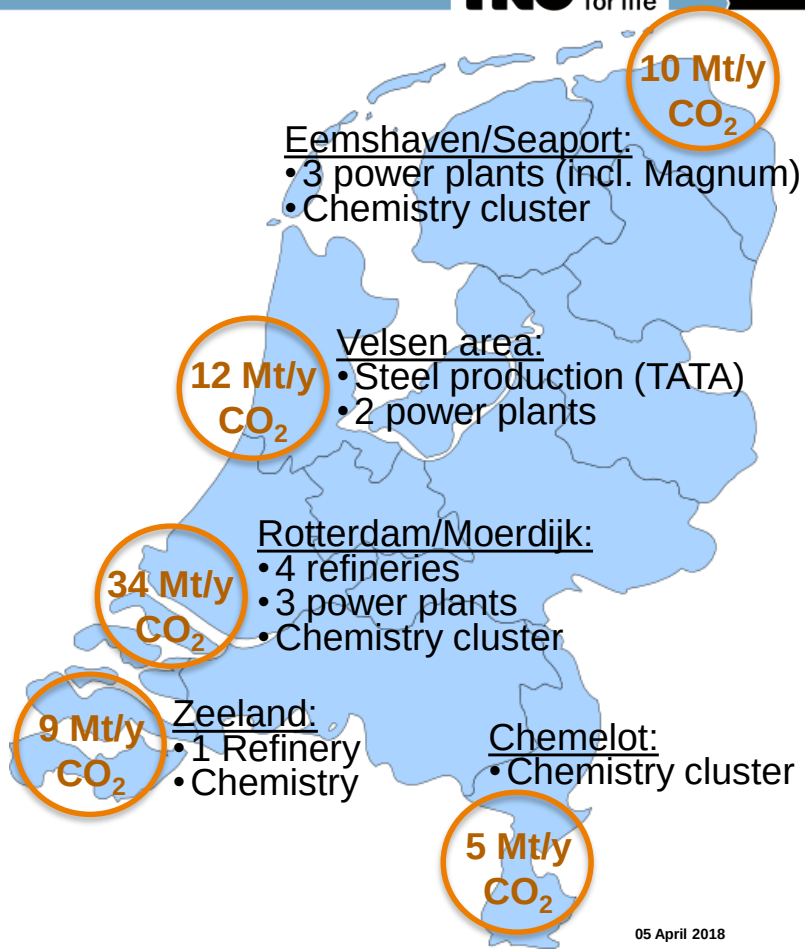
Decarbonization routes Dutch Industry

INDUSTRIAL CLUSTERS NL

- 40% of total CO_2 emissions NL
- Target 49% reduction in 2030:
  - 22 Mton Industry sector
  - 20 Mton Electricity sector



ROUTES FOR ACHIEVING A LOW CARBON FUTURE

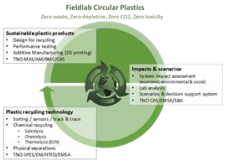
TNO innovation for life

Electrification and Energy carriers (H_2, NH_3)	• Electrification of chemical processes and utilities. • In(direct) production of chemicals/ fuels.
CO_2 capture and utilization	• Chemical/fuel production. • Food grade CO_2 production and greenhouses. • EOR, EGR, underground storage.
Bio-Based Conversion	• Bulk and speciality chemicals (high O_2). • Production of fuel/syngas. • Sea weed/ micro algae factories.
Circularity	• Polymer recovery • Integration with local opportunities. • Biomass and waste utilization.
Heat use & Process efficiency	• Pinch analysis energy (resource) available. • Heat pumps and CHP integration on overall site. • Heat use in combination with electrification.

