TECHNISCHE UNIVERSITÄT WIEN

Energy Economics Group

Modelling of regional and sectoral decarbonization pathways for Austria‘s industry by 2040

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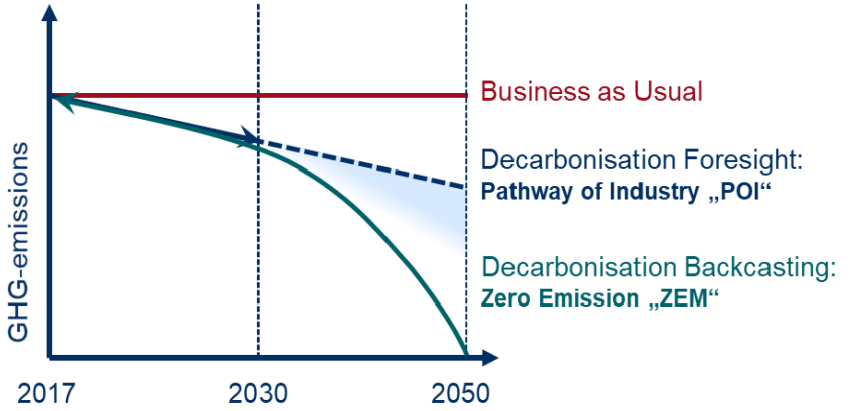
Research questions

1. What are the **minimum cost decarbonization pathways** for selected industry branches in Austria **up to 2040**, and what will be the impact on **energy consumption** of different energy carriers?

2. How does the available **energy network infrastructure** affect the results of the decarbonization pathways?

Motivation and background

NEFI
NEW ENERGY FOR INDUSTRY



A stylized representation of the three investigated scenarios in the NEFI report. Source: Pathway to industrial decarbonisation

Modeling insights from the Austrian national gas grid under declining natural gas demand and increasing domestic renewable gas generation by 2040

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ARTICLE INFO

Dataset link: 10.5281/zenodo.10454605, https://github.com/sebastianzwickl/modeling-national-gas-grid

Keywords:
Gas grid
Natural gas demand
Domestic renewable gas production
2040

ABSTRACT

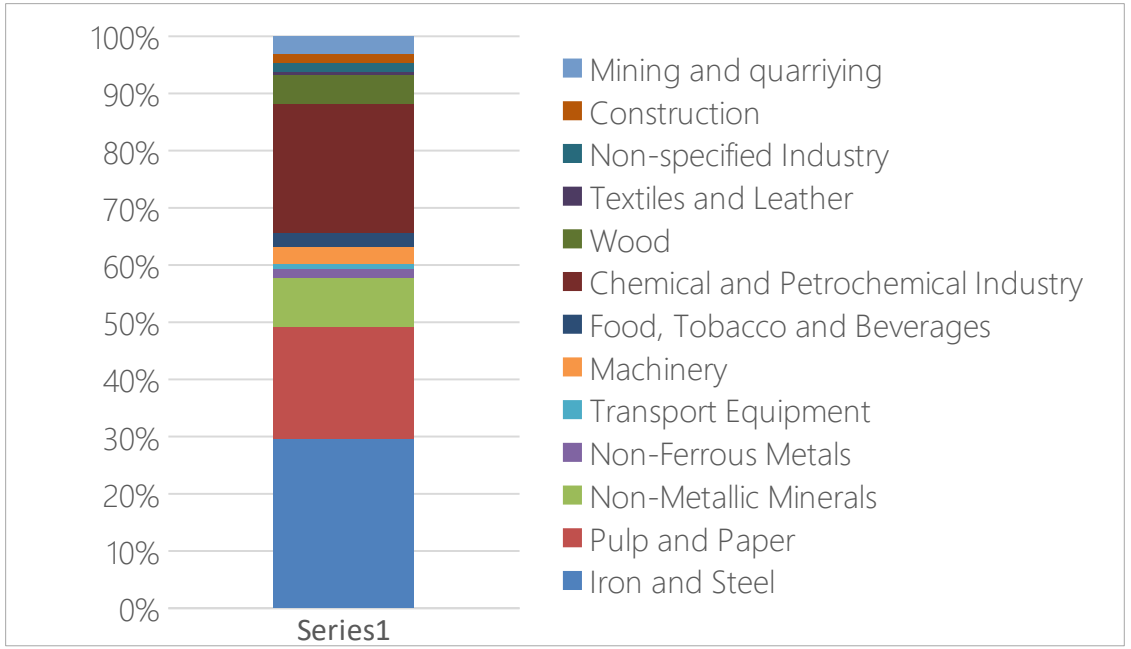
This paper studies the development of the Austrian gas grid by 2040 under different decarbonization scenarios, ranging from electrifying most energy services to importing large amounts of renewable methane. The Austrian gas grid serves as a case study representative for those gas grids confronted with a drop in natural gas demand and an increase in domestic renewable gas generation in the future. A mixed-integer optimization model with a focus on the detailed representation of the existing grid (gas grid levels, pipeline capacity, route, and age) is used to determine the cost-optimal trade-off decision between expected low-utilized gas pipelines and an off-grid supply alternative (e.g., trucking and on-site gas storage) in a decarbonized Austrian and European energy system. Optimality determines whether to operate, decommission, or make replacement investments in the grid's pipelines. Based on the required gas grid 2040 and its annual grid costs, estimates for tariffs of end customers are given. The paper's main conclusion is that the domestic distributed renewable gas generation uptake will be associated with the need for an area-wide gas grid, but one that will be significantly less utilized. Future work could address, among other things, the exploration of the spatial interplay of local production and demand by forming regional clusters of renewable gas.

