



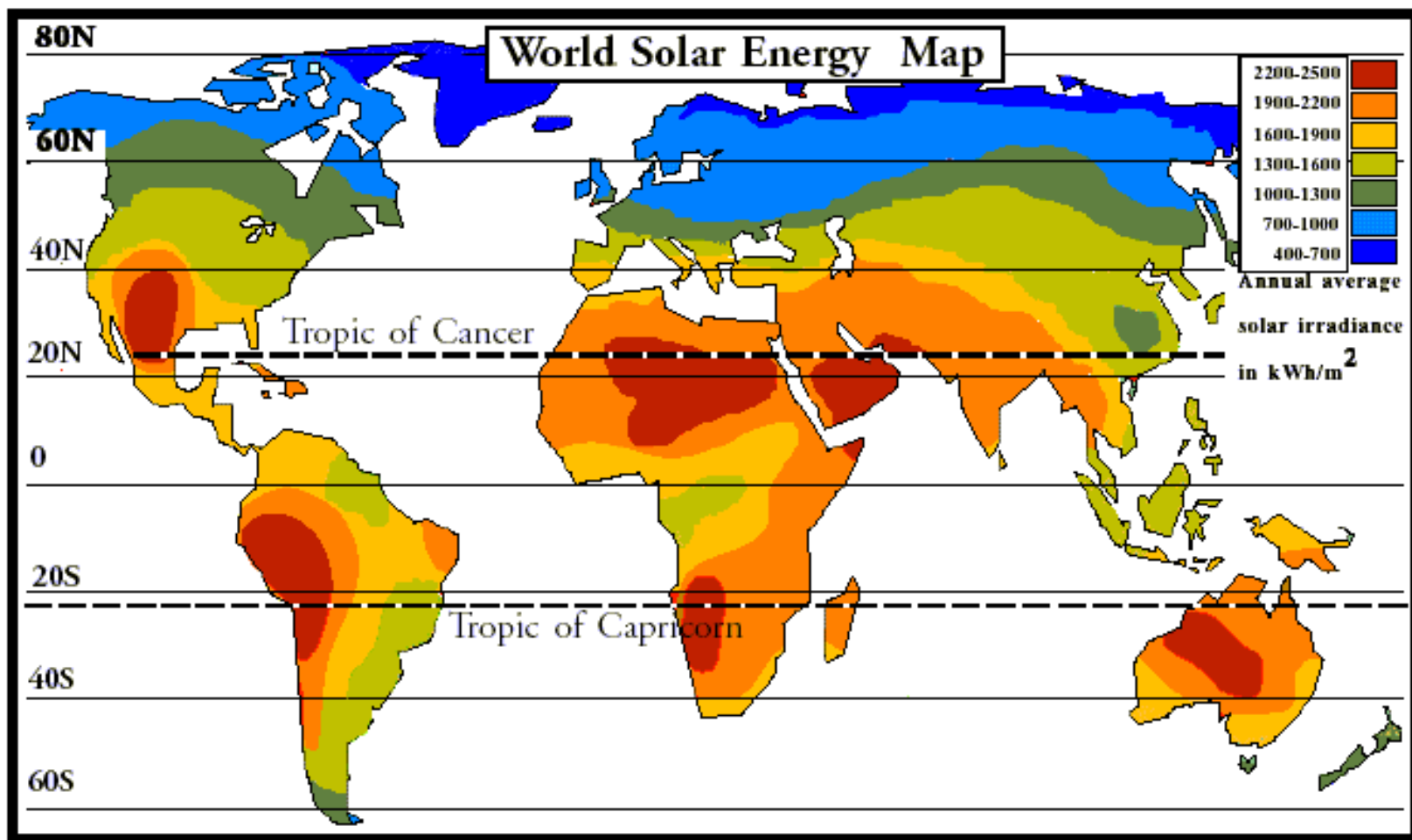
# Kansen en uitdagingen waterstof

13-11-2018

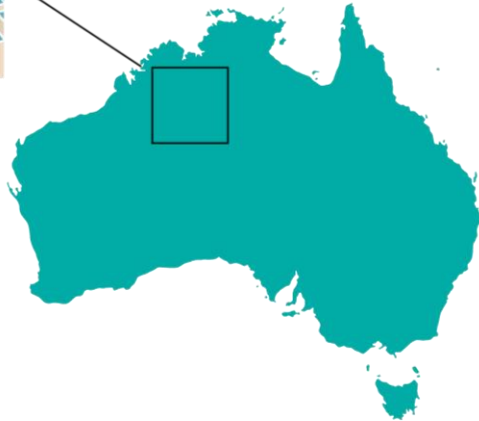
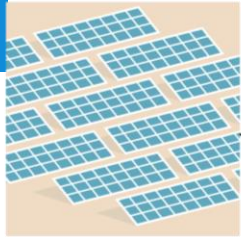
Prof. Dr. Ad van Wijk

# 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

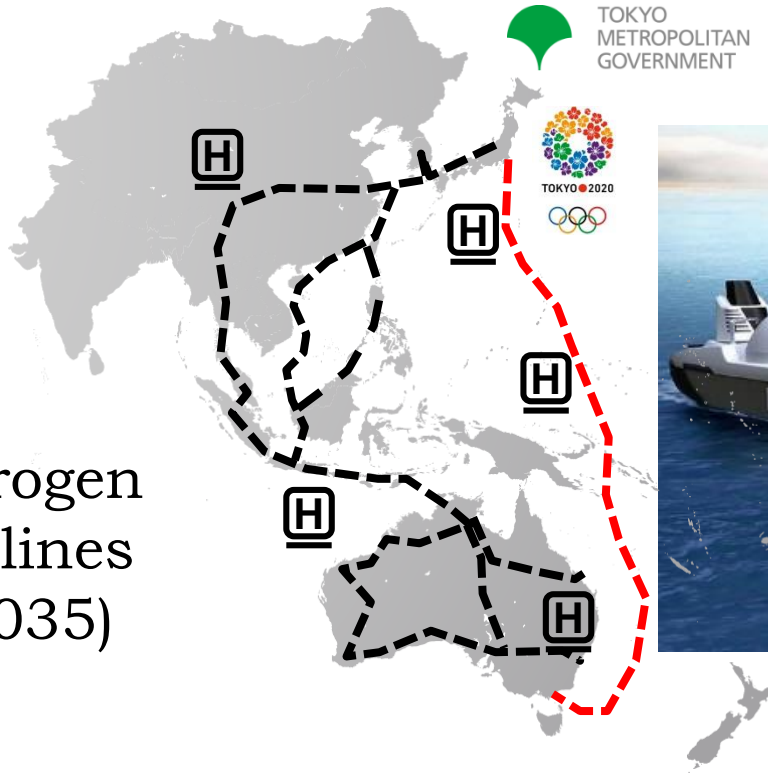


1.5% WIND PACIFIC OCEAN

# Tokyo Olympic Games 2020



Hydrogen  
Pipelines  
(~2035)

