gasunie
crossing borders in energy

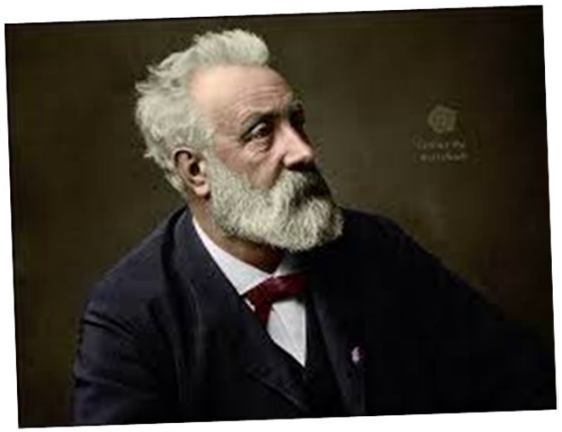
Brussels, 27 June 2019

Presentation Hydrogen backbone in the Netherlands

HIPS-NET workshop 2019

Adriaan de Bakker

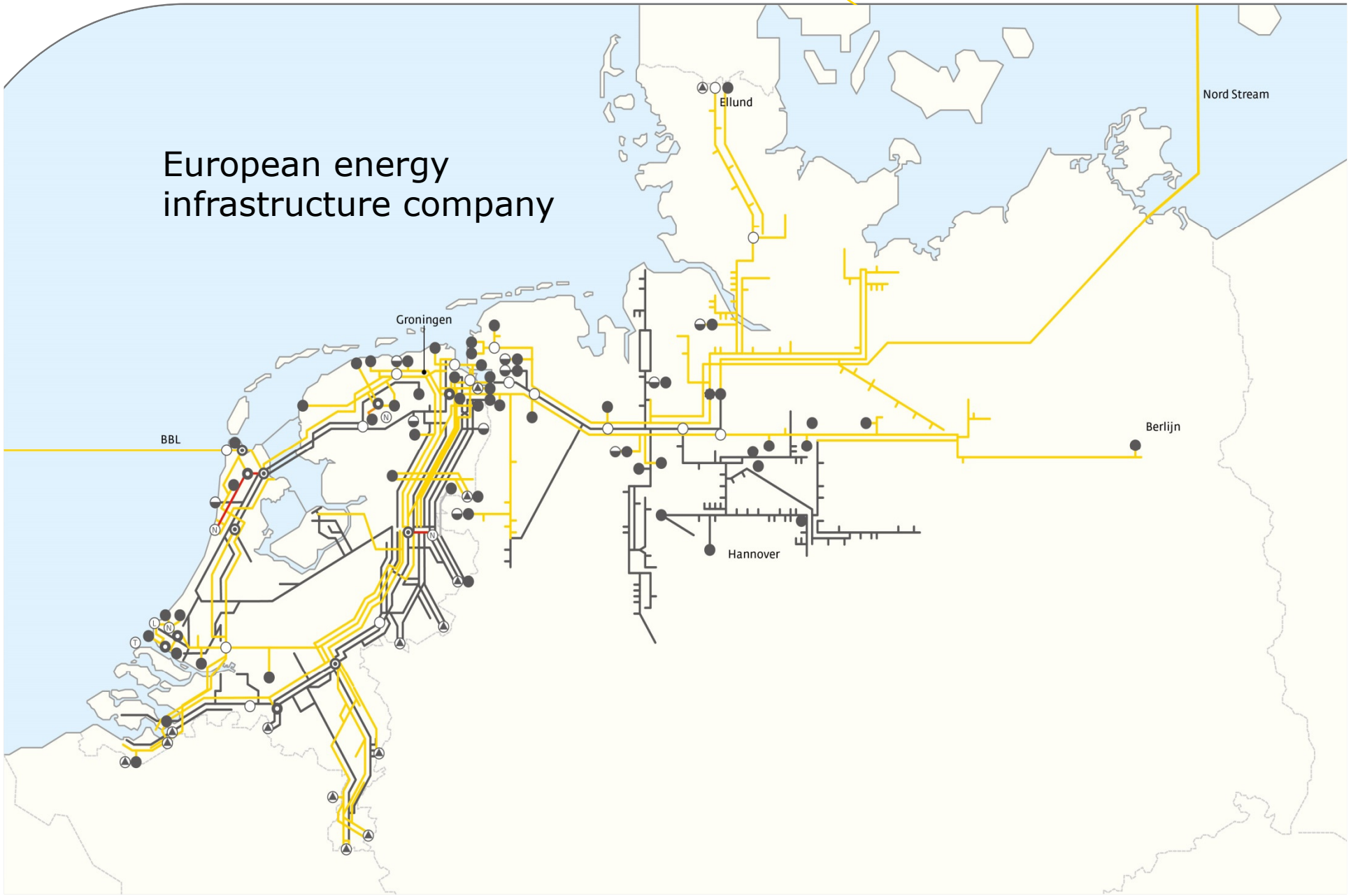
Someday…



”Yes, my friends, I believe that water will one day be employed as fuel, that hydrogen and oxygen which constitute it, used singly or together, will furnish an inexhaustible source of heat and light, of an intensity of which coal is not capable.”

