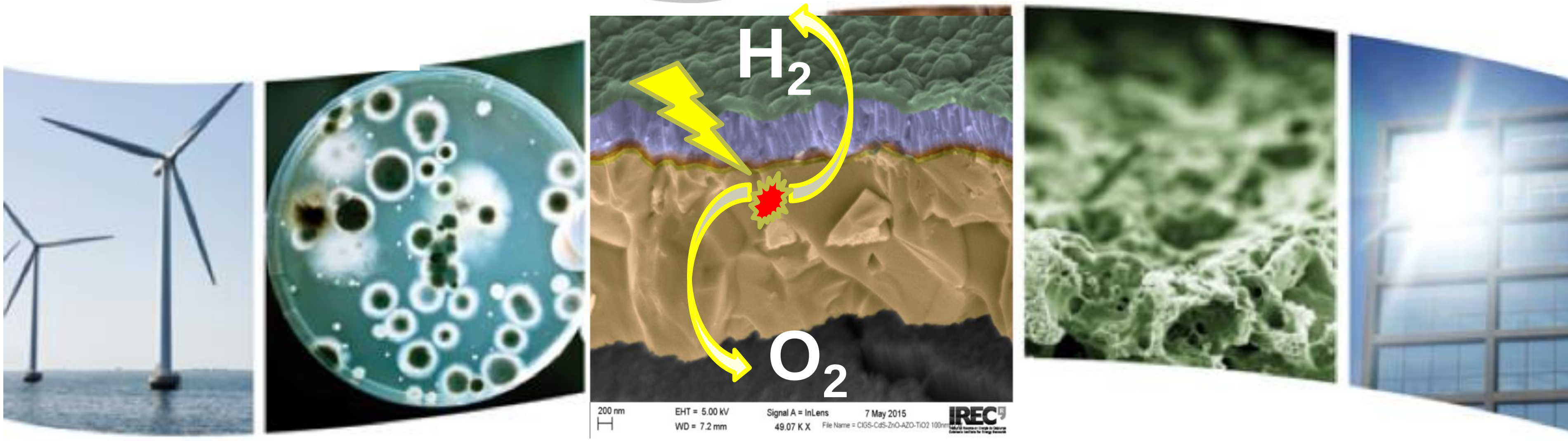
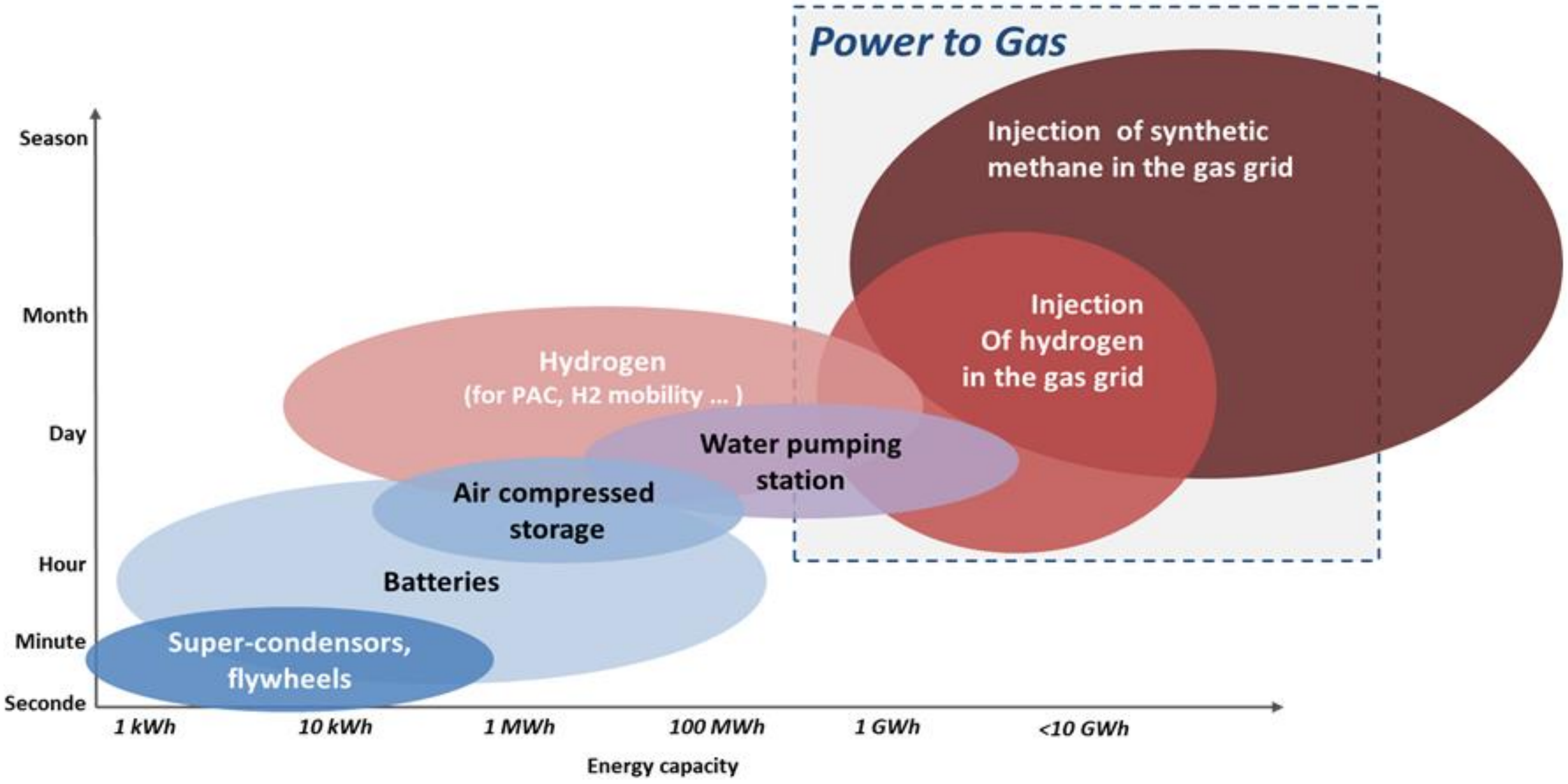


EJEMPLOS REALES DE IMPLEMENTACION DE TECNOLOGIAS DEL HIDROGENO

J.R.Morante & M. Torrell

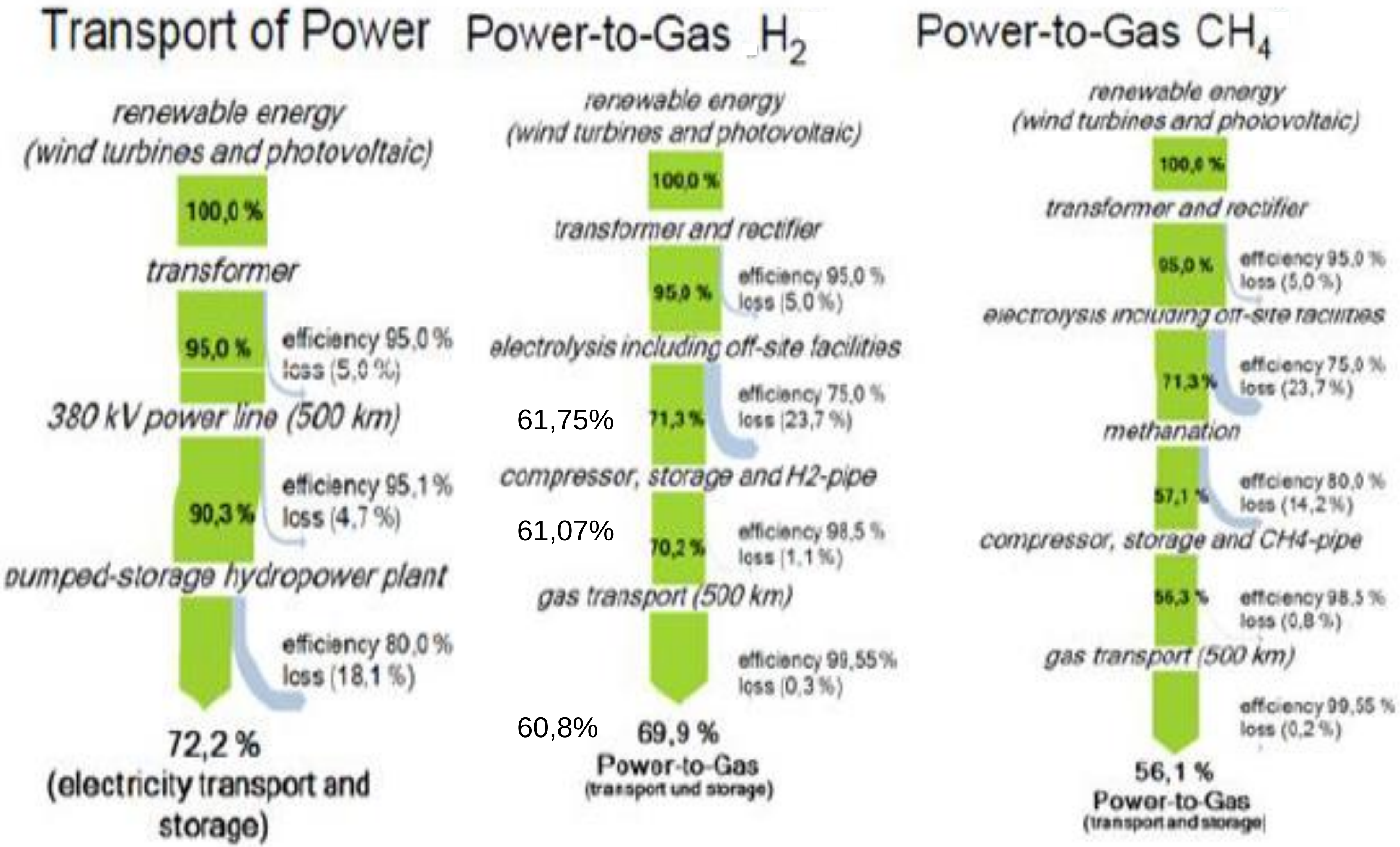
IREC, Catalonia Institute for Energy Research, Plaça de les Dones de Negre,1. Sant Adrià del Besòs, 08930. Spain.

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research



http://www.grtgaz.com/fileadmin/transition_energetique/documents/hydrogene_et_reseau_e-cube_GRTgaz.pdf

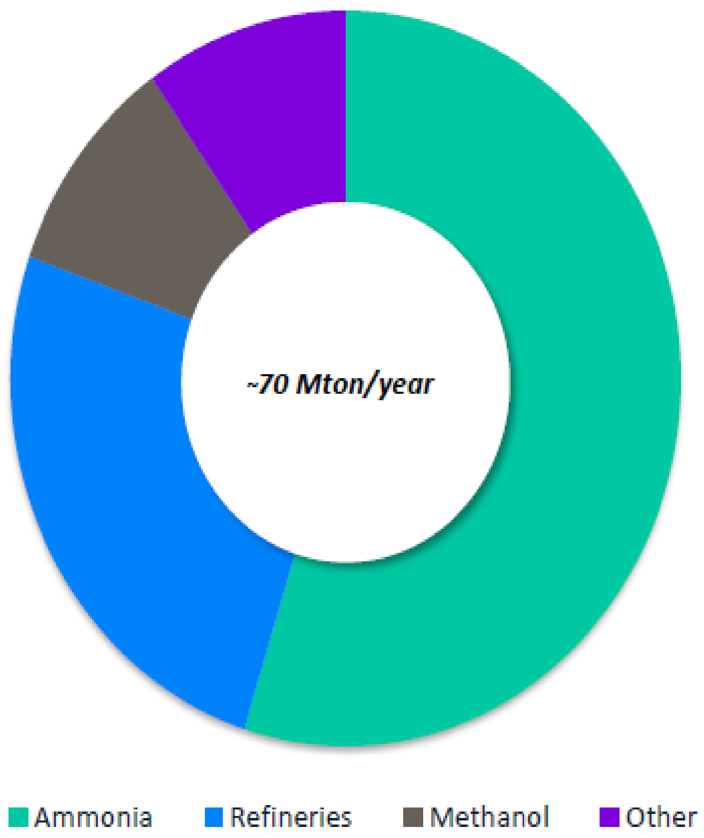
http://www.grtgaz.com/fileadmin/engagements/documents/fr/Power-to-Gas-etude-ADEME-GRTgaz-GrDF-complete.pdf



Source: IRES (Fraunhofer presentation) + IREC

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

Global hydrogen market, by end-user

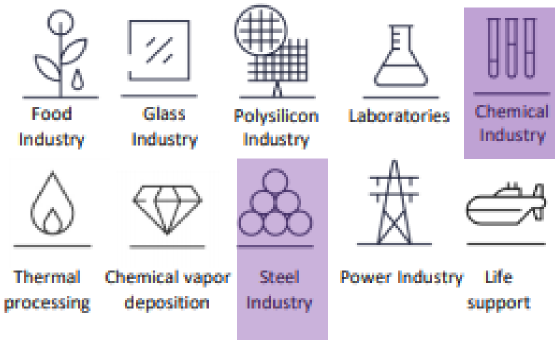


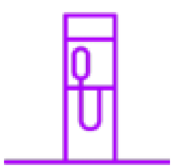
Large growth potential

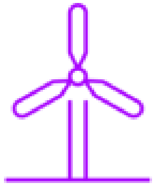
1) Increasing focus on climate & decarbonizing
2) Decreasing renewable prices
3) Decreasing electrolyser capex

Hydrogen is expanding its areas of application…

CONVENTIONAL INDUSTRY	MOBILITY	POWER-TO-X







Conventional industry

- Conventional industries represents "traditional" hydrogen markets
- Steady demand for hydrogen

