VOLTA CHEM

Electrification of the Chemical Industry

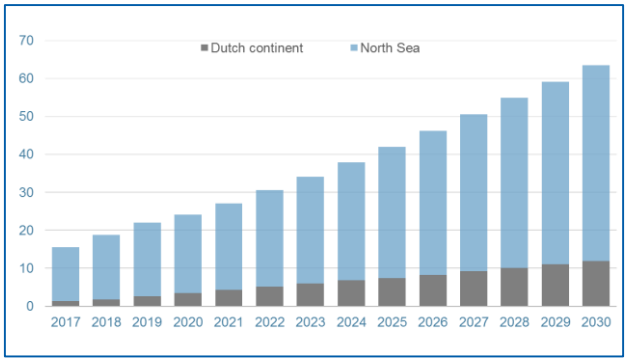
Electrification of the Industry

Yvonne van Delft

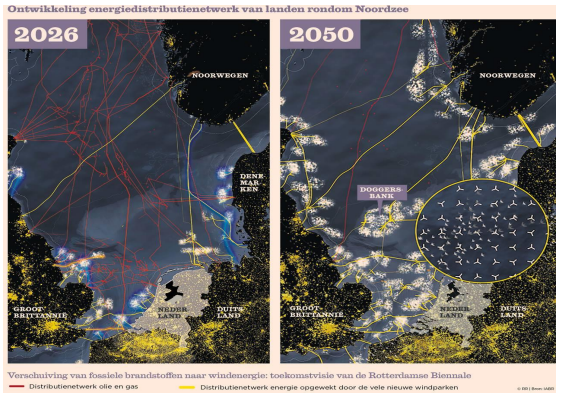
Brussels, 13 September 2018

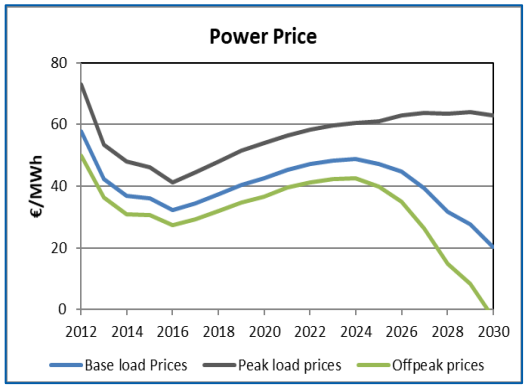
Powered by: TNO innovation for life ECN

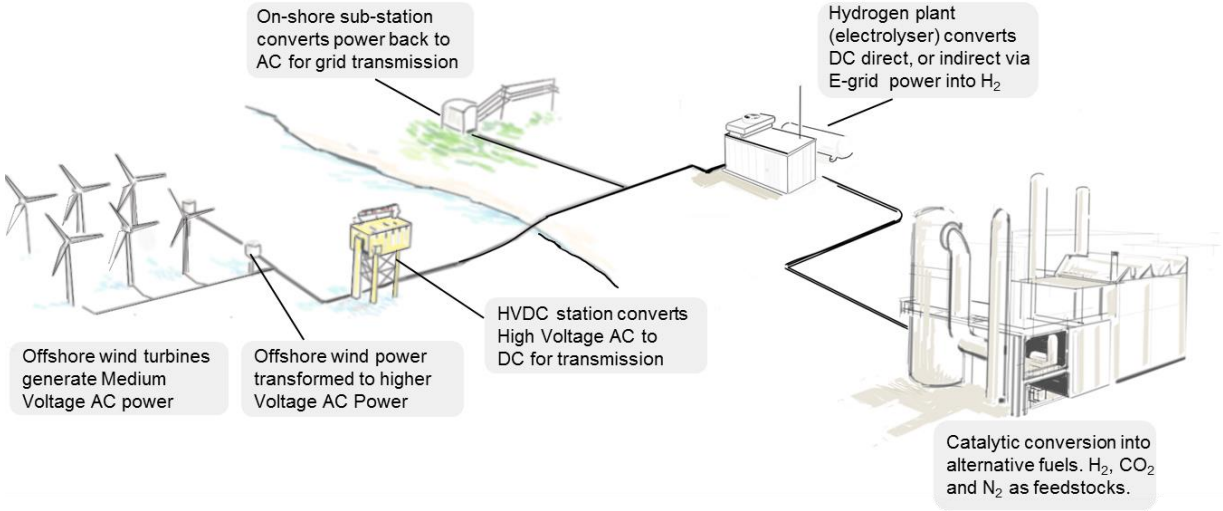
Renewables will create opportunities…



0.9 GW (2016) → 4.5 GW (2023) → 250? GW (2050)







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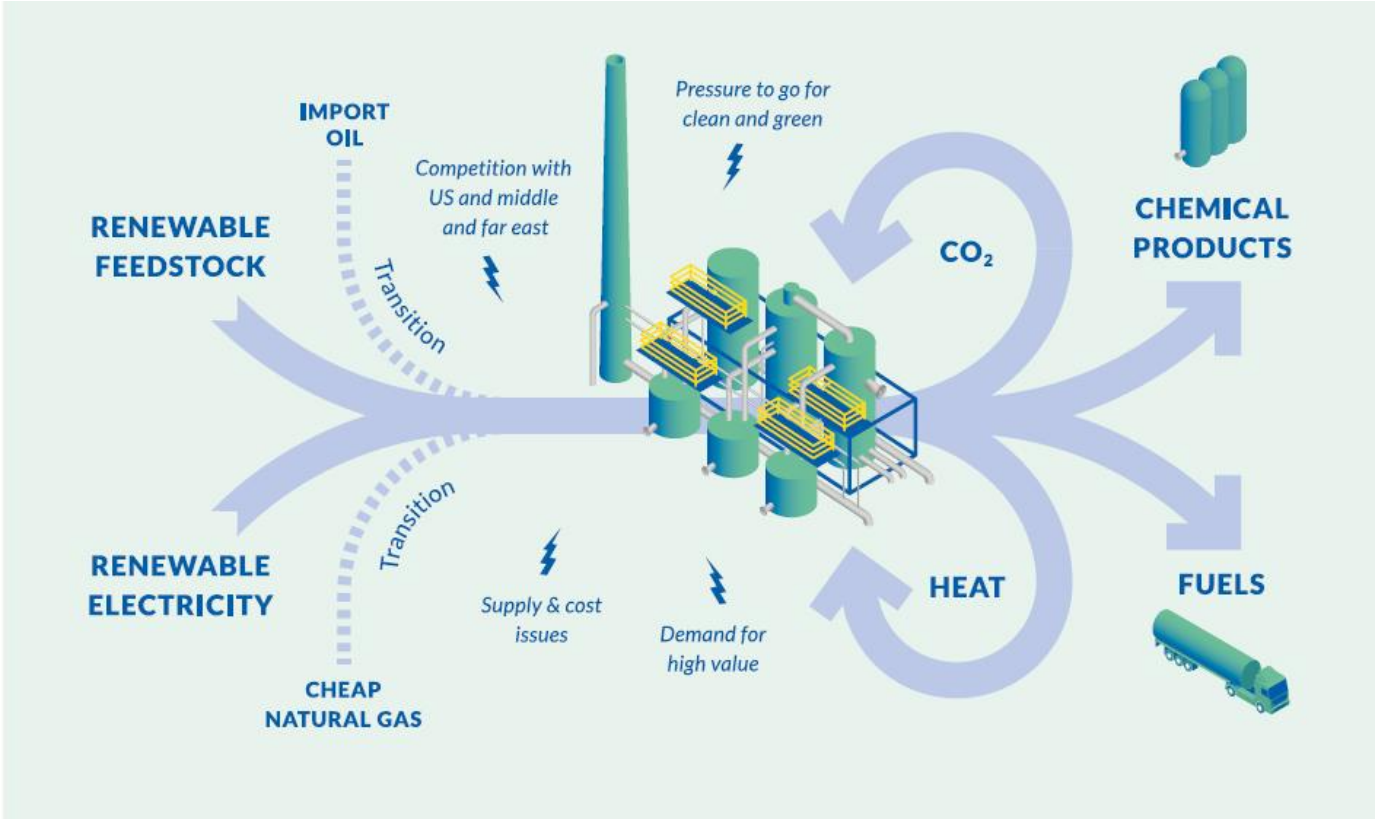
… employing industrial electrification …

