

ITOM-Petchem | *Brief description*

Version: January 2026

Model purpose

The European petrochemical sector is a strategic backbone for essential value chains. At present, it is characterised by high greenhouse gas emissions throughout the entire lifecycle, particularly during primary production and end-of-life incineration of plastic products. To align with the EU Climate Law and operate within planetary boundaries, the industry must undergo a fundamental shift from a linear to a circular carbon economy. This transition necessitates replacing fossil-based feedstocks with sustainable alternatives – namely biomass, recycled waste, and captured carbon – while simultaneously scaling renewable energy generation and infrastructure.

ITOM-Petchem covers the EU petrochemical industry's current landscape – including existing production sites, plants and technology portfolios – to calculate transformation pathways toward a climate-neutral and resilient future. Running various scenarios makes it possible to identify pivotal technological shifts and boundary conditions for a successful transformation, and assess the impact of policy measures on the sector's evolution.

Model Description

ITOM-Petchem implements the ITOM¹ model framework for the European petrochemical sector. The production chain represented in ITOM-Petchem includes the production of polymers from a range of raw materials and energy inputs. The key requirement of the model is to produce an externally defined amount of final products (polymers). Polymers are produced from intermediate products (e.g. high-value chemicals (HVCs), chlorine and ammonia). HVCs, in turn, can be produced from various processed feedstocks and secondary materials. The technical basis of the model includes various technologies for each of these steps in the production value chain.

Geographically, ITOM-Petchem covers the industry locations in the EU27+3. The EU27+3 are divided into five regions with regards to polymer demand as well as other parameters (see tables below). While the temporal resolution is flexible, ITOM-Petchem is typically used for scenarios with five-year steps.

It should be noted that ITOM-Petchem does not cover the whole chemicals industry. It does not include areas such as ammonia production for fertilisers, chlorine production for sanitation and specialty chemicals. The generation of process heat in combined heat and power (CHP) plants and boilers is also not part of the model. The energy supply costs that arise from the heat demand of the included production plants, are, however, considered as part of the cost optimisation.

¹ ITOM stands for Industry transformation model – see supplementary information below

Key features

- Spatially explicit representation of existing base chemicals sites and capacities in EU 27+3, as well as transport routes between them (product pipelines, shipping routes)
- Model-endogenous optimisation of production networks across sites and steps in the value chain (feedstock, HVCs, polymers)
- Includes chemical recycling technologies and biomass-based production, as well as use of imported synthetic feedstocks
- Includes modelled regionalised polymer demand and availability of plastic waste for chemical recycling over time
- Explicit consideration and endogenously optimised usage of by-products of various production processes

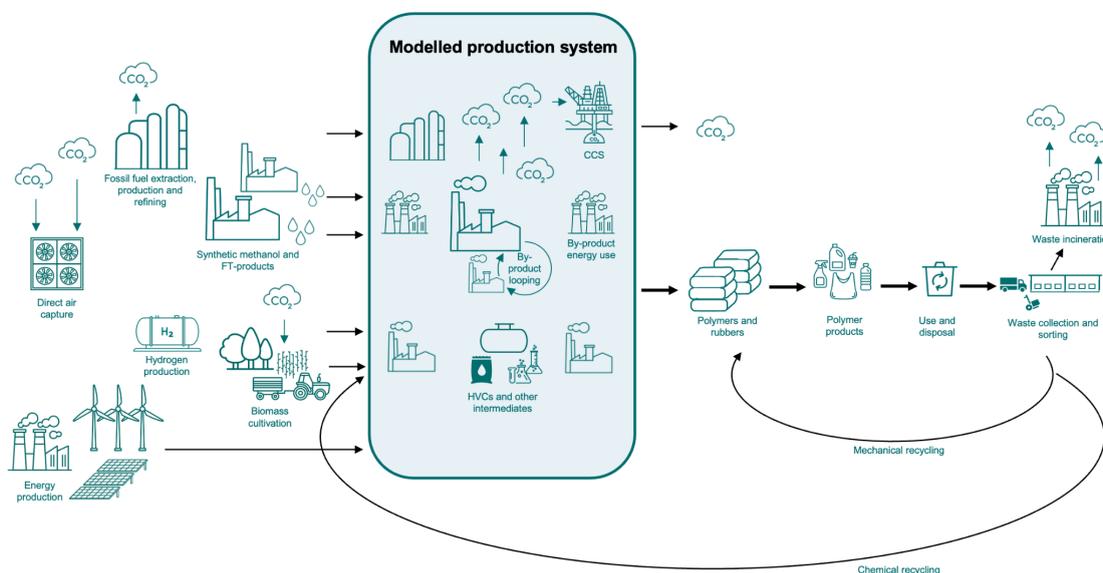


Figure: The production system modelled in ITOM-Petchem

Key model inputs and outputs

Inputs

Parameter	Description
Polymer demand	Yearly demand for polymer per region
Energy cost	Yearly and regional cost data for relevant energy carriers (e.g. electricity)
ETS price	Yearly carbon price development
Material cost	Yearly and regional cost data for relevant material inputs (e.g. fossil naphtha, green methanol)
CO ₂ transport and storage costs	Yearly cost data differentiated by site and spatial storage zones (e.g. onshore, offshore)
Installed plants	Capacity and age of existing plants and announced (or expected) projects
Biomass availability	Yearly and regional data on biomass cost and availability for use as chemical feedstock

