

**DEEP DECARBONIZATION OF INDUSTRY & SEARCH FOR THE KEY  
INGREDIENTS**

**OUTLINE OF THE DUTCH SITUATION, WITH EMPHASIS ON CROSS-  
BORDER ISSUES**

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## › CONTENT THAT YOU CAN EXPECT

GLOBAL DECARBONIZATION/IPCC

TRANSFORMATION OF THE CHEMICAL INDUSTRY

OVERALL SCHEMES OF CHEMICAL PRODUCTION

CHEMICAL INDUSTRY IN THE NETHERLANDS

CO<sub>2</sub> EMISSIONS OF THE CHEMICAL INDUSTRY

TRANSITION OPTIONS AND ROADMAP (DUTCH  
CASE)

CROSS BORDER ISSUES

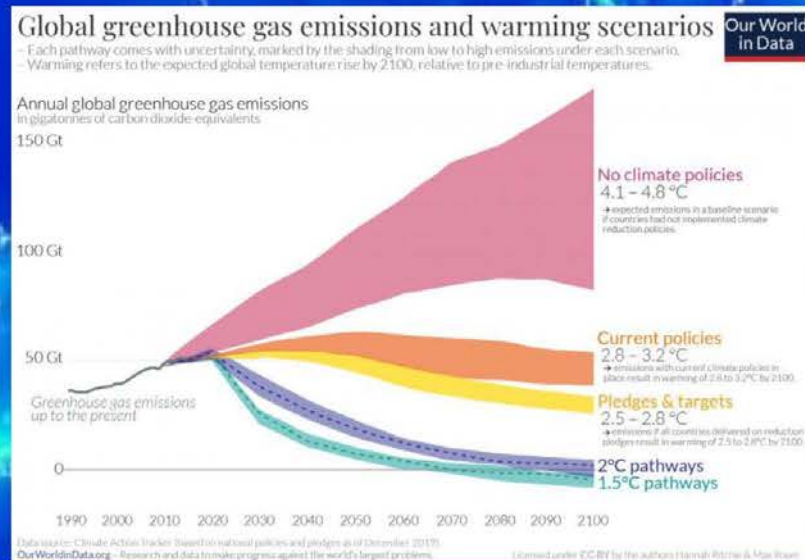
CONCLUSIONS

ECEE FRANCE, JUNE 6-12, 2022



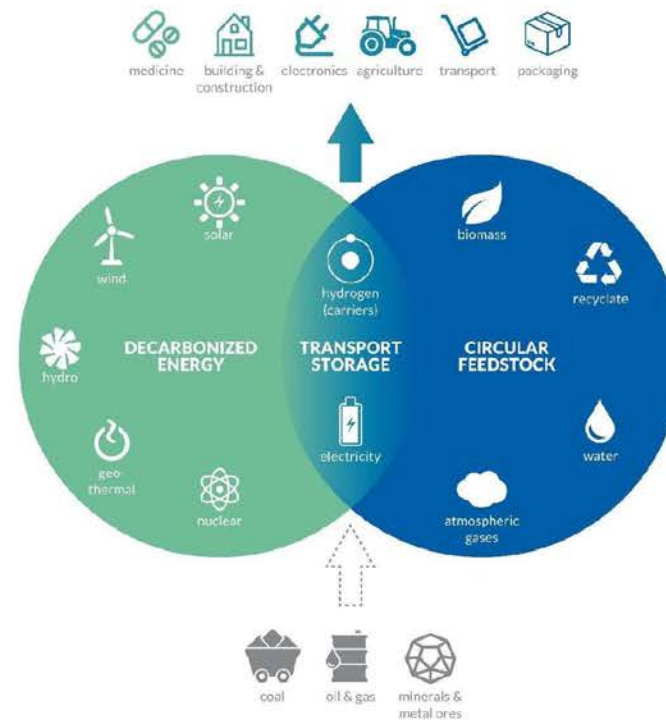
# Climate change calls for action...

The report finds that limiting global warming to 1.5°C would require “rapid and far-reaching” transitions in land, energy, industry, buildings, transport, and cities. Global net human-caused emissions of carbon dioxide (CO<sub>2</sub>) would need to fall by about 45 percent from 2010 levels by 2030, reaching ‘net zero’ around 2050. This means that any remaining emissions would need to be balanced by removing CO<sub>2</sub> from the air.