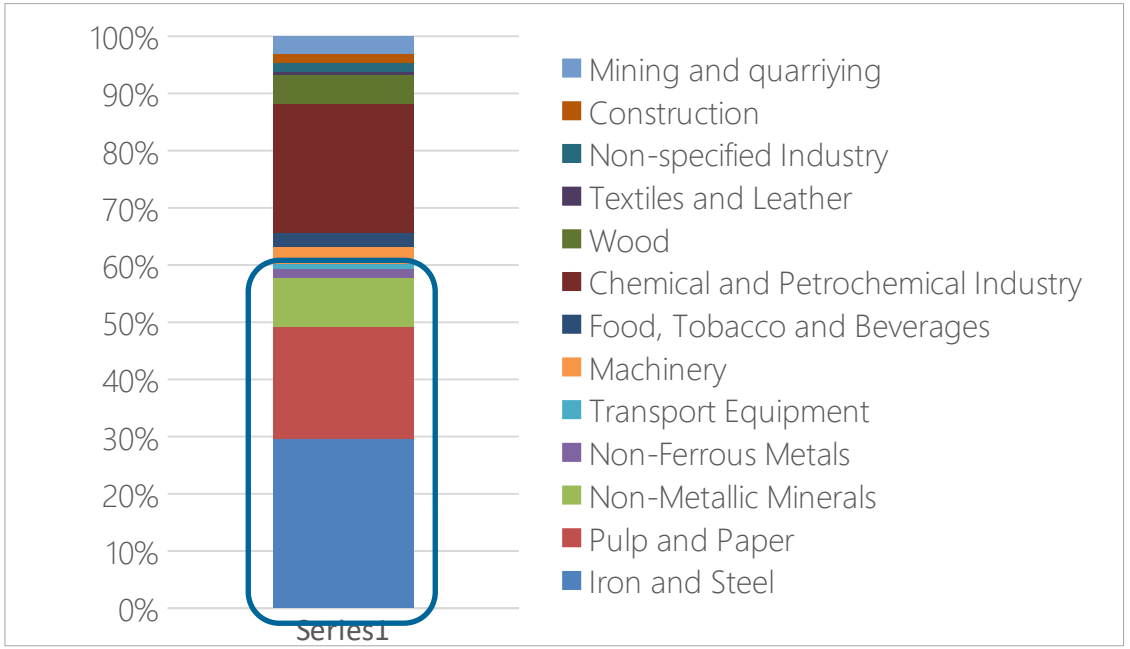
Scope of this work

Focus on 3 industrial subsectors and their decarbonization:

- Iron & Steel
- Pulp & Paper
- Non Metallic Minerals (Cement)

} Account for 64% of industrial emissions and 56% of industrial energy demand

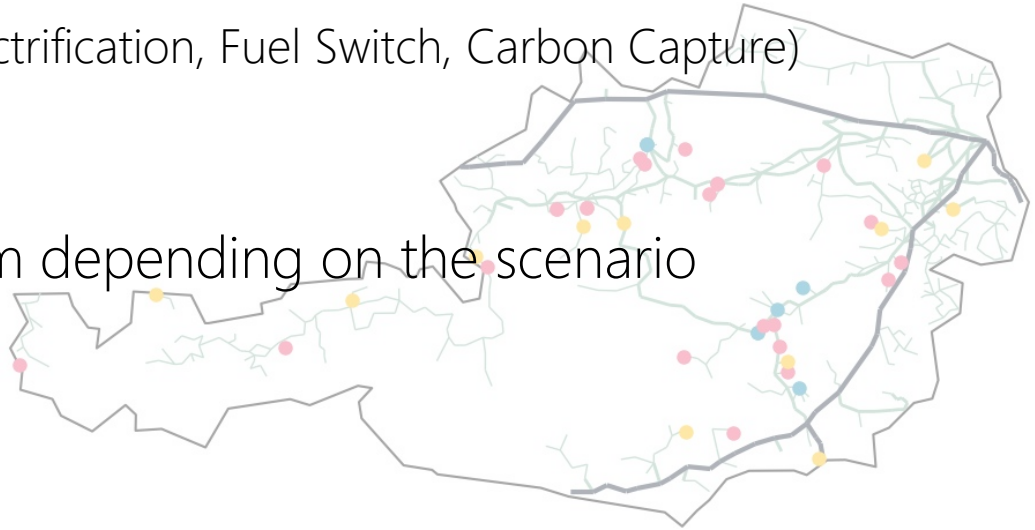




Share of total energy demand of the most relevant energy intensive industrial subsectors in Austria. Source: Statistik Austria

