

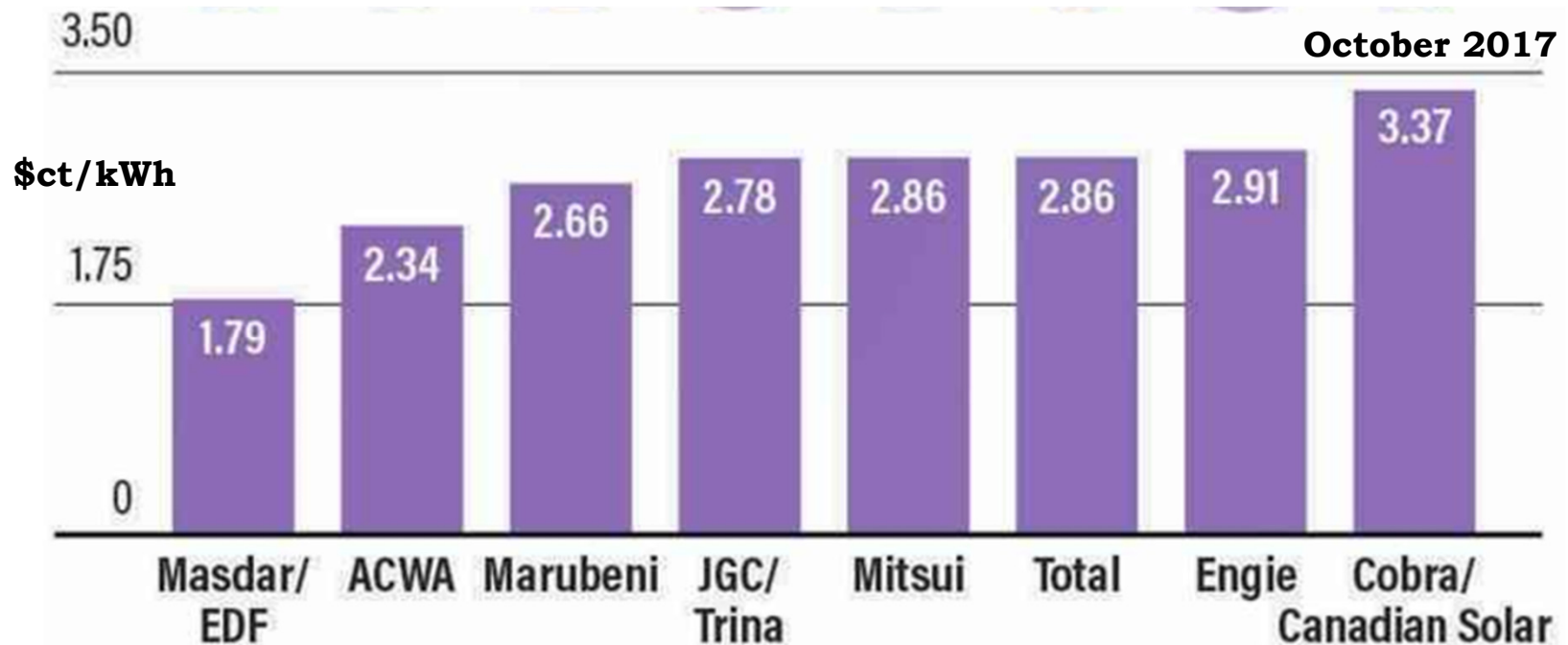


Waterstof Waarom en Waarvoor

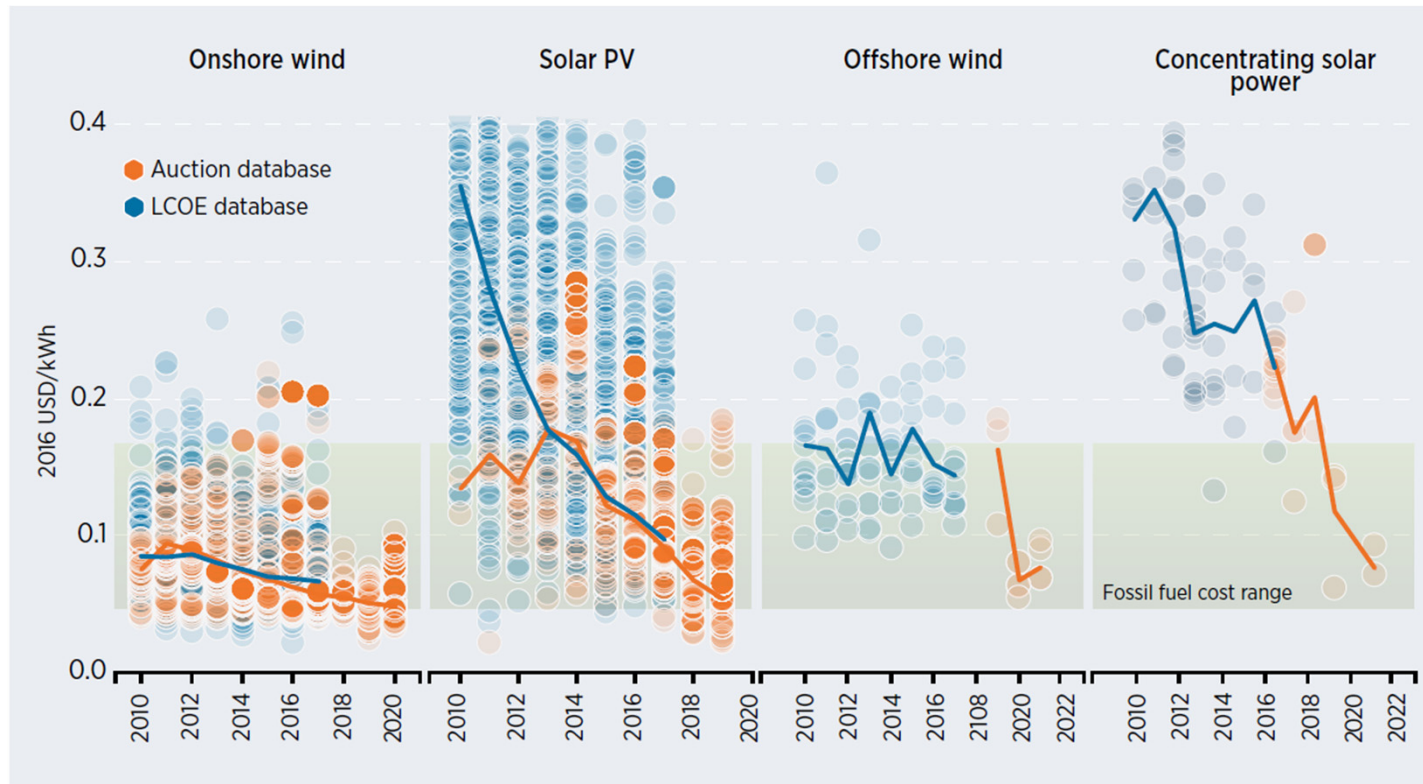
Prof. Dr. Ad van Wijk

10-9-2018

Bids for Saudi Arabia's 300 MW Solar Plant

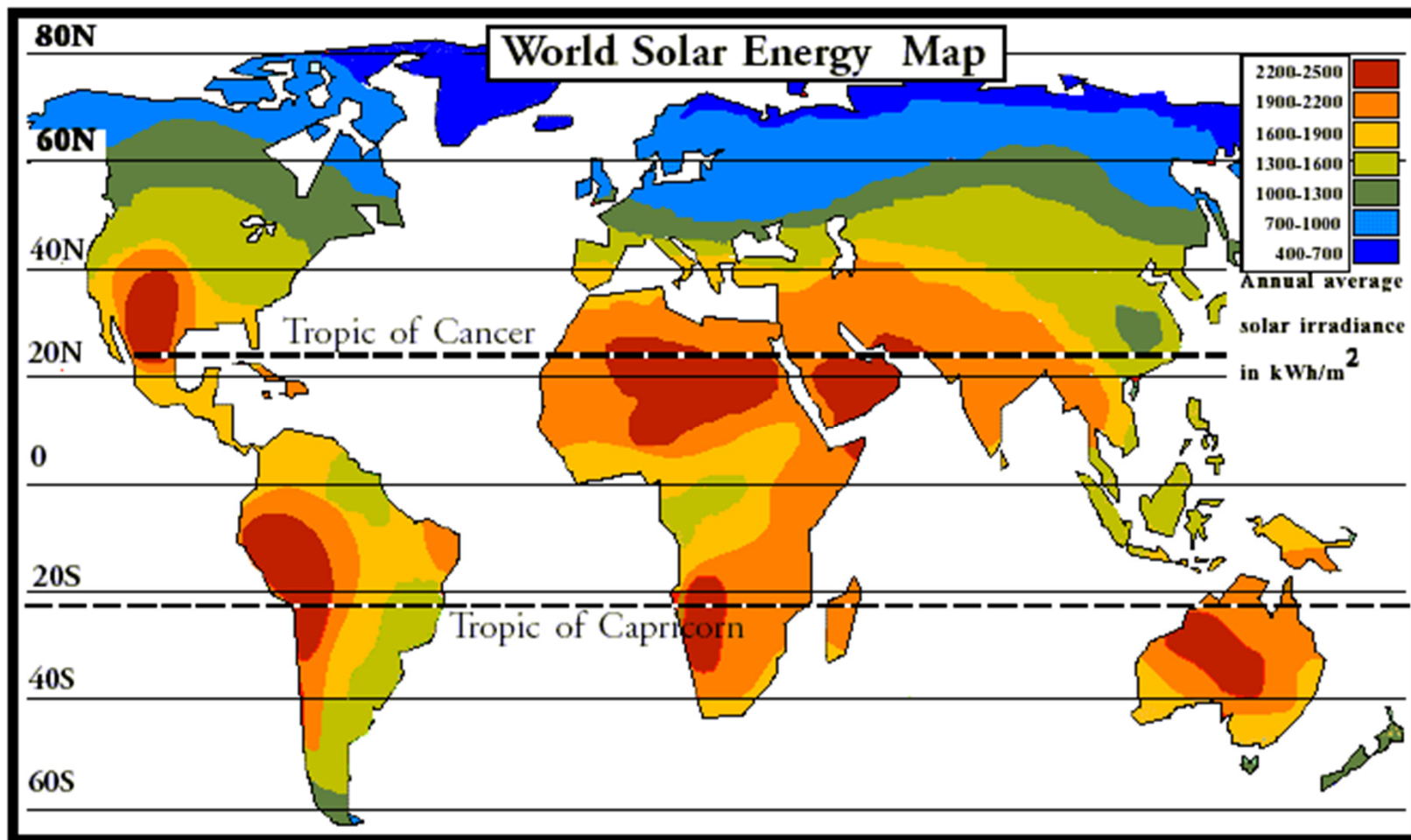


Levelized Cost of Electricity

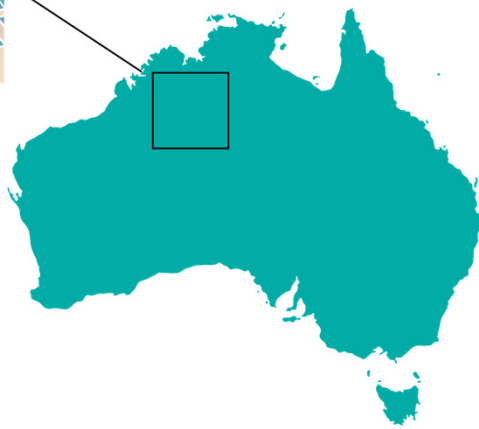
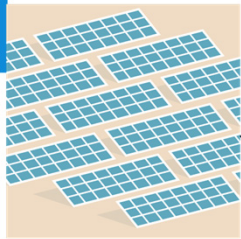


Source: IRENA Renewable Cost Database and Auctions Database.