From fossil feedstock to renewable electricity as primary energy source



TOPSECTOR ENERGIE
Empowering the new economy

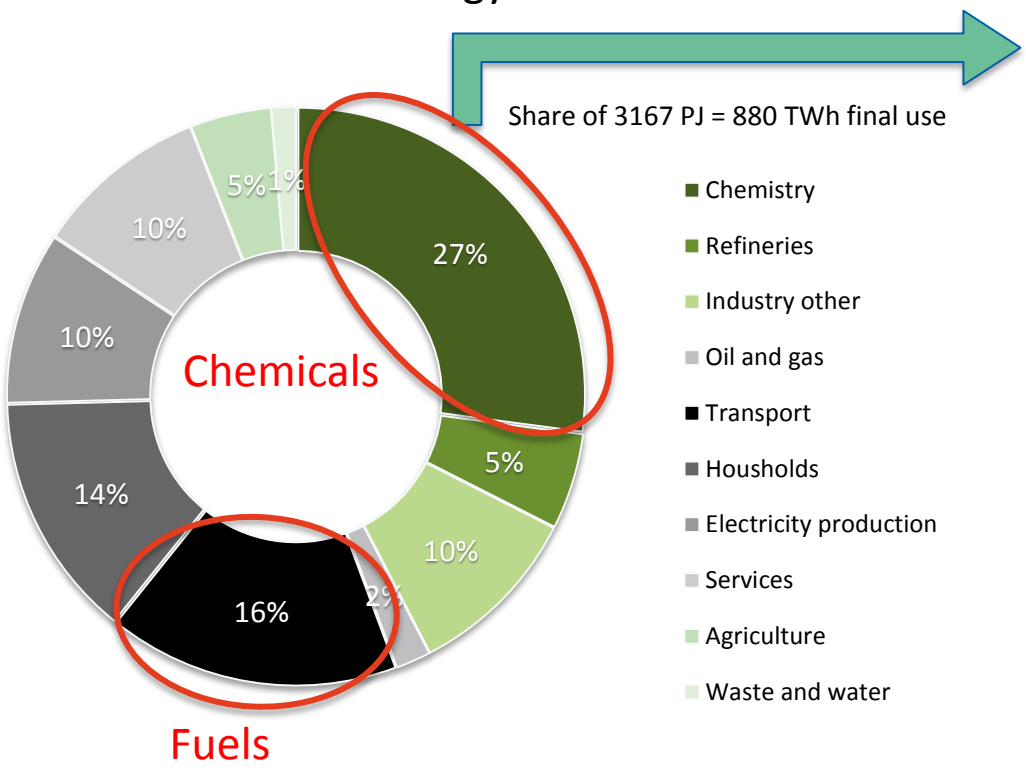
Topsector Chemie

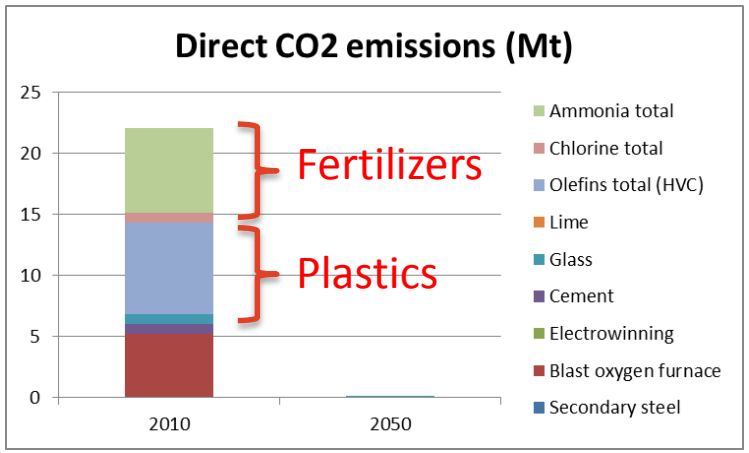
Holland High Tech
High Tech Solutions for Global Challenges