Refineries

Mobility

- Key market going forward – both within hydrogen production and fueling/dispensing
- Heavy duty sector developing faster than anticipated – hydrogen now relevant fuel for all forms of mobility

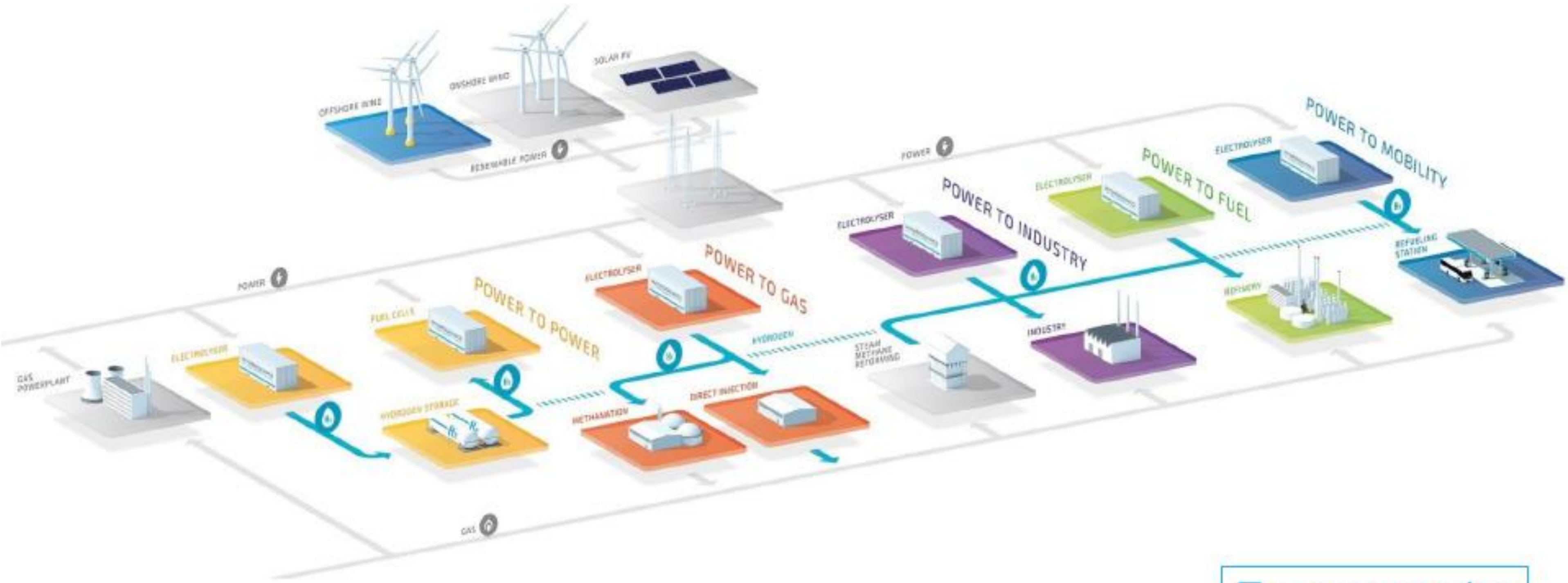
Power-to-X

- Decreasing cost of renewables and electrolyzers is accelerating market
- Vast opportunities within existing and new sectors

Steady growing market

Markets expected to see fast growth going forward

… to Renewable Hydrogen



Energy carrier

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

…with growth expected to be accelerated by transportation…

- Hydrogen has potential to become a preferred fuel alternative in the future:
  - True zero emission from production to use
  - Can beat fossil fuel applications on a TCO-basis
  - Low weight (compared to e.g. batteries), especially relevant in the heavy duty segment
  - Fast recharging (fueling) time
  - Long driving range
  - Low/no need for electric grid upgrades
  - Not dependent on rare metals (e.g. cobalt, lithium)
  - Global standards for fueling established
  - Same quality fuel used for small to large applications
- Initial development highly affected by policies and subsidies

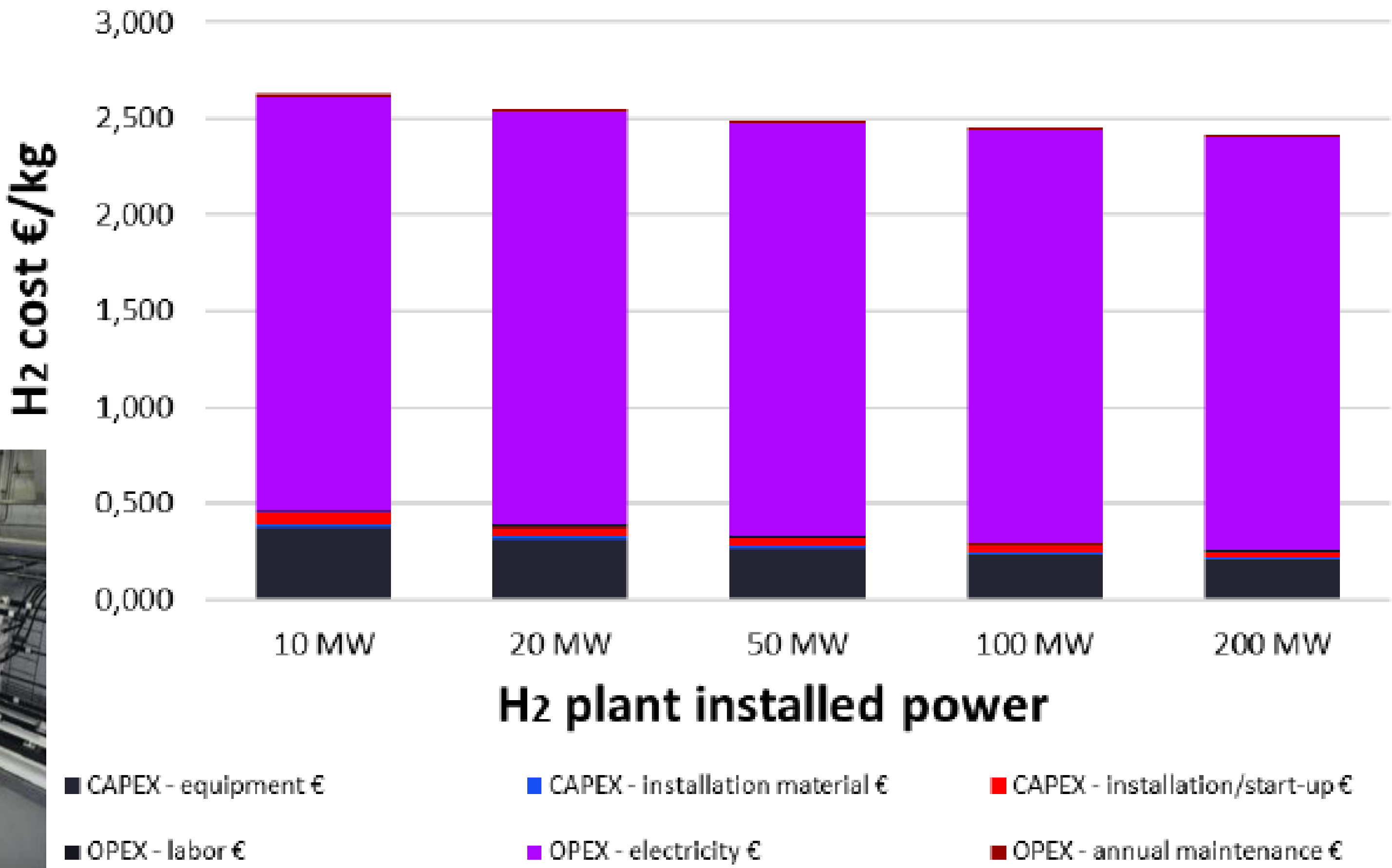
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

...and all forms of Power-To-X

- Wide variety of existing and new markets where electrolysis can play a major role
  - Exchanging fossil hydrogen with renewable hydrogen (f.ex fertilizer)
  - Exchanging coal with renewable hydrogen (f.ex steel manufacturing)
  - Oxygen & heat from electrolyzer adds value
- Electrolysis "bridges the gap" between the power and industry sector, increasing the value of electrons
- Ability to adapt to diverse and intermittent renewable energy sources becoming increasingly important

Often OPEX-driven projects

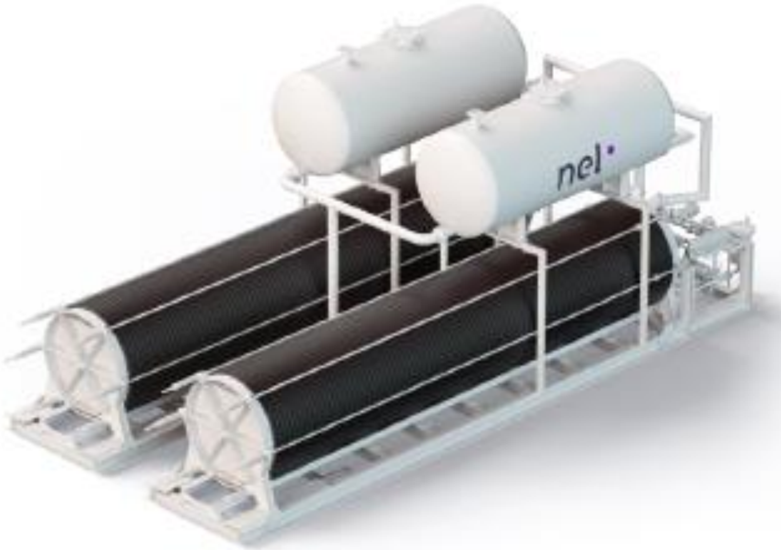
Electricity: main LCOE contributor



Assumptions: 40EUR/MWh, 10Y period, Utilities excluded (cooling, Nitrogen), cost related to civils & approvals

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

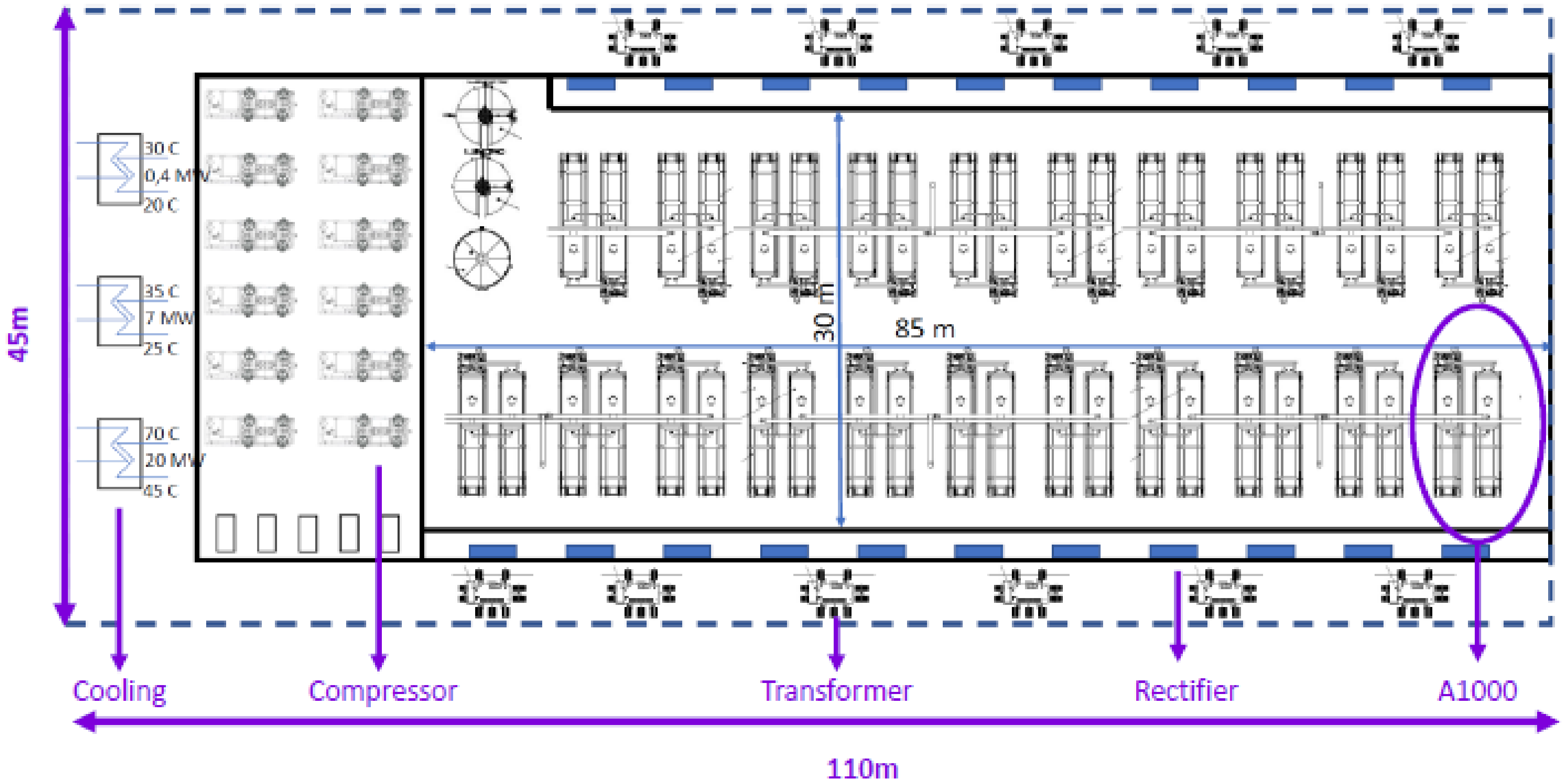
A1000: 2 tonnes/day (970Nm³/h)



Specifications	A1000 (4,4 MW)
Net capacity	600 – 970 Nm^3/h
Turndown	15 – 100%
Power cons. (stack)	3,8 – 4,4 KWh/Nm^3
H_2 purity	99,99 %
O_2 Content in H_2	< 2 ppm v
H_2O Content in H_2	< 2 ppm v

100MW optimized design – fully automated

30,370Nm³/h, 43,964kg/day, 5-200barg



Industrial site: 25MW/5'500Nm3/h.