# An industrial transformation is required

1. Energy Transition:
  - **Decarbonization** by electrification
2. Transport and Storage:
  - **Hydrogen (carriers)**
  - **Electricity (storage)**
3. Feedstock Transition:
  - **From fossil to Circular feedstocks**



## › GLOBAL DECARBONIZATION

Deep global decarbonization needs:

1. Massive renewable Electricity generation



2. Circular carbon (biomass, carbon waste streams, captured CO<sub>2</sub>)



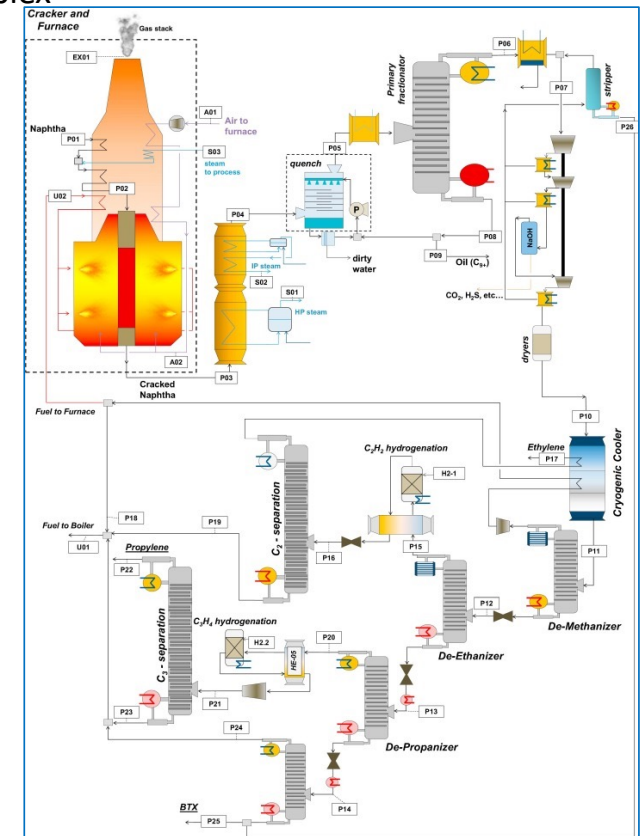


## TRANSFORMATION OF THE CHEMICAL INDUSTRY

- Today, most chemicals that are being produced are strongly connected to a refinery complex
- The refinery produces, among others, refinery gases (C1, C2, C3, C4) and naphtha
- Typically, some 10 % of these refinery gases/naphtha is sent to a petrochemical complex
- Here, these streams are converted to platform chemicals (ethylene, propylene, butylene, aromatics (BTX))