VOLTA CHEM

H-vision

Biorizon
The way to aromatics



PORTHOS CCS PROJECT: 2 MTON CO_2 STORAGE

H-vision

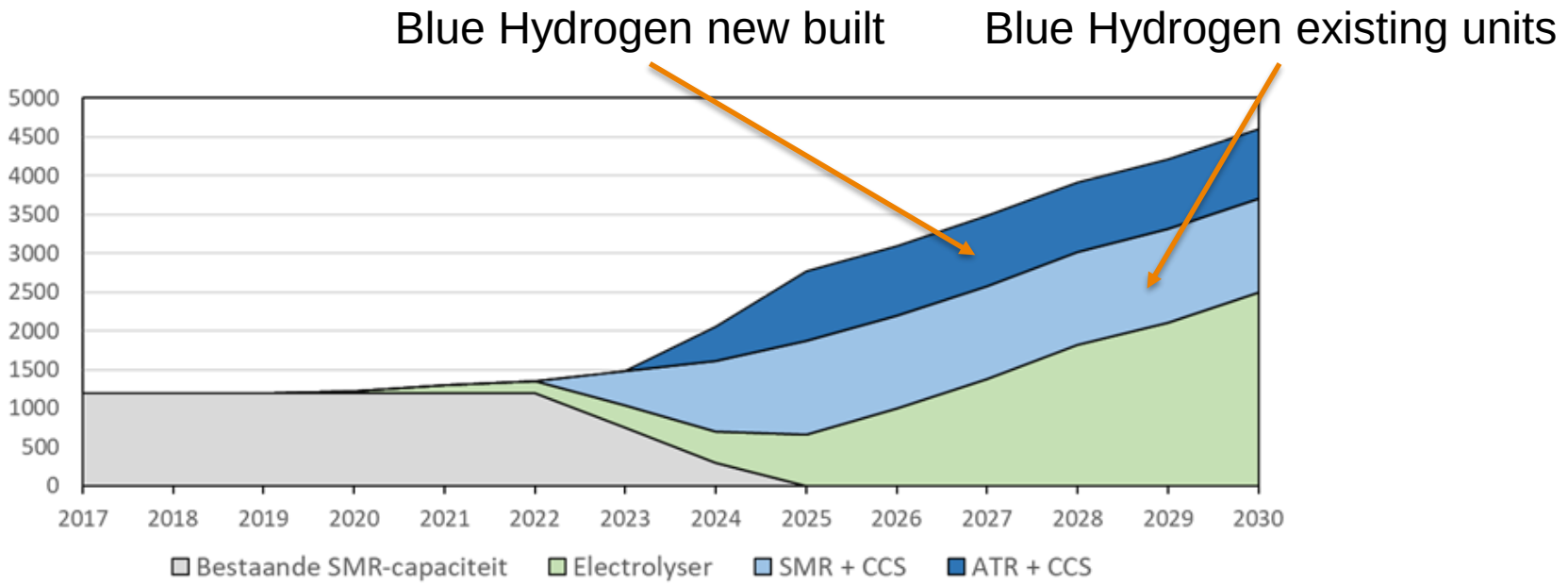
A VERSATILE ENERGY TRANSITION OPTION TOWARDS 2030

The Production and Deployment of Climate Neutral Hydrogen as Substitute for Natural Gas

