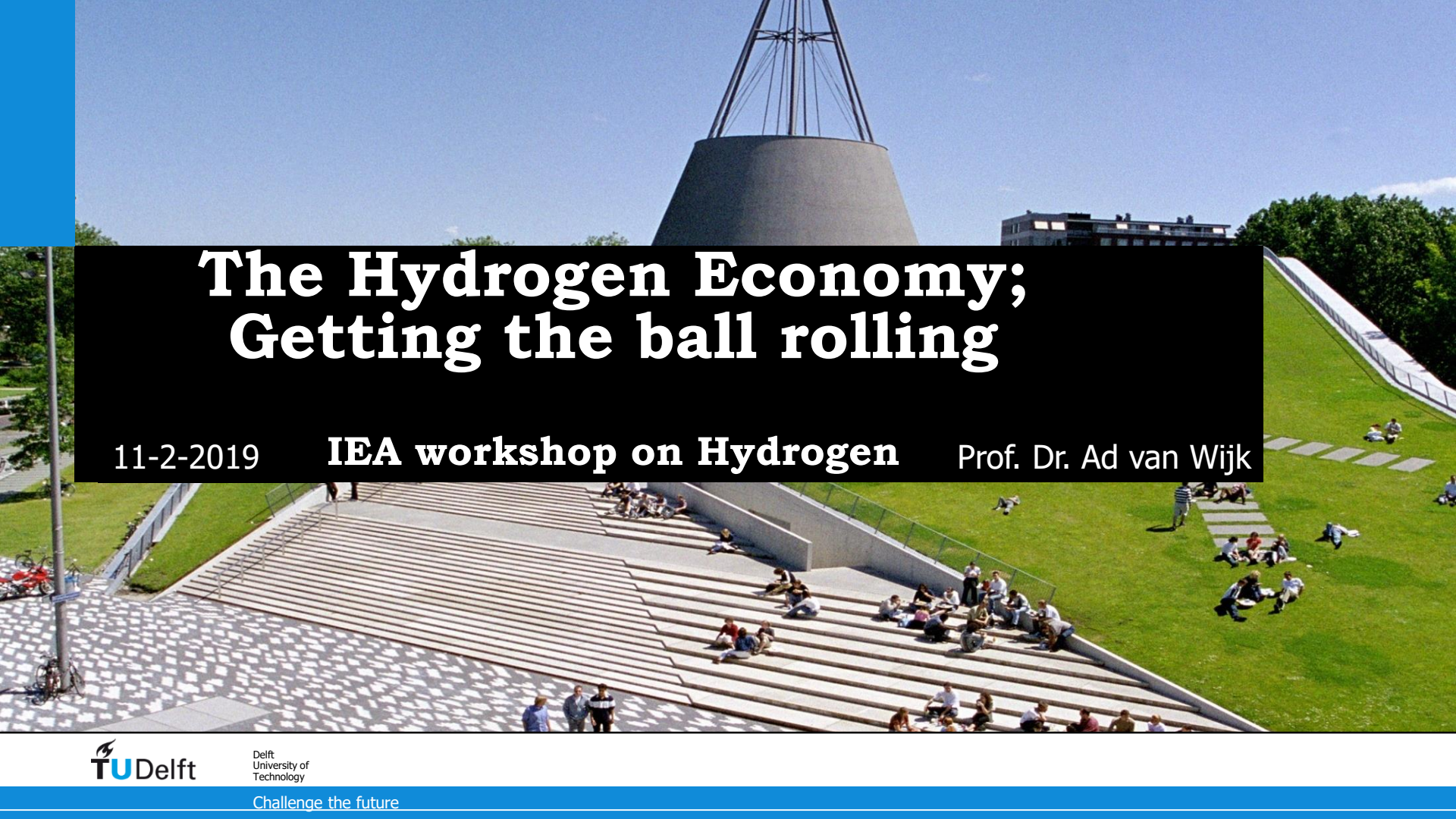


The background image shows a large, modern architectural structure with a tall, conical tower and a wide, tiered staircase. People are sitting on the steps and on the grassy area to the right. The sky is clear and blue.