Shell Moerdijk, naphtha cracker

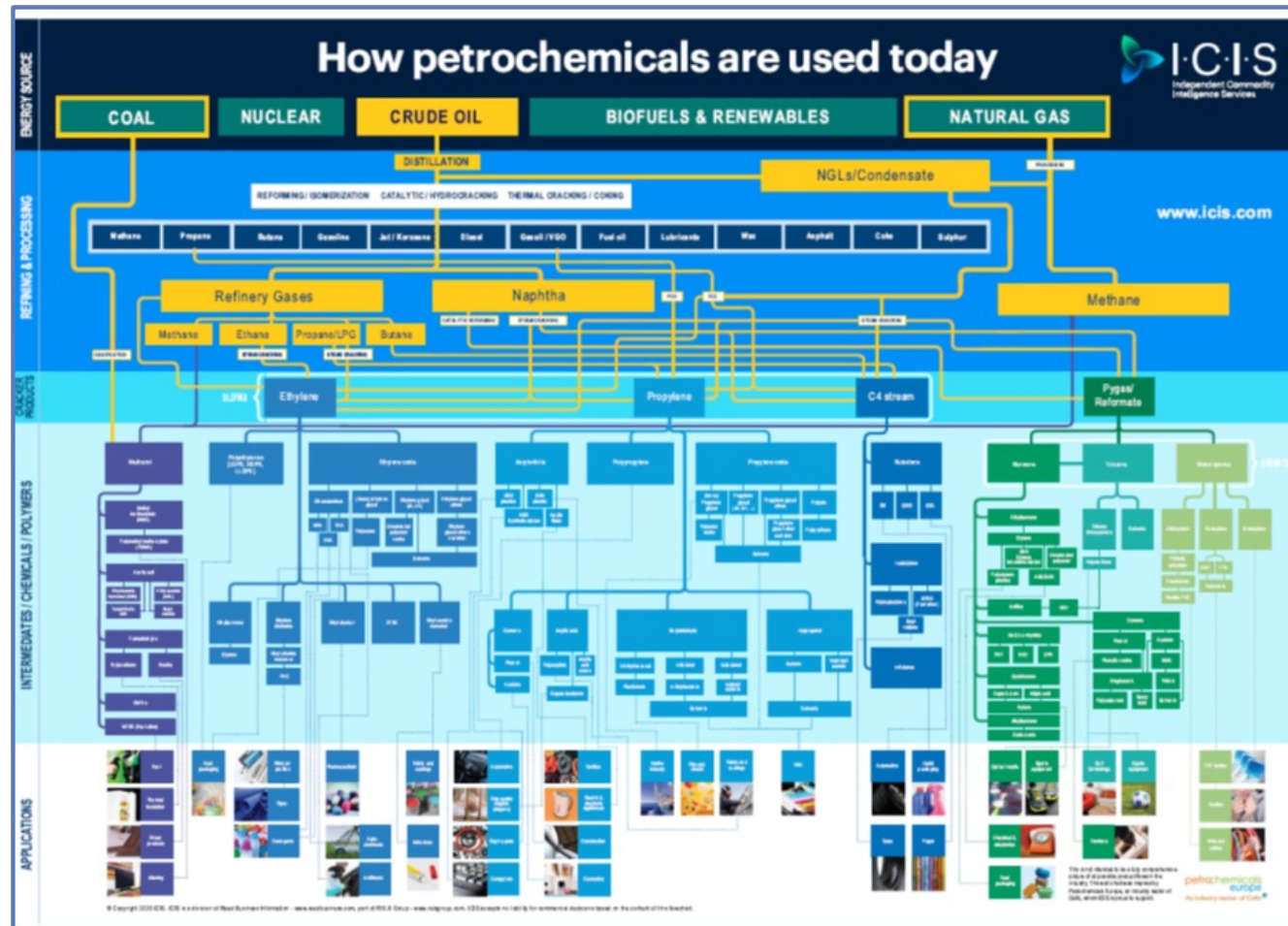


Vincenzo Spallina, et al, Energy Conversion and management 154, Dec. 2017, p.244-261

Typical thermal cracking scheme

**TNO** innovation for life

# OVERALL SCHEME OF PETROCHEMICALS