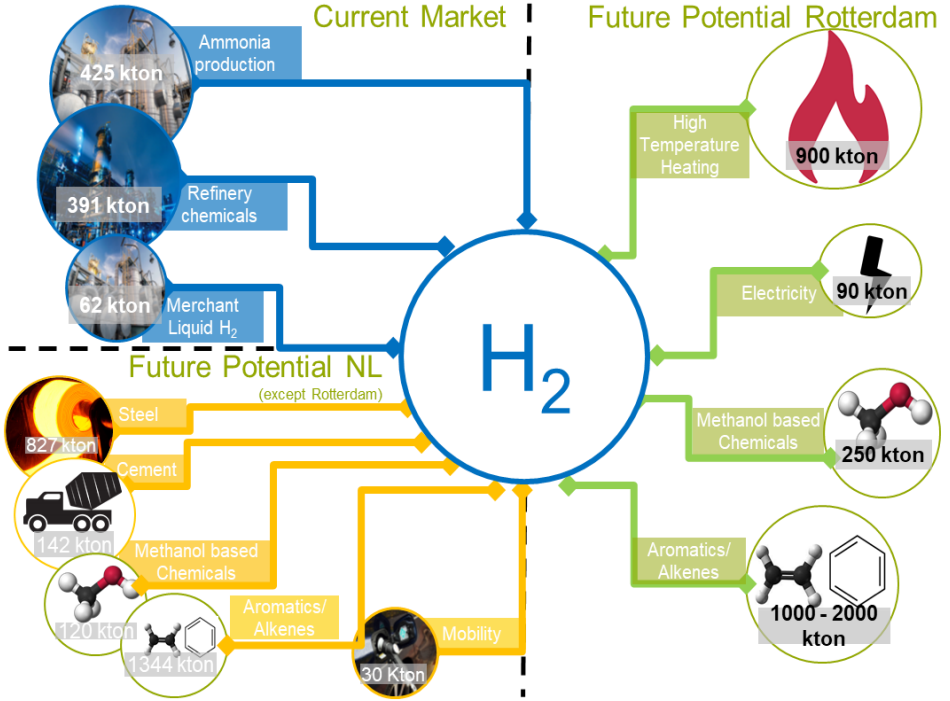
Siupported by:

- Air Liquide
- Deltalinqs
- Engie
- Equinor
- Gasunie
- OCI
- Port of Rotterdam
- Shell
- TNO
- Uniper
- VOPAK

HYDROGEN ROADMAP NL



HYDROGEN APPLICATIONS



Refineries: conversion of fuel gas, limited for green H_2. Petrochemical industry.

Subject to repowering of existing power plants, this can be increased to 1000 kton H_2.

Technology available, subject to economics and market incentives.

Technology development needed.

H-Vision concept Results in:

1. a significant contribution to Rotterdam CO2 reduction targets, reducing emissions by about 3 to 6 Mton/y;
2. a fast availability of clean hydrogen to be used for clean power, transport sector and feedstock for (petro)-chemical processing;
3. An interesting stage for early process electrification (clean power and clean hydrogen together);
4. a fast introduction of a CCUS infrastructure with an affordable ‘economy of scale’;
5. full operation < 2030 using well proven, existing technology;

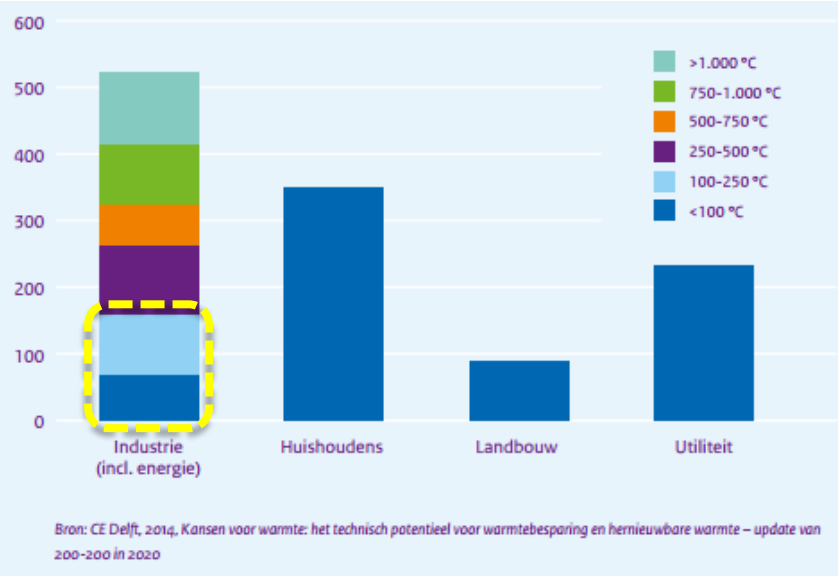
Hydrogen chain:

1. **Centralized Hydrogen production**
2. **Transportation of Hydrogen by using existing infrastrcuture .**
3. **Hydrogen as feedstock for industry**
4. **Hydrogen as feedstock for existing powerplants**
5. **Transportation and storage of CO_2**
6. **Storage of Hydrogen**