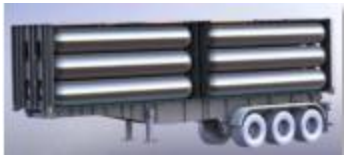
From hydroelectricity → Green H_2

- New manufacturing plant in Herøya
- 4.5MW electrolyser for fossil-free steel in Sweden.Objective is to replace the coking coal
- Collaboration agreement with Yara related to green fertilizer project

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

YARA

Large scale hydrogen production (hydro power available at numerous sites)



Trucked-in in pressurized tanks, 500 bar in a 40ft container, 1,300kg of H2

- Applying low cost industrial solution to transport applications, driving down cost
- Install an 8-stack electrolyser, produces 8 ton of hydrogen per day at full production – fully scalable
- Offers low cost hydrogen, grid balancing services as well as heat for district heating
- Can produce to and supply multiple applications, bus, truck, car, ferry, train, etc.
- Can support a large number of vehicles within each application

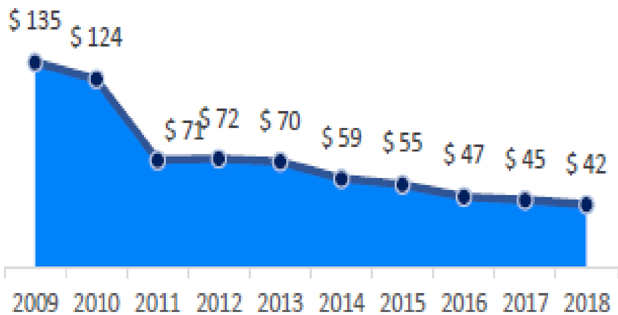
Vehicle	#	Kg/d/unit	Total kg/d
Bus	100	25	2 500
Truck	100	30	3 000
Car	2000	0.5	1 000
Ferry	4	250	1 000
Train	2	250	500
		Total (kg/d)	8 000

IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

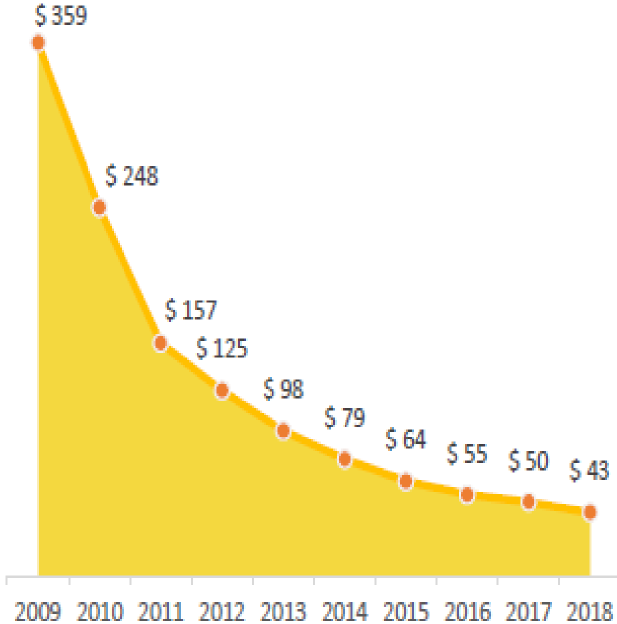
Green Electricity Prices Drop

Down 69 & 88% respectively in last decade, going from subsidized to unsubsidized

Wind LCOE
Unsubsidised ($/MWh) 2)



Solar PV LCOE
Unsubsidised ($/MWh) 2)



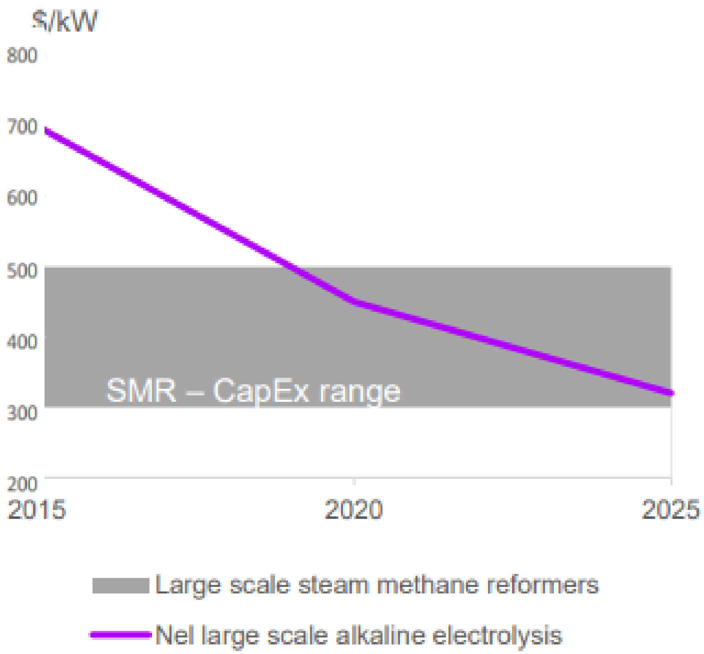
- H_2 follows the same trend as power is 70-80% of total cost of H_2 for large scale.
- Record low auction prices for solar PV & wind with $17.7/MWh & $17.86/MWh respectively (as of 2017) 3).
- Prices expected to drop further, LCOE of solar PV and onshore wind expected to fall by 71% & 58% respectively by 2050 4).

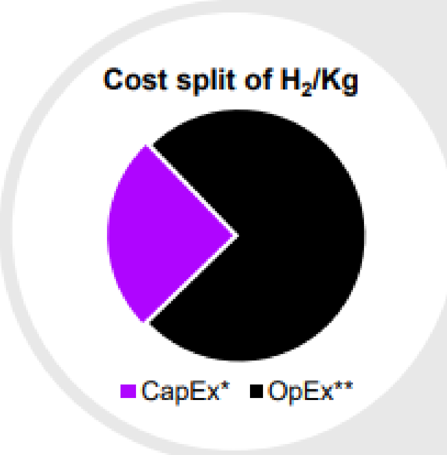
Source:
1) LCOE = Levelised cost of energy, which is a way of calculating the total production cost of building and operating an electricity-generating plant
2) Lazard; Renewables Now, 3) IRENA (International Renewable Energy Agency); 4) BloombergNEF New Energy Outlook 2018

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

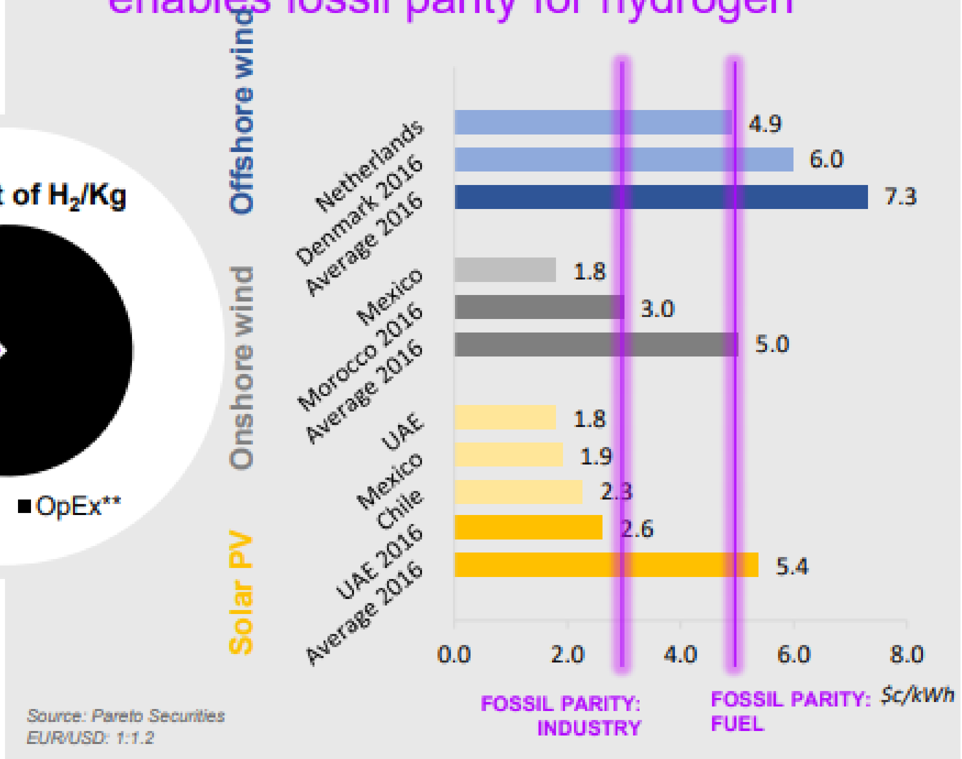
At $50/MWh renewable hydrogen is becoming competitive with fossil fuels
and
at $30/MWh renewable hydrogen is becoming competitive in all markets

CapEx: Electrolysers from Nel - becoming competitive with SMR





OpEx: Renewable energy already enables fossil parity for hydrogen



IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

Efficient hydrogen distribution:

- 2.5 hour travel distance for optimal distribution cost
- H2Station capacity can easily be added or expanded
- Fuel with 100% renewable hydrogen at attractive price

Ruter
10+++ busses at Bekkestua, other
Ruter#

HDV – Hyundai/SCANIA
Trucks, forklifts, cars
ASKO

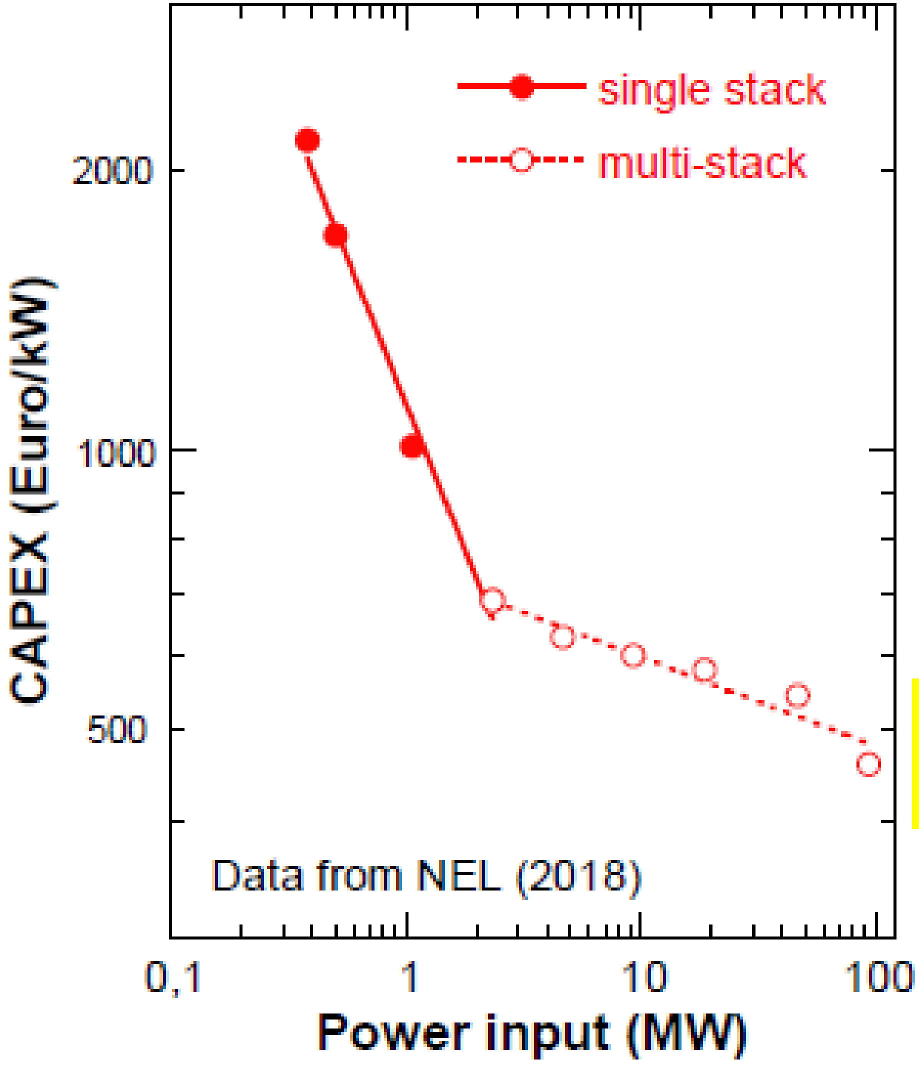
H2 Train
Kongsvinger-Elverum-Koppang
ALSTOM

LDV fueling station
700 bar, 5 kg in 3 min
Kjørebo, Hvam, Ås, etc.
Uno X

Norled / Ruter
Fast ferry (Oslo/Drøbak)
NORLED

OSL Gardermoen
Electrification airport internal traffic
AVINOR

Electrolyser CAPEX (alkaline)