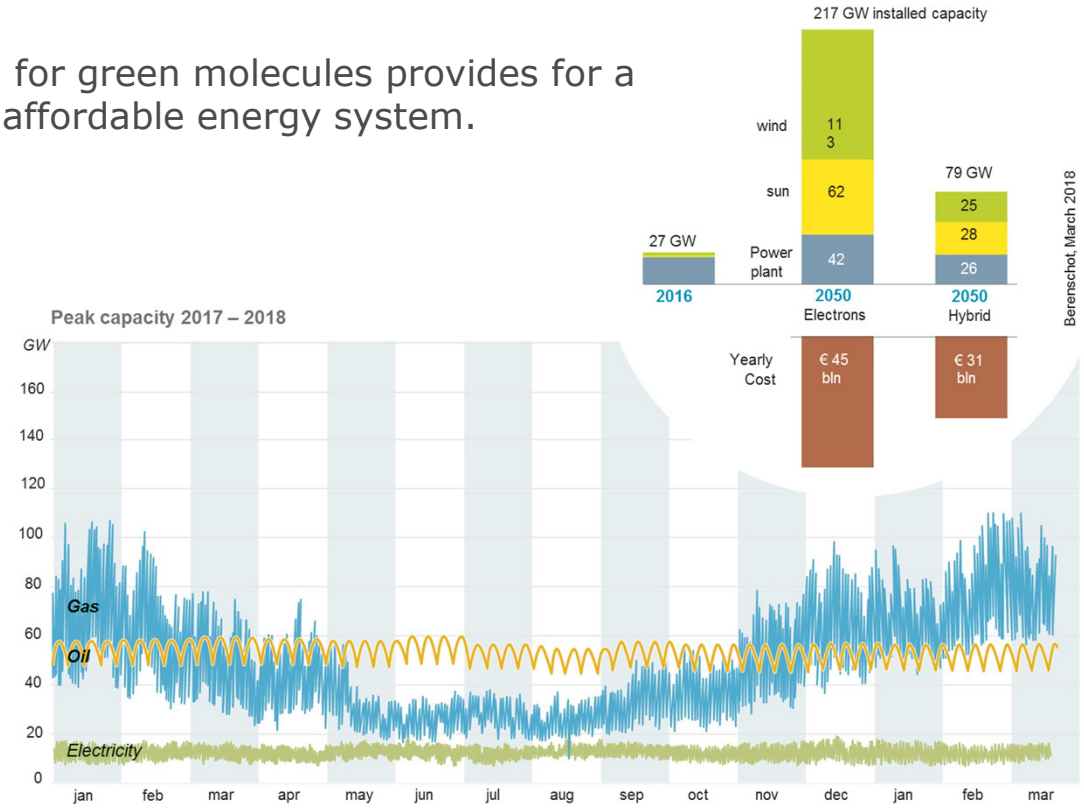
Jules Verne, The Mysterious Island, 1874

European energy infrastructure company



We foresee that gas infrastructure will play a key role in a decarbonised energy system with increased electrification

A smart role for green molecules provides for a reliable and affordable energy system.



Gas can be stored more efficiently than electricity

Cavern

Gas can be stored more efficiently than electricity

Volume
- 1 cavern with 1 mln m^3 of hydrogen equals 240,000 MWh (= 6,100 tons H_2)

Equivalents
- 24 mln. power walls (10 KWh, Tesla)
- 2400 of the largest batteries in the world (100 MWh, Tesla)

Experience
- H_2 storage in caverns is an existing technology
- Many years of experience in the UK and US

Costs
- Storing hydrogen is factor 1000 cheaper versus electricity in power wall

Battery

Transport of gas is much cheaper and more efficient than transport of electricity