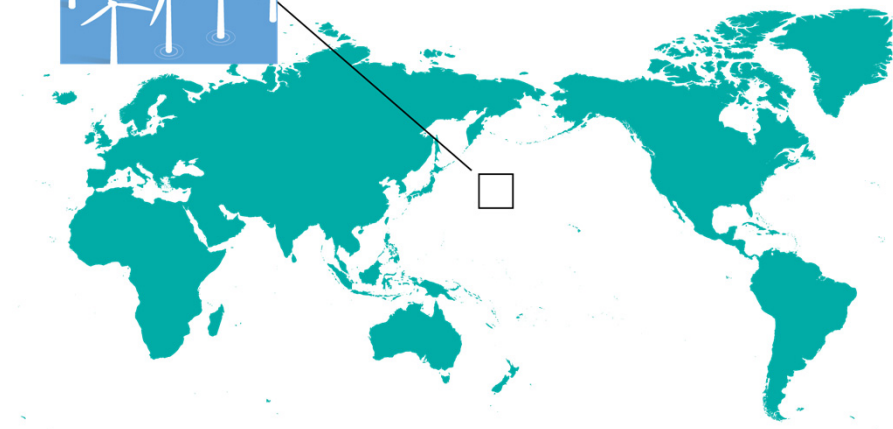
IRENA, January 2018, Renewable Power Generation Costs 2017



Surface needed to produce all the world's energy 556 EJ = 155.000 TWh



10% SOLAR AUSTRALIA

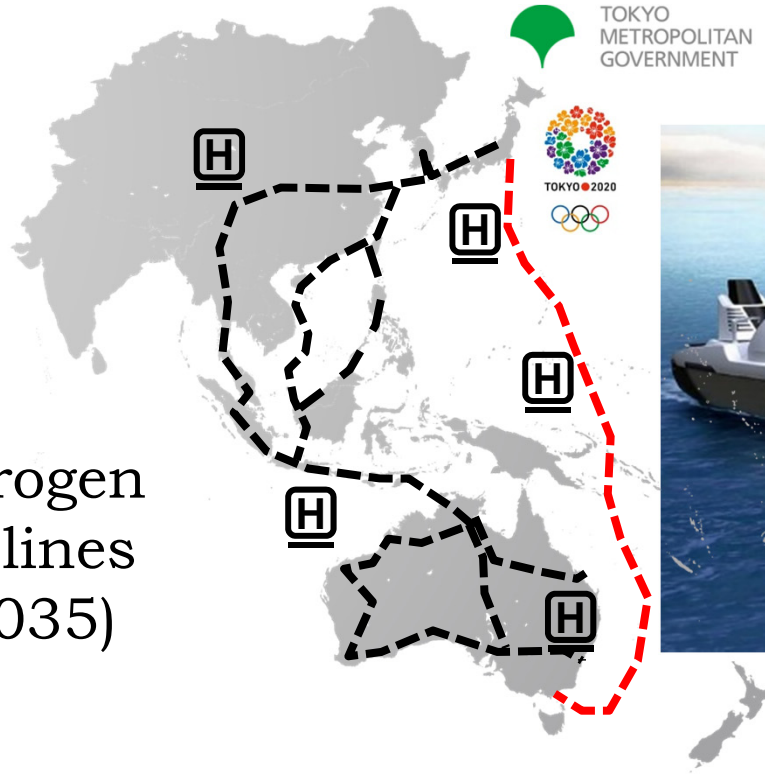


1.5% WIND PACIFIC OCEAN

Tokyo Olympic Games 2020



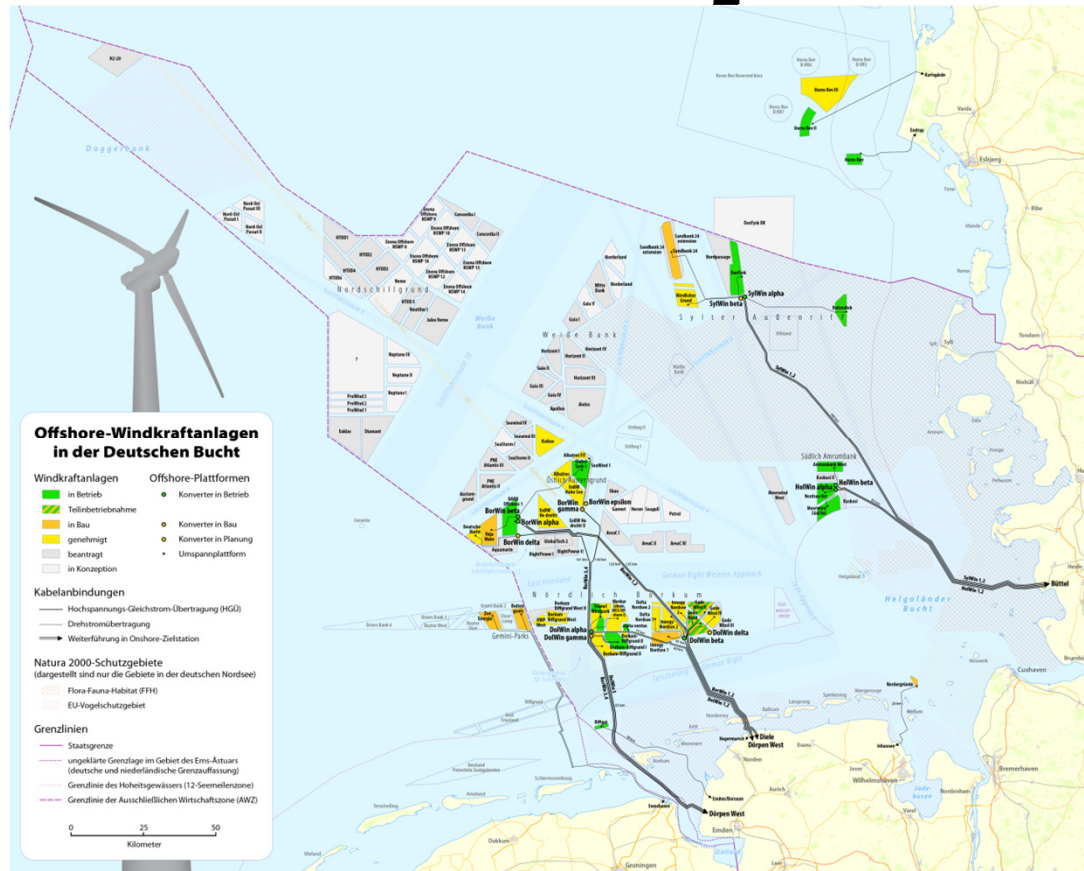
Hydrogen
Pipelines
(~2035)



Hydrogen
Shipping
(~2025)



