



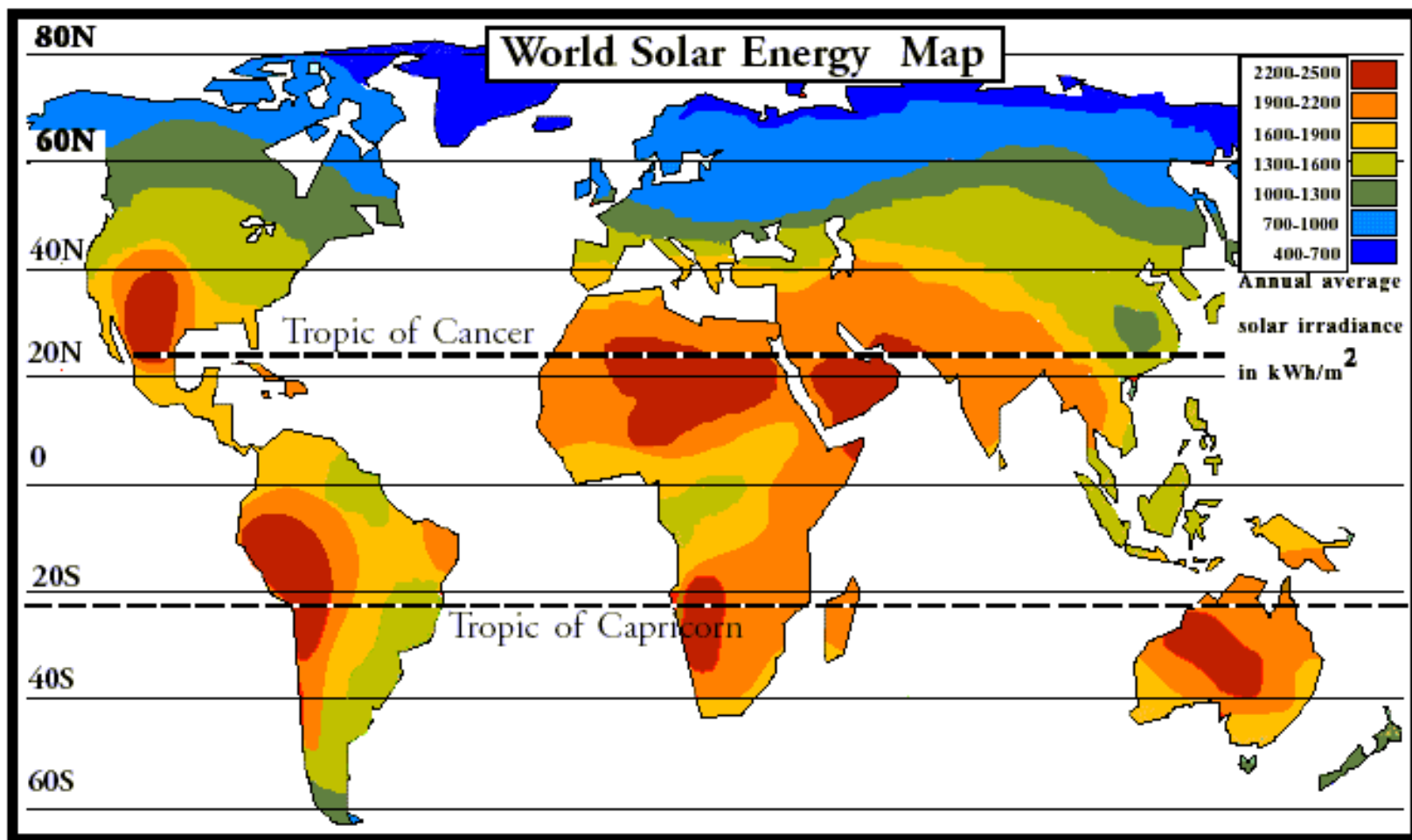
Waterstof de missing link in de energietransitie