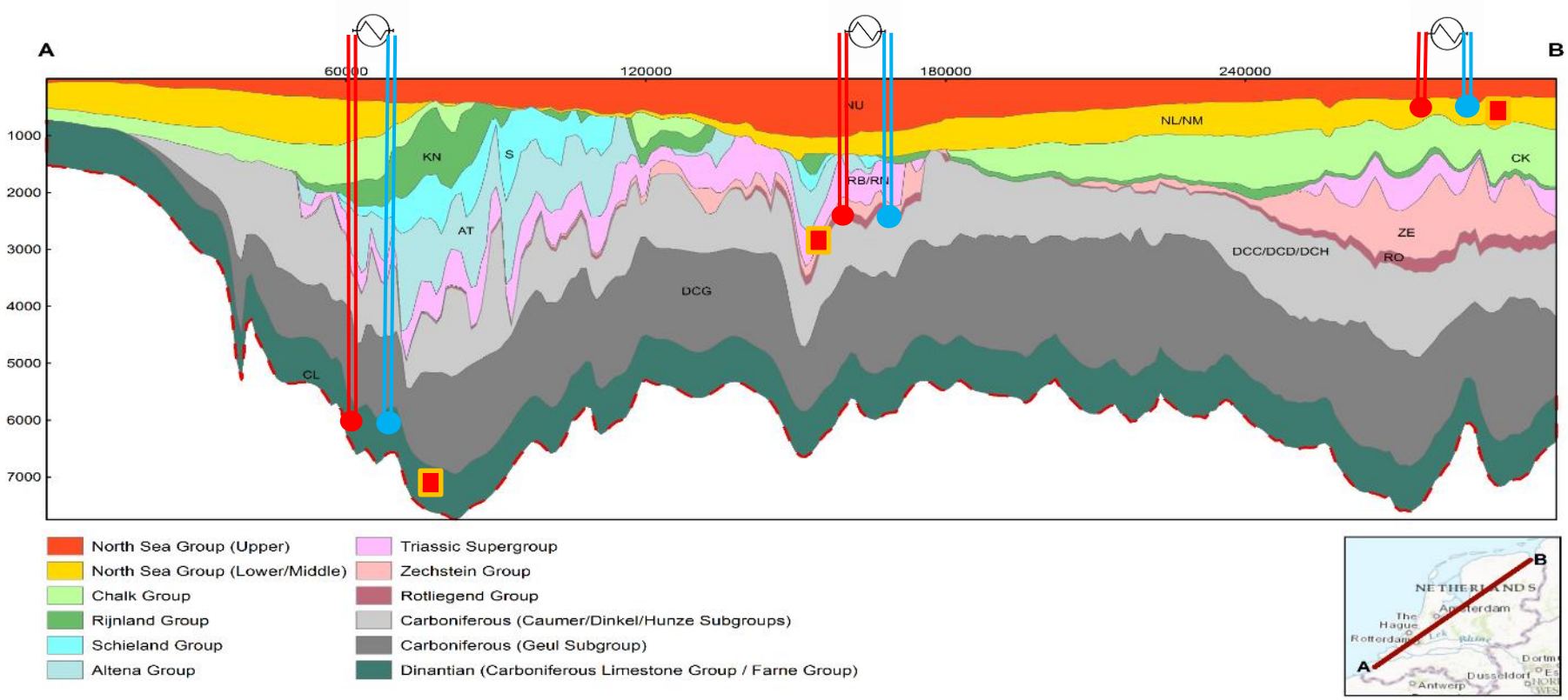
7. **Green Hydrogen**
   - Synergy with hydrogen from Natural gas
   - Energy storage & clean back up