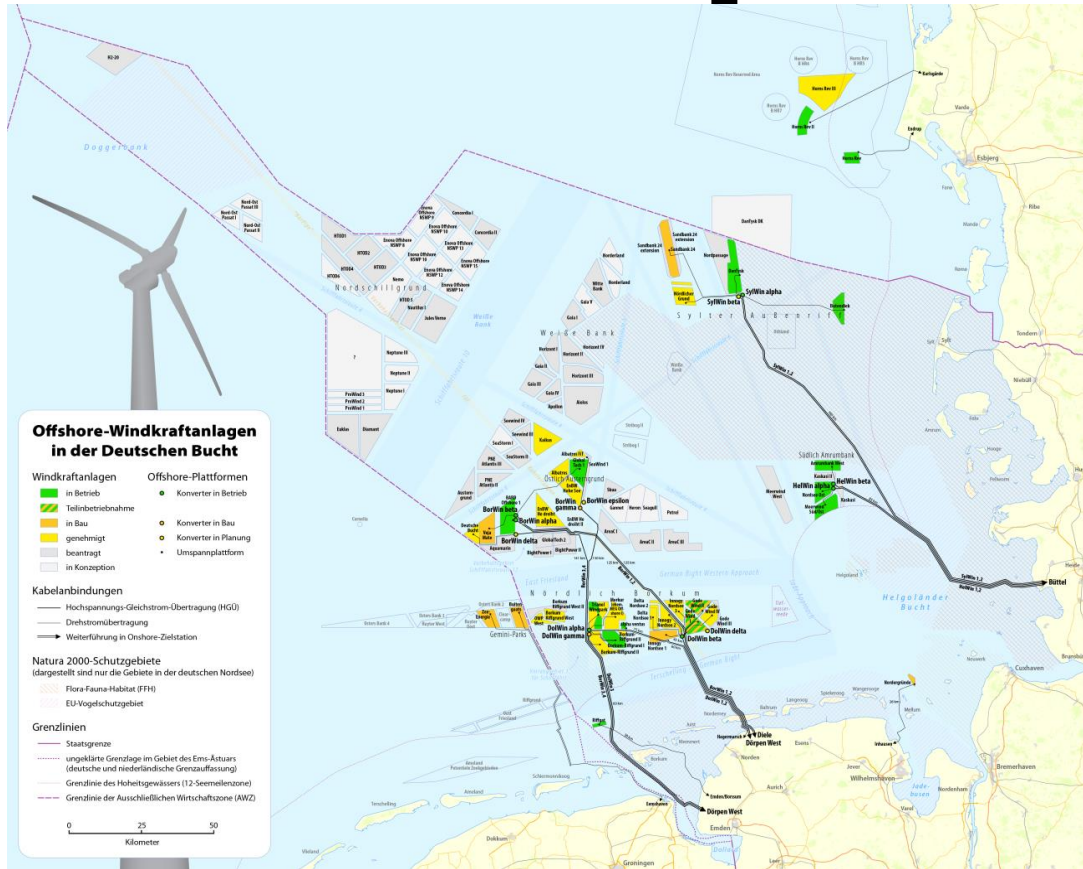


Hydrogen  
Shipping  
(~2025)