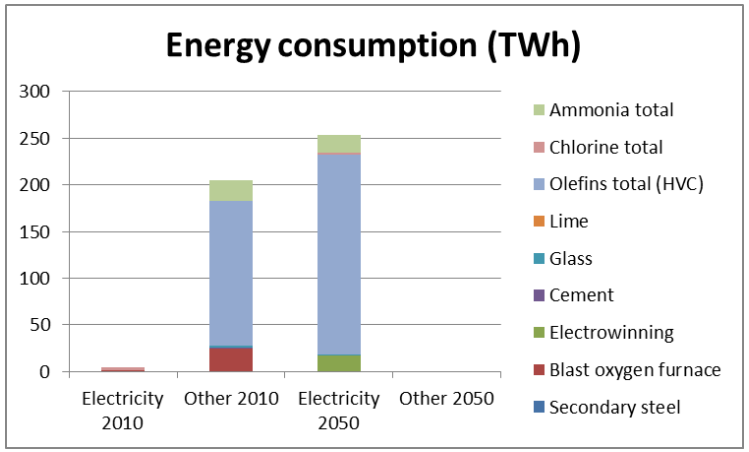
… in important industry clusters

Energy use in Dutch process industry

National energy use

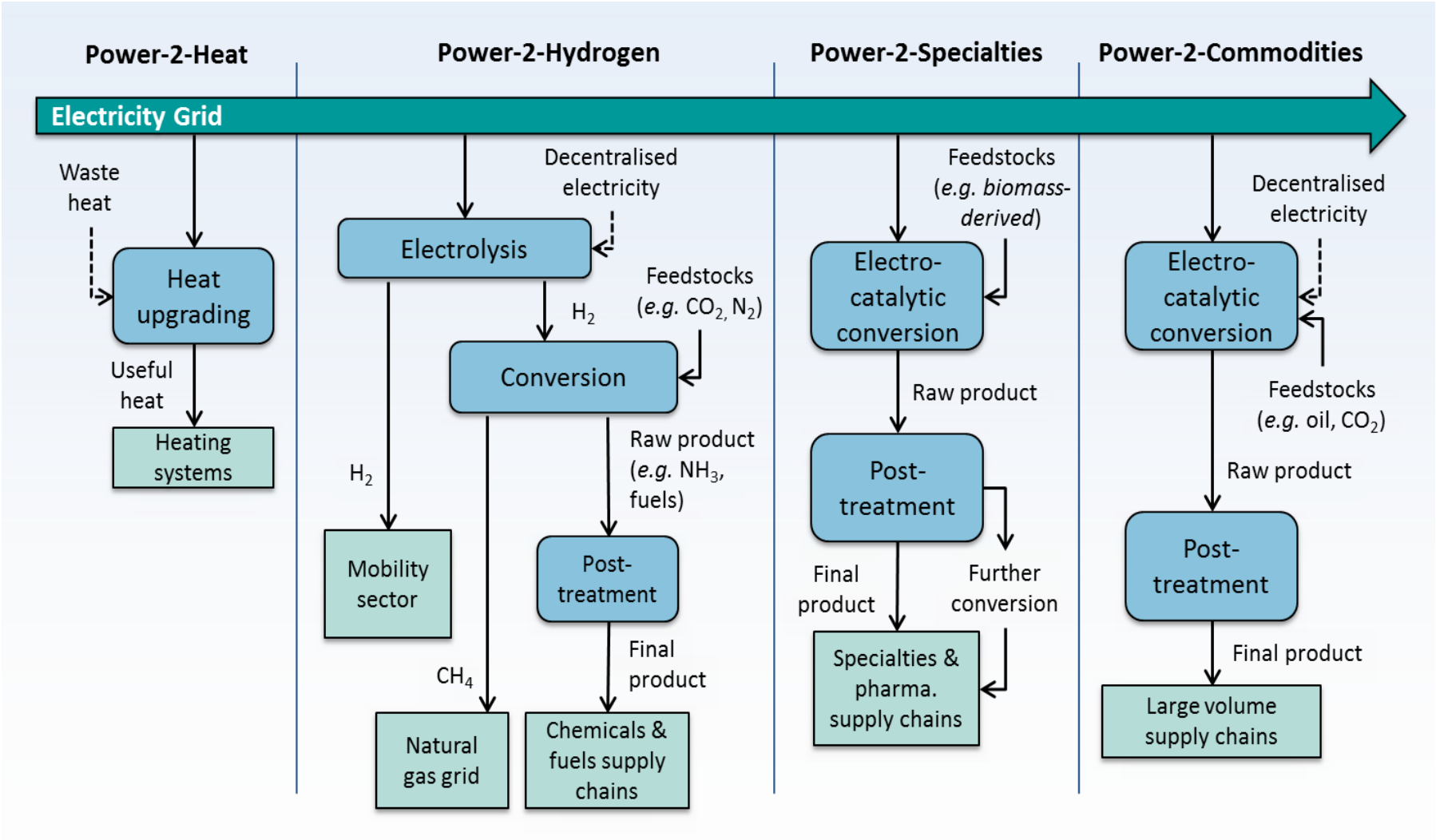






Focus on value chains: Fuels, Plastics & Fertilizers

Main routes for electrification



Why & when electrification?

- *Flexibility*
  - Response time - short
  - Operating hours – relatively low
  - Allowable investment costs – low
  - Technologies at high TRL

- **Short-term option**
- Power-2-Heat
- Power-2-Hydrogen

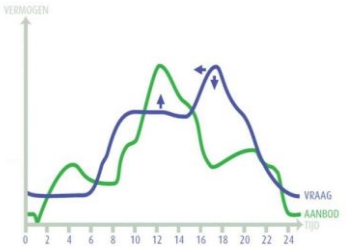
- *Electrification*
  - Response time – less an issue
  - Operating hours – high (base load)
  - Allowable investment costs – higher
  - Technologies at mid/low TRL

- **Mid/Long-term option**
- Power-2-Heat
- Power-2-Hydrogen
- Power-2-Chemicals

Power-to-Heat technology options

- *Flexibility*
  - Direct electrical heating
  - Heat/cold storage
  - Multifunctional/reversible equipment

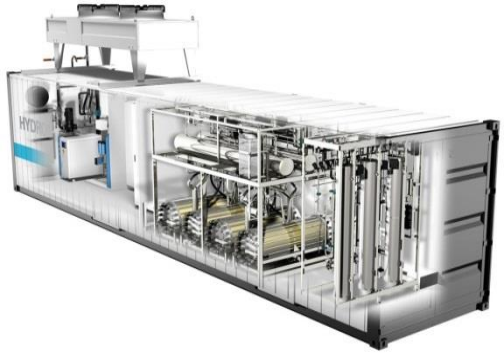