8-11-2018

Prof. Dr. Ad van Wijk

Bids for Saudi Arabia's 300 MW Solar Plant





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



10% SOLAR AUSTRALIA

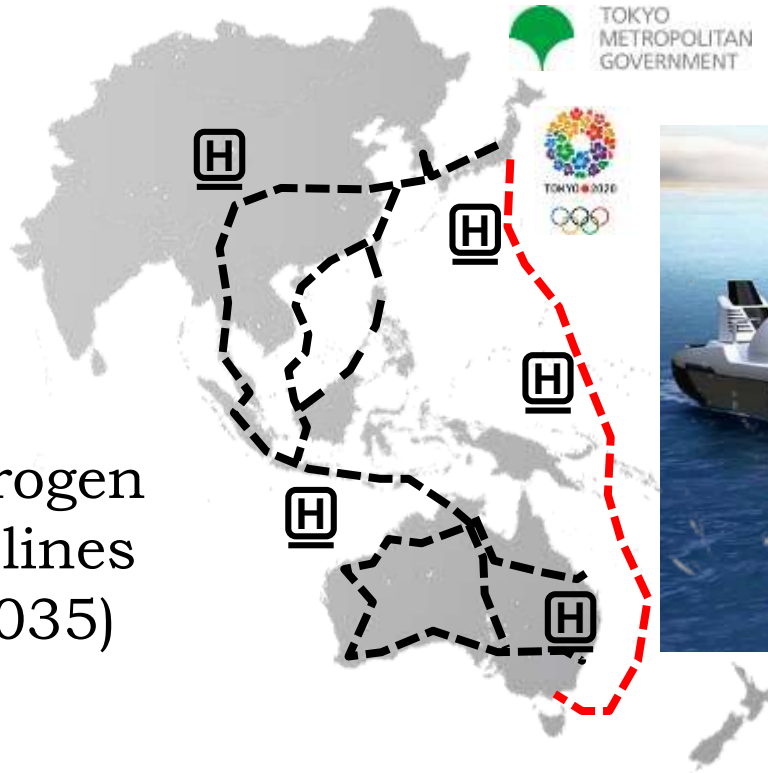


1.5% WIND PACIFIC OCEAN

Tokyo Olympic Games 2020



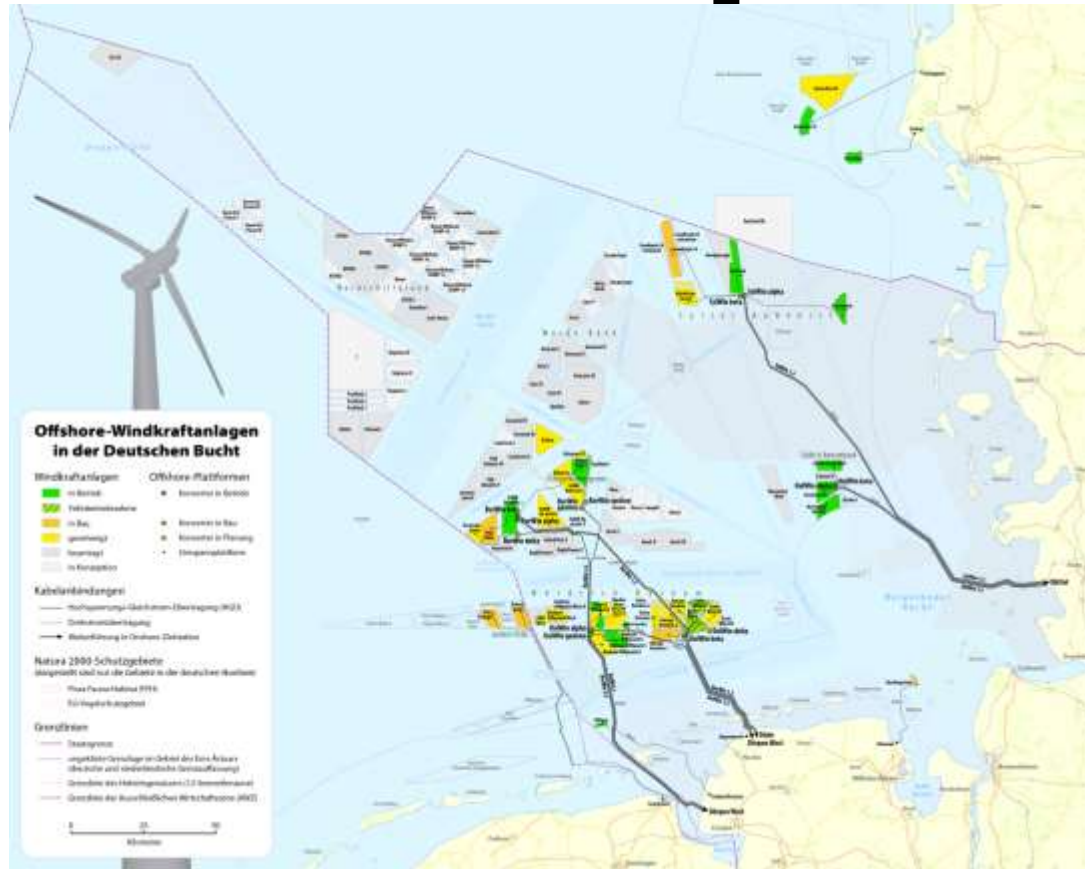
Hydrogen
Pipelines
(~2035)