PRODUCTION



## › CHEMICAL INDUSTRY IN THE NETHERLANDS



Figure 1-2 Clusters of chemical industries in the Netherlands [4]

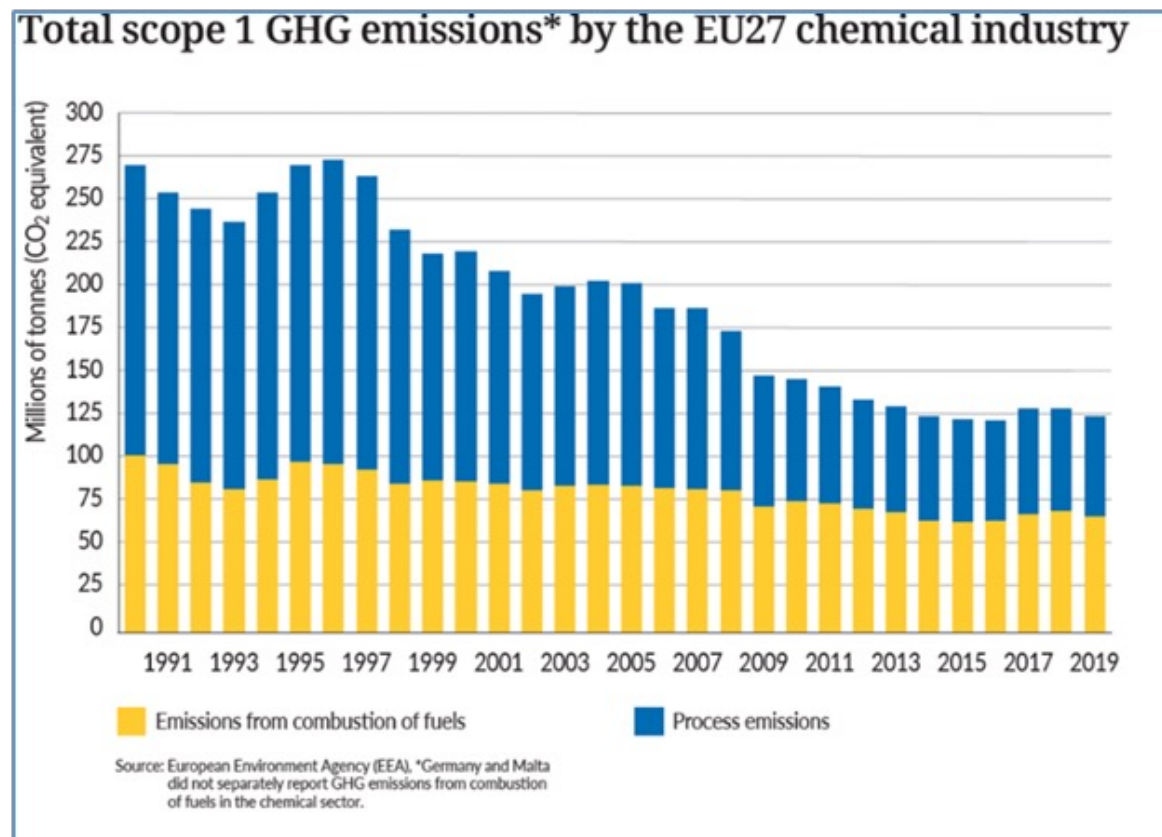
- Strongly connected to harbors, to Germany, Belgium
- Electricity network, pipelines for products