Up to 60 MW
in 1 unit



- *Electrification*
  - (Direct electrical heating)
  - Mechanical vapour recompression
  - Electrical heat pumps

Some other inspiring examples

Power-to-liquids (Sunfire)



Power-2-Gas (Hydrogenics)

Power-to-Methanol (Bayer)

Efficient Chlorine electrolysis (Wacker)

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Electrification of the Chemical Industry

Some examples of business cases

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Business case for Power-2-Heat

Steam recompression as an example

Process
- Mechanical energy is used to upgrade low quality steam to be used in industrial processes

Key parameters
- COP of 6 with temperature lift of 60 ºC from waste steam at 120 ºC
- 10 MW capacity
- Base load operations (96% on in base case)
- Lifetime of 80,000 hours with yearly ex

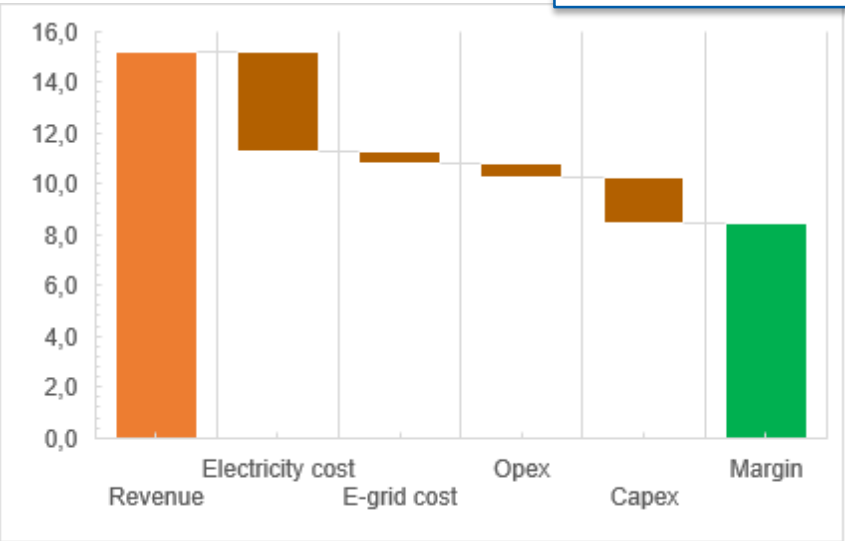
Business case is positive at all price scenario's. Base case cumulative NPV is positive after 3 year.