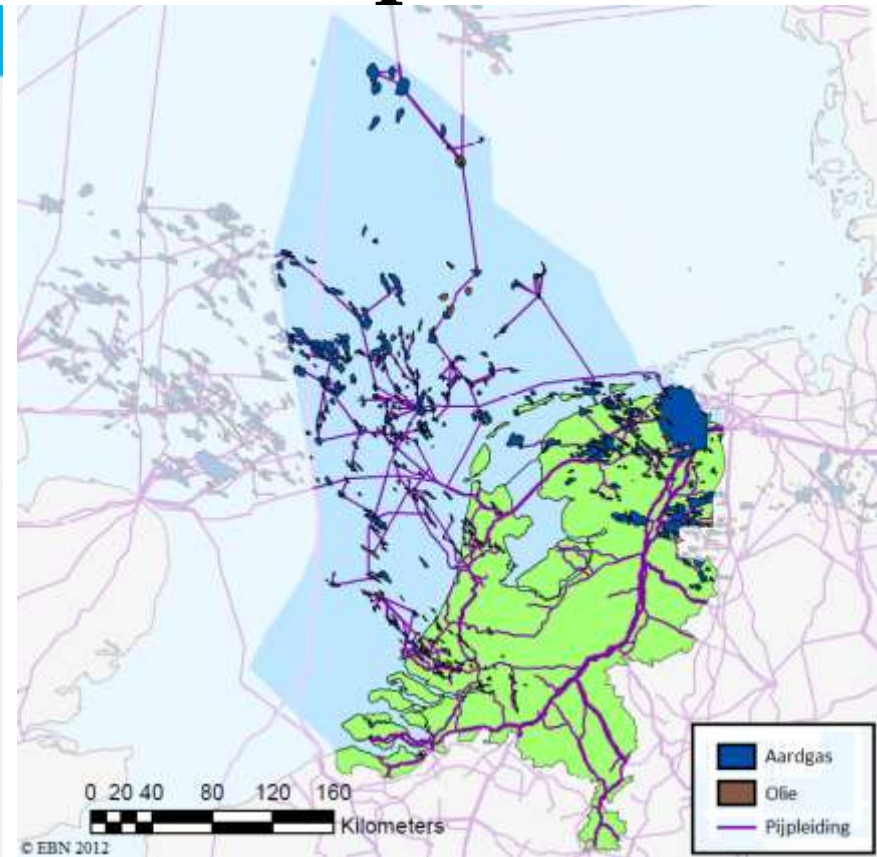
Hydrogen
Shipping
(~2025)



Offshore Wind Development Germany



Electricity and Gas Transport Grid



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

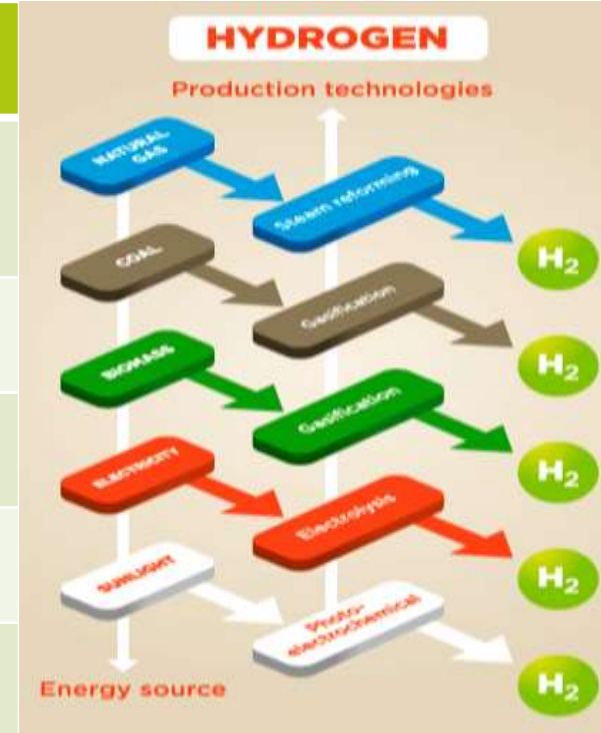
Transport and Distribution gas grids can be easily converted to hydrogen

- No technical issues, compressor needs to be adjusted
- System design development necessary; hydrogen quality, flow velocity, pressure, odorization, hydrogen measurement equipment, sensors, etc.
- Conversion cost are 5-10% of investment cost new pipeline