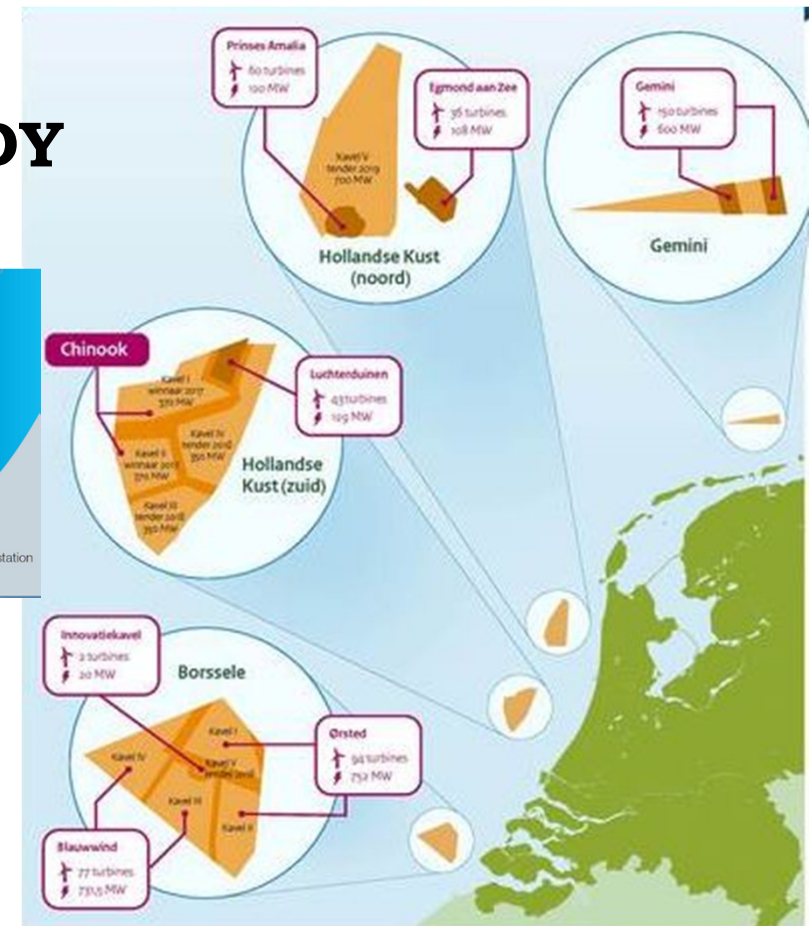
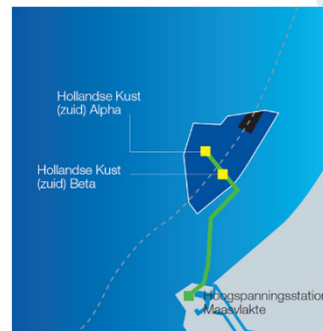
Offshore Wind Development Germany



VATTENFALL BUILDS WIND FARM WITHOUT SUBSIDY

19 March 2018

- Chinook, daughter Vattenfall
- 700 MW wind farm
- Operational 2022
- Location Hollandse Kust (Zuid)
- 22 km from the coast



Eemshaven; The Energy Harbor



Norned Cable 700 MW

Cobra Cable 700 MW (2019)