Power

BritNed

- 260 km
- € 600 mio
- 1 GW capacity
- € 230/kW/100 km

Gas

bbl company

- 230 km
- € 500 mio
- 20 GW capacity
- € 11/kW/100 km

Nord Stream

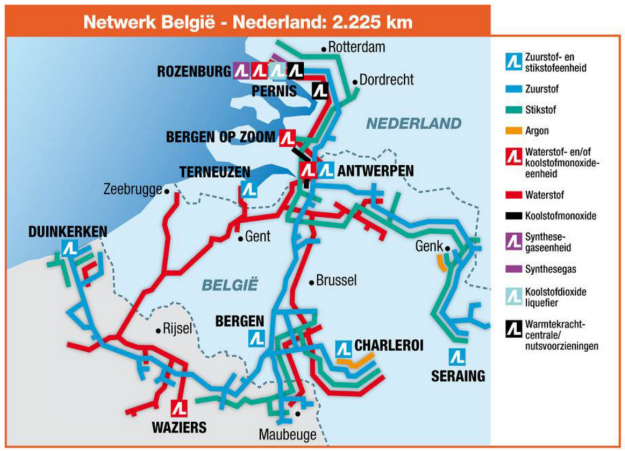
- € 9/kW/100 km

Hydrogen grids

1. Air Liquide network in Belgium and France
   - Length: ~1000 km
   - Operating pressure: ~100 bar
   - Diameter: ~25-30 cm
2. Air Products pipeline in Rotterdam
   - Length: ~140 km
3. Air Liquide pipeline in Rhine-Ruhr
   - Length: ~240 km

Hydrogen Pipelines	
Company	**km**
Air Liquide	1936
Air Products	1140
Linde	244
Praxair	739
Others	483
World Total	**4542**
U.S.	2608
Europe	1598
Rest of World	337
World total	**4542**

Figuur 4 - Bestaande Noordwest Europese leidingnet van Air Liquide



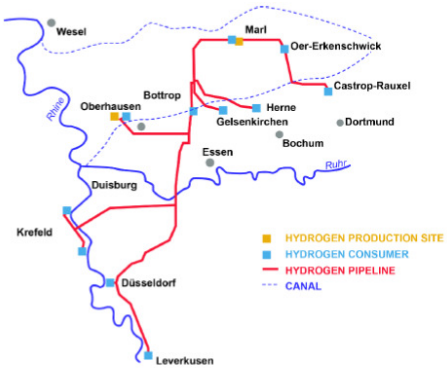


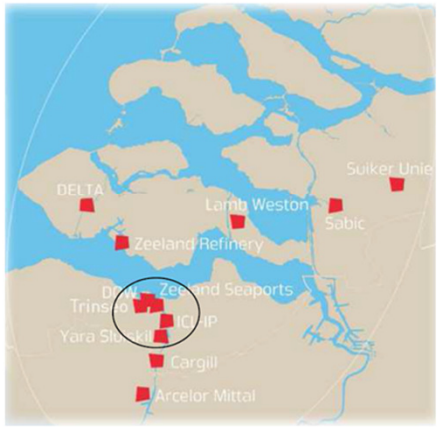
Fig. 4.6: Hydrogen pipeline in the Rhine-Ruhr area [CEW09]

Refit from natural gas to hydrogen pipeline

Project Symbiose

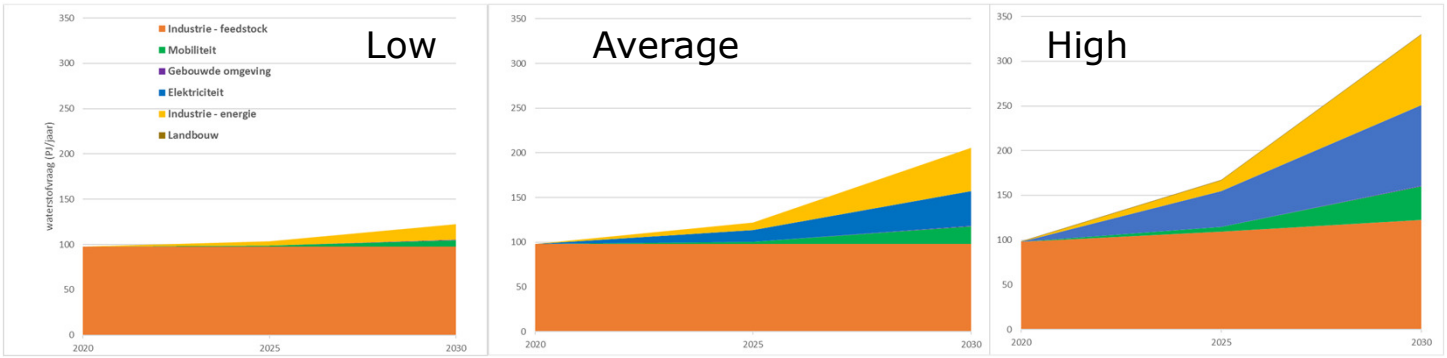
- Refitting an existing natural gas pipeline to hydrogen transport
- DOW has excess hydrogen and YARA uses hydrogen for fertilizer production