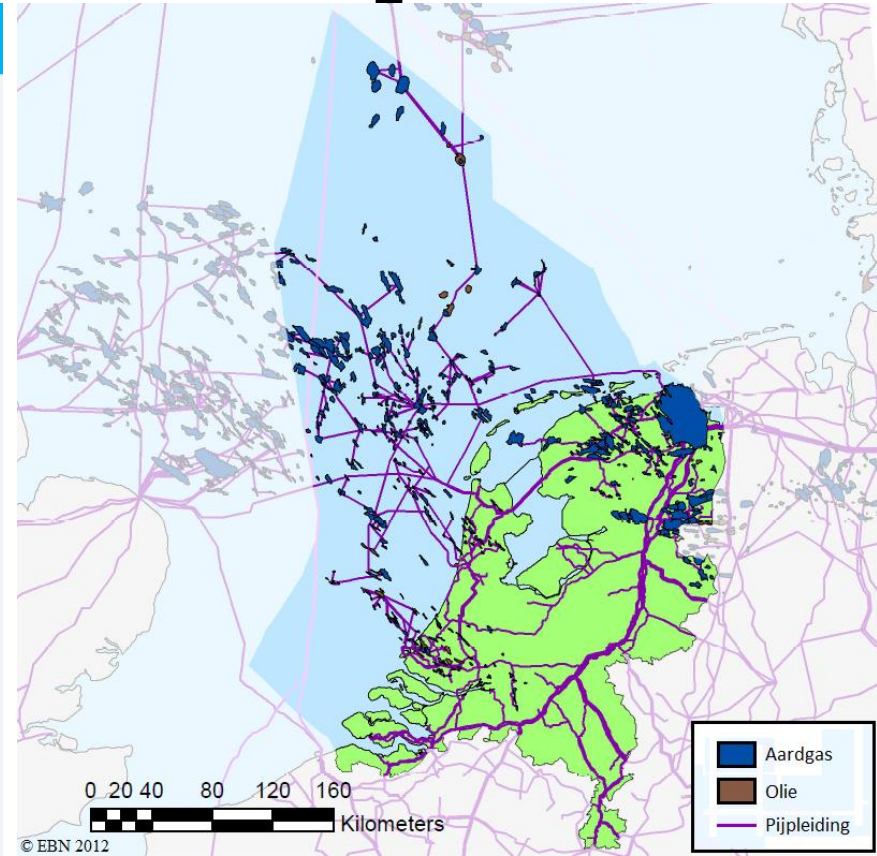




# Offshore Wind Development Germany



# Electricity and Gas Transport Grid



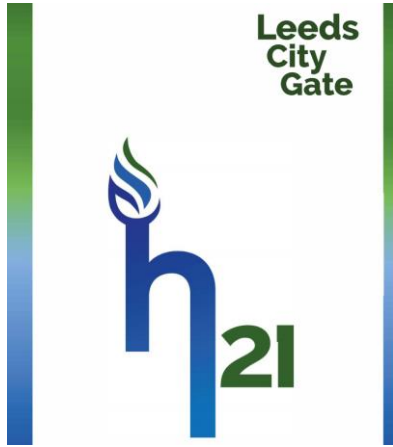
# Cable versus pipeline cost

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



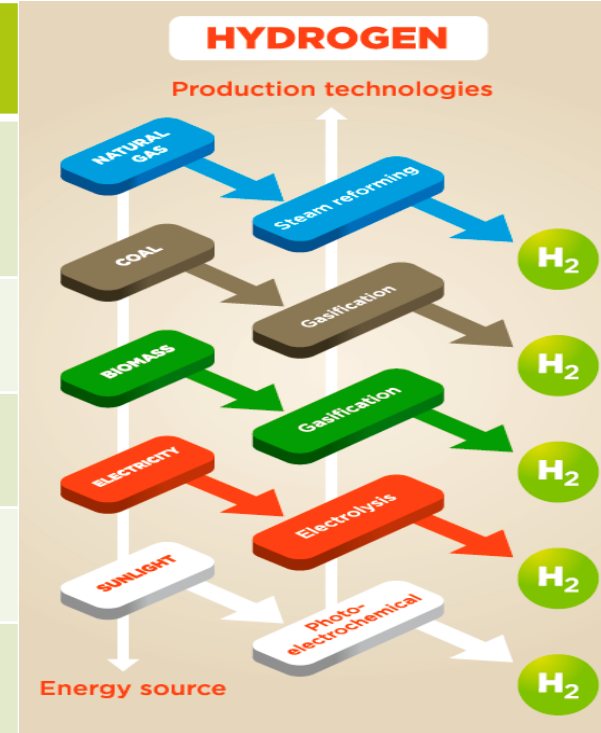
# Transport and Distribution gas grids can be easily converted to hydrogen

- 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

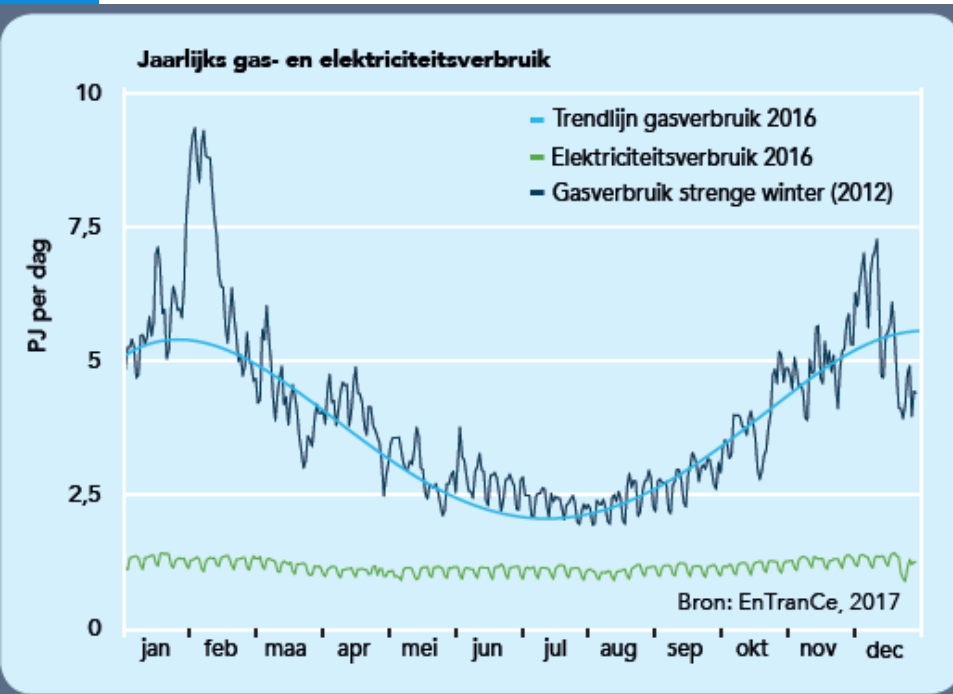


# Hydrogen production

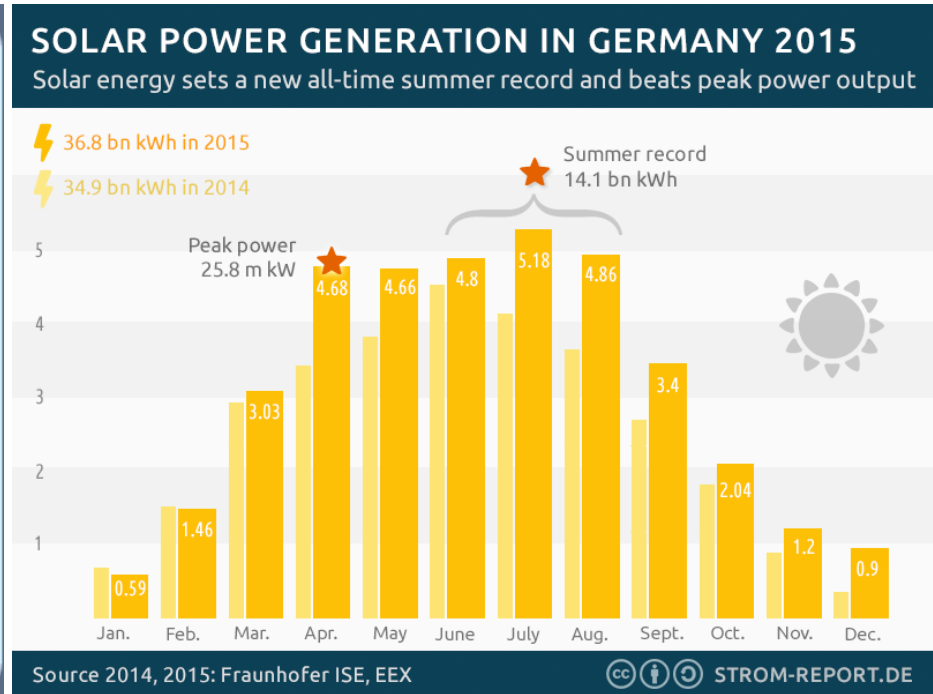
Source	Process	Efficiency Today
Natural gas Bio Gas	Steam reforming Auto-thermal reforming Solid Oxide Fuel Cell	70-75% >75% 80% (40-40)
Coal/Oil	Gasification	56%+ (=syngas)
Biomass	Gasification	44%+ (=syngas)
Electricity + Water	Electrolysis Alkaline and PEM	75-80% (90% exp.)
Sunlight + Water	Photoelectrochemical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