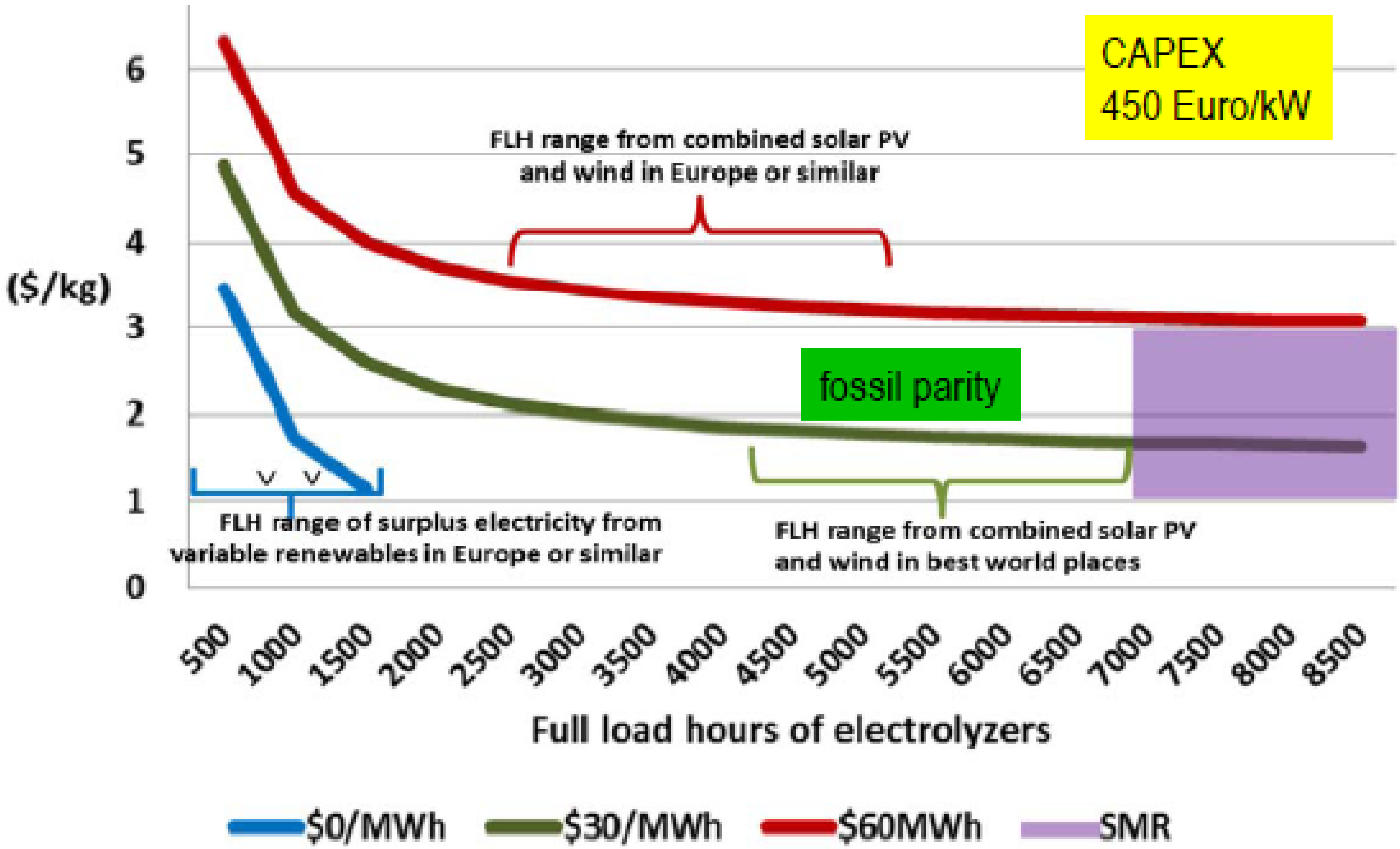


2

450 Euro/kW
@ 50-100 MW

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

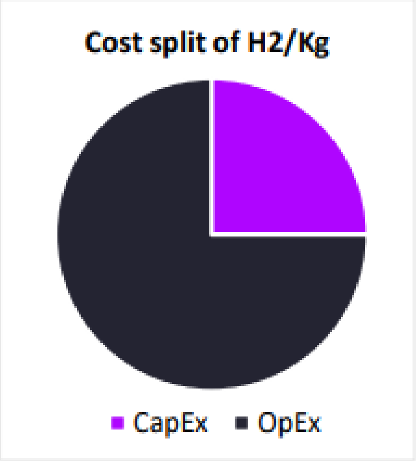
Electrolytic H_2 price (revisited)



IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

	~2015	~2020	~X-years
Nel electrolysis (large scale alkaline) [$/kW]	<700	<500	<350
Solar (utility scale) [$/kW]	~1,500	~700	<500
Solar PPA [$/kWh]	0.04 – 0.06	0.02 – 0.04	0.015 – 0.02
Total hydrogen production cost [$/kg]	**2.7 – 4.0**	**1.3 – 2.7**	**1.0 – 1.3**

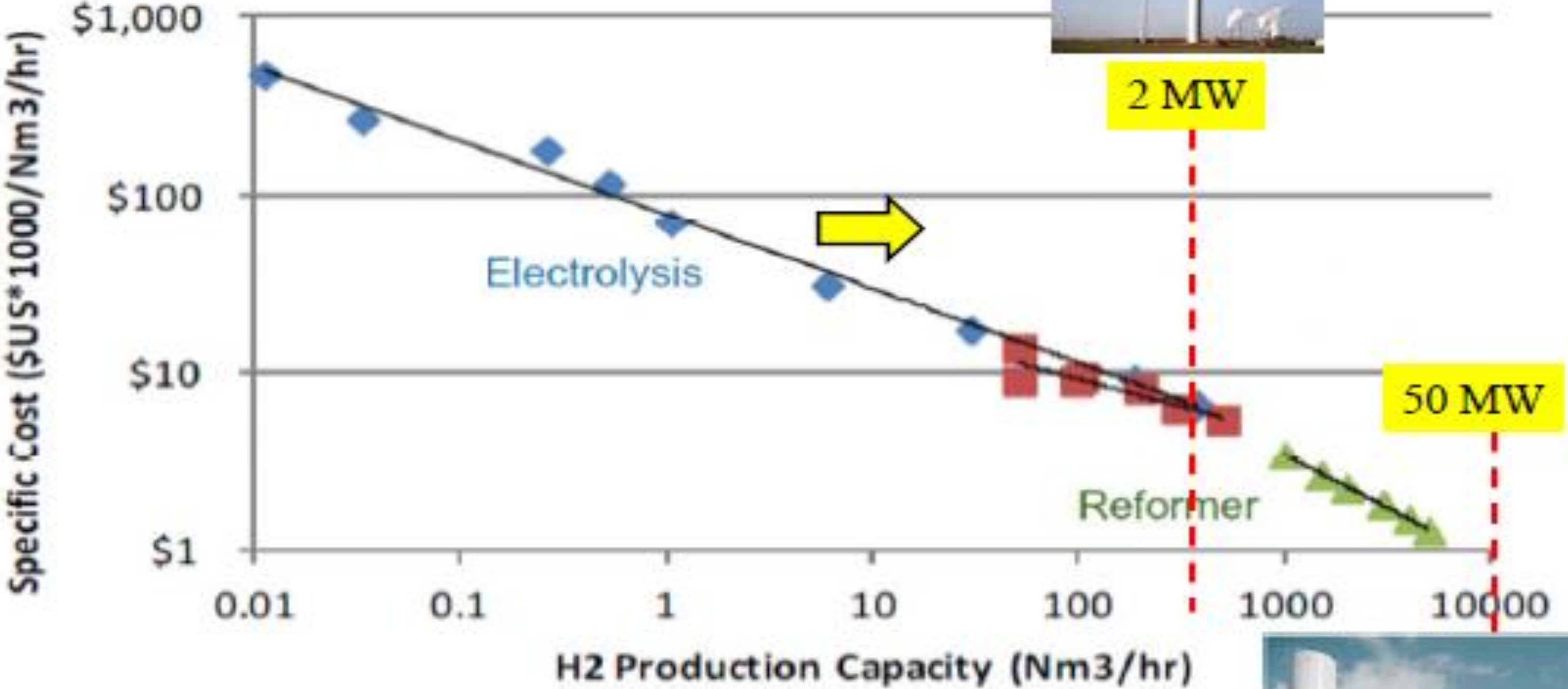
- Large electrolyzer facilities from Nel already at CapEx parity with medium scale SMR[1]
  - Nel targets to reach CapEx parity with large scale SMRs in foreseeable future
- Solar PV at utility scale has today reached a price of < 1 $/W
  - LCOE from solar expected to drop by another 66% by 2040[2]
  - At 0.04 $/kWh renewable hydrogen is reaching fossil parity on an OpEx basis



1: SMR – steam methane reformer
2: Bloomberg New Energy Outlook 2017

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

Water electrolysis scale up :
kW → MW



IEA/HIA Task 33 : *Local Hydrogen Supply for Energy Applications (2014)*

Alkaline & PEM electrolysers ...
(both futures look bright)

Technology		ALK		PEM	
	Unit	2017	2025	2017	2025
Efficiency	kWh of electricity/ kg of H_2	51	49	58	52
Efficiency (LHV)	%	65	68	57	64
Lifetime stack	Operating hours	80 000 h	90 000 h ~ 10 years	40 000 h	50 000 h ≈ 6 years
CAPEX – total system cost (incl. power supply and installation costs)	EUR/kW	750 @2 MW	480	1 200	700 @5 MW
OPEX	% of initial CAPEX/year	2%	2%	2%	2%
CAPEX – stack replacement	EUR/kW	340	215	420	210
Typical output pressure*	Bar	Atmospheric	15	30	60
System lifetime	Years	20		20	

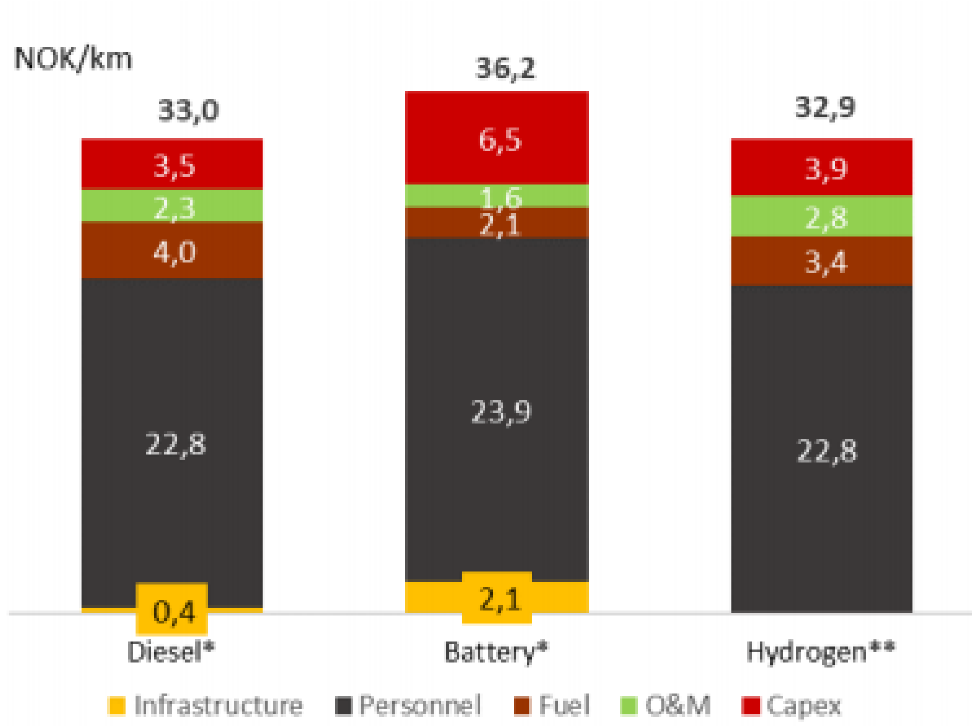
IRENA report, September 2018

E.g.: In Norway, hydrogen electric (FC) buses can reach fossil parity already

Hydrogen electric buses have the lowest Total Cost of Ownership (TCO), i.e. NOK/km

Assumptions:

- Bus price: 3.3 MNOK (350 k€/bus)
- Hydrogen: 47 kr/kg (5 €/kg)
- O&M: 2.8 kr/km (0.3 €/km)
- **Hydrogen electric buses have the lowest cost per km, lower than diesel and battery electric**



Source: *Ruter estimates for 2025,
**Nel numbers for 2020

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

E.g.: In Norway, hydrogen trains competitive with diesel

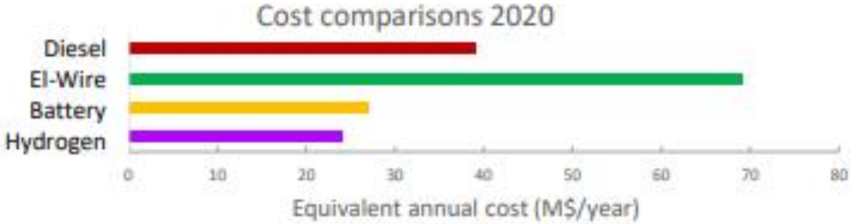
Major opportunities along Norwegian railroads

- Trønder- & Meråkerbanen (120 & 102 km)
- Rørosbanen & Solørbanen (384 & 94 km)
- Raumabanen (114 km)
- Nordlandsbanen (731 km)

- **Total of ~1 550 km not electrified in Norway, El-Wire investments would amount to NOK >20 billion**

SINTEF study, example: Nordlandsbanen

Single-track line, 731 km
About 3000 train movements/year
CO_2 emissions: 37 800 t/year



IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

M-Series Containerized PEM

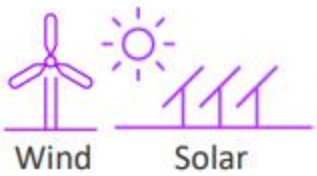
MC250 (323 to 539 kg/day) 1.25MW

MC500 (647 to 1,079 kg/day) 2.5MW

Agreement between NEL and H2Energy / Hydrospider for 30MW PEM (25.2.2019)

- 30MW agreement
- Proton® PEM water electrolysis
- Total expected 1,000 trucks from Hyundai Motor Company
- Also used for other applications.