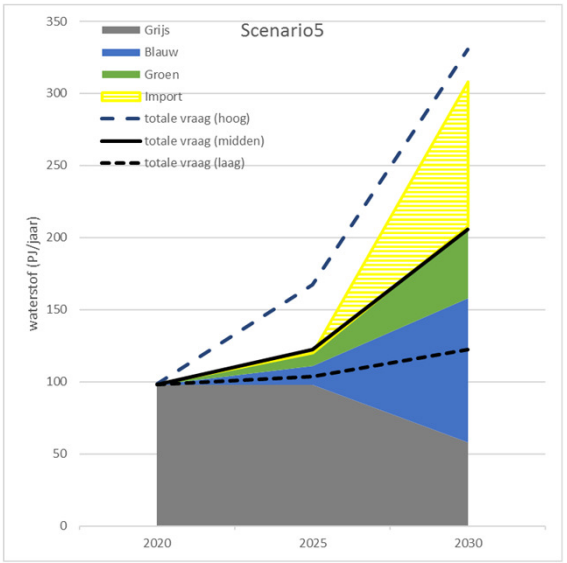
Zeeland Region



- Existing 16”, 66 bar, 12 km natural gas pipeline
- Operational as hydrogen pipeline end of 2018
- Saves 20-40 kton CO2 emissions per year

Hydrogen supply and demand scenarios





Dutch Climate Agreement Working Group on Hydrogen

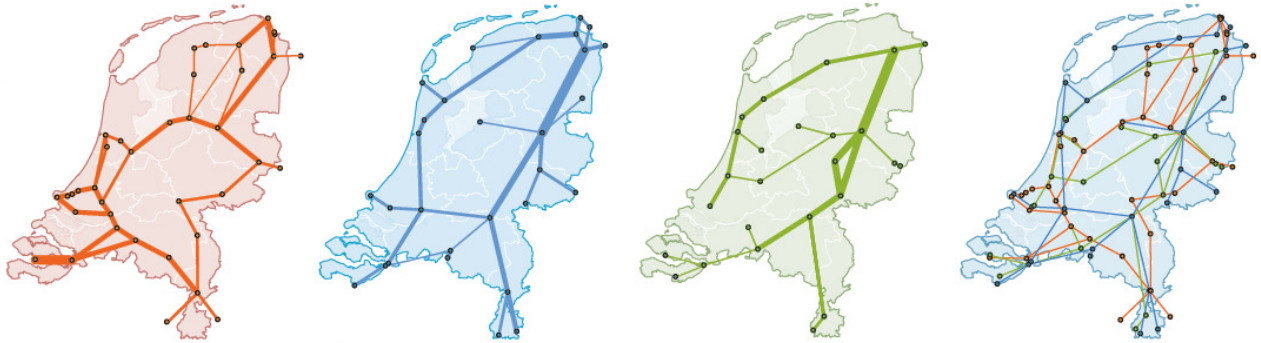
Proposed dedicated Hydrogen Network in the Netherlands

- Connects large industrial centers in the Netherlands, supply, storage, other countries
- Can be operational in 2030, also in smaller steps
- Capacity 5 – 29 GW
- 1,5 billion € (including storage)

Infrastructure Outlook 2050

- Joint study Gasunie and TenneT
- Netherlands and Germany

Electricity network + hydrogen network + methane network = combined network

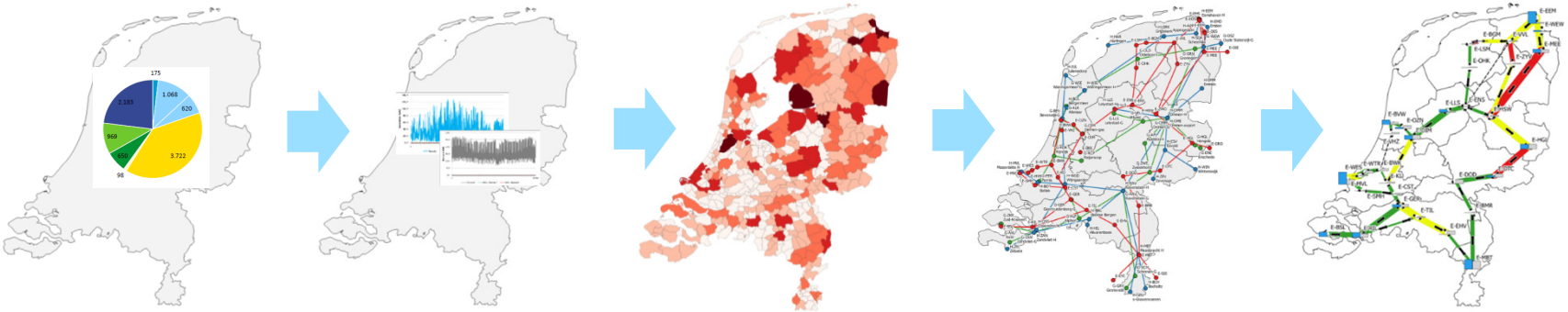


Capacity 20 GW

Capacity (H2+CH4) 350 GW

Connection points:
1. Power plants (methane or hydrogen)
2. Electrolysis

Method



Scenarios "Net voor de Toekomst"