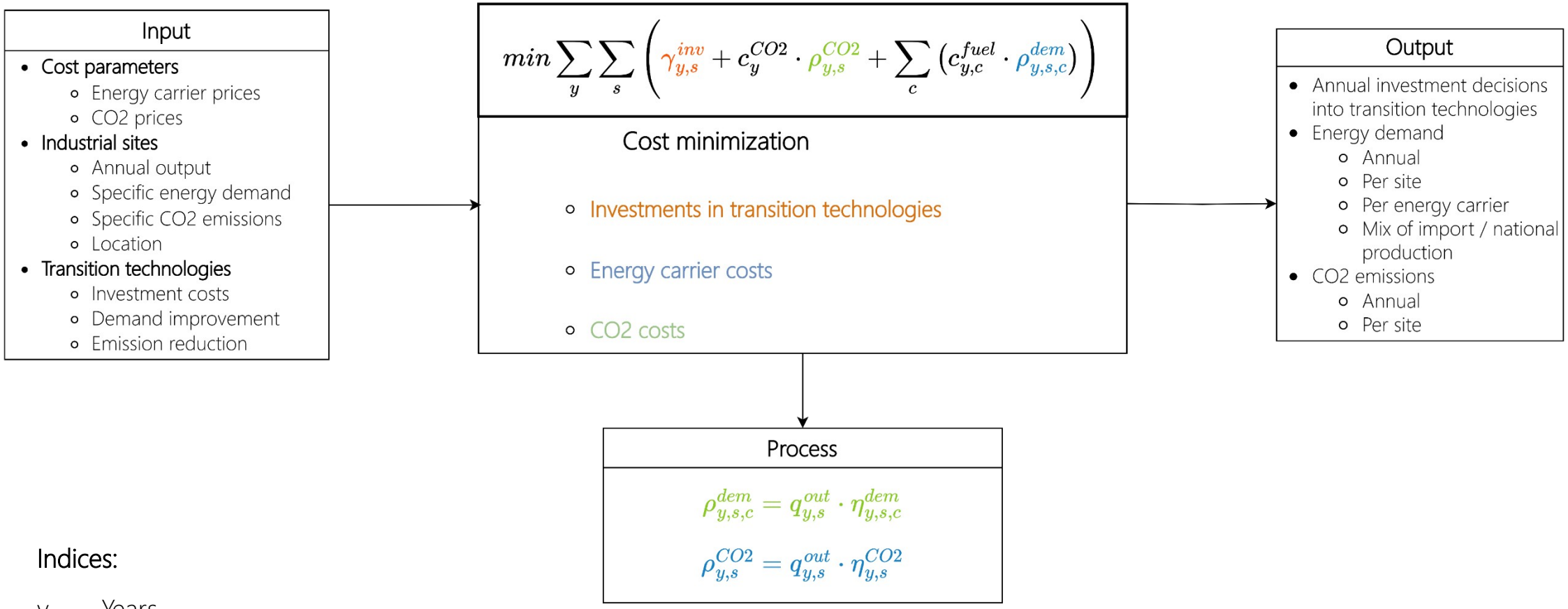
Modelling approach

- Identifying Austrian **industrial sites** in the respective subsectors
  - Annual production rate
  - Location
  - Specific energy demand and carbon emissions
- Research on **transition technologies,** their capability of process improvement, and their influence on the process
  - Pillar (Energy Efficiency Improvement, Electrification, Fuel Switch, Carbon Capture)
  - Technology readiness level
  - Emission reduction potential
- Energy carrier availability in the system depending on the scenario



Gas grid and industrial sites in 2020

Methodology



Indices:

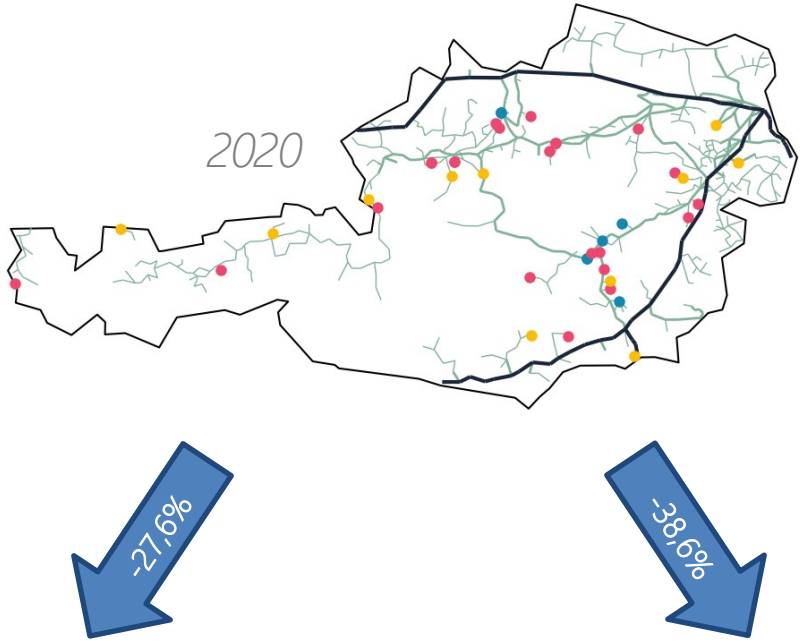
y ... Years

s ... Industrial sites

c ... Energy carrier

Scenarios

	2020	2040 *National*	2040 *Import*
Grid length	4.667 km Gas 0 km H2	3.381 km Gas 4864 km H2	2.866 km Gas 1993 km H2
Domestic renewable gas production	0 TWh	20 TWh	7,3 TWh
Domestic H2 production	0 TWh	14,3 TWh	7,2 TWh
Main assumptions		Low renewable gas and H2 prices	Low electricity prices