### Clusters of chemical industry in the Netherlands

(source : Deloitte, “the Chemical industry in the Netherlands 2030-2050 , February 2012)



## › GHG EMISSIONS OF THE CHEMICAL INDUSTRY (EU)



## › TNO, DECHEMA AND VITO FORMED A TRILATERAL COOPERATION, FOCUSING ON DECARBONISATION OF THE INDUSTRY IN CROSS BORDER REGIONS



## › CHEMICAL CLUSTERS AND CROSS BORDER ISSUES

### Cross border issues

› The structural changes in the chemical industry and the solution options are more complex as these projects require a broad array of stakeholders from different countries. For example, when initiating a common infrastructure project, alignment over a number of conditions is required, which include :

- Financing and risk allocation
- Energy regulation
- CO<sub>2</sub> allocation policy
- Industry policy
- Spatial planning
- Decarbonization incentive schemes
- Environment and safety regulations

TNO, together with VITO in Belgium and Dechema in Germany, have recognized those issues and have formed a joint trilateral partnership for cooperation.

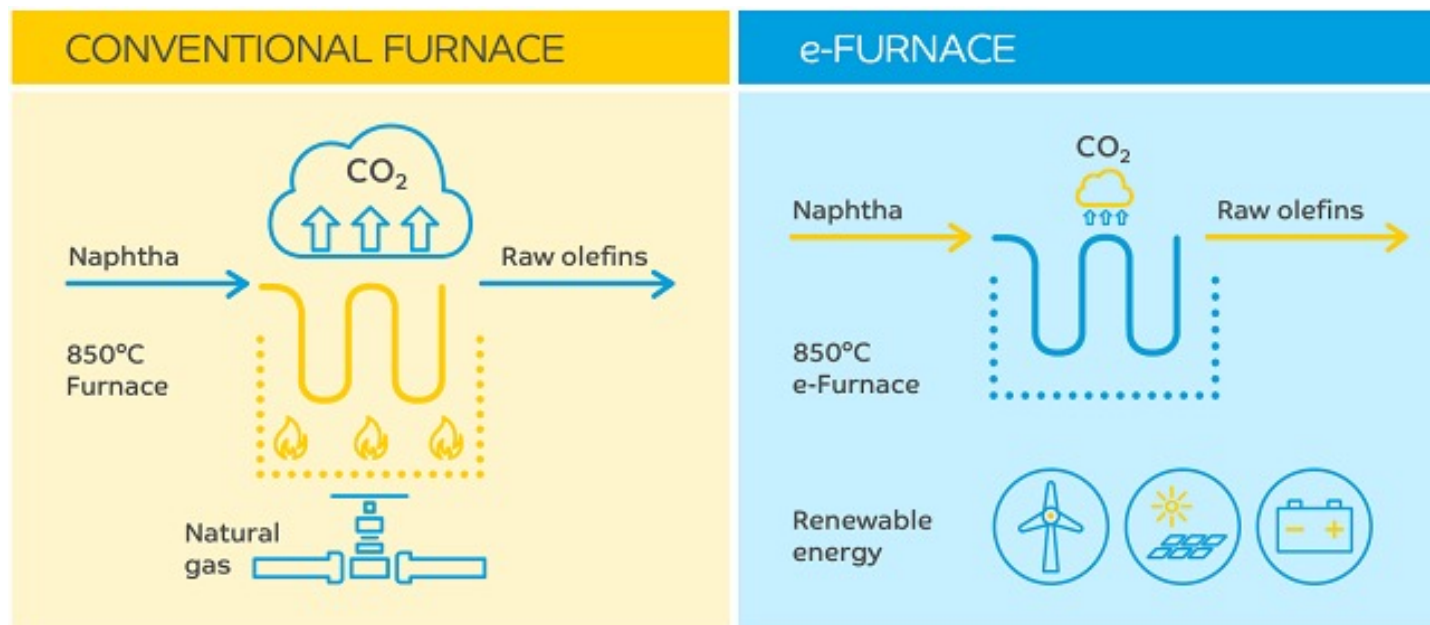


## › WHAT ARE THE TRANSITION OPTIONS FOR THE CHEMICAL INDUSTRY ?

- Renewable electricity infrastructure
- Green or Blue hydrogen infrastructure or local production
- CCS (carbon capture & storage)
- Access to a CO<sub>2</sub> network
- Biobased feedstocks
- Electric furnaces (like naphtha cracker)
- Electric boilers
- Energy efficiency
- Mechanical recycling
- Access to circular carbon
- Novel chemical pathways (in particular C1 chemistry, to connect hydrogen source and carbon source)