CE Delft

Generate hourly data

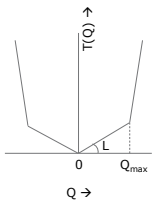
ETM van Quintel

ENERGY TRANSITION MODEL
Independent, Comprehensive and Fact-based

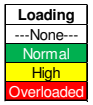
Calculate demand per area and per market

Calculate energy transport using integrated model

TenneT-GTS



Visualise energy flows and bottlenecks

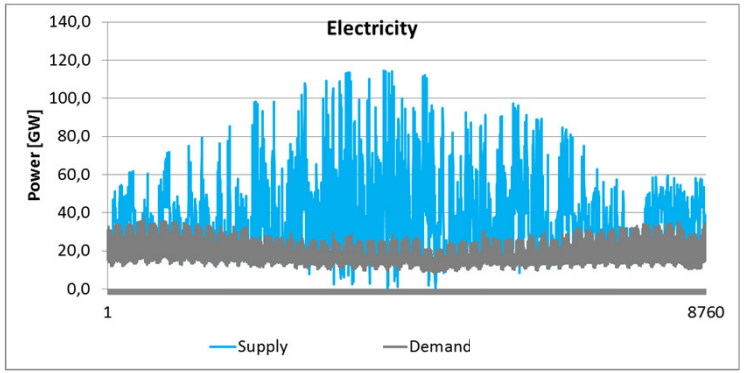


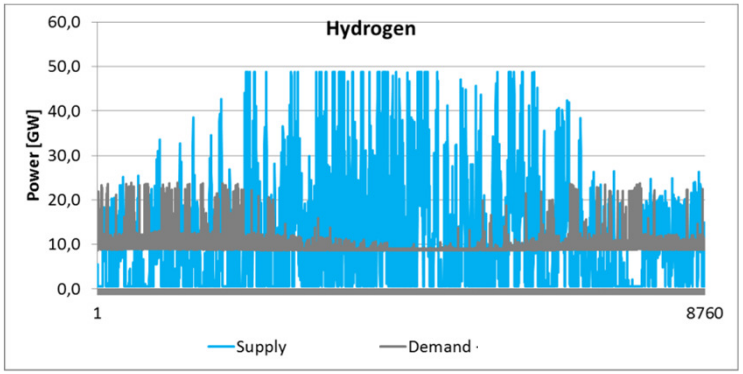
IO2050 - scenarios

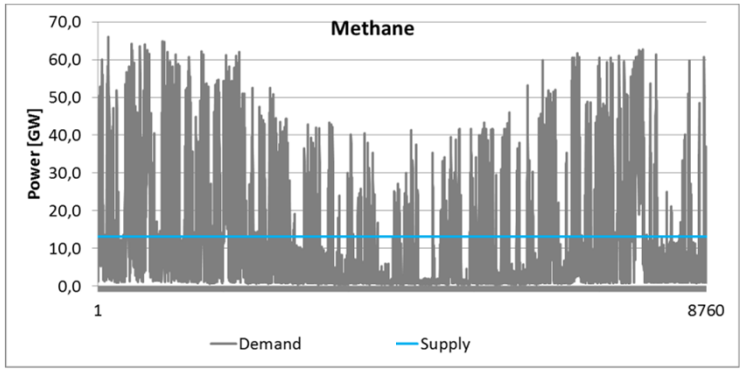
	Local	National	International
Power & Light	25% base-load savings through more efficient appliances. Substantial electrification of industry	25% base-load savings through more efficient appliances. Substantial electrification of industry	25% savings through more efficient appliances
Low-temperature heat	High penetration of heat grids and all-electric (restrictions on green gas, no H_2 distribution) Savings: 23%	High penetration of hybrid heat pumps burning H_2 (and green gas) (restrictions on green gas) Savings: 23%	High penetration of hybrid heat pumps burning H_2 and green gas (mild restrictions on green gas). Savings: 12%
High-temperature & feedstock industry	Circular industry and ambitious process innovation: 60% savings 55% electrification 97% lower CO_2 emissions	Circular industry and ambitious process innovation: 60% savings 55% electrification 97% lower CO_2 emissions	Biomass-based industry: 55% savings 35% biomass 14% electrification 95% lower CO_2 emissions
Passenger transport	100% electric	75% electric 25% hydrogen	50% electric 25% green gas 25% hydrogen
Freight transport	50% green gas 50% hydrogen	50% green gas 50% hydrogen	25% synthetic fuels 25% green gas 50% hydrogen
Renewables generation	84 GW solar 16 GW onshore wind 26 GW offshore wind	34 GW solar 14 GW onshore wind 53 GW offshore wind	16 GW solar 5 GW onshore wind 6 GW offshore wind
Conversion and storage	75 GW electrolysis 60 GW battery storage	60 GW electrolysis 50 GW battery storage	2 GW electrolysis 5 GW battery storage
Hydrogen	100 TWh domestic generation	158 TWh domestic generation	73 TWh import 4 TWh domestic generation
Methane	23 TWh domestic biomethane 35 TWh imported natural gas	46 TWh domestic biomethane 55 TWh imported natural gas	24 TWh domestic biomethane 72 TWh imported natural gas
Biomass			28 TWh import