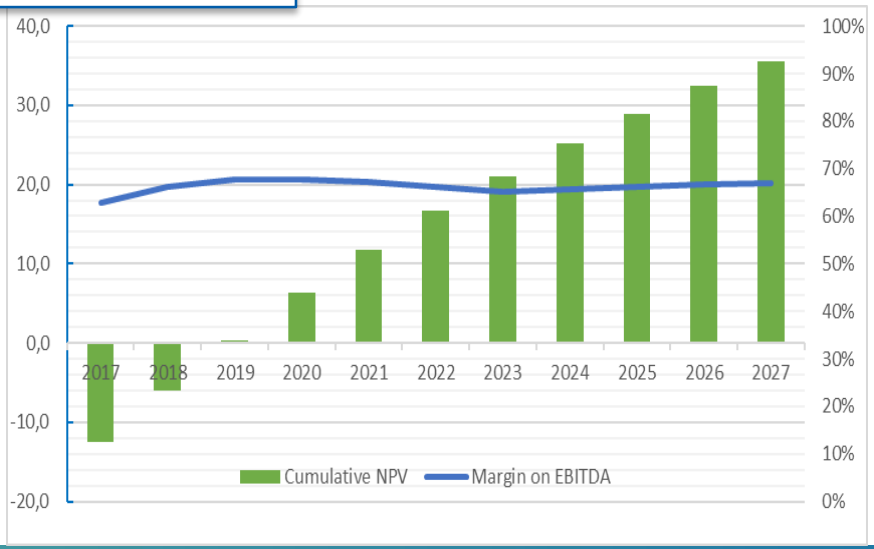
Scenarios based on the report "Scenarios for the Dutch electricity supply system: A report prepared for the Dutch Affairs", Frontier Economics,

Payback time 3 years

Base case scenario cash

s scenarios are for all scenarios positive





Business case for Power-2-Chemicals

CO_2 to CO as an example

Process
- Direct electrochemical reduction of CO_2 to CO
- H_2 produced simultaneously from reduction of water

Key parameters
- Based on laboratory system utilising copper-based electrodes (current density of 6 mA/cm^2 @ 90% efficiency)
- 0.7 MW capacity (1 Mton CO per year)
- Base load operation
- Lifetime of 80,000 hours with

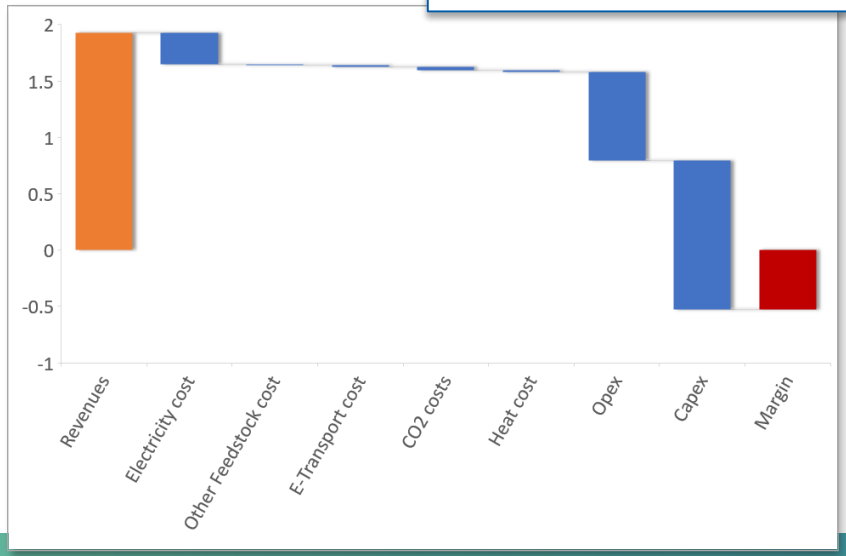
Business as usual (base case) does not result in a positive business case. The capital investment is the most important factor and can be decreased by increases in current density and system lifetime.

An increase in current density by a factor of 2.54 gives a breakeven NPV at year 20.

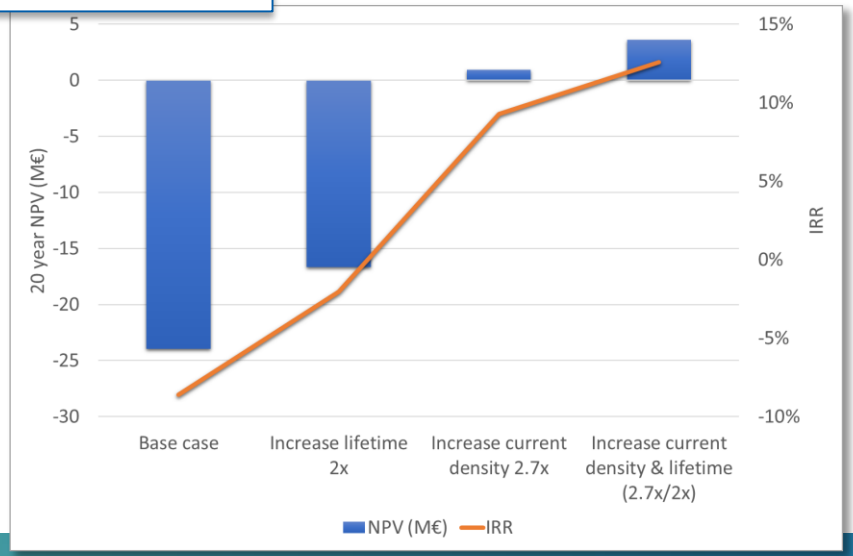
Decrease CAPEX by further development

rio based on Frontier Economics, 2015.