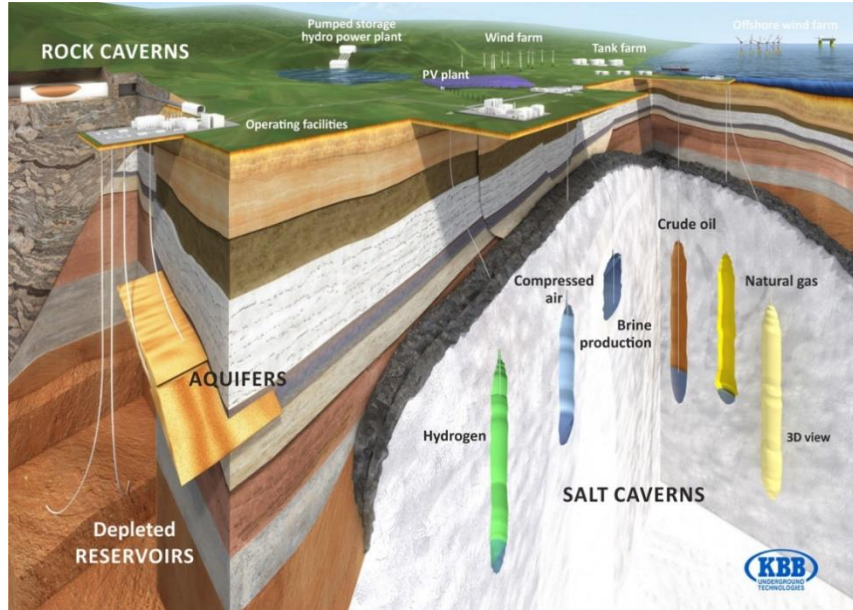
# Gas and electricity consumption in the Netherlands



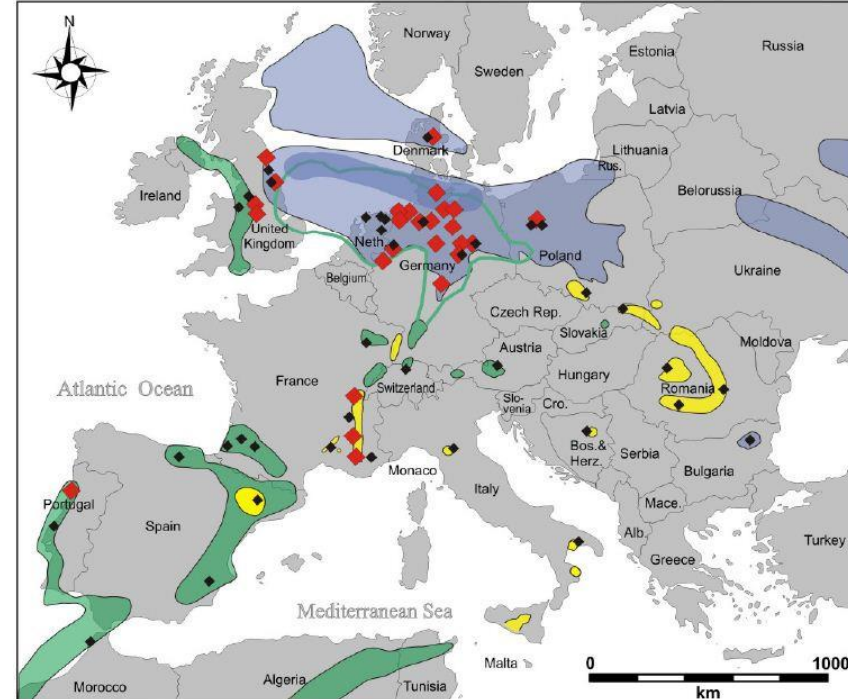
# Solar power production in Germany



# Hydrogen storage in Salt Caverns



# Salt formations and caverns in Europa



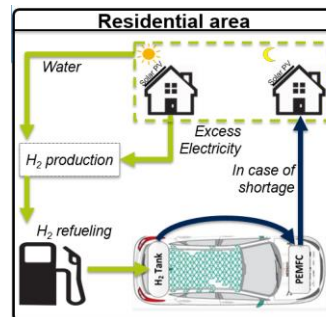
**1 salt cavern can contain 6,000 ton hydrogen  
Equivalent of 17 million Tesla Power walls**