Table 2: Main characteristics of the Dutch scenarios

Time series



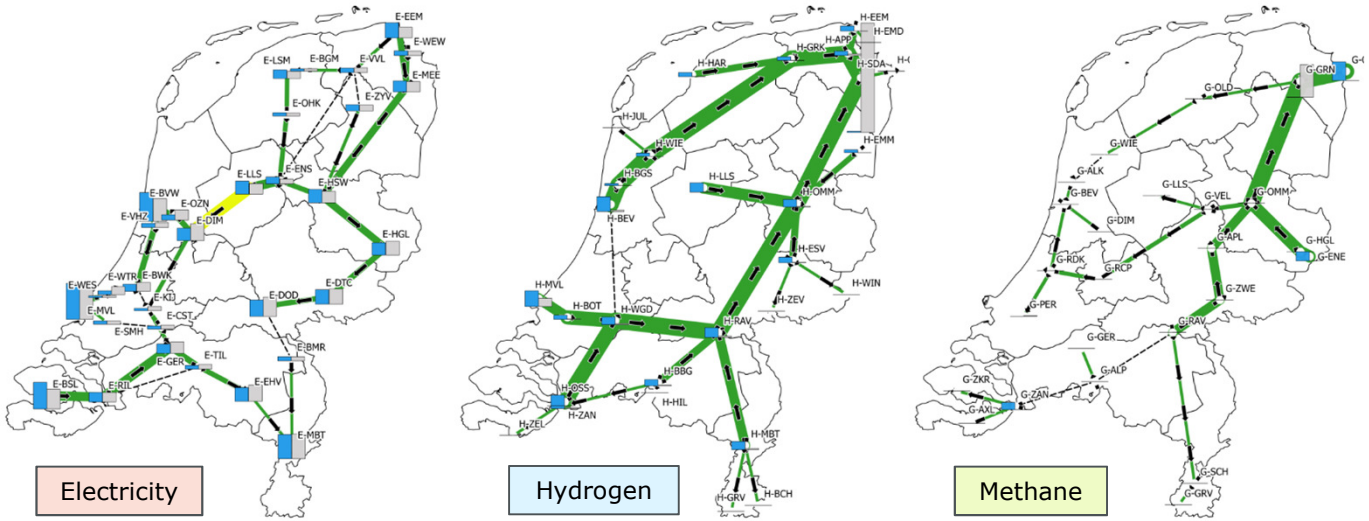




- Peak supply electricity much higher then peak demand: use batteries and electrolysis
- Peak supply hydrogen 50 GW electrolysis
- Flat supply methane: green gas production and import; fluctuating heat demand methane

Example snapshot 1

- Sunny summer day, high wind, low energy demand



Local scenario

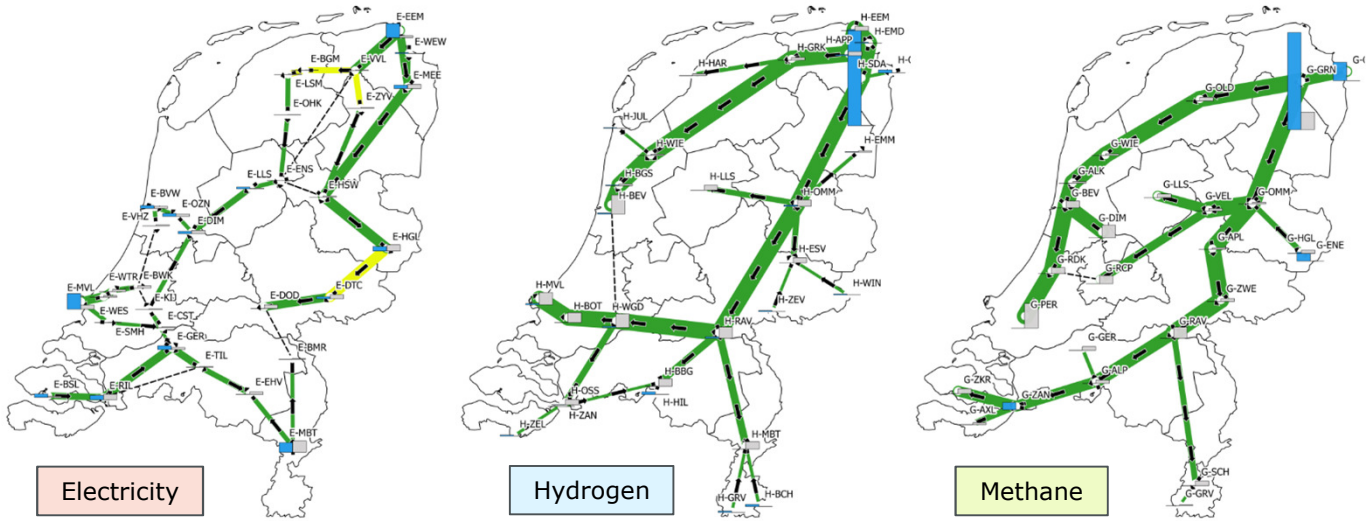
June 2050, 12:00 afternoon
Elektrolyses near location of sun and wind