- Solution for green hydrogen production and fast refueling of hydrogen at MEGA stations
- Zero emission fuel and freight based on renewable energy: same convenience and higher performance



Electrolysers
Hydrogen production
A-3880 - 8T/day

H2Station®
Hydrogen fueling
80 kg / 10 min

© Nikola Corporation

Delivery at sales at 50-70MPa

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

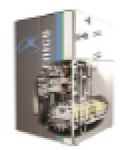
NIKOLA TWO

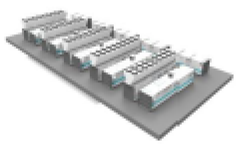
- 100% ZERO TAILPIPE EMISSIONS
- 100% ELECTRIC DRIVE
- HYDROGEN POWERED
- 750 km - 1,200 km RANGE
- AUTONOMOUS CAPABILITIES
- 2,000 FT. LBS TORQUE
- 1,000 HORSEPOWER
- 125kW-250 kWh BATTERY
- 240 kW FUEL CELL

HYDROGENICS

Electrolysers : product's line

Alkaline	PEM (Proton Exchange Membrane)



	HySTAT®-15-10	HySTAT®-60-10	HySTAT®-100-10	HyLYZER® -300-30	HyLYZER® -1.000-30	HyLYZER® -5.000-30
Output pressure	10 barg (27 barg optional)			30 barg		
Number of cell stacks	1	4	6	1	2	10
Nominal Hydrogen Flow	15 Nm^3/h	60 Nm^3/h	100 Nm^3/h	300 Nm^3/h	1.000 Nm^3/h	5.000 Nm^3/h
Nominal input power	80 kW	300 kW	500 kW	1.5 MW	5 MW	25 MW
AC power consumption (utilities included, at nominal capacity)	5.0 to 5.4 kWh/Nm^3			4.4 to 4.8 kWh/Nm^3		
Hydrogen flow range	40-100%	10-100%	5-100%	1-100%		
Hydrogen purity	99.998% O2 < 2 ppm, N2 < 12 ppm (higher purities optional)			99.998% O2 < 2 ppm, N2 < 12 ppm (higher purities optional)		
Tap water consumption	<1.4 liters / Nm^3 H2			<1.4 liters / Nm^3 H2		
Footprint (in containers)	1 x 20 ft	1 x 40 ft	1 x 40 ft	1 x 40 ft	2 x 40 ft	10 x 40 ft
Footprint utilities (optional)	Incl.	Incl.	Incl.	1 x 20 ft	1 x 20 ft	5 x 20 ft

Technical specifications

MODEL	HySTAT™-10-10	HySTAT™-15-10	HySTAT™-10-25
Operating Pressure	10 barg		25 barg
Max. Nominal Hydrogen Flow	10 Nm^3/h	15 Nm^3/h	10 Nm^3/h
Hydrogen flow range	40 - 100% (25–100% as an option)		
Hydrogen Purity (before HPS)	99,9%; H_2O saturated, O_2 < 1,000 ppm		
Hydrogen Purity (after HPS)	99,998% (99,999% as an option); O_2 < 2ppm; N_2 < 12ppm; Atm. Dew point: -60°C or -76°F (-75°C or -103°F as an option)		
Nr. of cell stacks	1		
Estimated AC power consumption (all included)	4,9 kWh/Nm^3 at full load		
Voltage	3 x 400 VAC ± 3% (3 x 480 or 575 VAC ± 3% as an option)		
Frequency	50 Hz ± 3% (60 Hz ± 3% as an option)		
Installed power	100 KVA	120 KVA	100 KVA
Max. cooling water t° (electrolyte)	40°C	40°C	30°C
Design flow cooling water (electrolyte)	2 m^3/h		
Max. cooling water t° (gas cooling)	15°C		
Design flow cooling water (gas cooling)	0,15 m^3/h		
Demineralized water consumption	< 1 liter/Nm^3 H_2		
Electrolyte	H_2O + 30% wt. KOH		
Approx. Electrolyte Quantity	300 L		
Installation Area	Indoor, in dedicated building		
Ambient Temperature Range	+5°C to +40°C		
Dimensions Process Part (LxWxH)**	1,7m x 1,85m x 2,6m		
Dimensions Power Rack (LxWxH)	0,9m x 0,9m x 2,3m		
Dimensions Control Panel (LxWxH)	1,0m x 0,5m x 2,1m		
Approx. empty Weight Process Part	1.350 kg	1.500 kg	1.400 kg
Weight Power Rack	750 kg		
Weight Control Panel	400 kg		

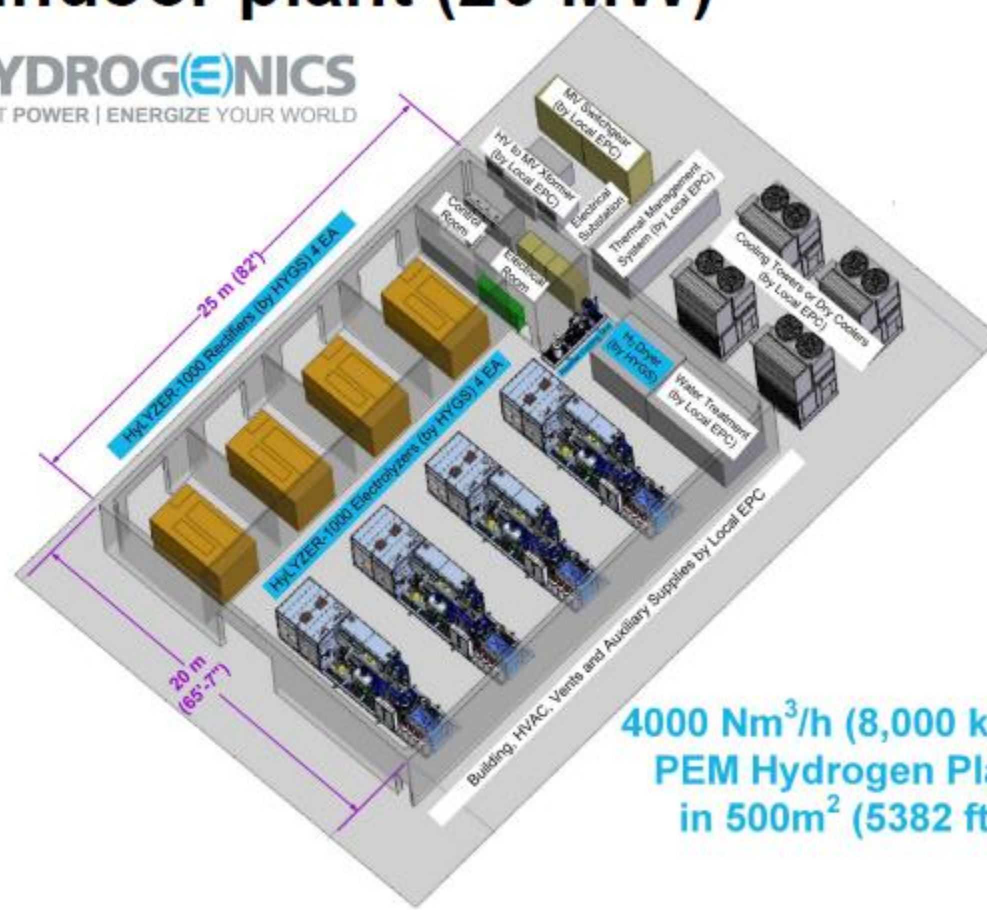
(*) HPS = hydrogen purification system
(**) including 'ATEX' enclosure

HYDROGENICS
Advanced Hydrogen Solutions

IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

Layout for 4000 Nm³/h indoor plant (20 MW)

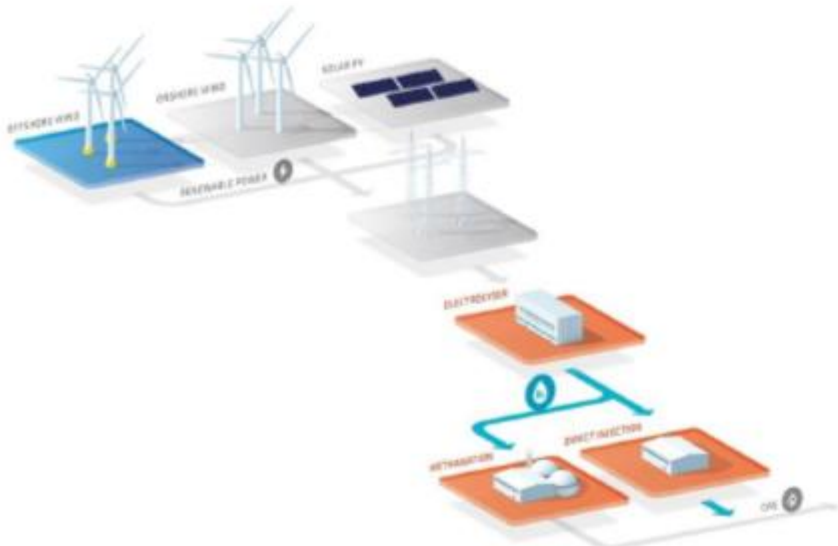
HYDROG(E)NICS
SHIFT POWER | ENERGIZE YOUR WORLD



4000 Nm^3/h (8,000 kgpd)
PEM Hydrogen Plant
in 500m^2 (5382 ft^2)

Wind-to-Gas Südermarsch in Brunsbuttel, Germany (2018)

Power-to-Gas

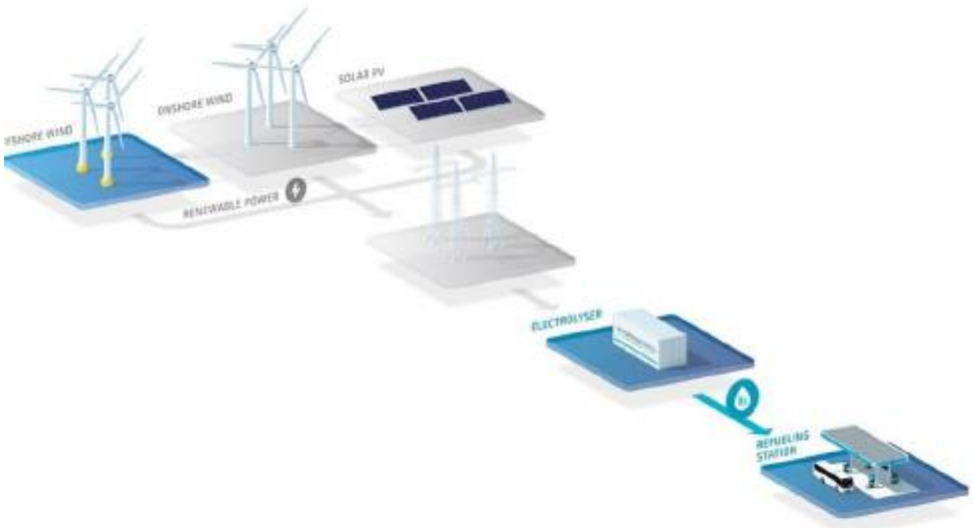


wind2gas energy

More information: www.w2g-energy.de

2,4 MW
Direct injection
PEM

Maximator Refuelling station in Wuppertal, Germany (2019)



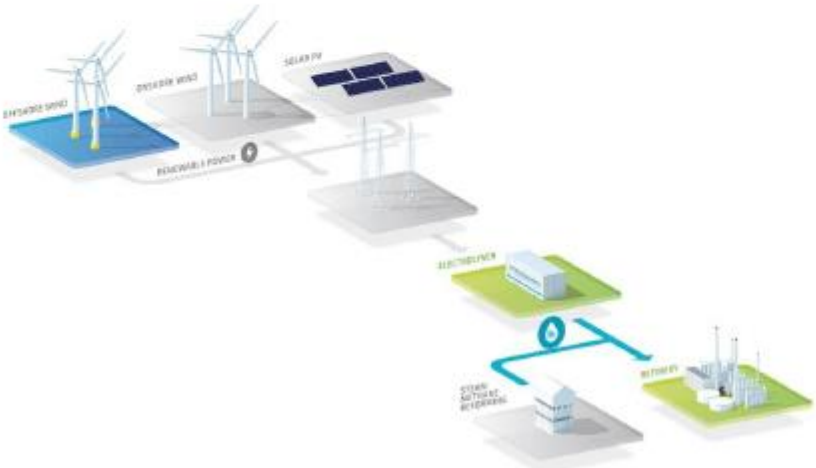
1 MW upgradable to 2,5 MW

MAXIMATOR®
Maximum Pressure.

More information: https://www.maximator.de/flycms/en/web/10/

MEFCO$_2$: Power-to-Methanol in Niederaußem, Germany (2018)

Power-to-Fuels



1 MW
PEM

i-deals

RWE

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement (No 637016).