## › EXAMPLE 1

# ELECTRIC FURNACE



Source : SABIC, in cooperation with BASF and Linde

## › EXAMPLE 2

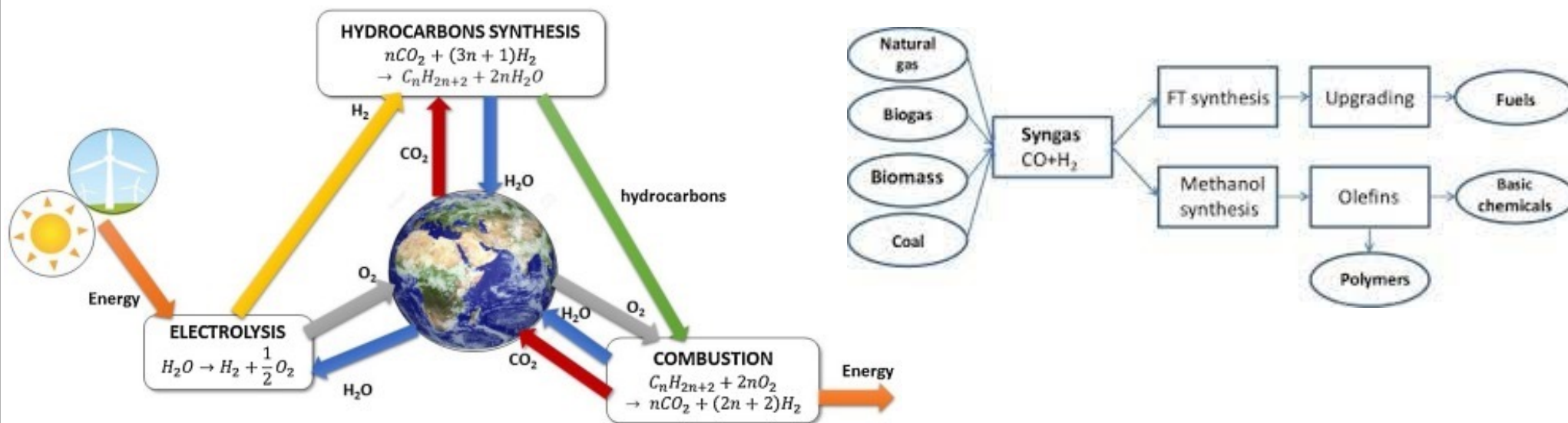
### SEWGS TECHNOLOGY TNO





## EXAMPLE 3

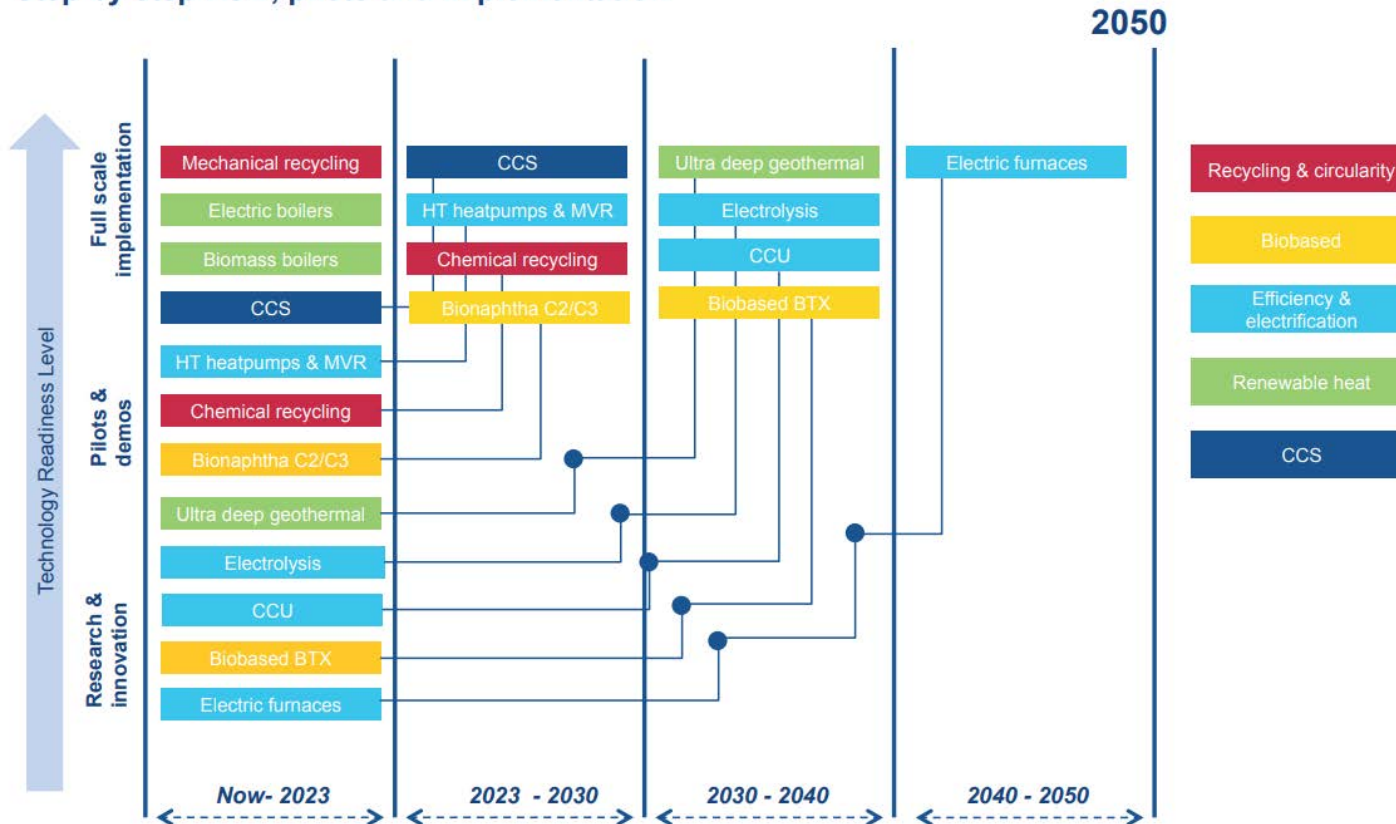
# C1 CHEMISTRY AND CATALYSIS



Carlotta Panzone, et al, Journal of CO<sub>2</sub> utilization,  
May 2020, p. 314-347

# › ROADMAP DUTCH CHEMICAL INDUSTRY

Step by step R&D, pilots and implementation



A long term innovation and implementation program, with testing of technology, economic analysis, regulation.

## › CONCLUSIONS

- › Industrial decarbonization in the chemical industry is required to achieve climate targets (“FIT for 55”) for CO<sub>2</sub> reduction
- › Infrastructure of green electricity, production of green hydrogen and renewable carbon are essential elements for low carbon transformation of the chemical industry, together with new innovative synthesis routes
- › A dedicated innovation program of the chemical industry, companies, government agencies and knowledge partners should facilitate testing of technology, scale up, economic analysis and develop accompanying regulations
- › Regional cooperation on long-term implementation programs including border regions are essential elements of this innovation program

### For Discussion:

1. Is there a future for a European chemical industry in the FIT for 55 landscape ?
2. What are main issues for the chemical industry in border regions ?
3. What is the best option for circular carbon ?





**FOR MORE QUESTIONS AND  
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