Supply
Demand

Loading
---None---
Normal
High
Overloaded

Example snapshot 2

- Cold winter evening



International scenario

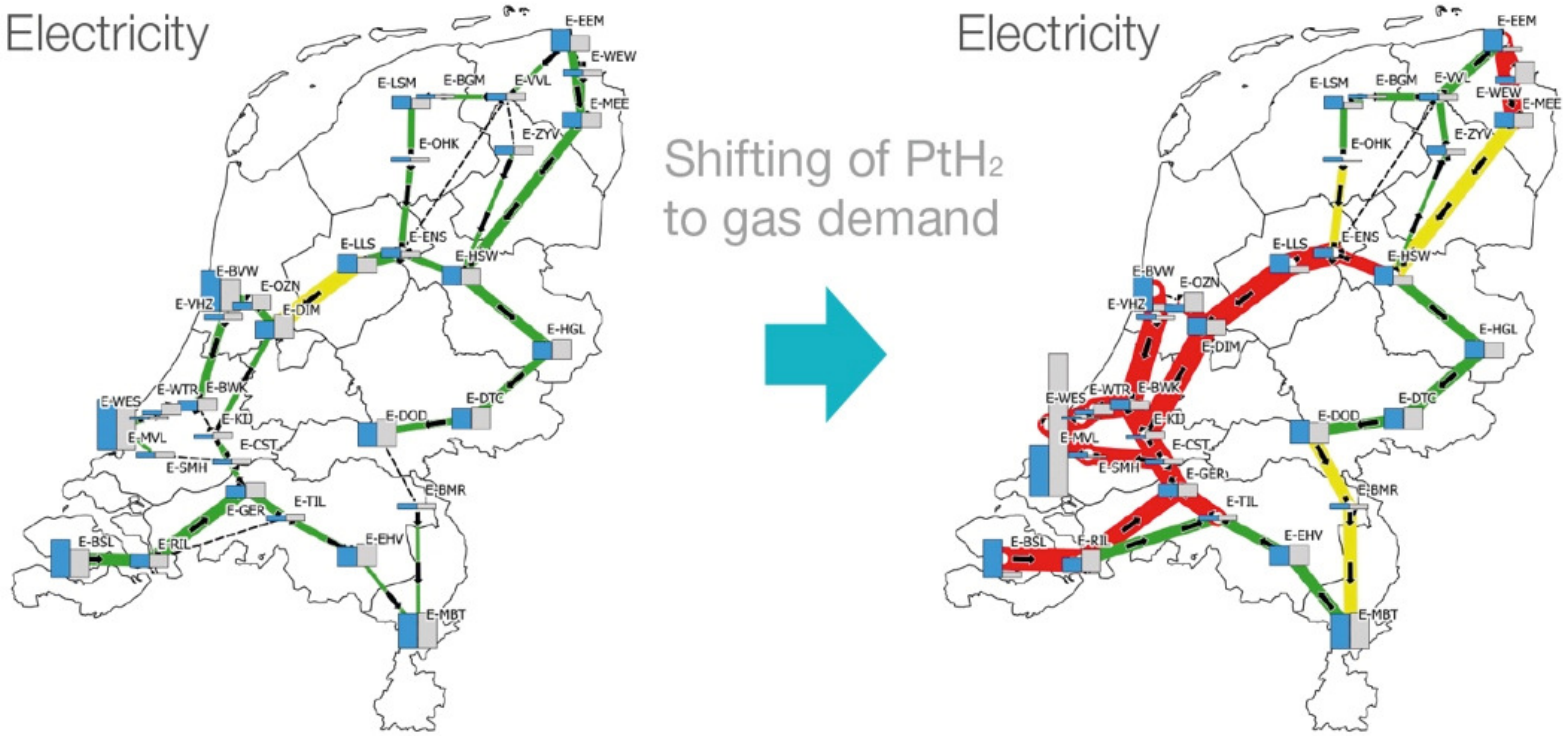
February 2050, evening
maximal production storages