Gemini Offshore Wind Farm 600 MW

Onshore Wind Farms > 275 MW

Nuon Magnum power plant 1,320 MW

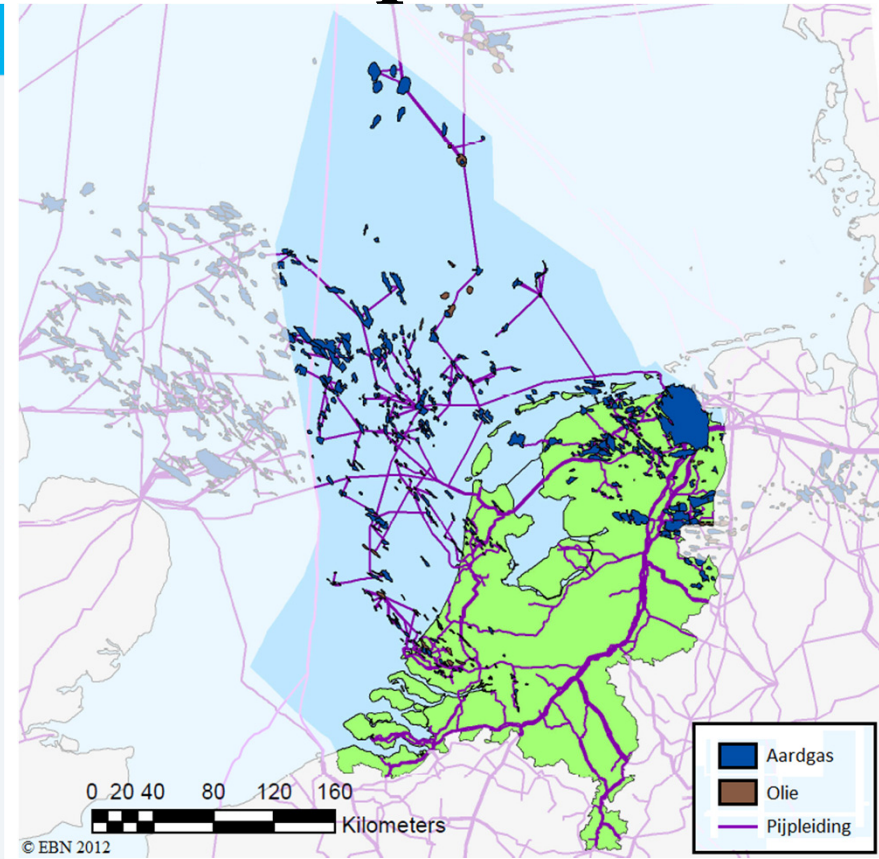
RWE Coal fired power plant 1,560 MW

Engie Gas fired power plant 2,450 MW

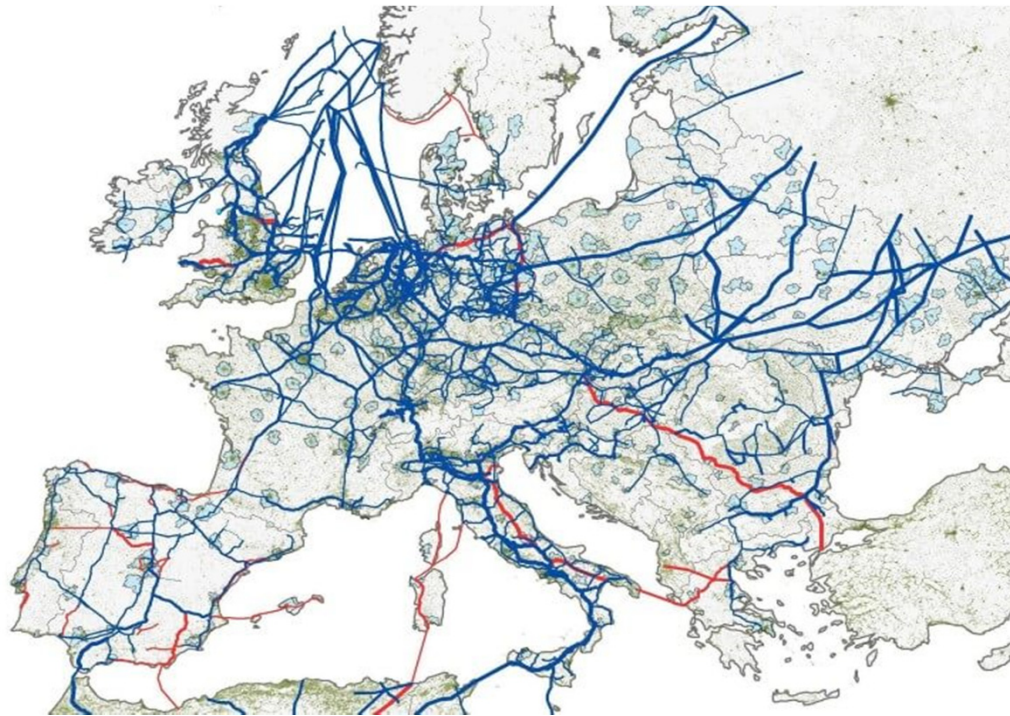
Cable Inland 4,000 MW

Expansion to 5,610 MW

Electricity and Gas Transport Grid



European Gas Infrastructure

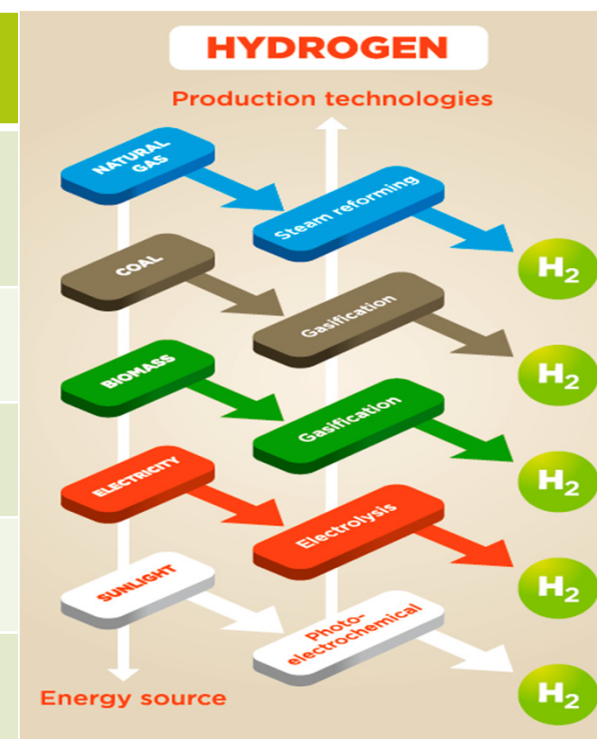


Cable versus pipeline cost

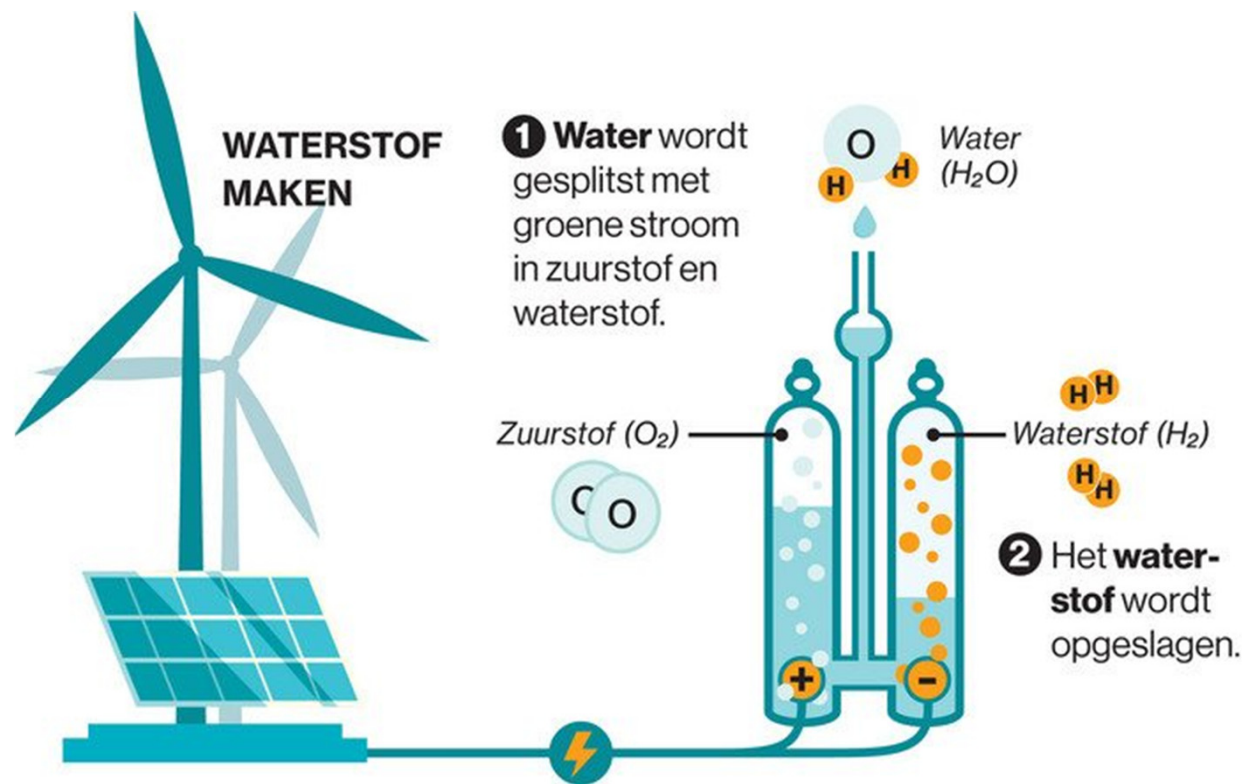
	Cable (BritNed)	Pipeline (BBL)
Capacity	1 GW	15 GW
Construction Cost	€ 500 mln	€ 500 mln
Volume (year)	8 TWh	120 TWh

Hydrogen production

Source	Process	Efficiency Today
Natural gas Bio Gas	Steam reforming Solid Oxide Fuel Cell	72% 80% (40-40)
Coal/Oil	Gasification	56%+ (=syngas)
Biomass	Gasification	44%+ (=syngas)
Electricity + Water	Electrolysis Alkaline and PEM	75-80% (90% exp.)
Sunlight + Water	Photoelectrochemical	14% (lab)

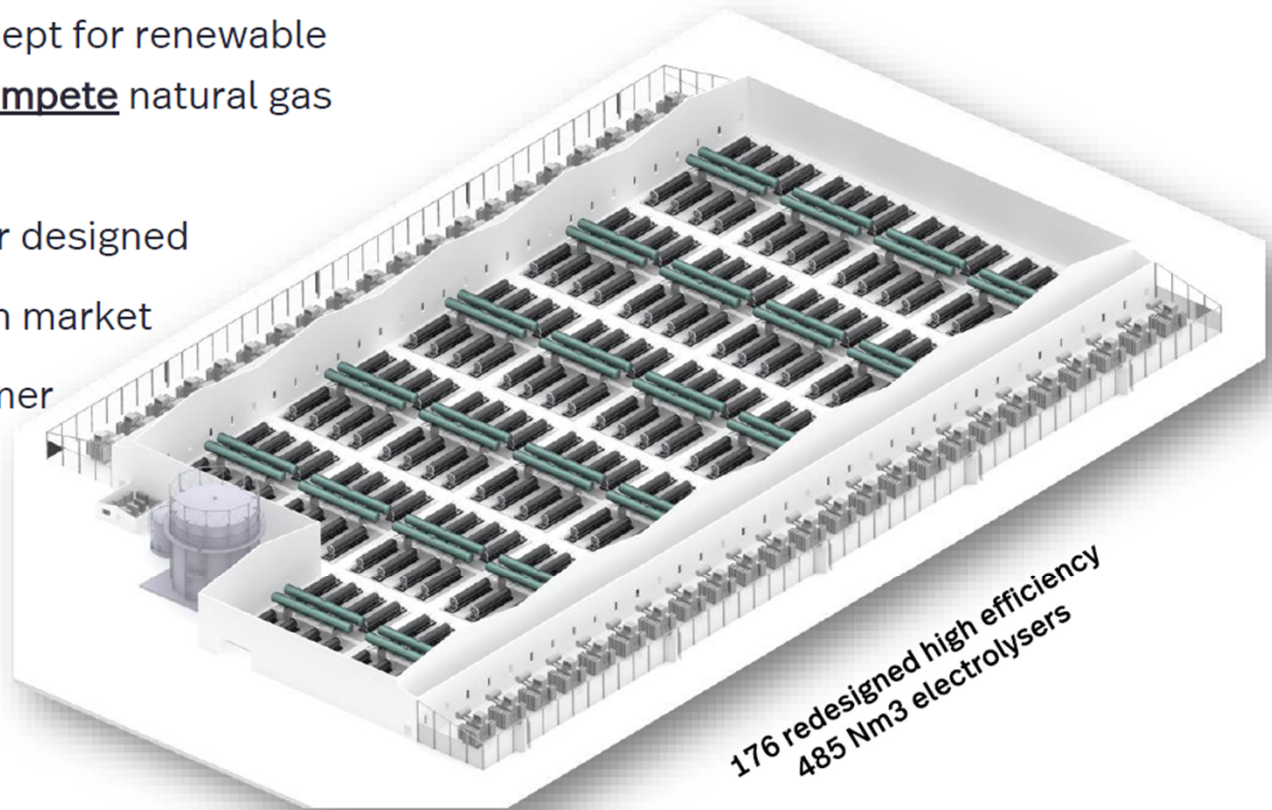


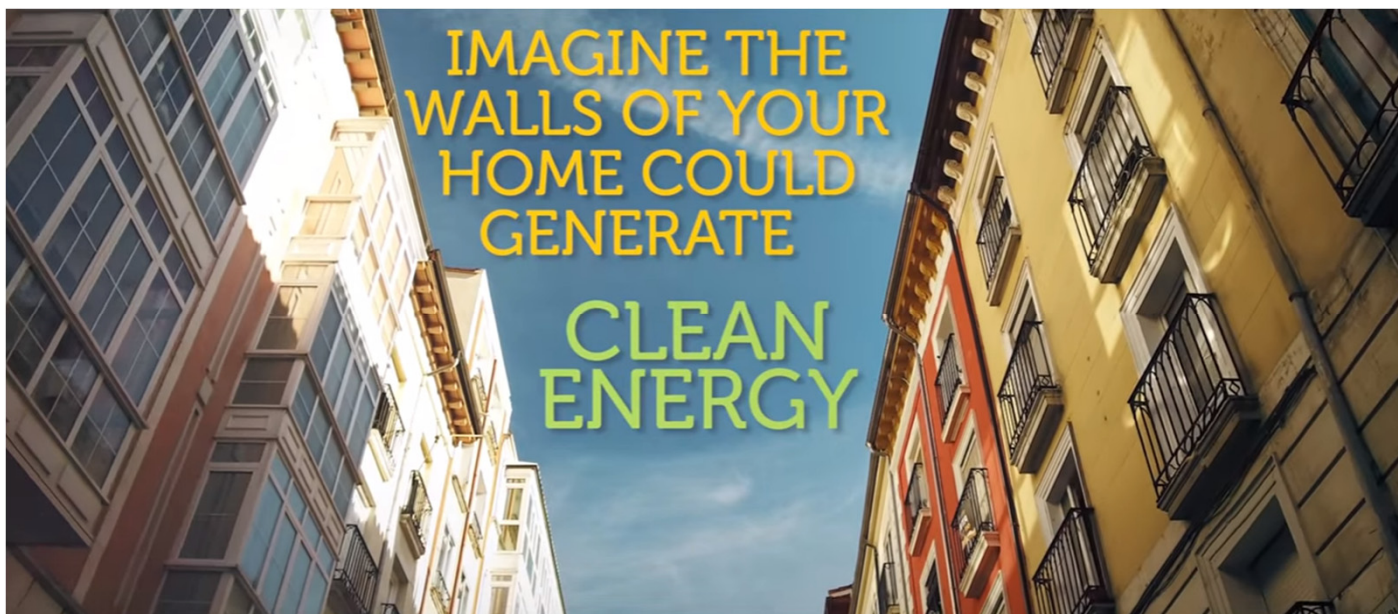
Elektrolyse van Water



NEL 400 MW Alkaline Electrolyzer

- Working on GIGA factory concept for renewable hydrogen production to outcompete natural gas reforming
- Largest electrolyser plant ever designed
- Addressing a USD ~ 150 billion market
- International industrial customer
- Tied to solar power
- CapEx of USD ~175 million
- Benchmark CapEx ratio:
 - 0.45 MUSD/MW