Base case scen



ults of sensitivity analysis



Electrification scenario's

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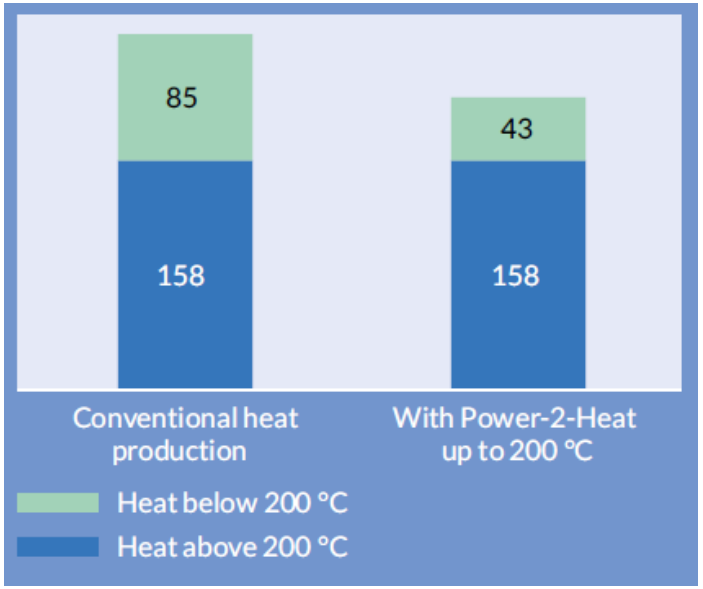
Mid-term potential Power-2-Heat

- Assumptions:
  - Current heat consumption in chemical industry 243 PJ (43% > 200°C).
  - Full implementation of Heat Pumps & residual steam upgrading by Mechanical Vapour recompression in industry.
  - Giving 50% savings for high temperature steam.

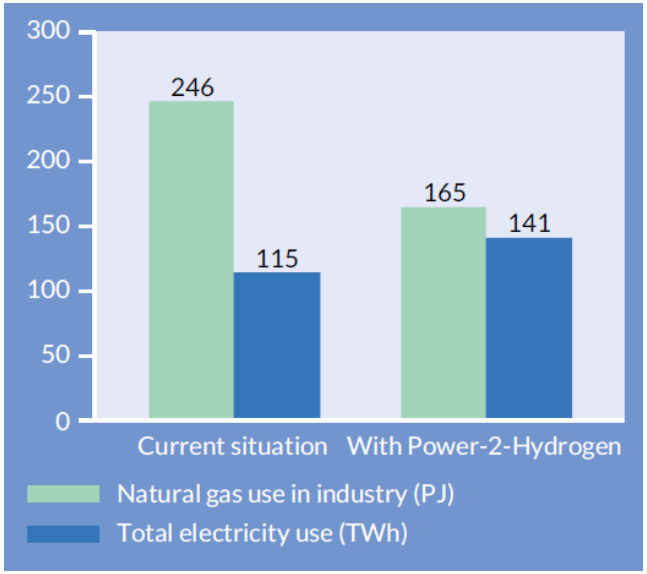
- Result:
  - 15-20% energy savings.
  - 2 TWh / year electricity consumption.
  - 6 Mt / year CO2 reduction.
  - 1 GW peak electricity use.
  - 4% of renewable capacity in 2030.



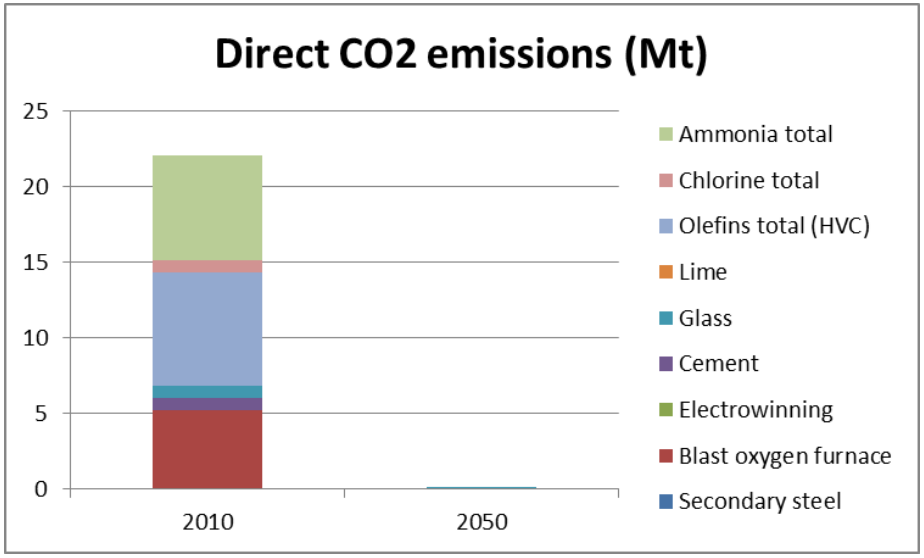
Mid-term potential Power-2-Hydrogen

- Assumptions:
  - Current hydrogen consumption in Netherlands 63 PJ (requiring 81 PJ of natural gas as feedstock).
  - Full replacement of SMR by electrolyzers.