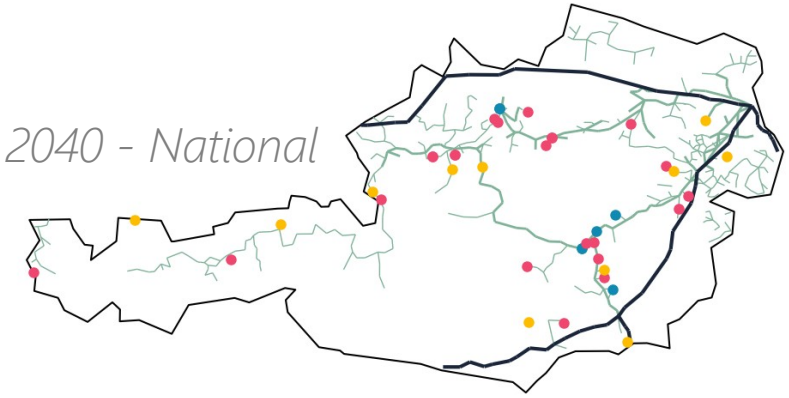
Gas Transmission Grid

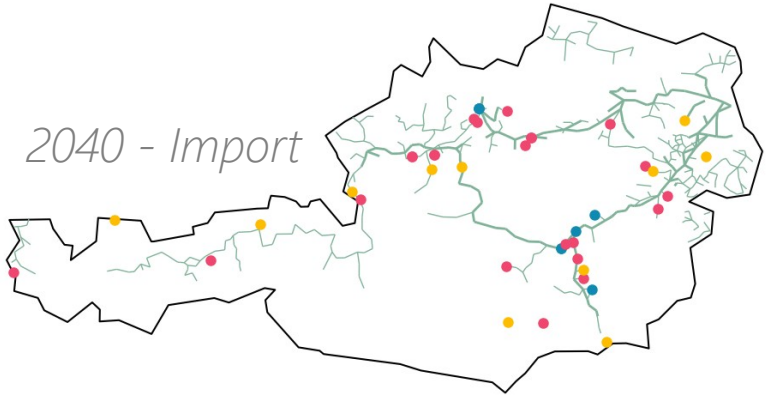
Gas High-/Mid-pressure Grid

Iron & Steel

Pulp & Paper

Cement





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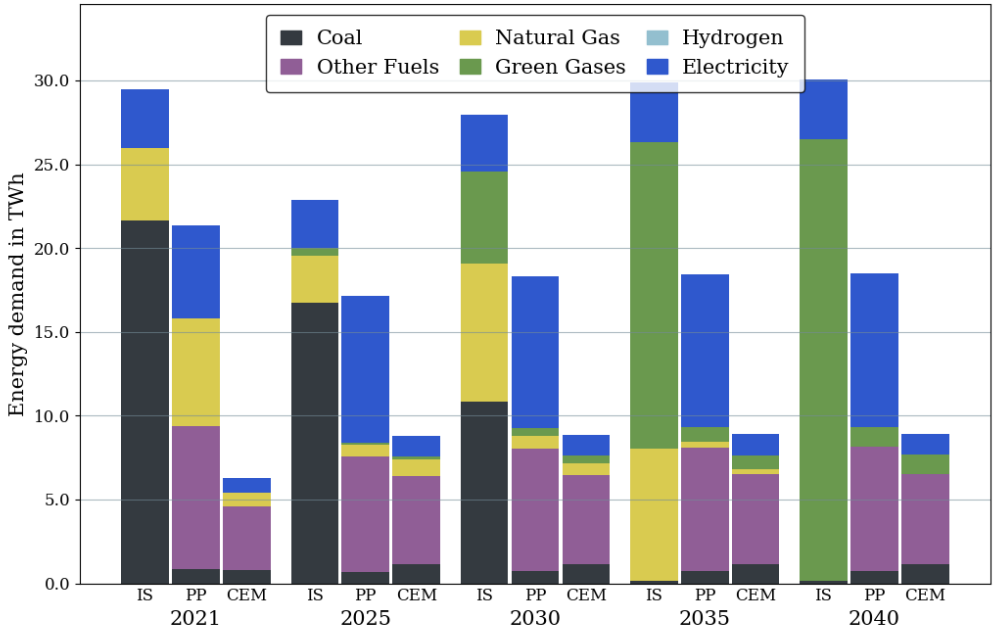
Results