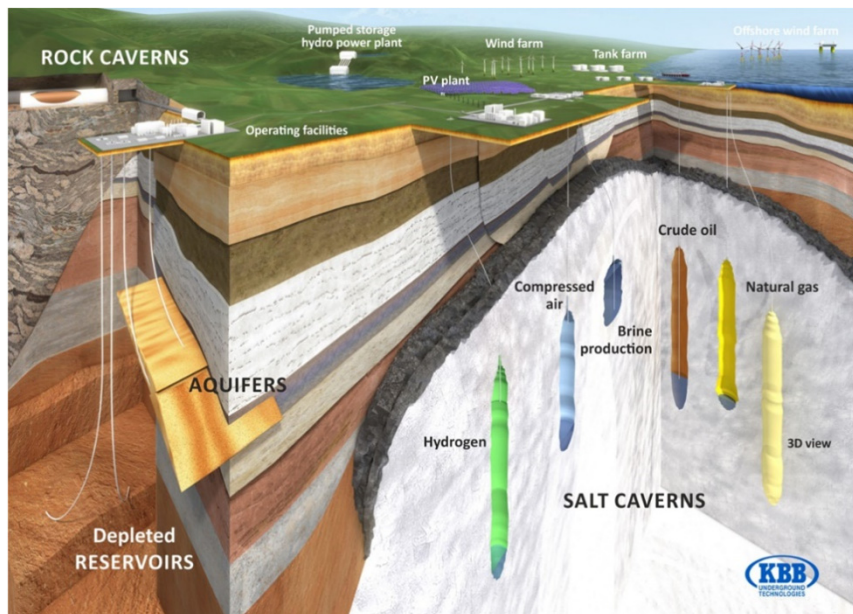




Hydrogen Cost development

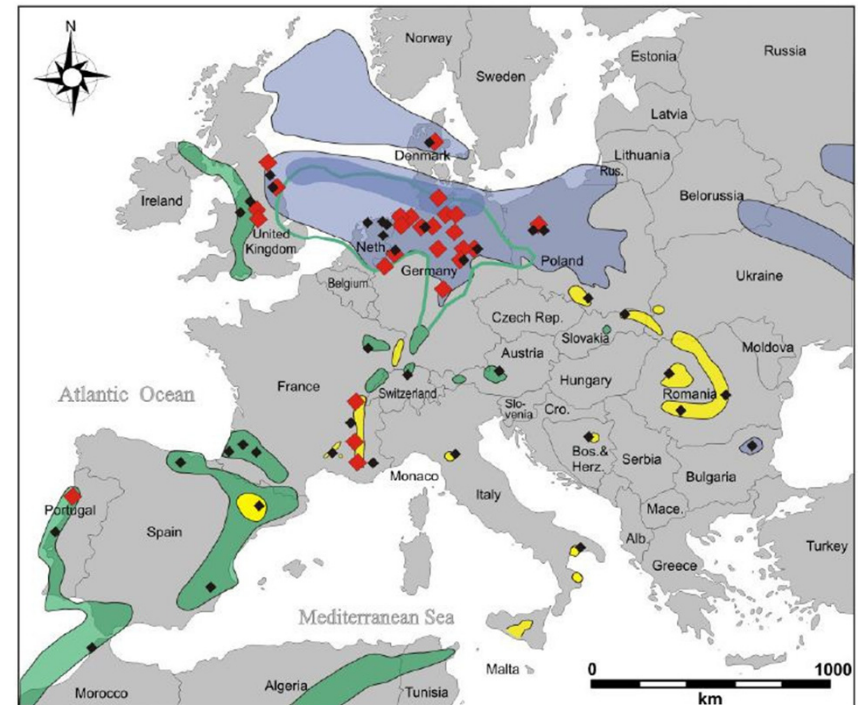
	Investment cost Euro/kW	Efficiency	Electricity Price Offshore Wind Euro/MWh	Hydrogen Price Euro/kg
Till 2020	600-900	72-75%	40-50	3-4
2020- 2025	300-600	75-78%	30-40	2-3 = Blue H ₂
2025- 2030	250-400	78-80%	25-35	1.5-2.5
After 2030	<250	>80%	20-30	1-1.5 = Grey H ₂