- Result:
  - 4.1 Mt / year CO2 reduction.
  - 26 TWh / year electricity consumption.
  - 6 GW electricity use at 50% load.
  - 20% renewable capacity in 2030.



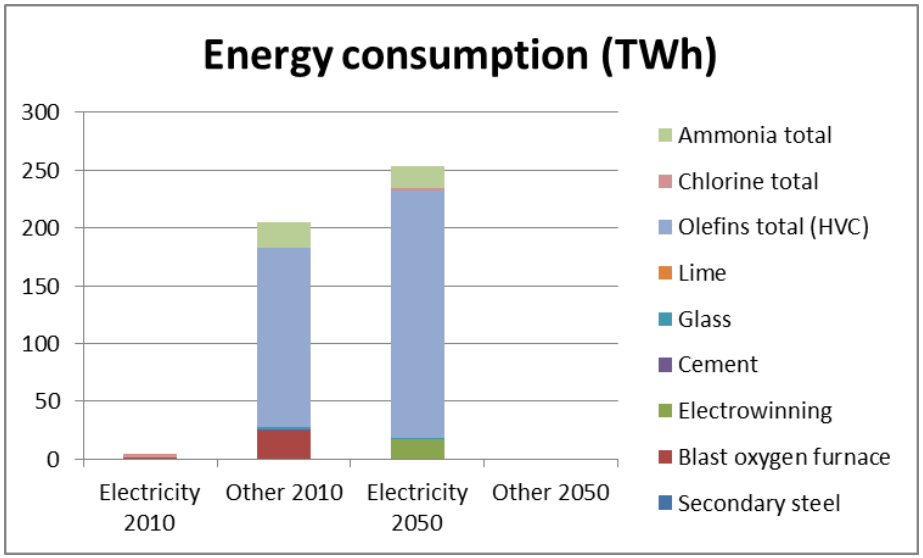
Full industrial electrification 2050 NL



Full electrification decreases CO_2
22 Mt / year

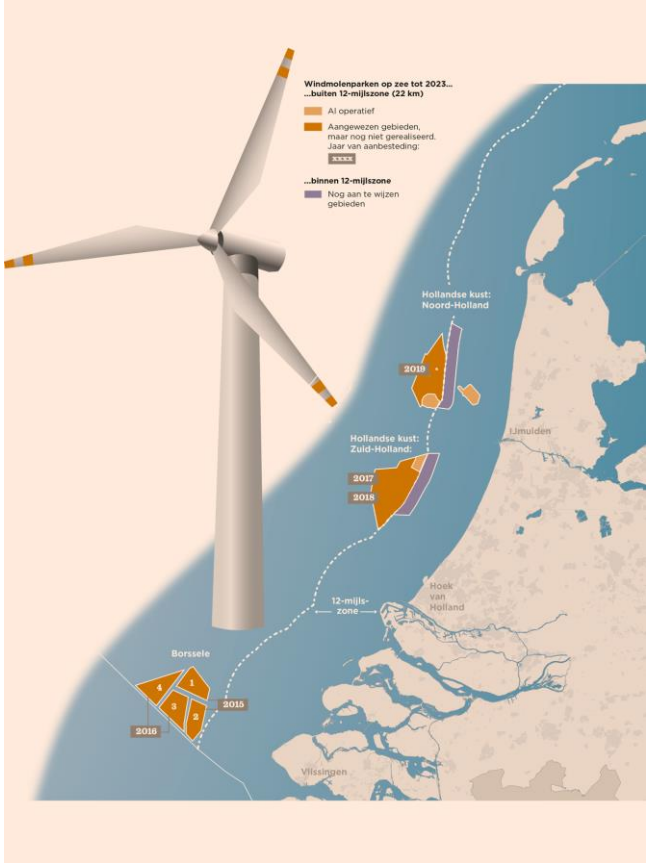
CO2 as feedstock with 3 t_{CO_2} / $t_{olefins}$
23 Mt/year CO2 use