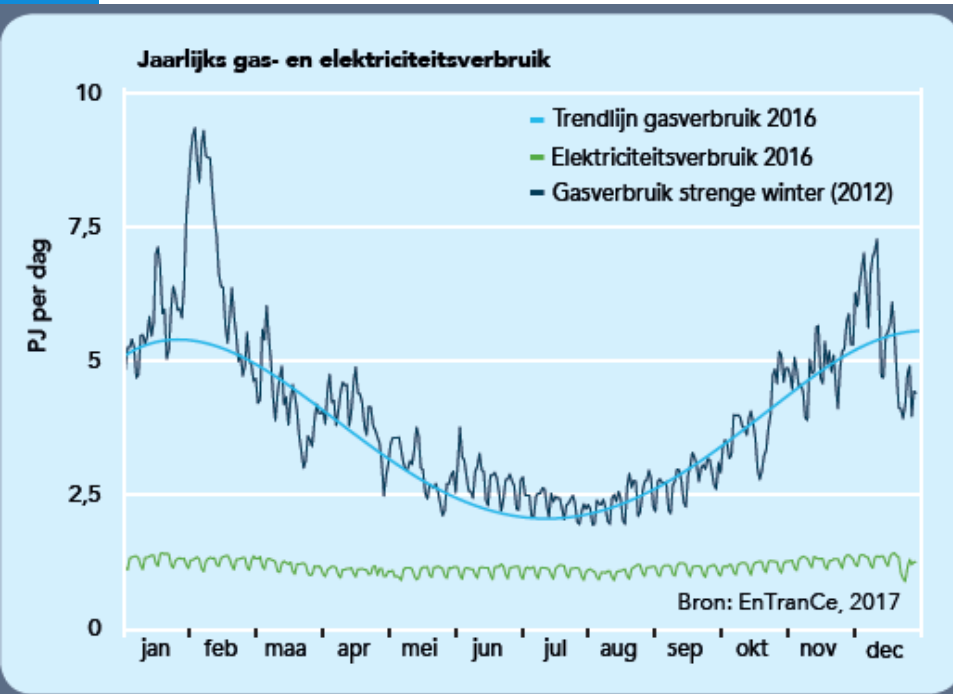


Hydrogen production

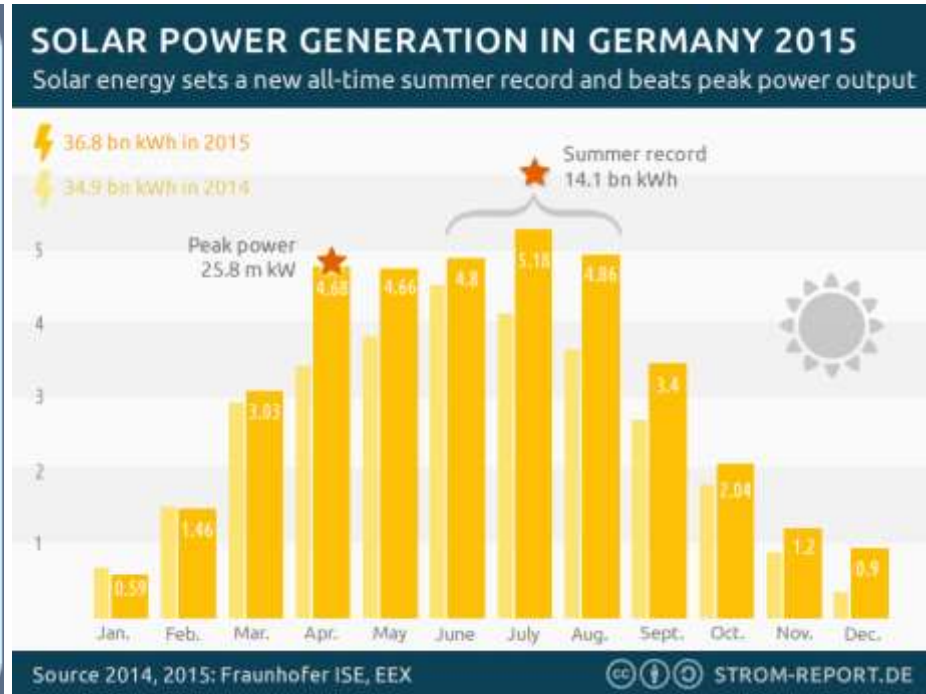
Source	Process	Efficiency Today
Natural gas Bio Gas	Steam reforming Auto-thermal reforming Solid Oxide Fuel Cell	70-75% >75% 80% (40-40)
Coal/Oil	Gasification	56%+ (=syngas)
Biomass	Gasification	44%+ (=syngas)
Electricity + Water	Electrolysis Alkaline and PEM	75-80% (90% exp.)
Sunlight + Water	Photoelectrochemical	14% (lab)