Hydrogen storage in Salt Caverns

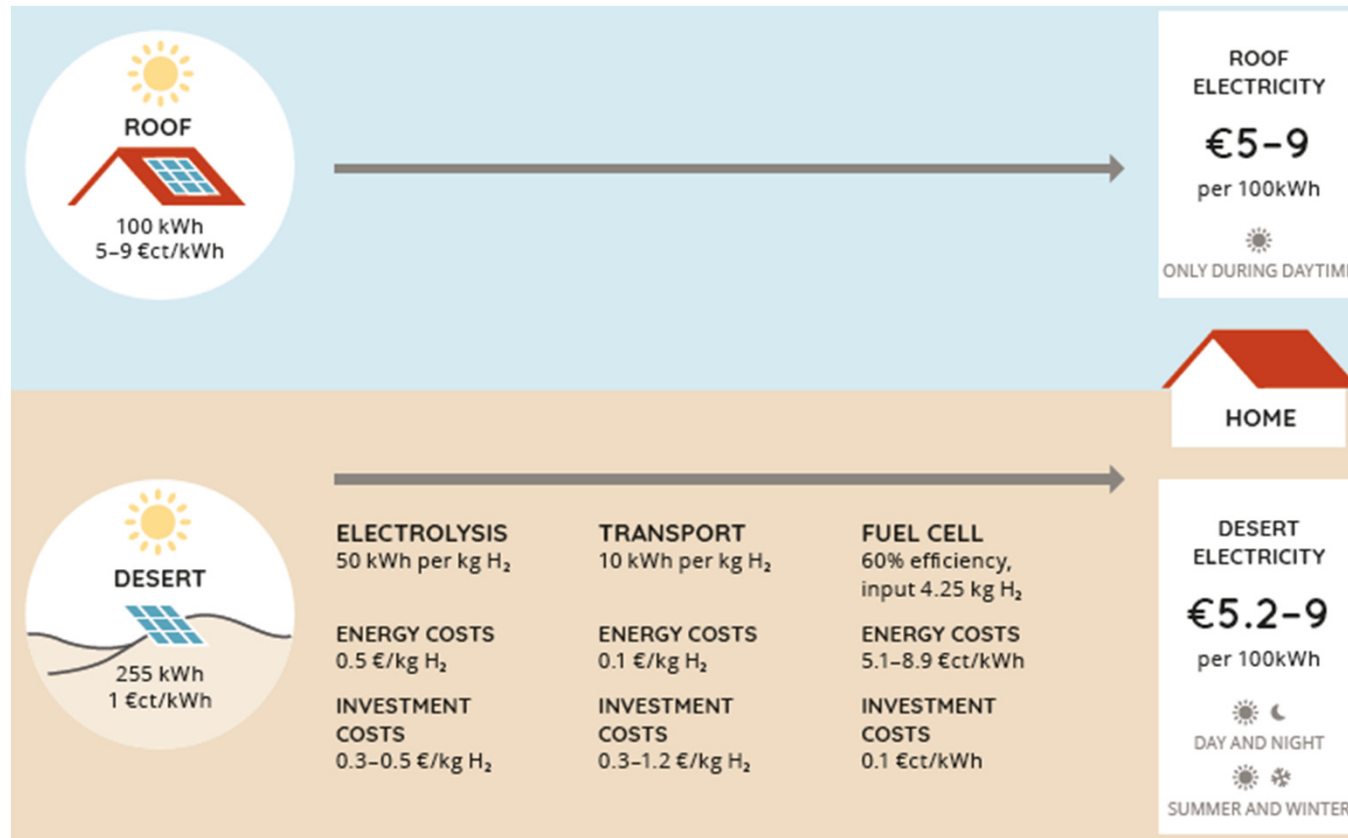


**1 salt cavern can contain 6,000 ton hydrogen
Equivalent of 17 million Tesla Power walls**

Salt formations and caverns in Europa



Roof versus Desert Solar



Hydrogen Coalition

3-4 GW electrolyser capacity 2030



Gasunie

Backbone Hydrogen Infrastructure
2030, 15 GW capacity, 1 billion Euro



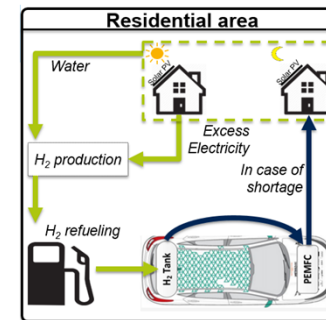
The Netherlands

Green Hydrogen Markets

Chemical Feedstock/Steam



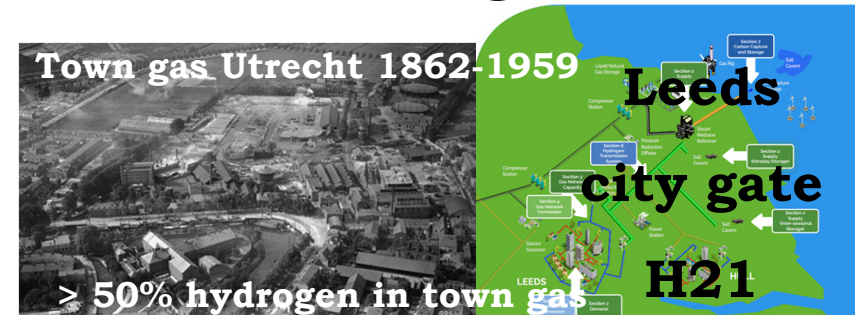
Electricity Balancing



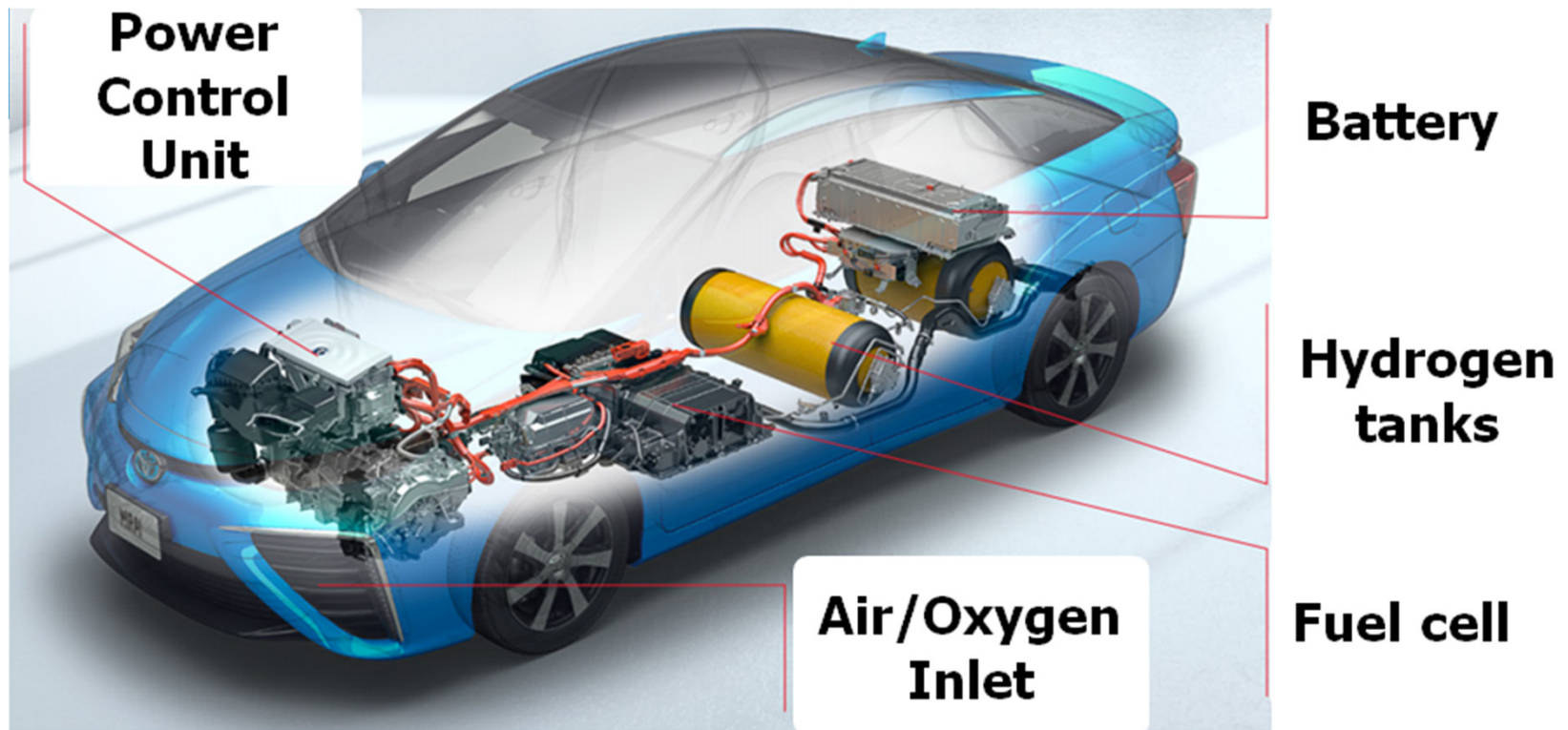
Transport



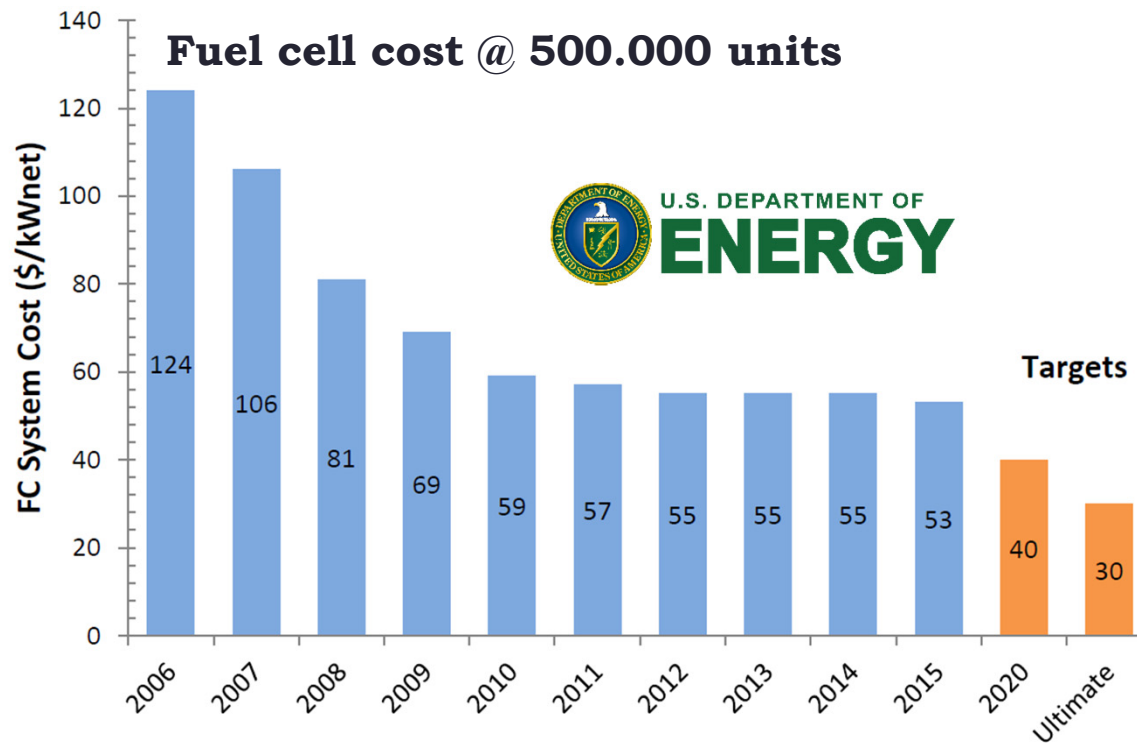
Heating



Toyota Mirai; Fuel cell car



Fuel cell cost

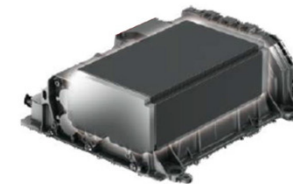


TOYOTA

2008 FUEL CELL STACK

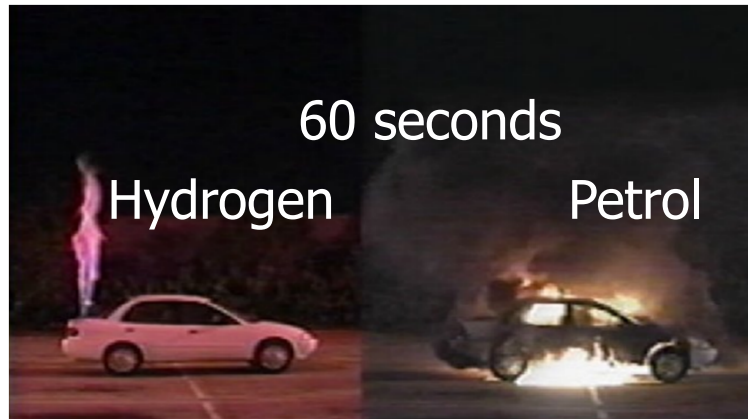
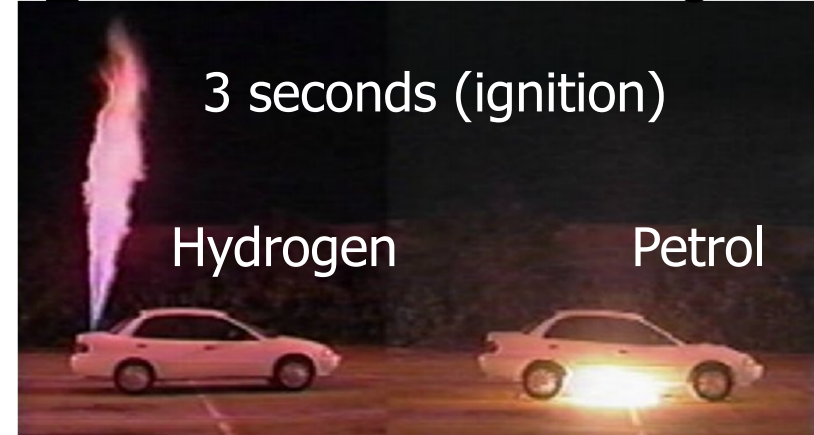
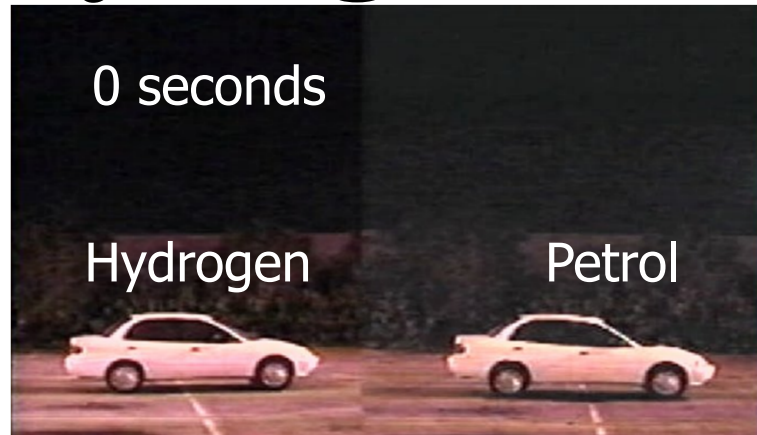