More information: www.mefco2.eu

IREC

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

More Information

- www.Refhyne.eu
- YouTube video

REFHYNE

CLEAN REFINERY HYDROGEN FOR EUROPE

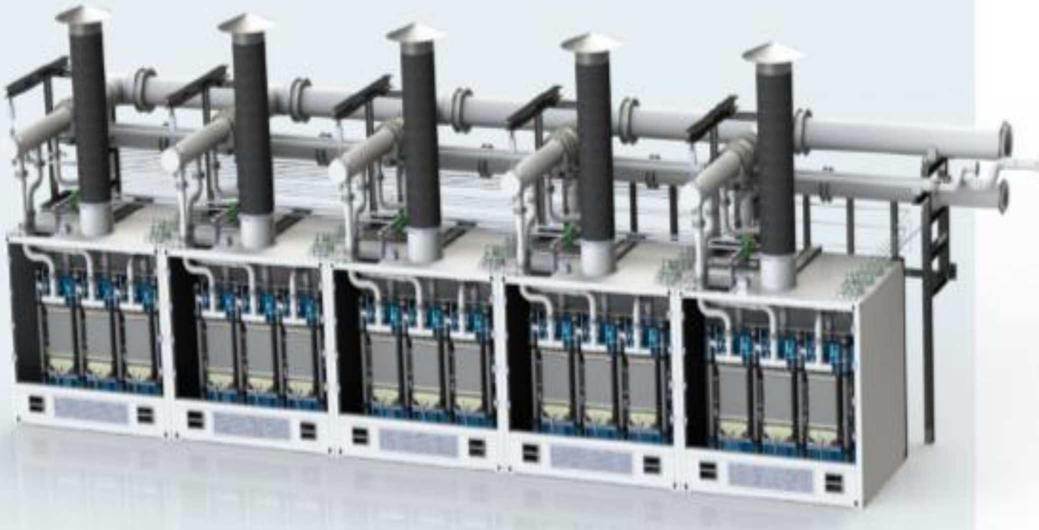
Project Team

- ITM - electrolyser design, build, O&M
- Shell Deutschland Oil (SDO) – design & build site, H_2 end user
- Sintef – Project co-ordinator
- Element Energy & Thinkstep – modelling, analysis & dissemination

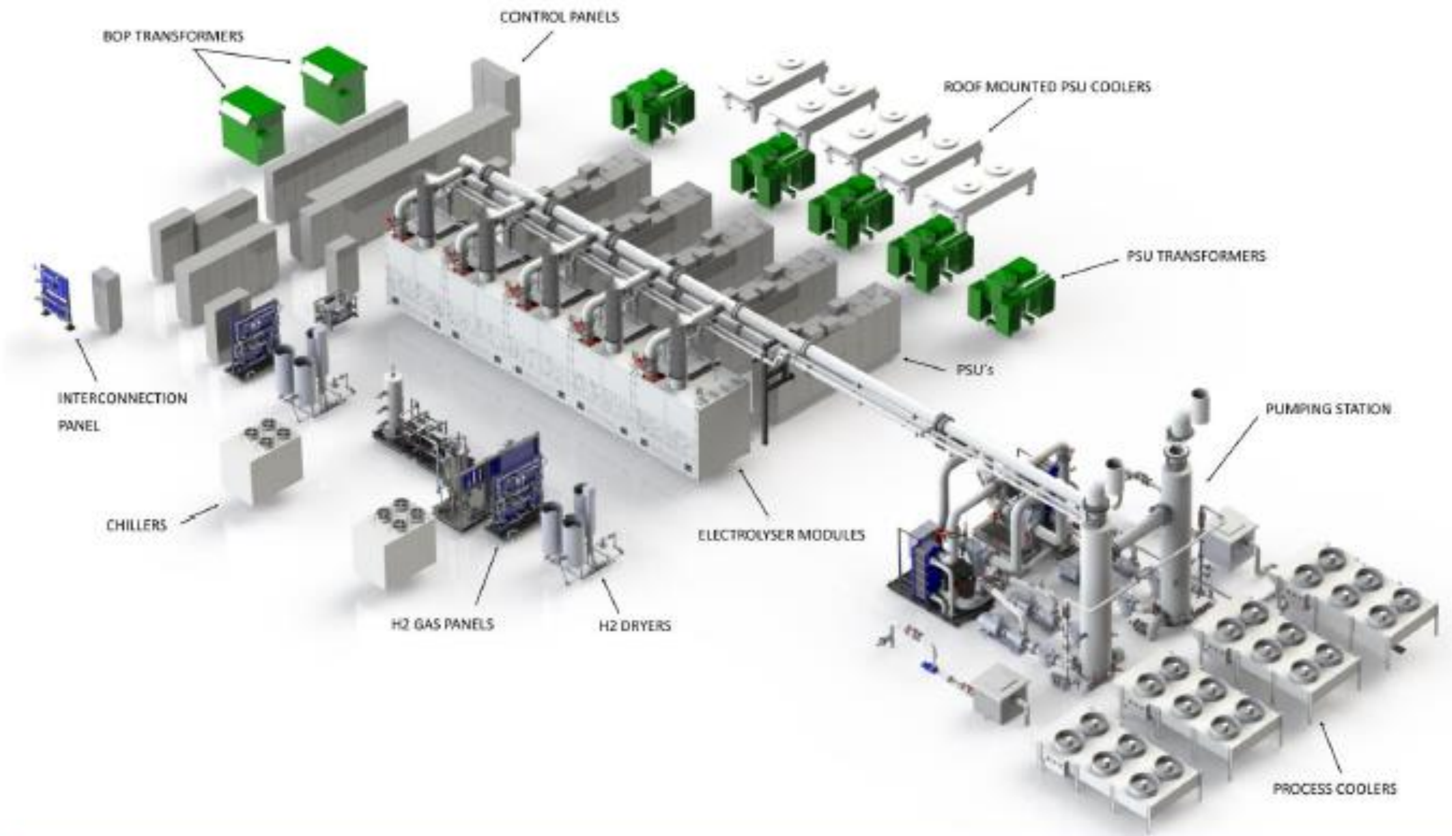
The REFHYNE Project: Grant Agreement Number 779579

10MW Stack Overview

- 5 x 2MW modules to achieve 10MW stack skid
- Stack skid can be replicated to achieve higher capacity
- Each module is independently controllable
- No single point of failure
- Ability to phase maintenance
- Integrated ventilation arrangement
- Avoid generating ATEX environment in building



Standard 10MW Stack Skid



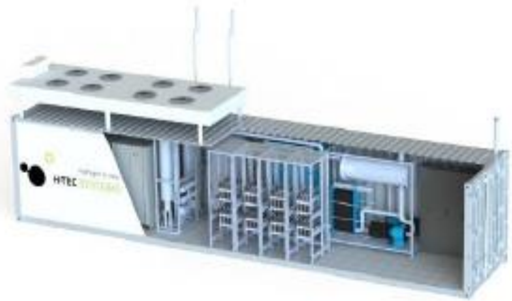
Development of Design & Building Layout

IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

Green Hydrogen mobility

CO_2 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[1]

Other usages:

2
H_2 Trains

20+
H_2 Busses

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

H-TEC SYSTEMS references

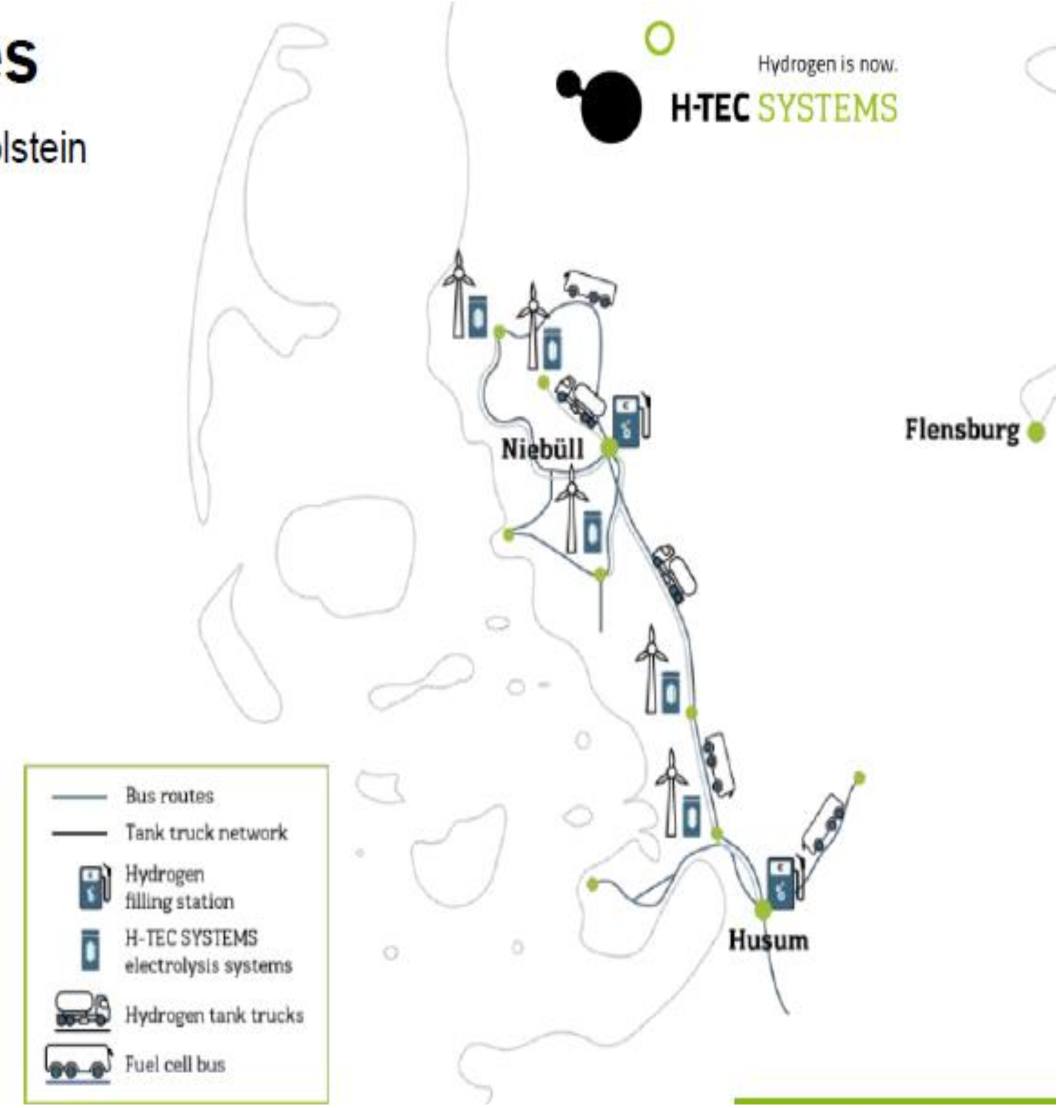
Hydrogen mobility : eFarm concept in Schleswig-Holstein

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 CO_2 emissions
- Annual CO_2 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



Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

H-TEC SYSTEMS references

Key elements of the eFarm concept

Hydrogen is now.
H-TEC SYSTEMS

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

H-TEC SYSTEMS references

Further projects

Hydrogen is now.
H-TEC SYSTEMS

140 kW Testing Facility in Buttenwiesen (Bayern) in Operation

- Prototype & Test Bed at GP JOULE Site in Buttenwiesen
- Electric Load 140 kW
- Operational since February 2017

Prototype in Reußenköge (Schleswig-Holstein) in Operation

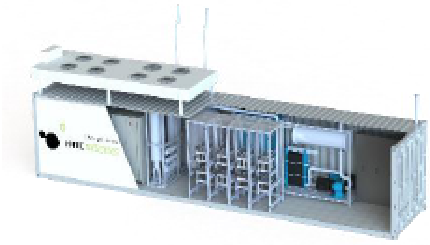
- Prototype ME 100/350 at GP JOULE Site in Reußenköge
- Electric Load: nominal 225 kW, max. 350 kW
- Production Rate: 47 Nm³/h
- Operational since July 2017

Customer Project in Westre (Schleswig-Holstein) in Production

- ME 100/350 for supply of H2 refuelling station
- Electric Load: nominal 225 kW, max. 350 kW
- Customer: Energie des Nordens
- Production rate: 47 Nm³/h
- Starting date: Q4 2019

windpark ellhöft

1 MW Customer Project in Haurup (Schleswig-Holstein)



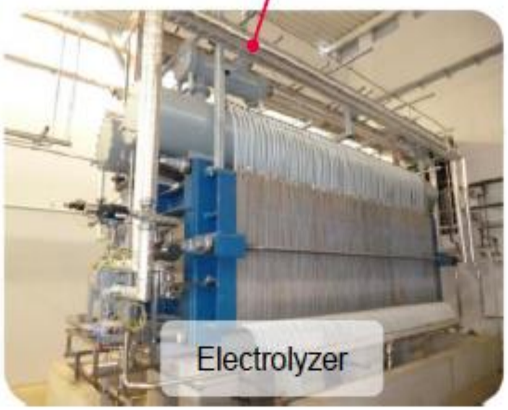
- ME450/1400 for injection into the gas pipeline in Haurup
- Project within NEW 4.0 regional network scope in Northern Germany
- Electric load 1 MW
- Customer: Energie des Nordens, Greenpeace Energy
- Production rate: 210 Nm³/h
- Starting date: 2020