# The Hydrogen Economy; Getting the ball rolling

11-2-2019

**IEA workshop on Hydrogen**

Prof. Dr. Ad van Wijk

# Hydrogen Integrated Action Program

## Production

- GW scale wind-solar hydrogen production
- Biomass gasification; green H<sub>2</sub> and green CO<sub>2</sub> (for feedstock) production
- Hydrogen production from coal, oil and gas at or close to the resource with direct CCS
- Import/Export Hydrogen by ship (liquid, ammonia, MCH) and by pipeline

## Infrastructure

- Public hydrogen gas pipeline infrastructure connecting production, storage and markets; new and converted natural gas infrastructure
- Hydrogen large scale storage facilities, salt caverns, empty gas fields (if possible)
- Hydrogen Harbor facilities; LH<sub>2</sub>, ammonia, MCH terminals and storage tanks
- Hydrogen Fueling infrastructure, road, water, air

## Hydrogen Implementation

## Markets

- Feedstock existing (petro)chemical industry
- Feedstock new; synthetic fuels, synthetic chemicals, reduction process in metal industry, circular material processing.
- High temperature heat industry
- Mobility; road, water, air
- Electricity Balancing
- Heating/cooling houses and buildings

## Policy and Regulations

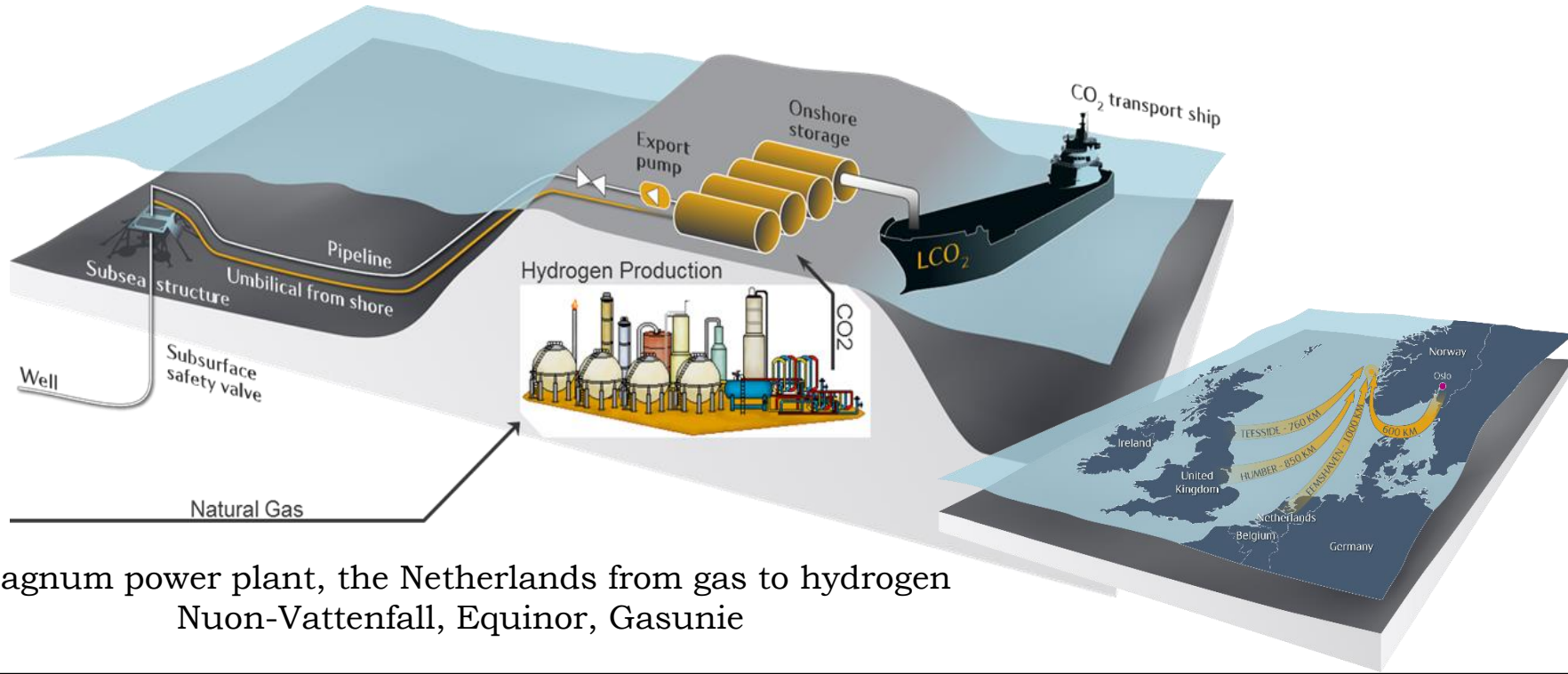
- Market design and regulations
- Implementation in existing energy and climate policy
- Standards; quality, physical, certificates, etc.
- Safety regulations
- Human resource agenda