Weight **-48%** Volume **-43%** Power **+26%**



2016 FUEL CELL STACK

Hydrogen versus petrol safety



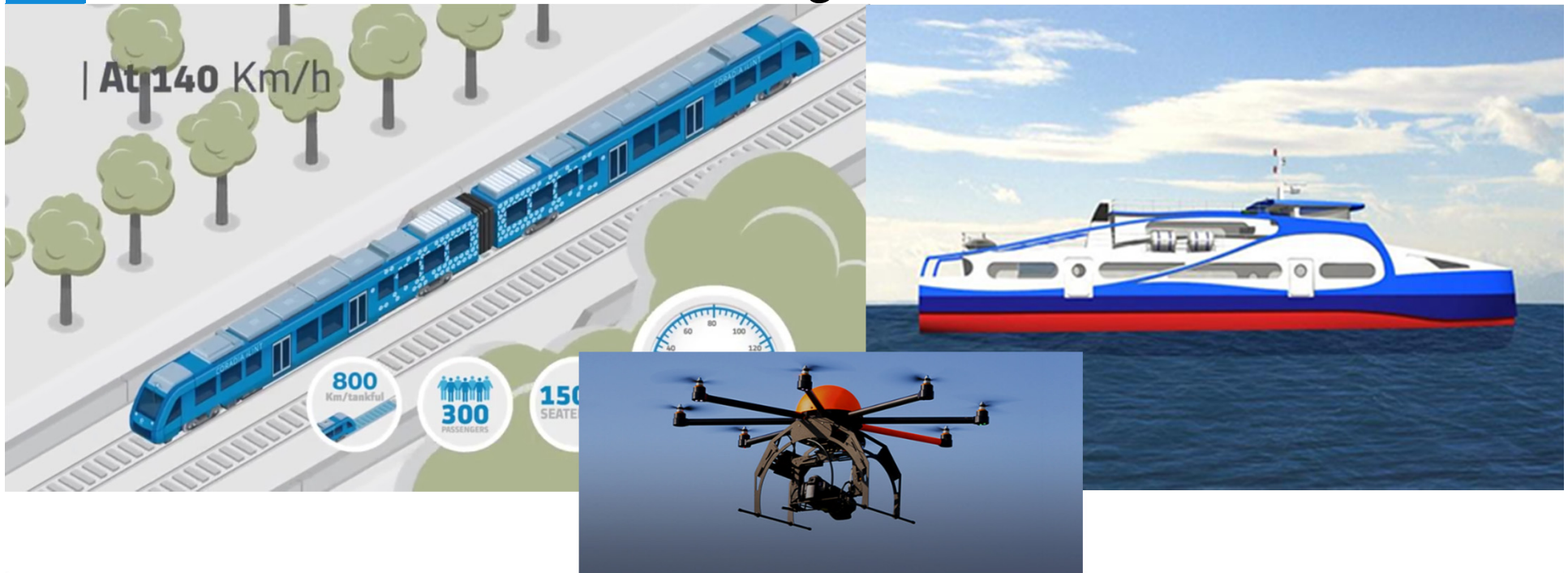
Toyota Fuel Cell Hydrogen Truck and Bus



Fuel cell Hydrogen versus Diesel



Fuel Cell Hydrogen Train, Ferry, Drone



City Groningen vehicles on hydrogen



Company Holthausen converts vehicles to fuel cell hydrogen;
Garbage trucks and sweepers for the city of Groningen, may 2017

Holthausen converted Tesla in Hesla

Nov 2017



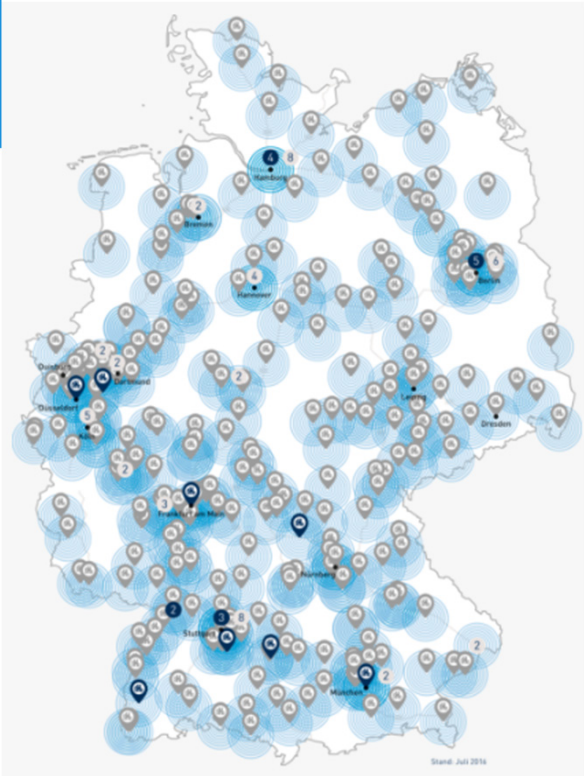
Hydrogen fuelling stations

Rhoon

Hamburg



Germany 400 hydrogen fueling stations in 2023



400 hydrogen fueling stations in 2023, at existing fueling stations.

Investments: 350 million Euro, half government, half companies.

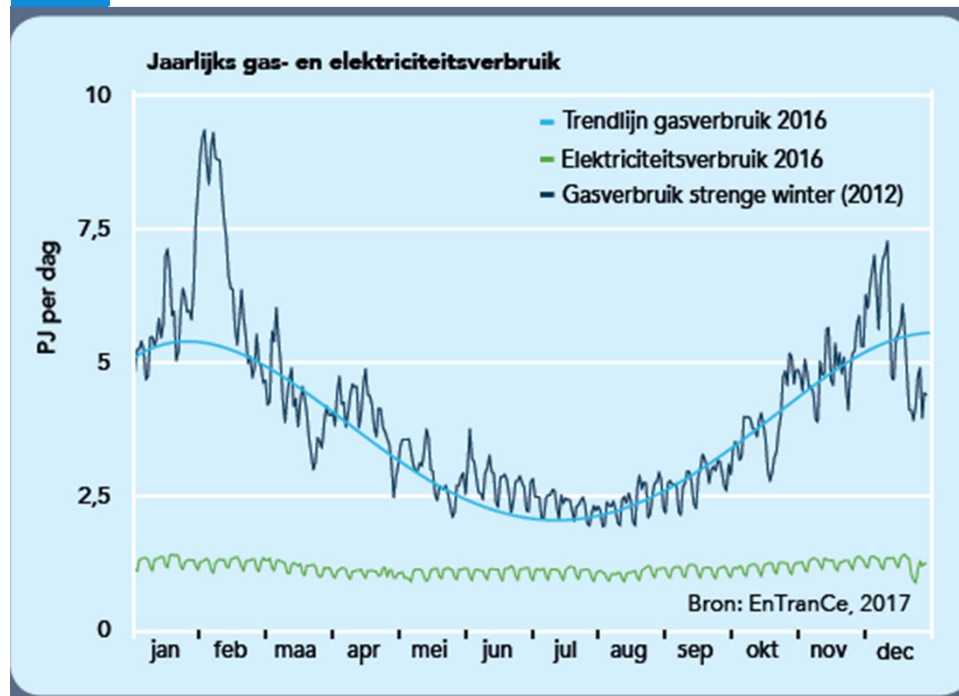
Consortium: Shell, Total, Linde, Air Liquide, OMV, Daimler, BMW, Volkswagen, Toyota, Honda, Hyundai, NOW (German government)



Energy for heating buildings

- Energy use for heating and cooling our buildings is roughly 25% of all energy.
- But why do we use energy in our buildings?
 - In winter time it is too cold and we have to heat our buildings
 - In summer time it is too hot and we have to cool our buildings
- It is not an energy problem it is a storage problem

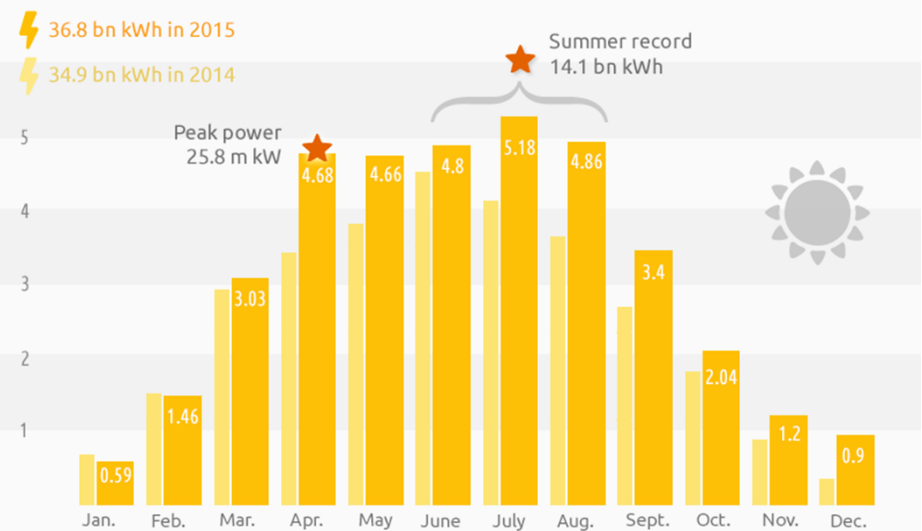
Gas and electricity consumption in the Netherlands