ENERGIE DES NORDENS

IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

MAN ES power-to-SNG reference in Werlte

A demonstrator in operation since 2013



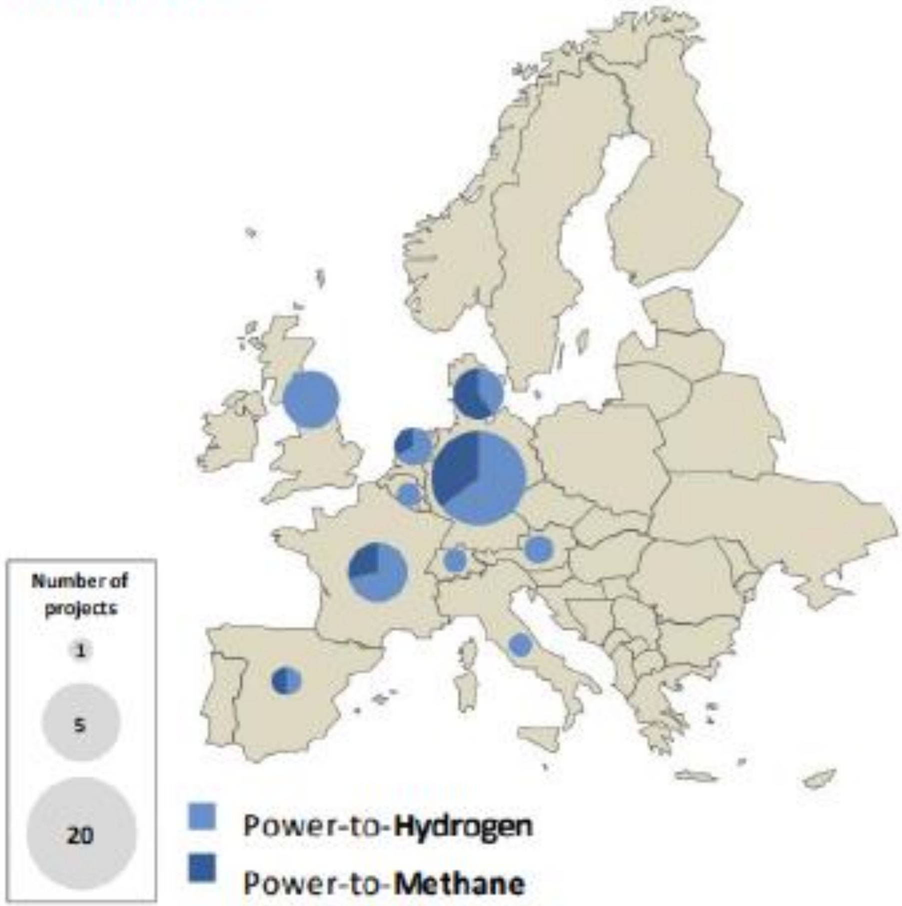
Key facts:

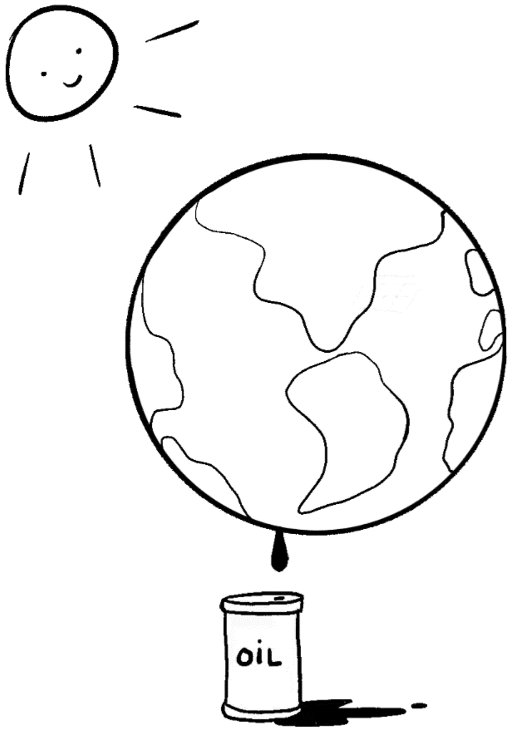
- 6 MW power input for alkaline Electrolysis
- SNG used as e-fuel for Audi customers
- Methanation reactor by MAN ES Deggendorf

➔ **Plant in commercial operation since 2013**

Picture source: Audi

Installed $P2H_2$ & $P2CH_4$ plants in Europe[2]: Status of 2016





https://youtu.be/2D_rL9k12z0

IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research


BAETSEN
BAETSEN
BAETSEN B.V.
VELDHOVEN
100% electric

https://www.youtube.com/watch?v=QTBQbG5aMio#action=share

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

IREC

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

IREC

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

Hydrogen into gas grid applications provide a sustainable solution for renewables-based storage and transformation of energy grids

Hydrogen into gas grid

1/4

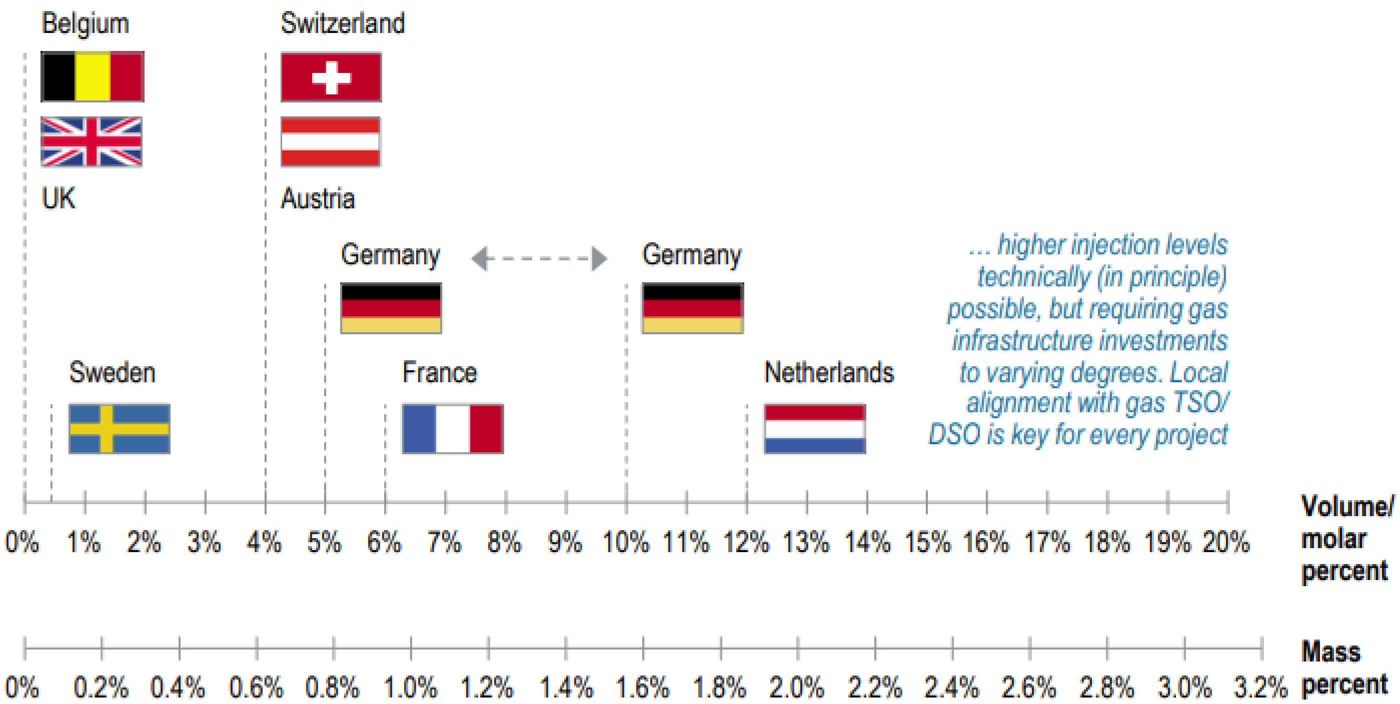
Brief description: Hydrogen can be converted from renewable energy sources and injected into existing natural gas grids for initial (or long-term) storage and subsequent use in a range of different applications (power generation, heat provision, transport applications such as gas-fuelled urban buses or passenger cars)

Use Case: Cities and regions can inject (or call for / incentivise the injection of) green hydrogen (i.e. from power-to-hydrogen P2H sources) into gas grids to further promote renewable energy sources, decarbonise the gas grid and provide long-term energy storage solutions

Fuel cells in commercial buildings

Key components	Electrolyser, fuel cell, blending/injection system
Electrolysis technology for P2H	Alkaline (ALK), PEM, (Solid Oxide)
H_2 production efficiencies	50-83 kW_{el}/kg (2013), 36-63 kW_{el}/kg (2030)
Cost of H_2 production for P2H	*dep. on electrolyser size, technology, power input price, etc.*
Maximum H_2 blend level	5 – 20% (potentially even 25%, dep. on gas infrastructure)
Hydrogen provider	E.on, RWE, Thüga
Gas distributors	Private and municipal utilities (e.g. German Stadtwerke), gas TSOs or DSOs
Typical customers	Public and private utilities, public and private TSOs or gas shippers, ultimately e.g. passenger car fleet operators
Competing technologies	Other energy storage (e.g. pump storage, batteries)

#1 – Regulatory framework, esp. maximum blend level / H_2 injection limit



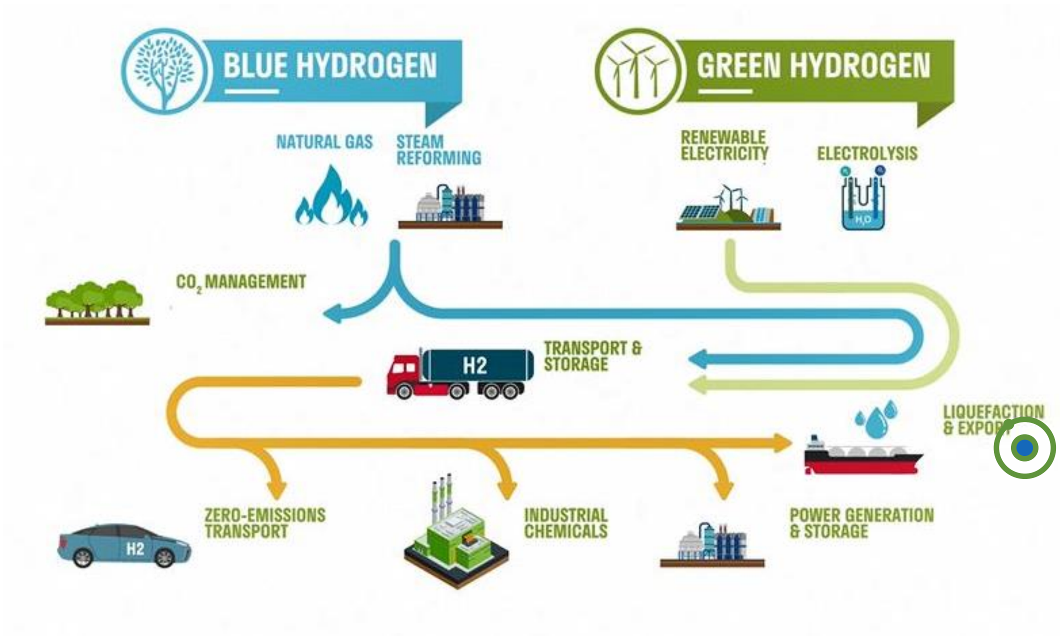
> Regulatory injection limit varies greatly across Europe and even within countries (e.g. local limits in Germany of $2\%_{vol}$ in case of presence of downstream CNG refuelling stations or storage (e.g. underground)

> CEN and EASEE-gas are working toward a harmonized standard for gas quality in the EU. Due to the type II vessels for CNG vehicles, $2\%_{vol}$ hydrogen tolerance in the gas mix is the current basis for discussion

> Higher H_2 blend levels might require add. pipeline monitoring/maintenance measures (gas TSO/DSO); degrading durability of metal pipes and materials when exposed to hydrogen may also necessitate infrastructure upgrades

USOS INDUSTRIALES DEL H2

Rutas de producción de H2



https://www.woodside.com.au/innovation/hydrogen

Hidrógeno azul

+ El hidrógeno azul es hidrógeno neutro en carbono creado a partir del gas natural.
+ El hidrógeno azul se produce al hacer reaccionar el gas natural con alto temperatura de vapor para producir hidrógeno y una pequeña cantidad de dióxido de carbono.
+ Para crear hidrógeno azul, la emisión de CO2 generada en la reacción debe ser compensada con sistemas de captura de CO2 o proyectos como la plantación de árboles.

Hidrógeno verde

+ La energía renovable se puede utilizar para crear hidrógeno verde. + El hidrógeno de las energías renovables es la forma de energía más limpia porque no contiene carbono se crea durante el proceso.