Plastic waste availability Yearly and regional data on plastic waste availability for chemical recycling

Outputs

Parameter	Description
Production volume by technology / mode of operation	Per product (final or intermediate), and per region / location and year.
Material use	Per region and year
Installed capacity by technology	Per region / country / location and year. Can e.g., be used to examine intra-EU relocation.
Energy use	Per technology, and per region / country / location and year
CO ₂ emissions	Per technology, and per region / country / location and year
CO ₂ captured and stored	Per country / location / storage region and year

Selected project references

TRANSitioning towards an Efficient, carbon-Neutral Circular European industry (TRANSCIENCE)

Period: 01/2024 – 12/2027

Sponsor: European Commission, Horizon Europe

The project is developing a consistent, fully open-source model ecosystem for the transformation of European industry (MIC3 – Model for European Industry Circularity and Climate Change mitigation) to map and analyse the transition to a climate-neutral, sustainable and circular industry.

<https://www.transience.eu/>

EU Industry Pathways

Runtime: 08/2025 – 03/2026

Client: Agora Industry

In this project, researchers from Agora Industry, the Wuppertal Institute and the University of Kassel are developing and comparing three transformation scenarios for the European steel, petrochemical and cement industries with regard to Europe's strategic sovereignty – as well as the potential advantages of a moderate relocation of energy-intensive production steps within Europe.

<https://wupperinst.org/p/wi/p/s/pd/2521/>

EU-CHINA BRIDGE

Period: 01/2024 – 12/2026

Sponsor: European Union, UK Research and Innovation

The EU-CHINA BRIDGE project aims to accelerate the transition toward climate neutrality by fostering collaborative research on industrial decarbonisation, co-developing advanced modelling frameworks for sustainable pathways, and

establishing comprehensive emissions data through intensive stakeholder dialogue between Europe and China. In this project, the Wuppertal Institute is developing technology inventories, scaling-up paths and technology roadmaps for the European petrochemical and steel sector.

<https://www.eu-china-bridge.eu/>

Green Feedstock for a Sustainable Chemistry – Energy Transition and Resource Efficiency in the Context of the Third Feedstock Transformation in the Chemical Industry (GreenFeed)

Period: 02/2022 – 02/2025

Sponsor: German Federal Ministry of Economic Affairs and Energy (BMWE)

This project investigated pathways for the German petrochemical industry to transition from fossil fuels to a circular, climate-neutral system using renewable raw materials and carbon recycling. In collaboration with industry partners, researchers from the Wuppertal Institute, the University of Kassel, the DBFZ and the Karlsruhe Institute of Technology employed scenario analyses to develop robust, greenhouse-gas-neutral value chains.

<https://wupperinst.org/en/p/wi/p/s/pd/1993>

KNDE-Update 2024 – Climate-Neutral Germany – From Target Setting to Implementation

Client: Agora Agriculture, Agora Energiewende, Agora Industry, Agora Verkehrswende, Prognos

Runtime: 01/2024 – 10/2024

Building on the 2021 KNDE – Climate Neutral Germany study, this project provided an updated roadmap for Germany to achieve its 2045 net-zero goals while accounting for recent economic shifts and delays in the transport and building sectors. The Wuppertal Institute used detailed bottom-up modeling to refine industrial scenarios to ensure robust decarbonisation strategies.

<https://wupperinst.org/en/p/wi/p/s/pd/2384>

KNDE – Climate Neutral Germany 2050/2045

Runtime: 04/2020 – 06/2021

Client: Agora Energiewende, Agora Verkehrswende, Climate Neutrality Foundation

In a consortium led by Prognos and including the Öko-Institut and the Wuppertal Institute, this project developed comprehensive strategies to achieve climate neutrality in Germany by 2050/2045. The Wuppertal Institute utilised advanced system modelling to investigate industrial transformation, accounting for technological developments and reinvestment cycles to ensure a viable path toward a zero-emission economy.

<https://wupperinst.org/en/p/wi/p/s/pd/928>

Selected publications

Clemens Schneider, Max Åhman, Stefan Lechtenböhmer, Mathieu Saurat: A defossilised EU petrochemical production system: Consequences for the meta-cluster in the Antwerp-Rotterdam-Rhine-Ruhr Area. *Energy and Climate Change*, Volume 6, 2025, 100173, ISSN 2666-2787, <https://doi.org/10.1016/j.egycc.2024.100173>.

Supplementary information

ITOM GitHub code repository: <https://github.com/wupperinst/itom>

ITOM code documentation: <https://itom.readthedocs.io/en/latest/index.html>

ITOM PetChem model and full documentation:

<https://zenodo.org/records/15773104>

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