Gas and electricity consumption in the Netherlands



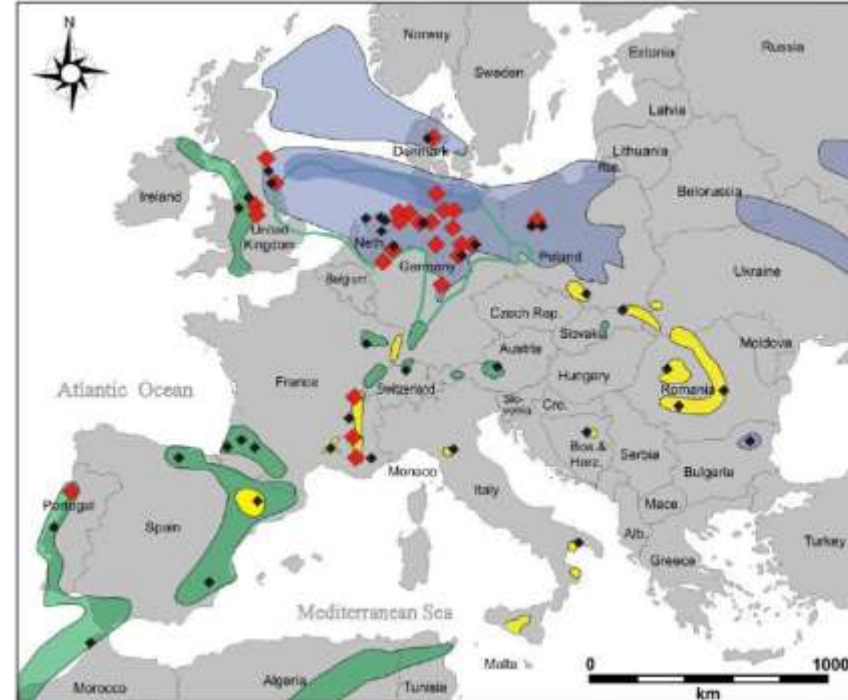
Solar power production in Germany



Hydrogen storage in Salt Caverns

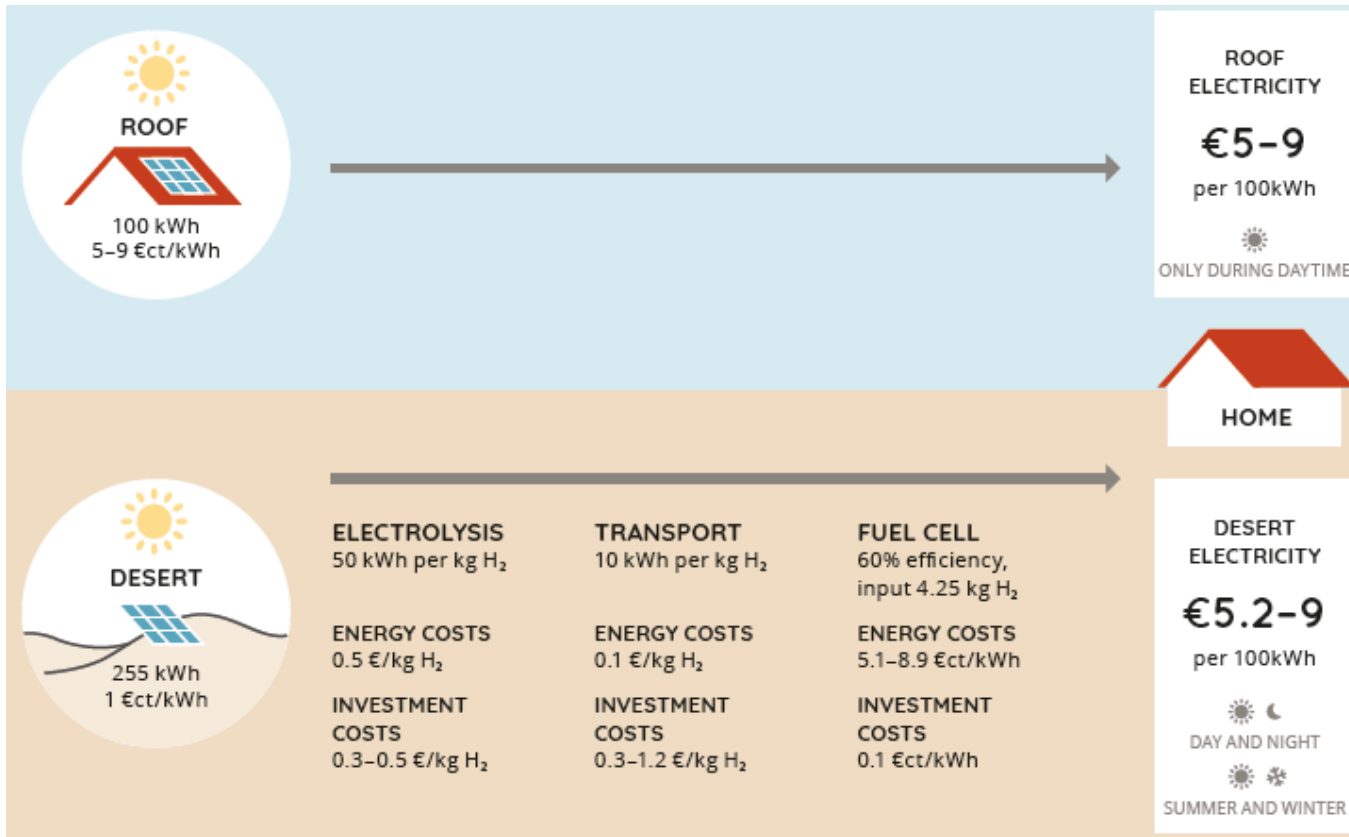


Salt formations and caverns in Europa



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

Roof versus Desert Solar