HEAT DEMAND INDUSTRY

- 520 PJ
- Match with geothermal energy (UDG): 170 PJ
- NL policy: UDG ~ 65PJ



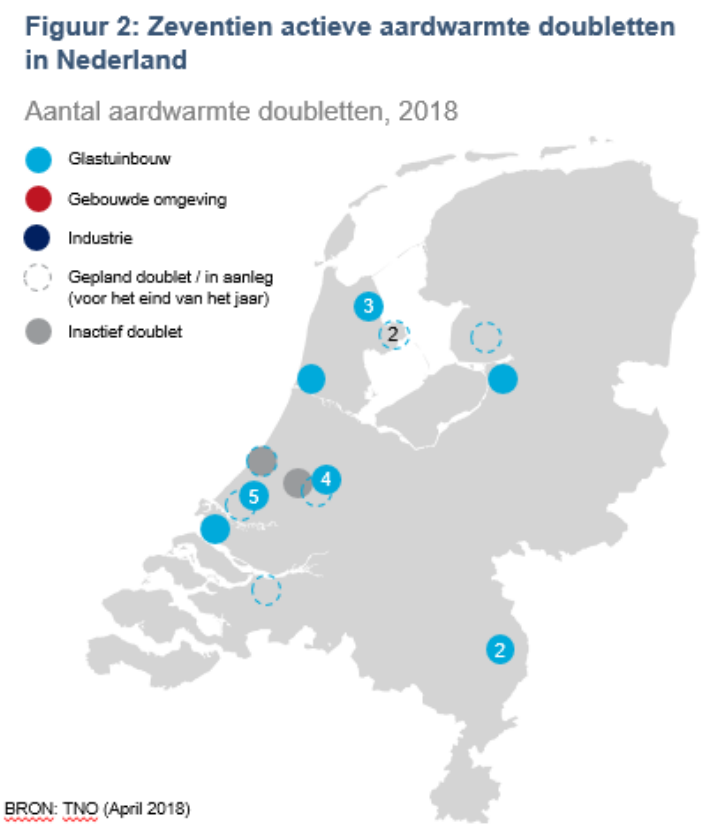
GEOTHERMAL ENERGY IN NL



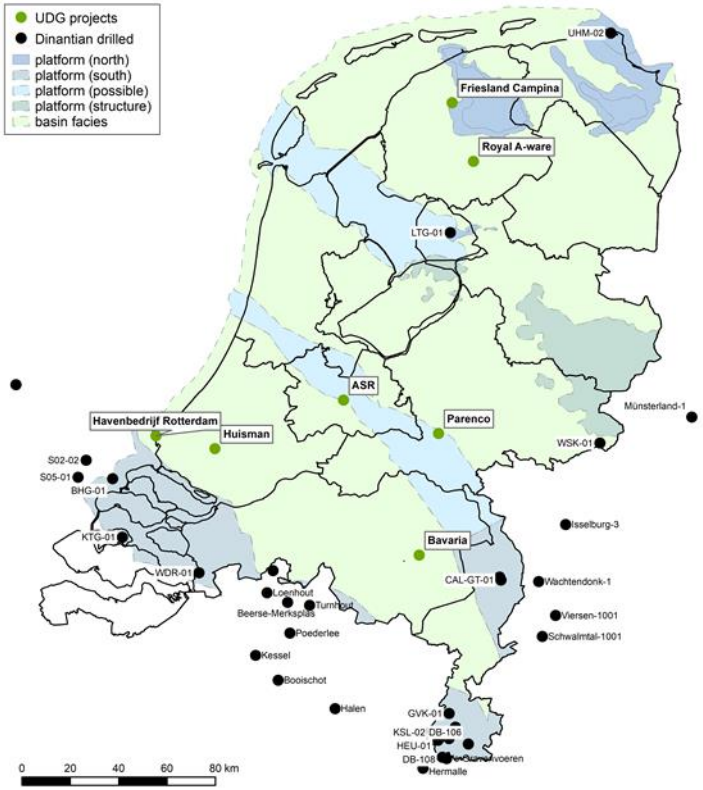
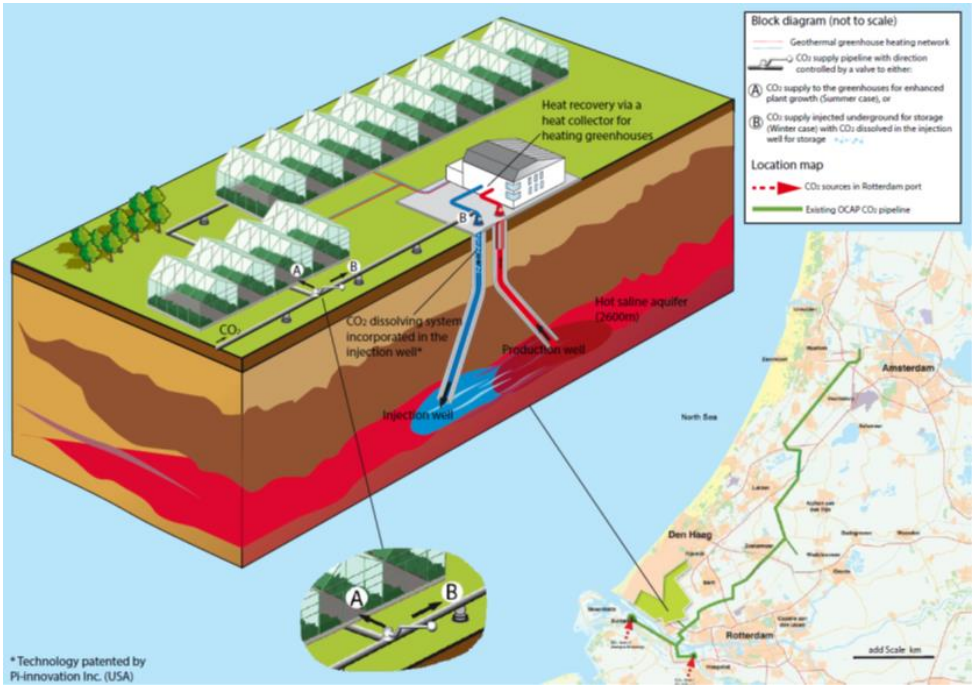
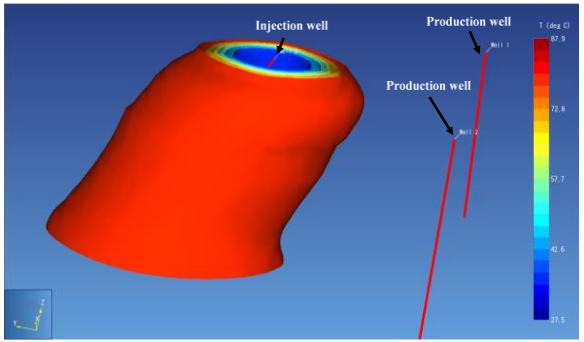
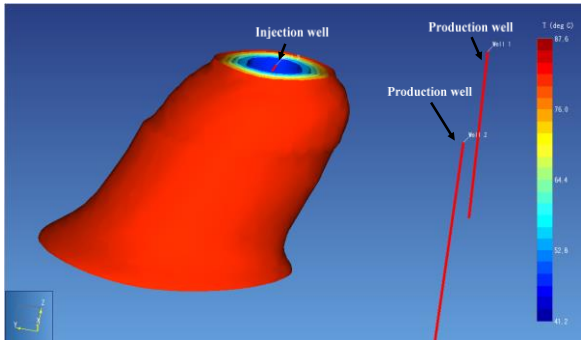
ULTRADEEP GEOTHERMAL PROGRAM (UDG)

- 3 year program supported by the Ministry of Economic Affairs & Climate
- Run jointly by TNO and EBN (Dutch state participation in energy production)
- 7 commercial project partners
- Focus on (deep) Dinantian carbonates depth ~4000-7000m
- Exploration: seismic acquisition (29M) & exploration wells
- Goal: have 1-3 deep geothermal wells in 2020-2022

Figuur 2: Zeventien actieve aardwarmte doubletten in Nederland



BRON: TNO (April 2018)



Combined geothermal and dissolved CO_2 storage system