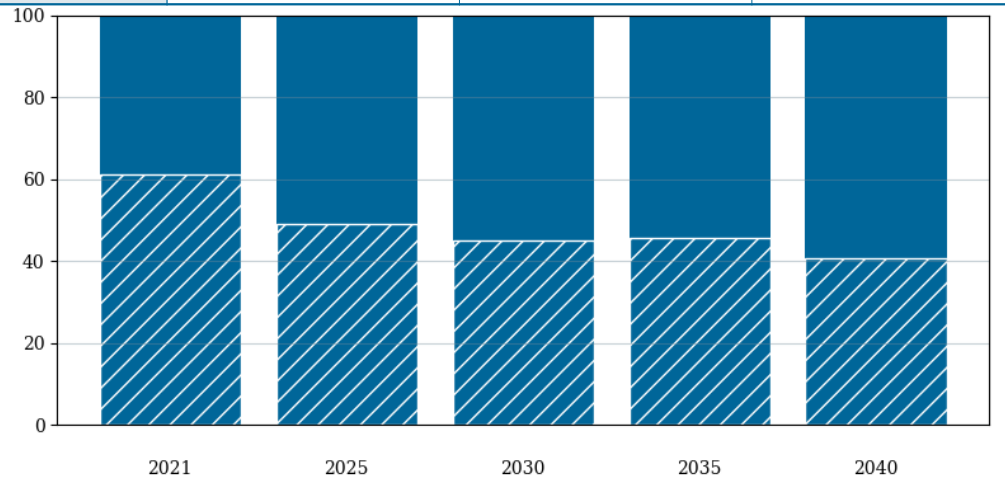
1. Results of scenarios *Import* and *National*
   - Energy demand of Iron & Steel, Pulp & Paper and Cement industry.
   - Costs:
     - Investment costs in transition technologies
     - Energy carrier costs
     - CO2 costs
   - Import ratio of the required energy
2. CO2 emission reduction 2020 – 2040
3. Result of a case from scenario *National*

Results – *Import* scenario



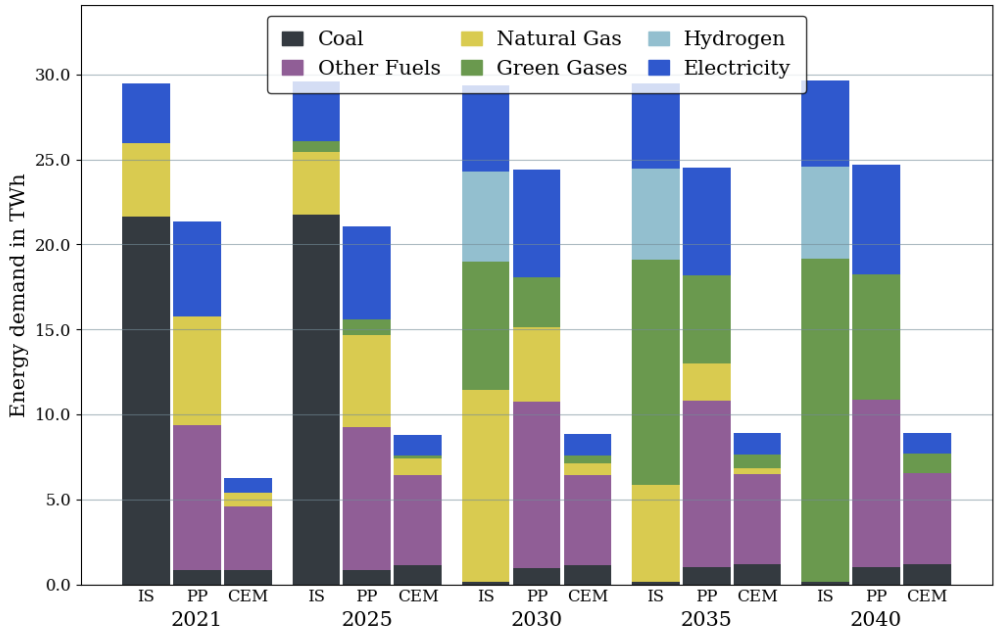
The energy demand of Iron&Steel, Pulp&Paper and Cement industry in Austria in the Import scenario.