# Tender Wind/Solar Hydrogen Production

because 70-80% of hydrogen cost is electricity cost

|                   | Investment cost   | Efficiency | Electricity Price Offshore Wind  | Hydrogen Price                 |
|-------------------|-------------------|------------|----------------------------------|--------------------------------|
| <b>Till 2020</b>  | 600-1.000 Euro/kW | 70-75%     | 40-50 Euro/MWh                   | 3.5-5 Euro/kg                  |
| <b>2020-2025</b>  | 400-600 Euro/kW   | 75-80%     | 30-40 Euro/MWh                   | 2-3 Euro/kg                    |
| <b>2025-2030</b>  | 300-500 Euro/kW   | 80-85%     | 25-35 Euro/MWh                   | 1.5-2.5 Euro/kg                |
| <b>After 2030</b> | <300 Euro/kW      | >85%       | 20-30 Euro/MWh<br>10-20 Euro/MWh | 1-1.5 Euro/kg<br>0.5-1 Euro/kg |

# Tender Hydrogen Production from Coal/Gas combined with CCS (Carbon Capture and Storage)

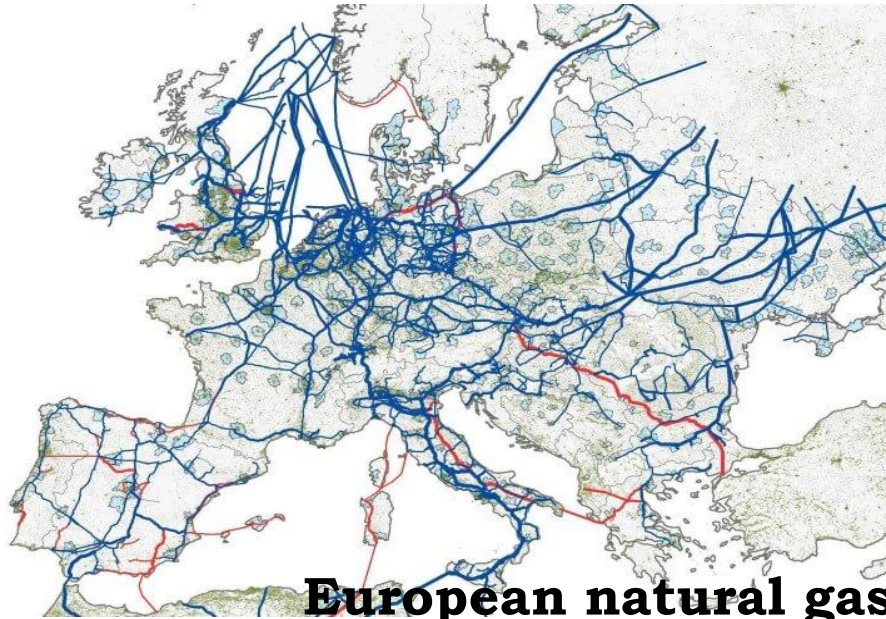


Magnum power plant, the Netherlands from gas to hydrogen  
Nuon-Vattenfall, Equinor, Gasunie