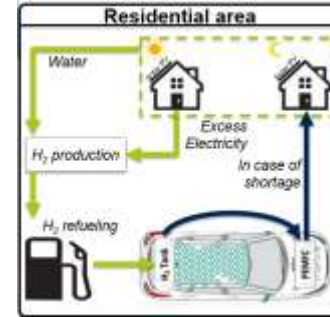
Green Hydrogen Markets

Chemical

Feedstock/Steam



Electricity Balancing



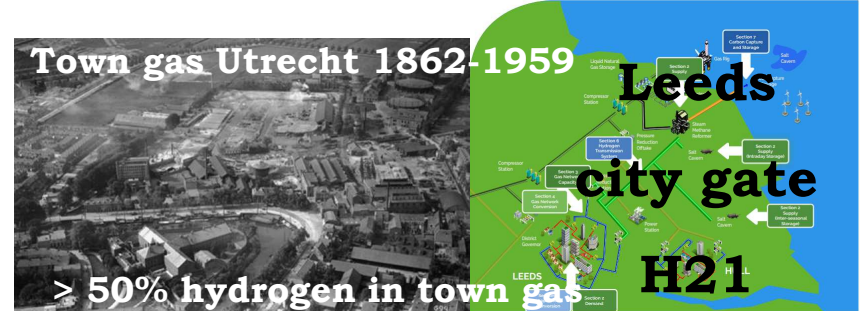
NUON Magnum power plant



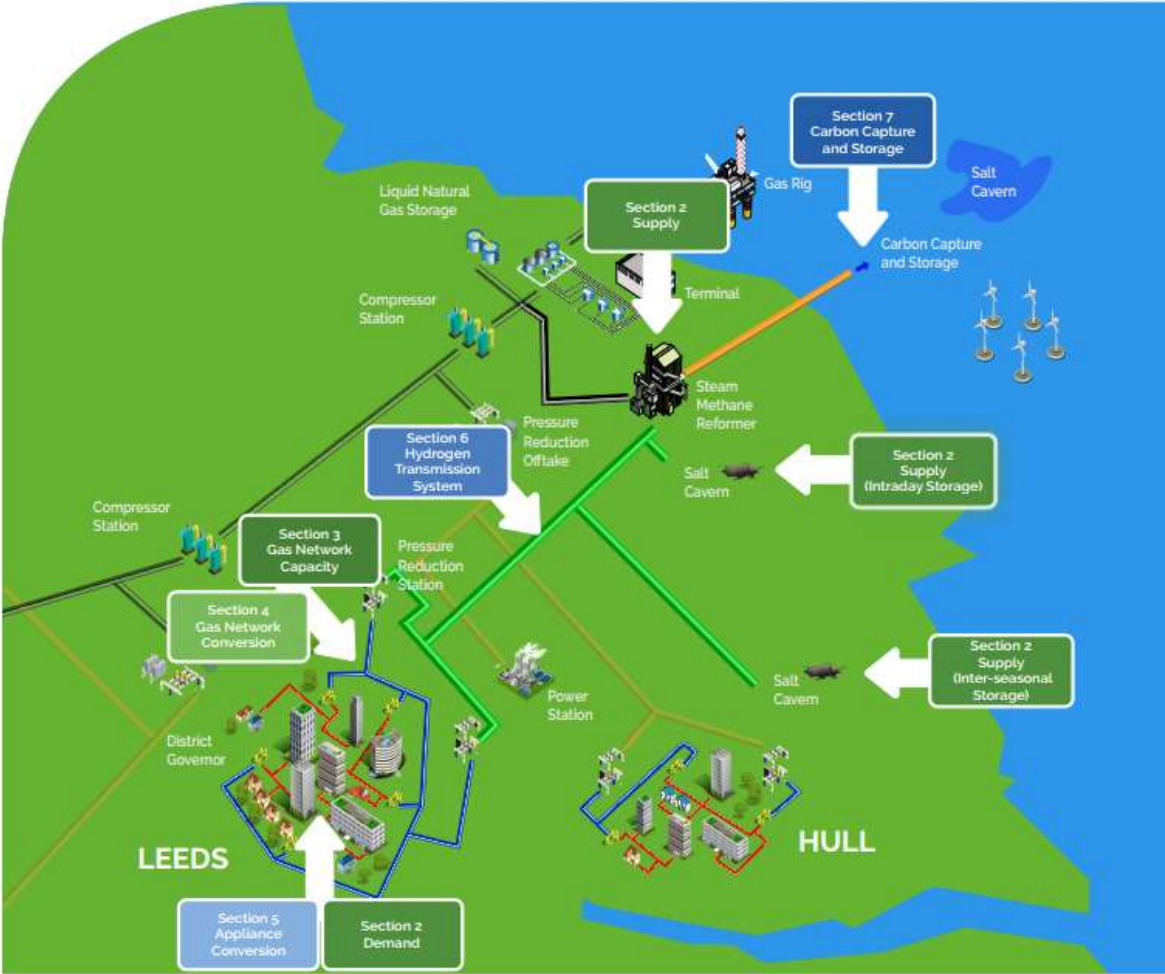
Transport



Heating

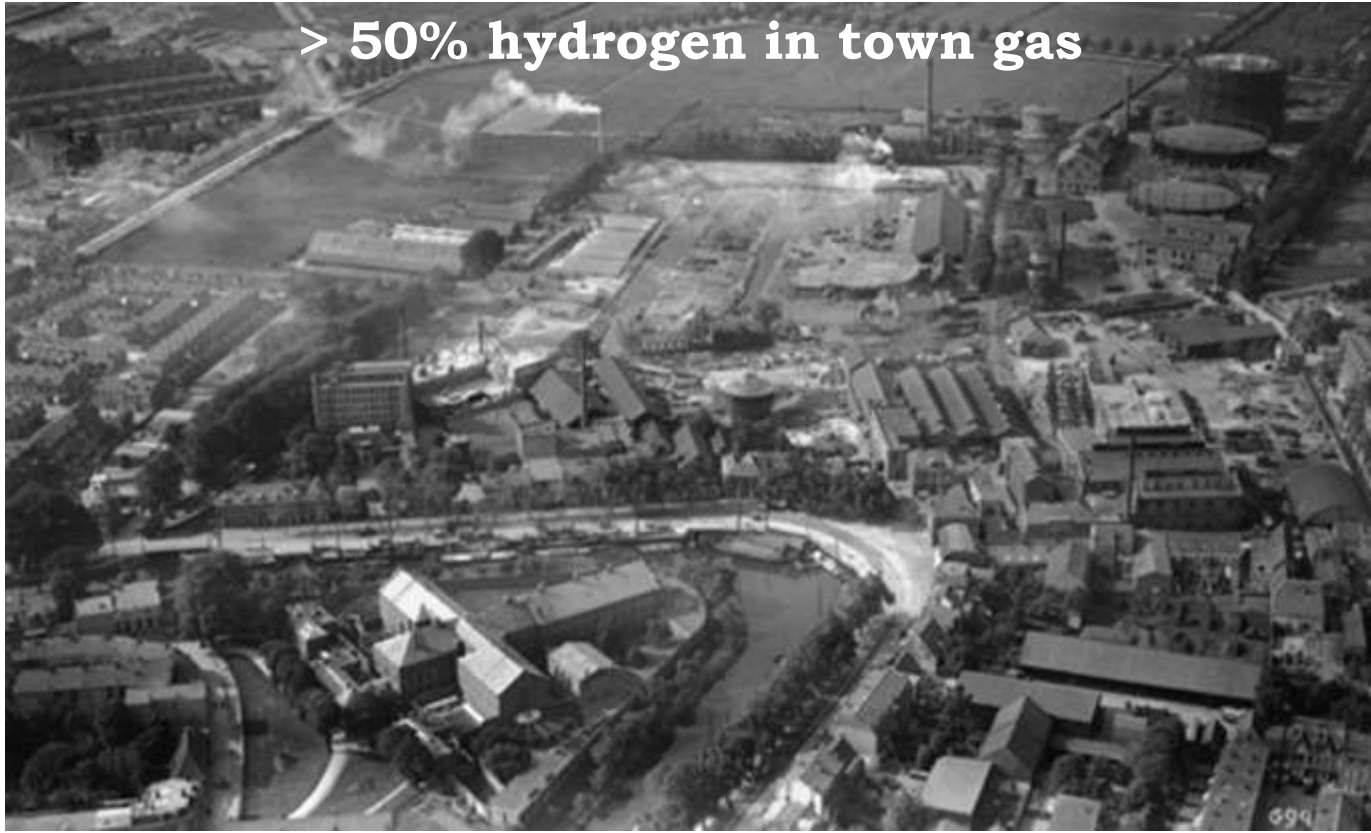


Leeds City Gate Project



Town Gas production Utrecht 1862-1959