# Green Hydrogen Markets

## Feedstock/Steam



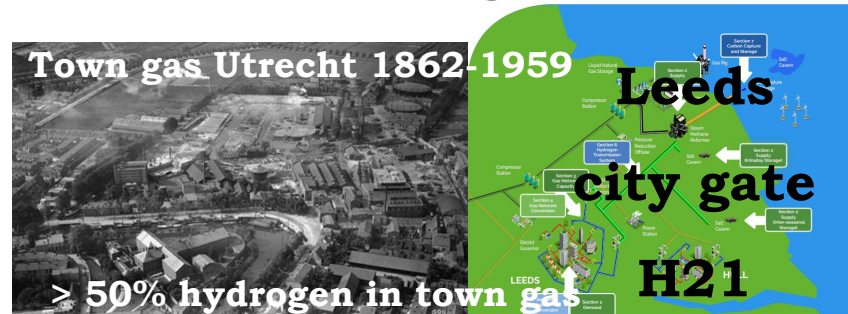
## Electricity Balancing



## Transport



## Heating





# The Future is Electric!



**Tesla Model S**

 **HYUNDAI**

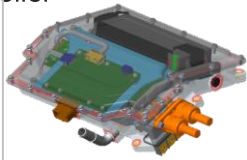
**NEXO**



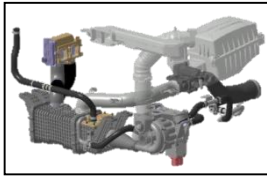
**Hyundai NEXO**

# Hyundai NEXO

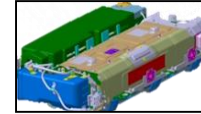
Controller



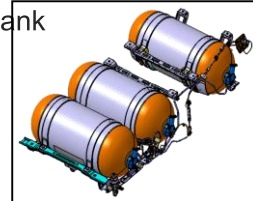
BOP



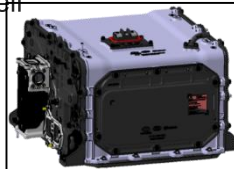
Battery System



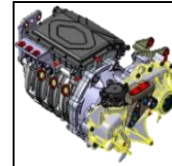
H2 Tank



Fuel Cell Stack

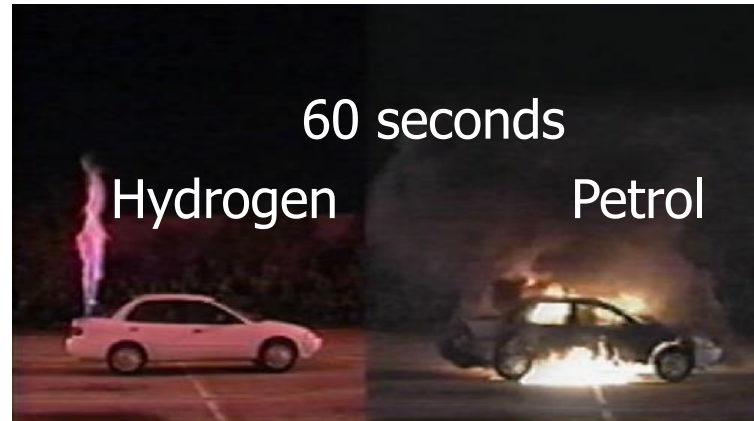
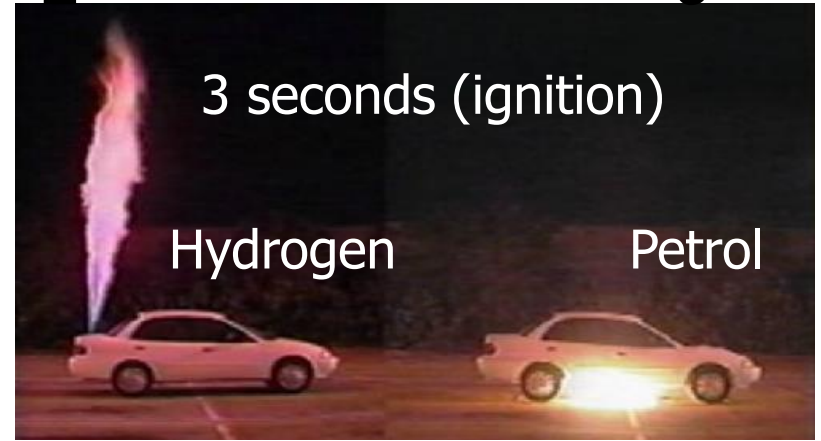
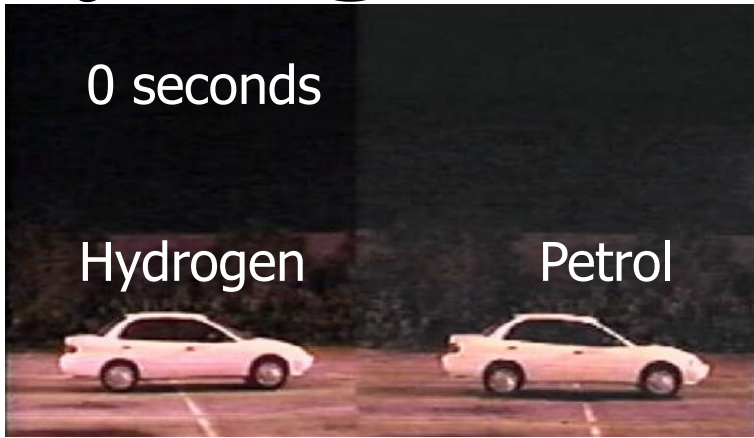