**Realize public hydrogen infrastructure via new and converted natural gas pipelines**

**Socialize hydrogen and natural gas infrastructure cost over  
combined hydrogen and natural gas volume**

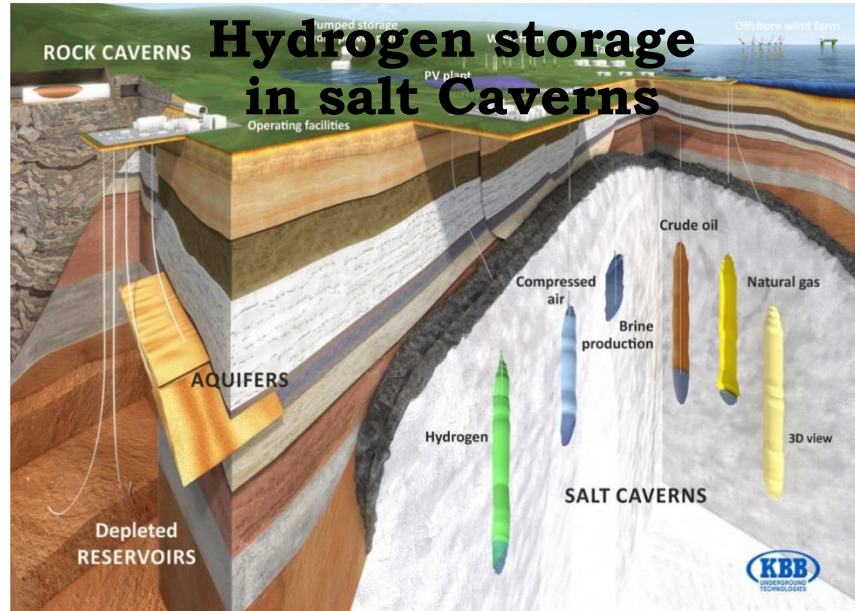
**Obligation to connect all hydrogen production and demand locations**



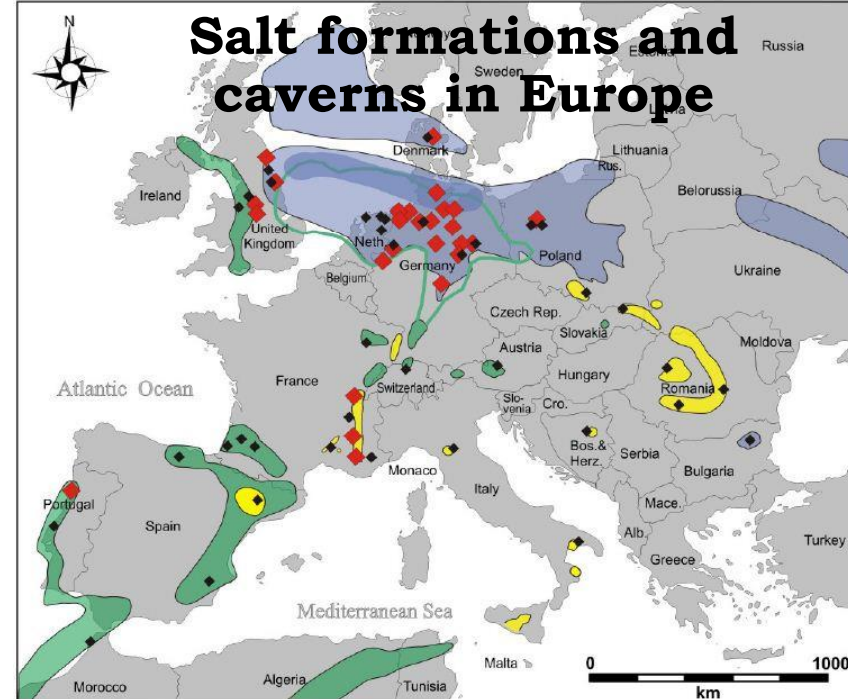
**European natural gas infrastructure**



# Integrate hydrogen storage in public hydrogen infrastructure; financial, organisational and legal



**1 salt cavern can contain 6,000 ton hydrogen  
Equivalent of 17 million home batteries (14 kWh)**



**Red colored caverns in use for natural gas storage**