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

USOS INDUSTRIALES DEL H2

Proyecto H2FUTURE

Comienzo: 01/01/17
Duración: 4.5 años

H2FUTURE
Green Hydrogen

H2FUTURE es un proyecto emblemático europeo para la generación de hidrógeno verde a partir de electricidad a partir de fuentes de energía renovables. Bajo la coordinación de la empresa de servicios públicos VERBUND, el fabricante de acero voestalpine y Siemens, un fabricante de electrolizadores de membrana de intercambio de protones (PEM), se instalará y operará un sistema de electrólisis PEM a gran escala de 6 MW en la planta de acero voestalpine Linz en Austria. El operador del sistema de transmisión austríaco (TSO) Austrian Power Grid (APG) apoyará la precalificación del sistema de electrolizadores para la prestación de servicios auxiliares. El centro de investigación de Holanda, TNO y K1-MET (Austria) estudiarán la replicabilidad de los resultados experimentales a mayor escala en EU28 para la industria del acero.

https://www.h2future-project.eu/

11 de noviembre de 2019 |

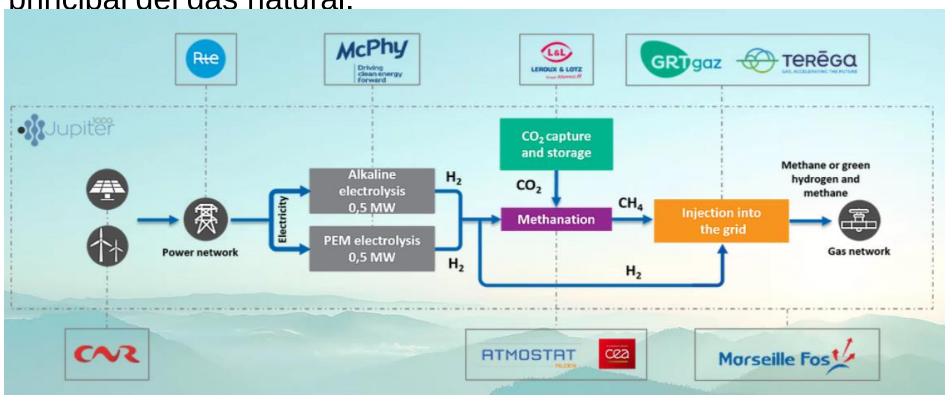
La que actualmente es la planta piloto más grande del mundo para la producción de hidrógeno neutral en CO_2 ha comenzado con éxito la operación en el sitio de voestalpine en Linz, Austria, estableciendo simultáneamente un hito internacional en el avance de nuevas opciones de suministro de energía. Como parte del proyecto H2FUTURE, financiado por la UE, los socios voestalpine, VERBUND, Siemens, Austrian Power Grid, K1-MET y TNO están investigando la producción industrial de hidrógeno verde como un medio para reemplazar los combustibles fósiles en la producción de acero a largo plazo.

USOS INDUSTRIALES DEL H2

Proyecto JUPITER 1000

Comienzo**:** 2018

Jupiter 1000 es el primer proyecto de Power to Gas en Francia, con el objetivo de transformar el exceso de electricidad de fuentes renovables en hidrógeno. Este hidrógeno limpio se inyectará en la red de gas natural directamente o después de su transformación en metano, el componente principal del gas natural.



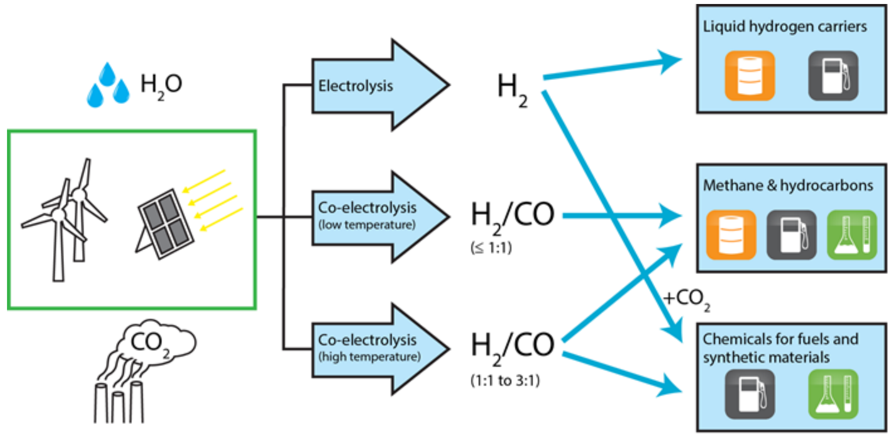
GRTgaz coordina el proyecto, cuyos objetivos principales son construir y operar un demostrador de Power to Gas con metanización, captura y recuperación de CO2.

Los dos electrolizadores de 1 MW en total: un electrolizador alcalino de 0.5 MW y unoPEM de 0.5 MW.

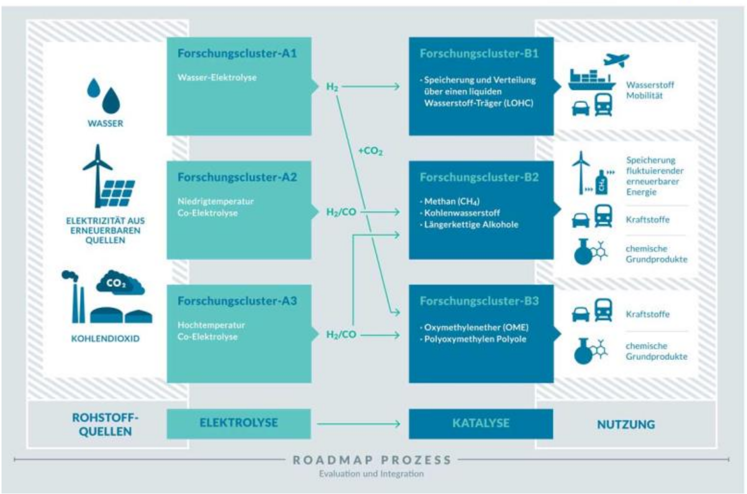
USOS INDUSTRIALES DEL H2

KOPERNIKUS PROJEKTE
Die Zukunft unserer Energie

Federal Ministry of Education and Research



KOPERNIKUS-PROJEKT POWER-TO-X:
STRUKTUR DES FORSCHUNGSPROGRAMMS



EJEMPLOS REPRESENTATIVOS

El proyecto BIG HIT ha permitido crear un territorio de hidrógeno en las Islas Orcadas en Escocia mediante la implementación de un modelo totalmente integrado de producción, almacenamiento, transporte y utilización de hidrógeno para calefacción, energía y movilidad.

La electricidad renovable generada en las islas de Eday y Shapinsay es utilizada por electrolizadores para producir hidrógeno, por electrólisis de agua. Este hidrógeno se almacena como gas a alta presión en los remolques de tubos, que pueden transportarse a las Orcadas continentales.

https://www.bighit.eu/

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

EJEMPLOS REPRESENTATIVOS

FlixBus lanzará autobuses de hidrógeno para viajes de larga distancia en Europa

El mayor proveedor de autobuses de larga distancia de Europa también apuesta por el combustible de hidrógeno en autobuses que funcionan con celdas de combustible en las rutas de autobuses de larga distancia.

En términos de rendimiento, el autobús de hidrógeno debe estar a la par los que funcionan con diésel y con una autonomía de 500 km sin repostar.

https://innovationorigins.com/flixbus-plans-european-long-distance-bus-with-fuel-cell-drive/

IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

EJEMPLOS REPRESENTATIVOS

Alstom suministrará "la flota de trenes de celdas de combustible más grande del mundo"

Alstom ha ganado este año 2019 un contrato de 500 millones de euros (557,3 millones de dólares) para suministrar la "flota de trenes de celdas de combustible más grande del mundo" a la filial de Fahma de la autoridad de transporte de Rin-Main RMV.

El fabricante francés entregará 27 Coradia iLint para el 2022. Los trenes de celdas de combustible reemplazarán a los trenes diesel existentes en Hesse, Alemania.

La orden también incluye el suministro de hidrógeno, que Alstom proporcionará en cooperación con Infraserv, y 25 años de mantenimiento. La estación de servicio estará ubicada en las instalaciones del parque industrial Höchst.

https://www.h2-view.com/story/alstom-to-supply-worlds-largest-fleet-of-fuel-cell-trains/

EJEMPLOS REPRESENTATIVOS

HyFlyer: vuelos de cero emisiones para Orkney, Escocia

El avión de seis plazas Piper M-class de ZeroAvia se utilizará en las pruebas de vuelo de HyFlyer

ZeroAvia apunta inicialmente a vuelos de 500 millas para atender los mercados de viajes aéreos de corta distancia, que representan casi la mitad de los vuelos comerciales en todo el mundo.

Se han otorgado £ 5,3 millones de fondos gubernamentales al proyecto HyFlyer para demostrar la tecnología de celdas de combustible de hidrógeno para la aviación, que culminará con la demostración de un vuelo de cero emisiones fuera de Orkney.

https://www.h2-view.com/story/zeroavia-receives-2-7m-uk-government-grant-for-hyflyer-project/

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

EJEMPLOS REPRESENTATIVOS

Central hidroeléctrica IBAarau en Aarau, Suiza - 2016

En la central hidroeléctica de IBArau se instaló la primera planta de electrólisis del mundo que genera hidrógeno sostenible directamente de una planta hidroeléctrica. El combustible utilizado para alimentar los camiones de hidrógeno de Coop es producido por H2 Energy AG, en la central hidroeléctrica de IBAarau.

Logística de hidrógeno para movilidad:
H2Energy ha estipulado con el Coop Mineraloel un contrato para el suministro de hidrógeno producido en la central hidroeléctrica se transportará en un semirremolque a la estación de repostaje de hidrógeno de Coop.

https://h2energy.ch/en/business-fields-2/

EJEMPLOS REPRESENTATIVOS

Central hidroeléctrica de Gösgen, Niedergösgen, Suiza

El primer sistema en Suiza para la producción comercial de hidrógeno comenzó en el 2019 en la central hidroeléctrica de Gösgen.

Número de turbinas:	5 turbinas Kaplan (una de las cuales suministra potencia de tracción para la compañía de ferrocarriles federales Suizos SBB)
Capacidad:	51.3 MW
Producción eléctrica media anual:	300 GWh

A partir de principios de 2020, Alpiq y H2 Energy construirán un sistema de 2 MW que producirá hasta 300 toneladas métricas de hidrógeno por año utilizando electricidad de la central eléctrica de Gösgen.

Alpiq y H2 Energy planean utilizar la energía hidroeléctrica para producir hidrógeno para unos 50 camiones eléctricos alimentados con celdas de combustible.

https://h2energy.ch/en/alpiq-and-h2-energy-achieve-milestone-for-the-development-hydrogen-powered-mobility-in-switzerland/

https://www.alpiq.com/power-generation/hydrogen-production/

IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

EJEMPLOS REPRESENTATIVOS

10MW Refinery Hydrogen Project with Shell

Construction of the new plant, which features advanced polymer electrolyte membrane (PEM) technology, is expected to be completed in the second half of 2020. The plant will produce up to 1,300 tons of hydrogen per year when operating at peak rates.

Hydrogen will be produced using electricity instead of natural gas. Producing hydrogen with electricity generated from renewable power sources could help significantly reduce CO2 emissions from the Shell Rheinland refinery.

Shell expects a new hydrogen model region to be set up in the Cologne area, based on activities around filling stations, cars and buses. The project is based on the idea of a “hydrogen model region” that can jointly demonstrate the potential of hydrogen in the energy turnaround.”

EJEMPLOS REPRESENTATIVOS

Primera aplicación de tecnologías de hidrógeno en equipos de manipulación portuaria de Europa.

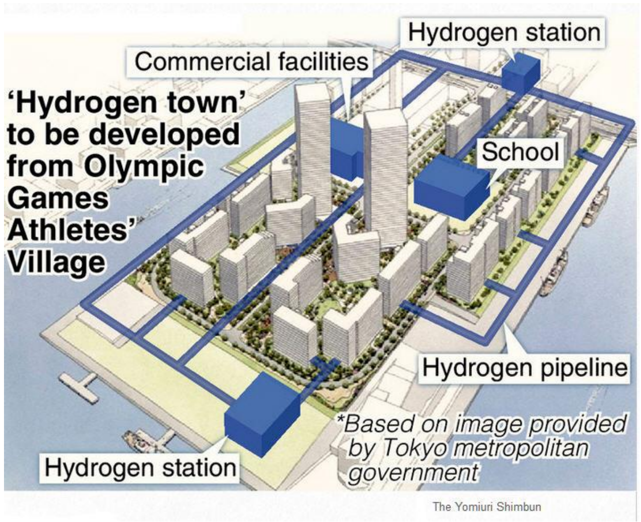
El proyecto piloto, denominado H2Ports, será el primer puerto de Europa en utilizar la energía del Hidrógeno en sus terminales de contenedor y también incorpora la instalación de una estación móvil de suministro de hidrógeno o "hidrolinera" .

https://h2ports.eu/

Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

EJEMPLOS REPRESENTATIVOS

La construcción continúa en la primera Villa Olímpica del mundo impulsada por hidrógeno. Japón pretende promover una economía del hidrógeno y su visión para los Juegos Olímpicos ya constituye una de las mayores apuestas en combustible de hidrógeno en el mundo.



KHI está construyendo el primer portador de hidrógeno licuado del mundo en Kobe. El buque comenzará las pruebas en el mar durante los Juegos Olímpicos y será el primer buque de hidrógeno licuado del mundo.

https://www.shell.com/inside-energy/japan-tokyo-olympics-hydrogen.html

IREC
Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research

SERVICIOS Y CAPACIDADES DE IREC

Las capacidades y servicios de IREC comprenden las siguientes áreas de conocimiento:

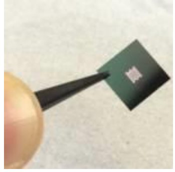
- Energía Térmica y Edificación
- Bioenergía y Biocombustibles
- Electricidad y Electrónica de Potencia
- Materiales Avanzados para la Energía

Los servicios que ofrece IREC incluyen:

- CONSULTORÍA CIENTIFICO-TÉCNICA DE TECNOLOGÍAS DEL H2 (electrolizadores, compresores, sistemas de almacenamiento de H2)
- ESTUDIOS DE VIABILIDAD TECNOLÓGICA Y DE NEGOCIO
- ANÁLISIS ESPACIAL para estudio de viabilidad, determinar localización óptima para estaciones de recarga de H2.

Sede de IREC en Barcelona Sede de IREC en Tarragona





Institut de Recerca en Energia de Catalunya
Catalonia Institute for Energy Research