Solar power production in Germany

SOLAR POWER GENERATION IN GERMANY 2015

Solar energy sets a new all-time summer record and beats peak power output

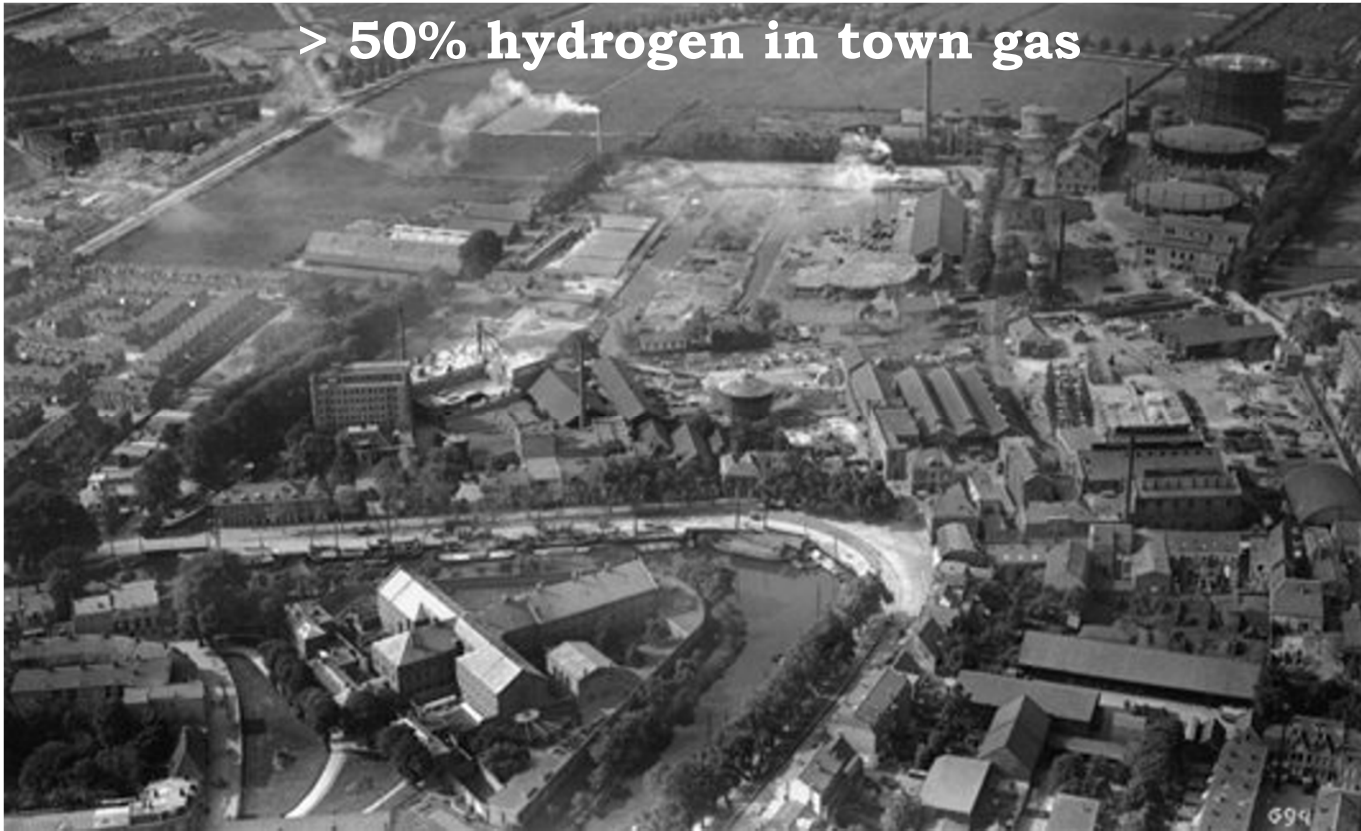


Source 2014, 2015: Fraunhofer ISE, EEX

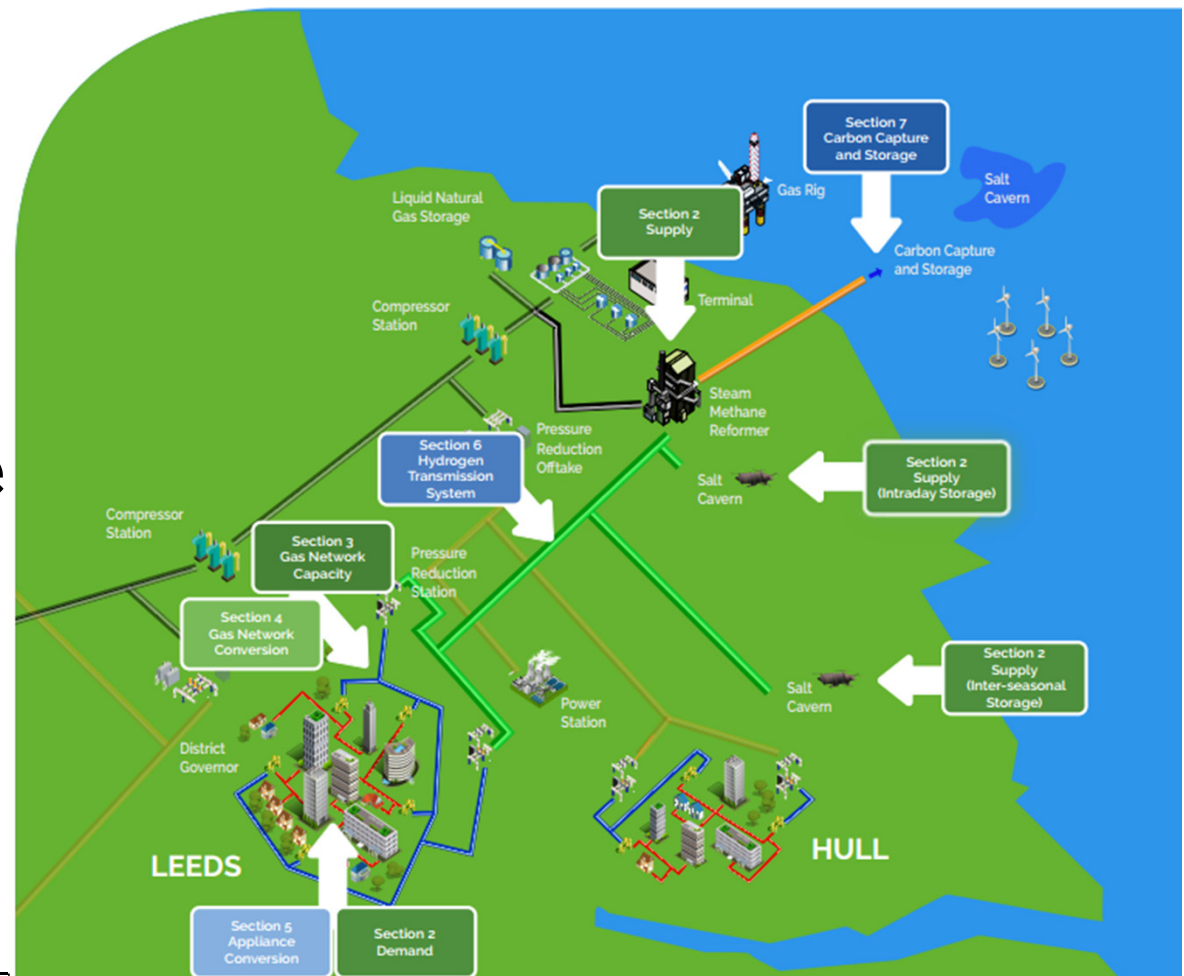
CC BY STROM-REPORT.DE

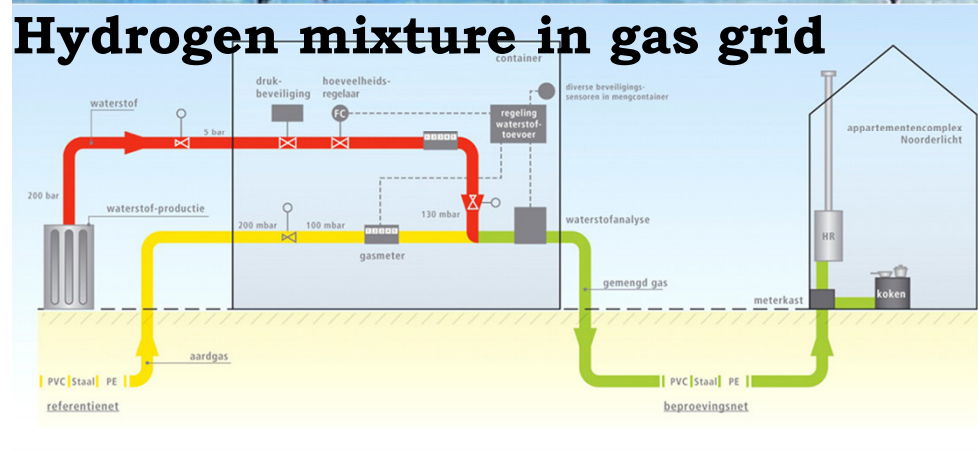
Town Gas production Utrecht 1862-1959

> 50% hydrogen in town gas



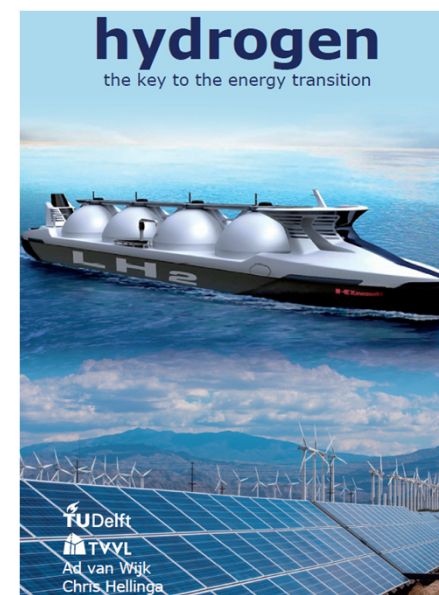
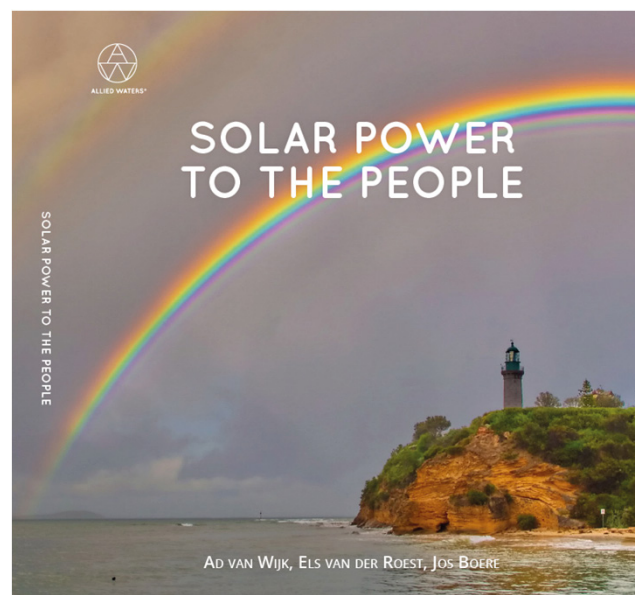
Leeds City Gate Project





Verder Lezen over waterstof

www.profadvanwijk.com



Gratis downloaden in Engels en Nederlands

Defying Death Valley