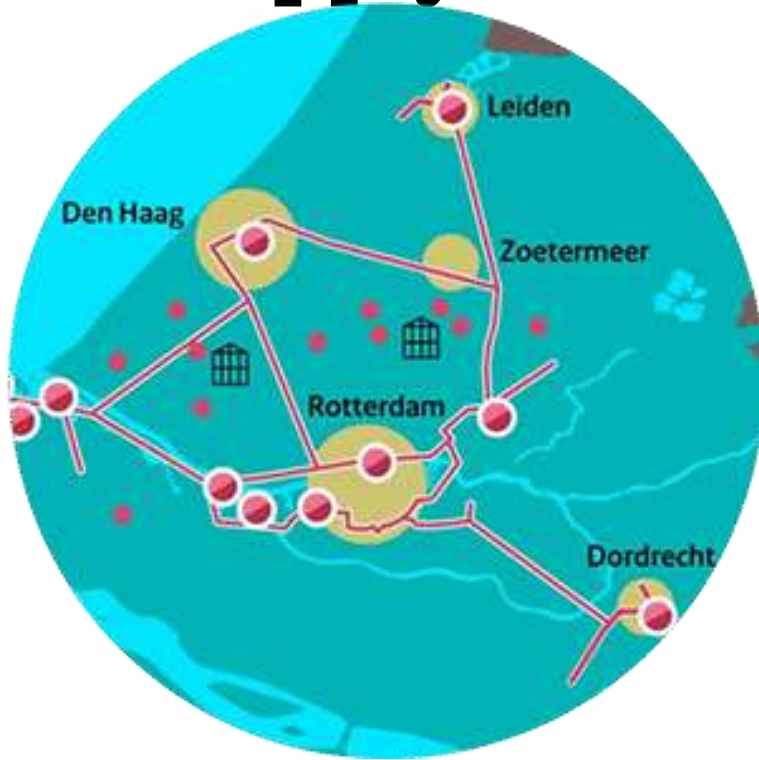
> 50% hydrogen in town gas



Hybrid Heat Pump + Boiler



'Warmterotonde' with hydrogen to supply additional heat in winter



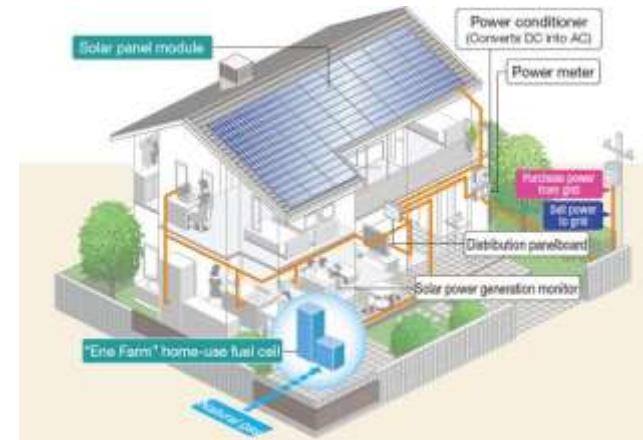
Ene Farm: Home Fuel cell systems Japan

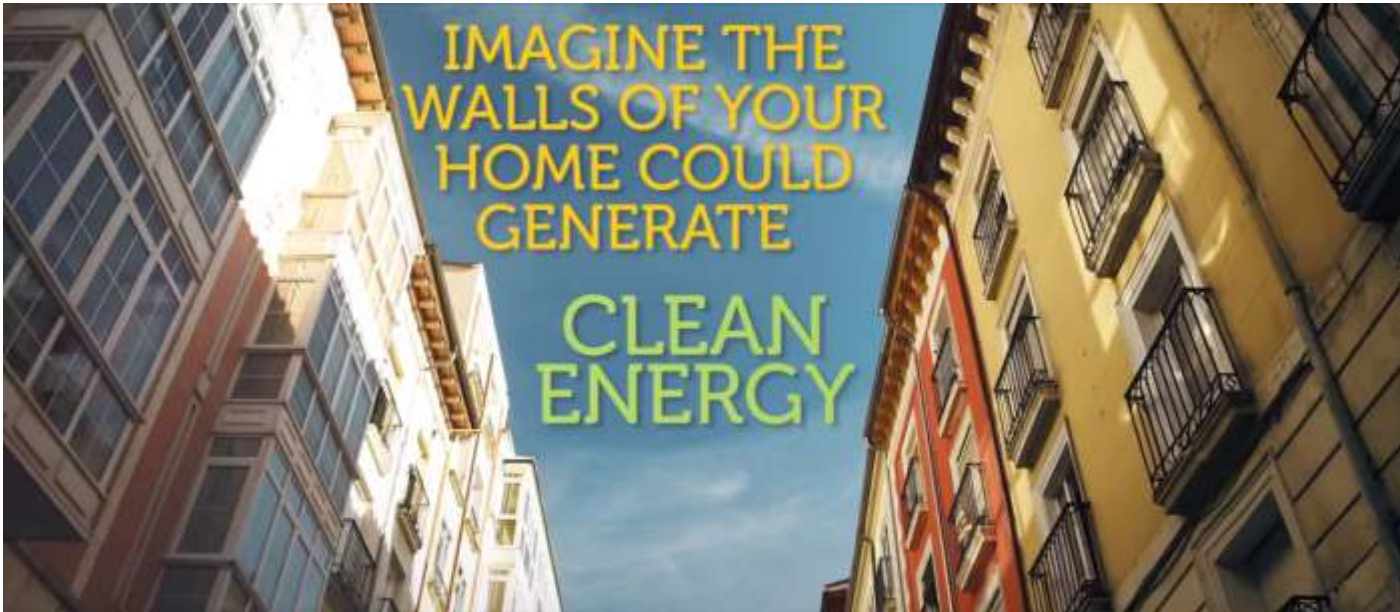
- Japan 200.000 sold 2017