Motor

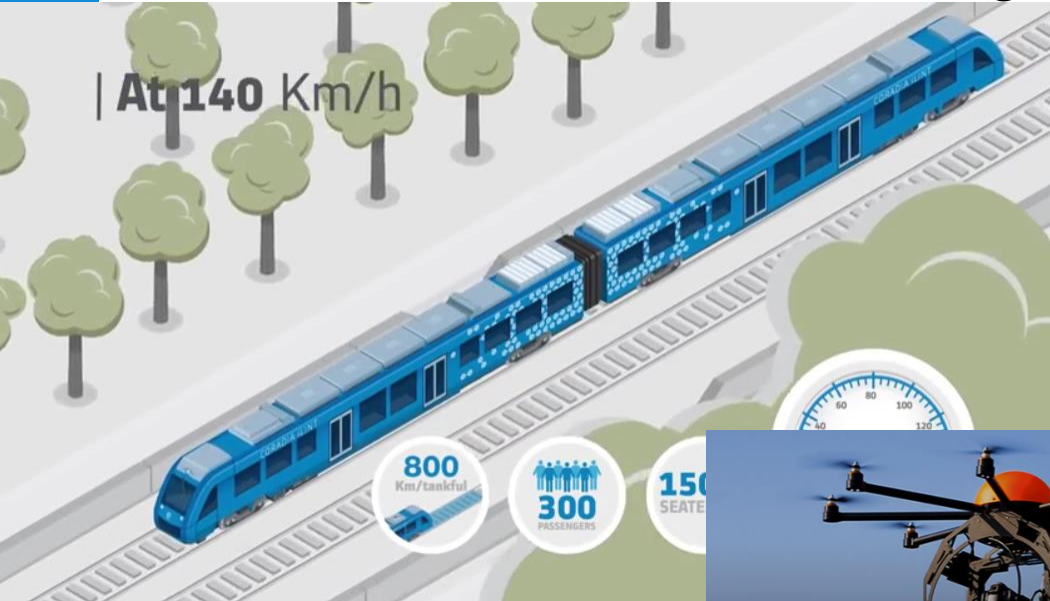




# Hydrogen versus petrol safety

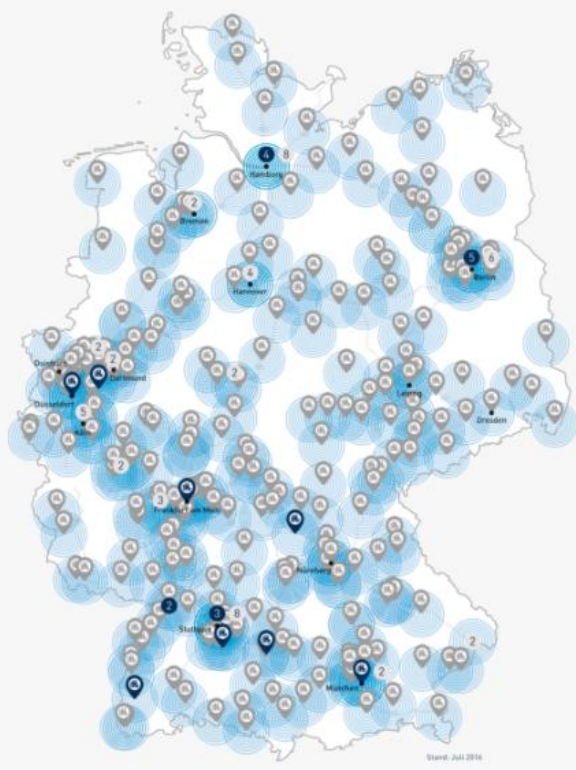


# Fuel Cell Hydrogen Train, Ferry, Drone





# Germany 400 hydrogen fueling stations in 2023

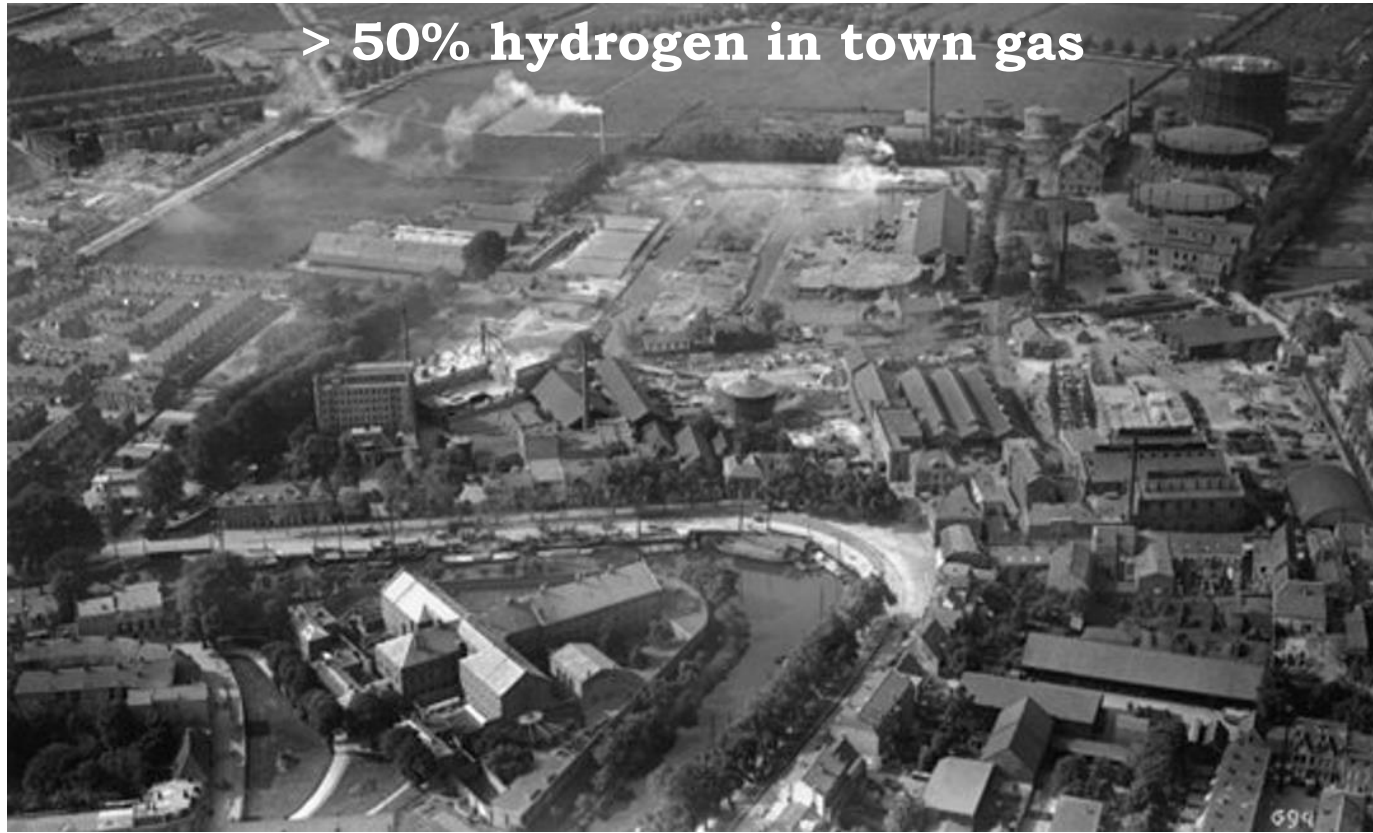


400 hydrogen fueling stations in 2023, at existing fueling stations.