Supply
Demand

Loading
---None---
Normal
High
Overloaded

Example comparison

- Sunny summer day, high wind, low energy demand

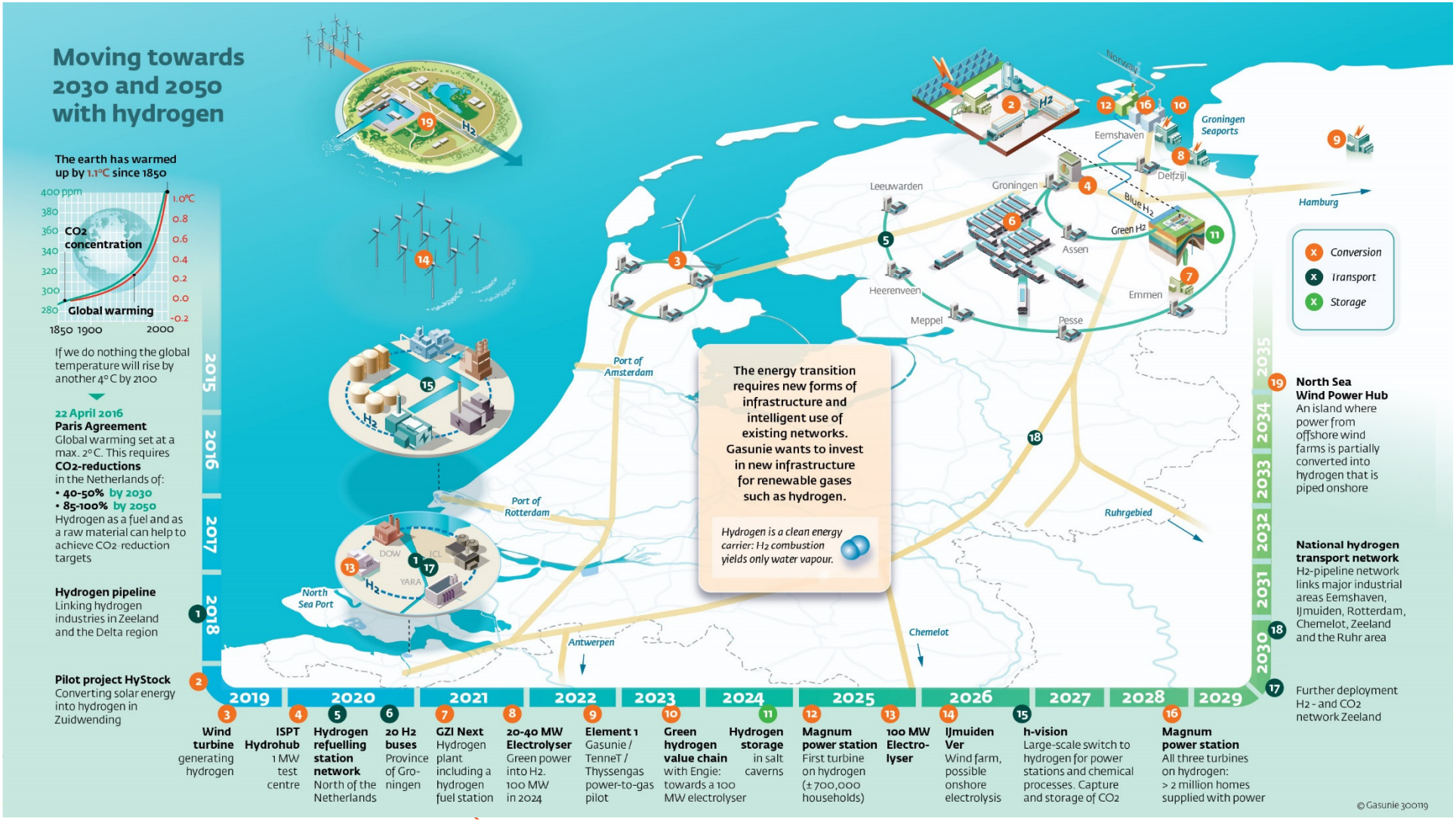


Some conclusions

- Energy networks need further integration. The existing gas network can be split into a hydrogen and methane network, with enough capacity in 2050
- Also after 2030 electricity networks will need to grow to accommodate the growing demand for electricity
- Total seasonal storage needs: ~35 TWh. Of this, 15 TWh of hydrogen is needed (for which North Netherlands has enough potential for caverns)
- Important to place and size electrolysis in close discussion with both electricity and gas TSO's. Location close to renewable electricity production helps integrating large amounts of wind/solar energy

➢ Gasunie, TenneT, and regional network operators, will in 2021 report on an integral infrastructure study 2030-2050 (legal requirement)

Gasunie (joint) hydrogen projects



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