- Aim 1.4 million end 2020
- Panasonic with Viesmann started sales in UK and Germany in 2017
- Kyocera makes systems for restaurants, hotels, etc.



Hot water unit

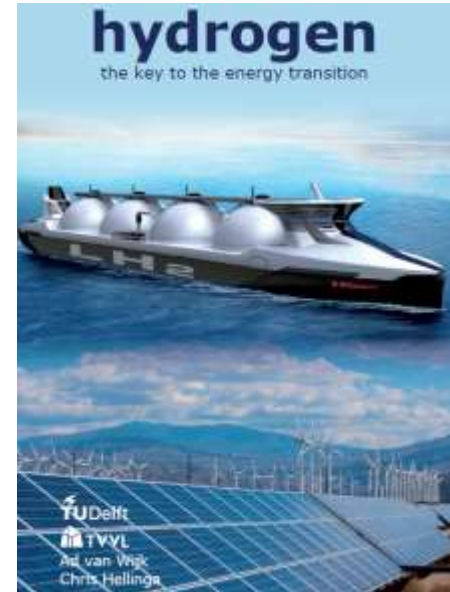
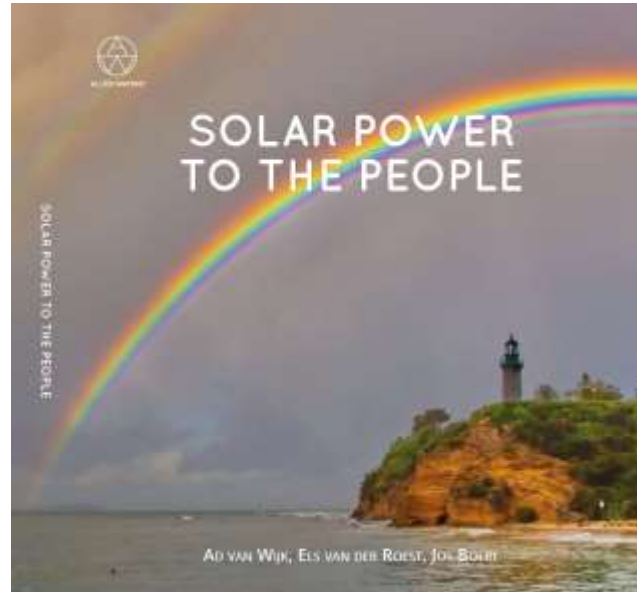
Fuel cell





Verder Lezen over waterstof

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