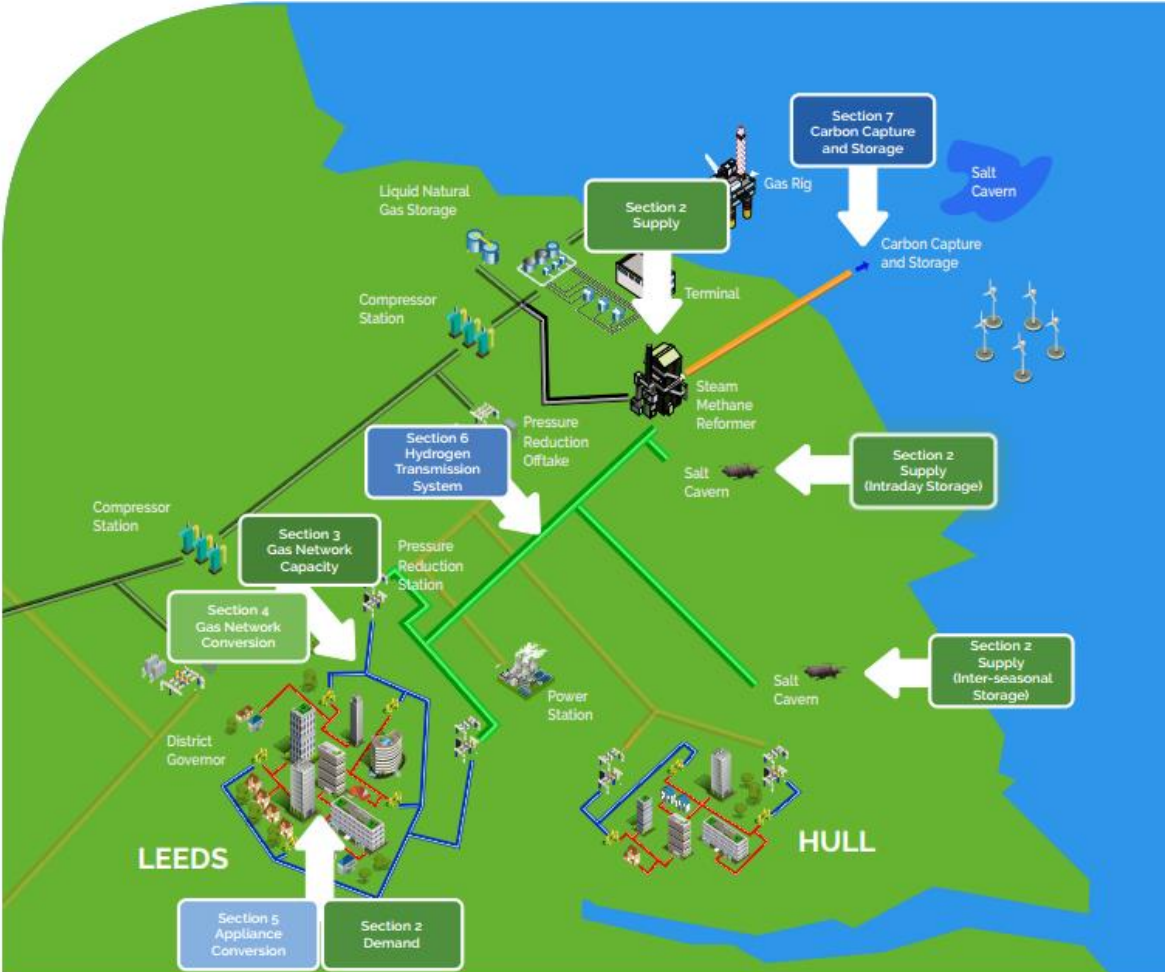
Investments: 350 million Euro, half government, half companies.

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

# Town Gas production Utrecht 1862-1959



# Leeds City Gate Project



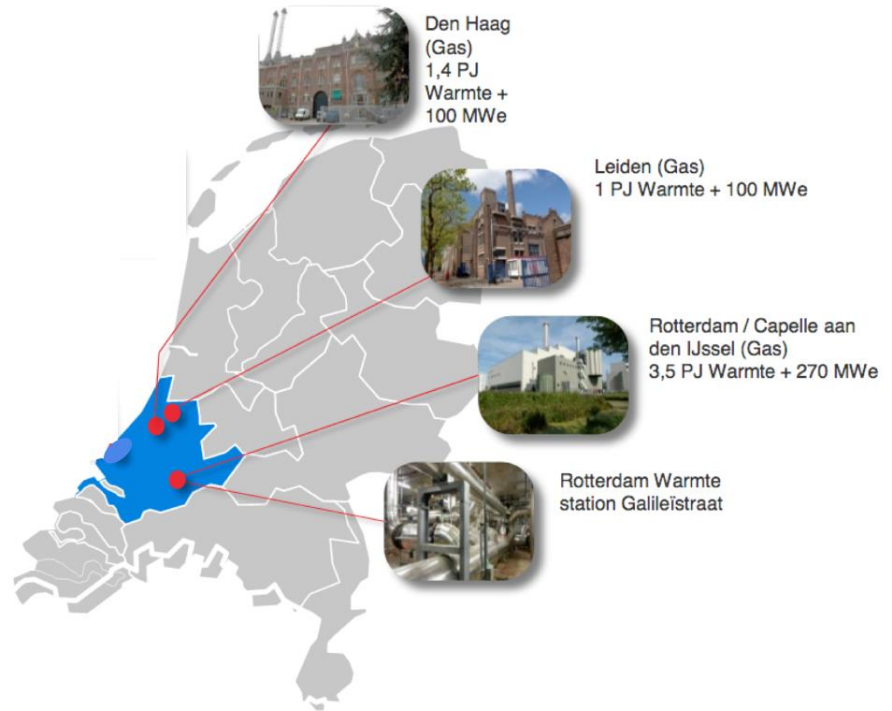
# Hybrid Heat Pump + Boiler

## Natural gas shifting to hydrogen





# 'Warmterotonde' with hydrogen to supply additional heat in winter





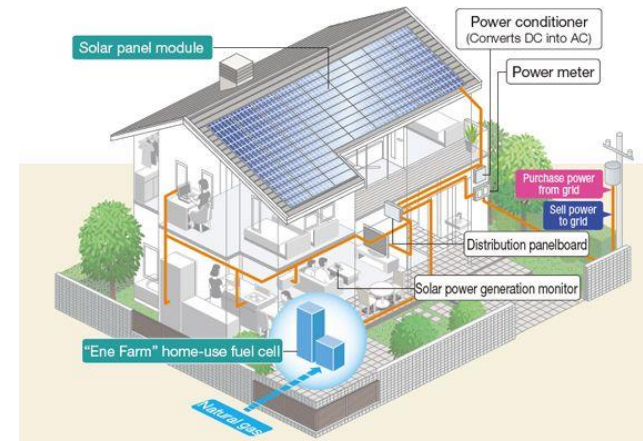
# Ene Farm: Home Fuel cell systems Japan