Full electrification needs
250 TWh / year

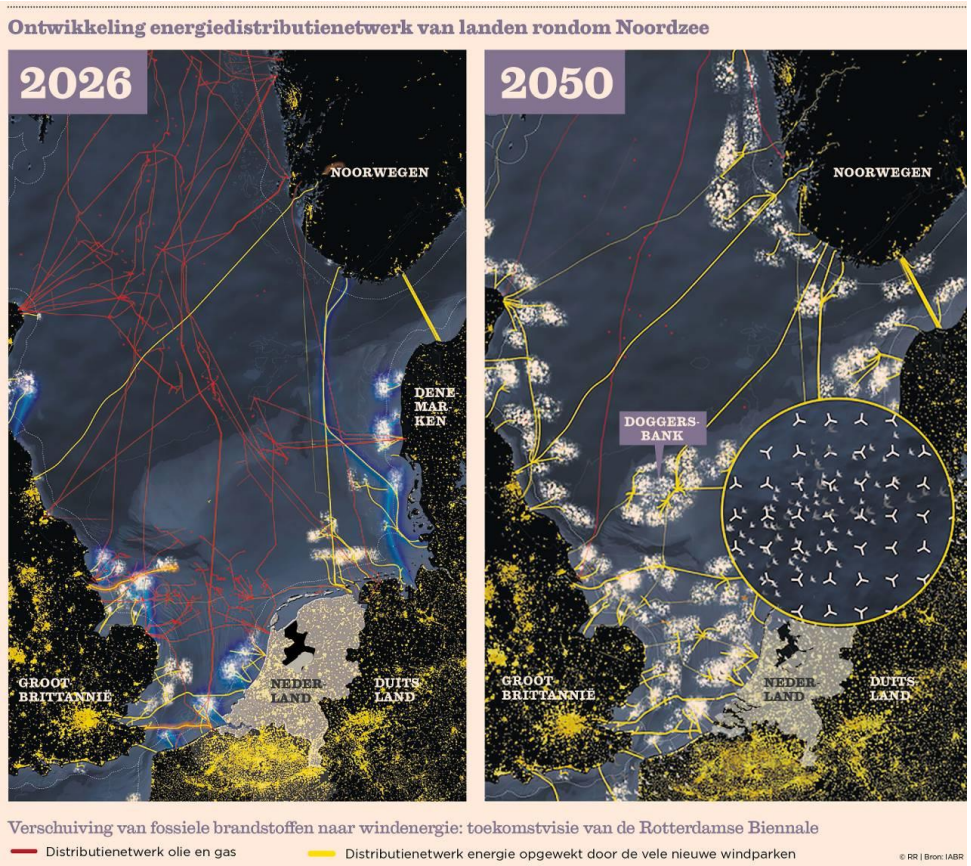


Is this scenario technically realistic???

Source: FD, 22-3-2016



Source: FD, 15-4-2016



2016: 0.9 GW = 4 TWh ➡ 2023: 4.5 GW = 18 TWh ➡ 2050: 250 GW = 1000 TWh

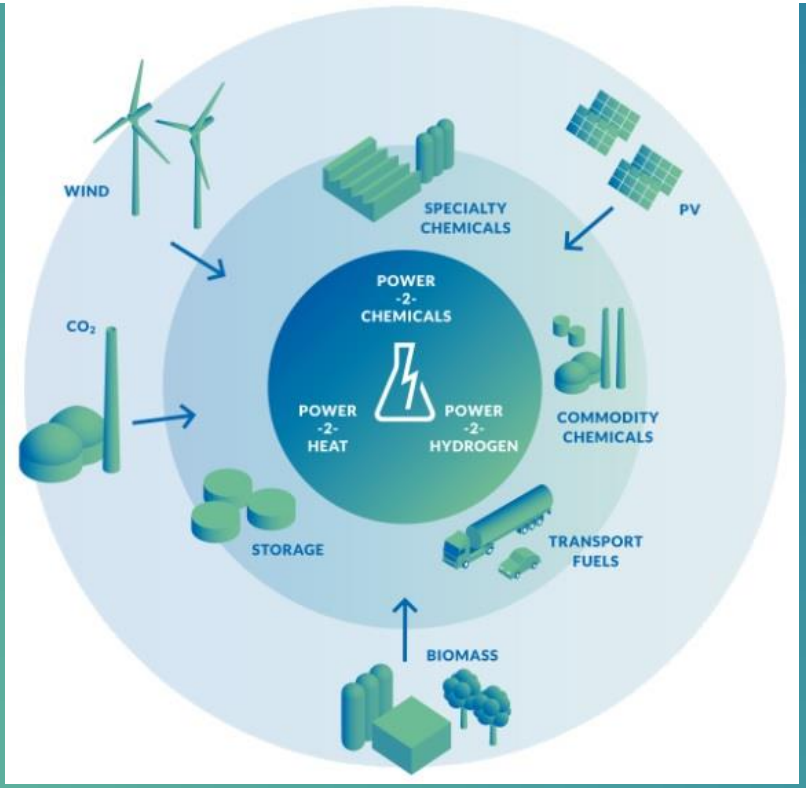
Conclusions

- <u>The future is unpredictible but industry will play an important role</u>
  - The (chemical) industry uses 44% of all energy in The Netherlands
  - Future determined by step-changes in *technology development*, by the *societal and market* conditions and by *regulations*
  - Keep options open and invest at the right time with the right business driver.

- <u>Short-term electrification potential in flexibility</u>
  - Business cases driven by flexibility & incentives
  - Power-2-Heat & Power-2-Hydrogen
  - Upward potential:
    - 10 Mt/year CO_2 reduction.
    - 28 TWh/year electricity use.

- <u>Long-term electrification potential in products</u>
  - Business cases driven by product value & CO_2 regulations.
  - Power-2-Chemicals
  - Upward potential:
    - 45 Mt/year CO_2 reduction.
    - 250 TWh/year electricity use.

Want more information?



Yvonne van Delft
Innovation Manager
vandelft@ecn.nl

Martijn de Graaff
Business development
martijn.degraaff@tno.nl

www.voltachem.com

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