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

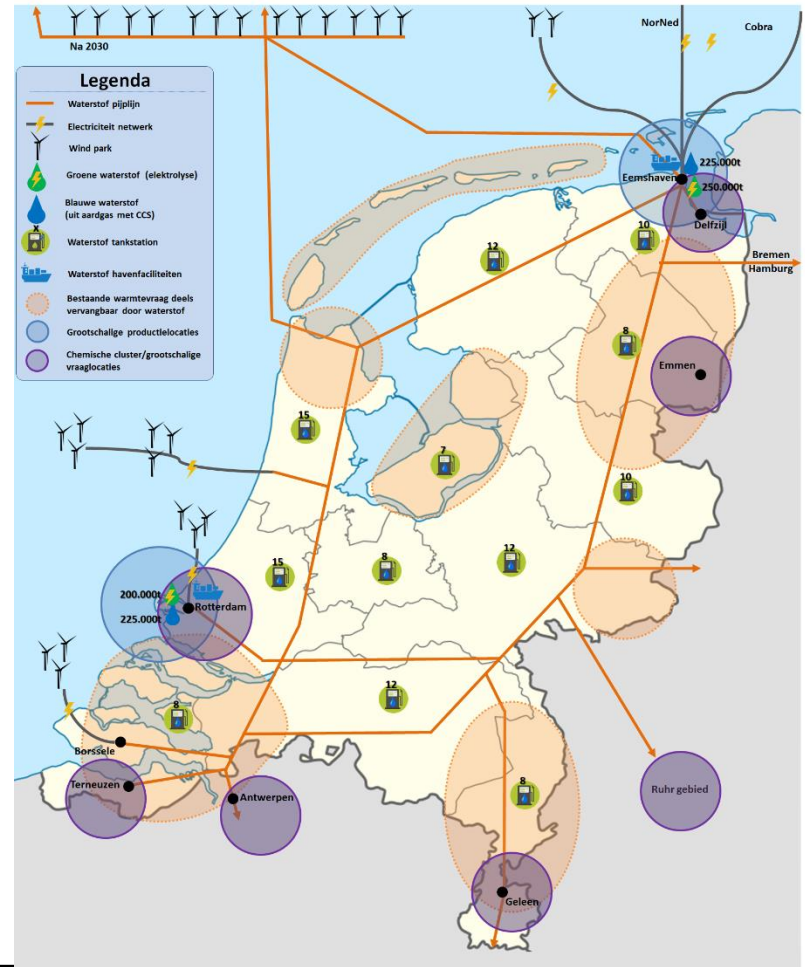


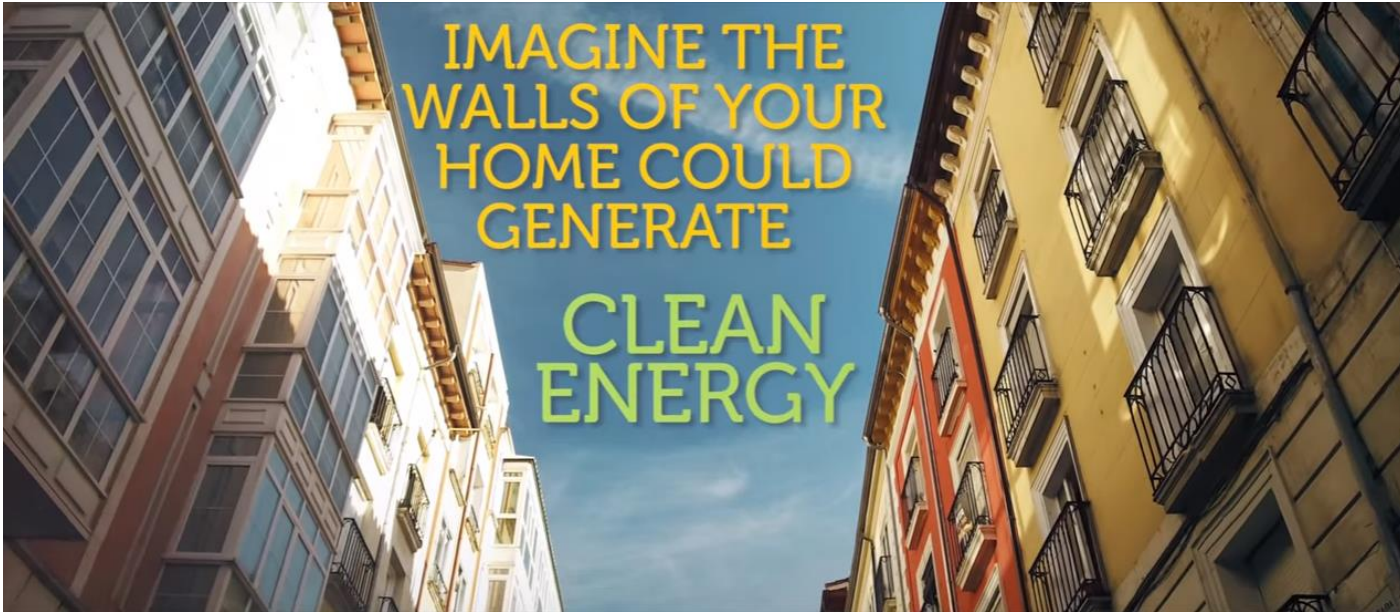
Hot water unit

Fuel cell



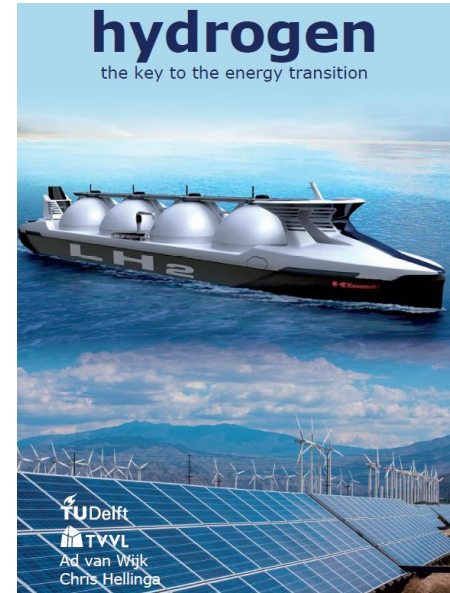
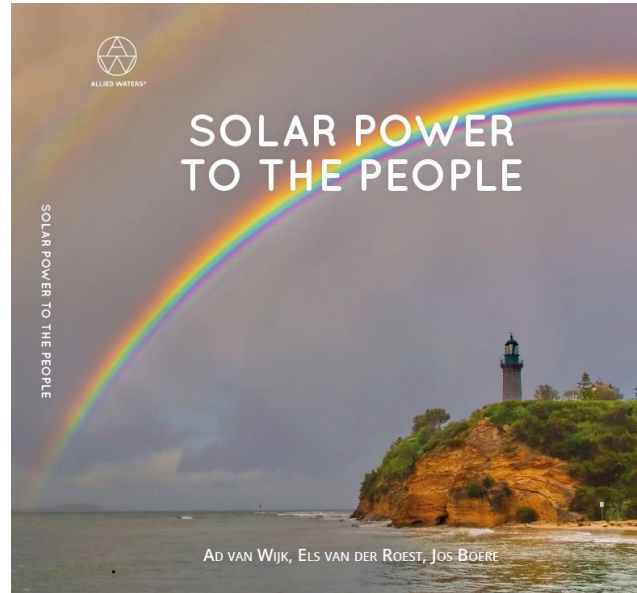
# Geografische ontwikkeling van waterstof productie, infra-structuur en vraag





# Verder Lezen over waterstof

[www.profadvanwijk.com](http://www.profadvanwijk.com)



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