	Investment costs	Energy carrier costs	CO2 costs
Iron & Steel	9 Mrd.€	18,57 Mrd.€	8,9 Mrd.€
Pulp & Paper	1,15 Mrd.€	12,04 Mrd.€	732 Mio.€
Cement	1,26 Mrd.€	4,05 Mrd.€	636 Mio.€
Total	11,42 Mrd.€	34,66 Mrd.€	10,27 Mrd.€



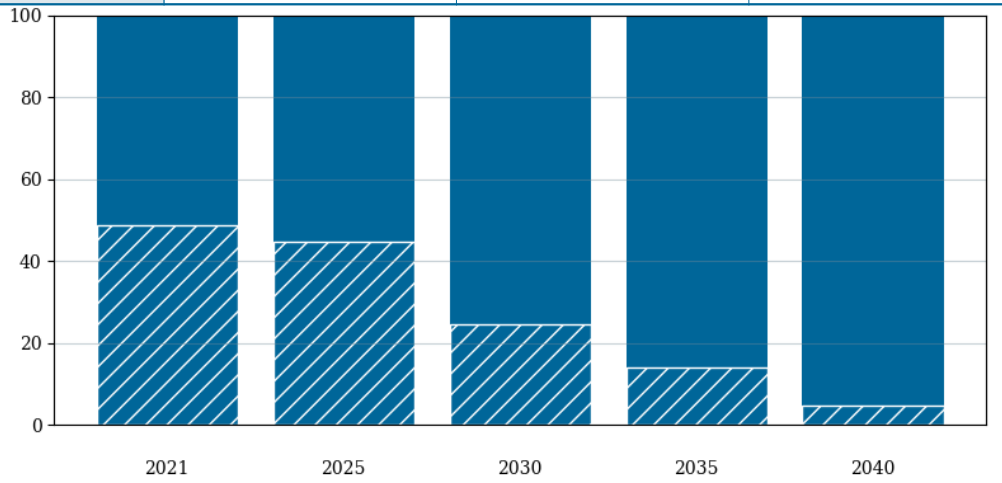
Import ratio (hatched) of the energy carrier demand (solid).

Results – *National* scenario



The energy demand of Iron&Steel, Pulp&Paper and Cement industry in Austria in the National scenario.

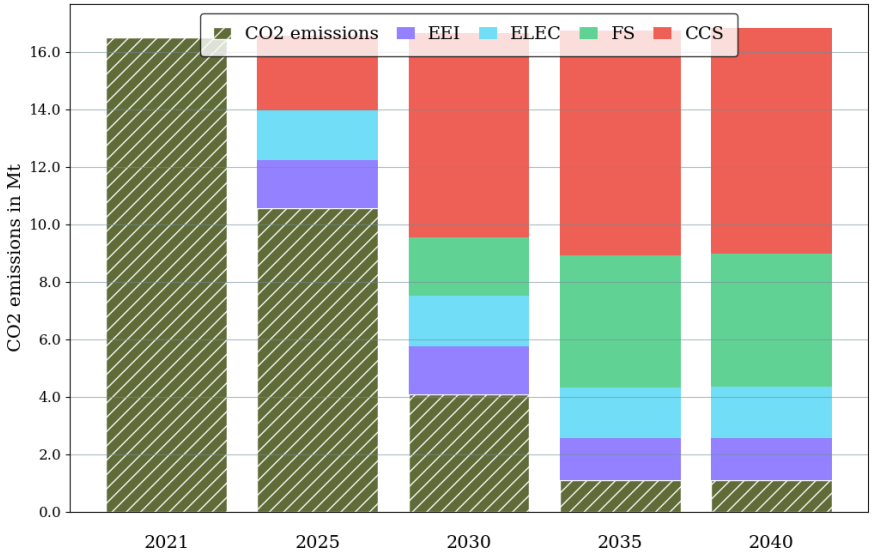
	Investment costs	Energy carrier costs	CO2 costs
Iron & Steel	7,43 Mrd.€	19,68 Mrd.€	8,25 Mrd.€
Pulp & Paper	1,07 Mrd.€	18,46 Mrd.€	816 Mio.€
Cement	710 Mio.€	5,09 Mrd.€	689 Mio.€
Total	9,21 Mrd.€	43,23 Mrd.€	9,76 Mrd.€



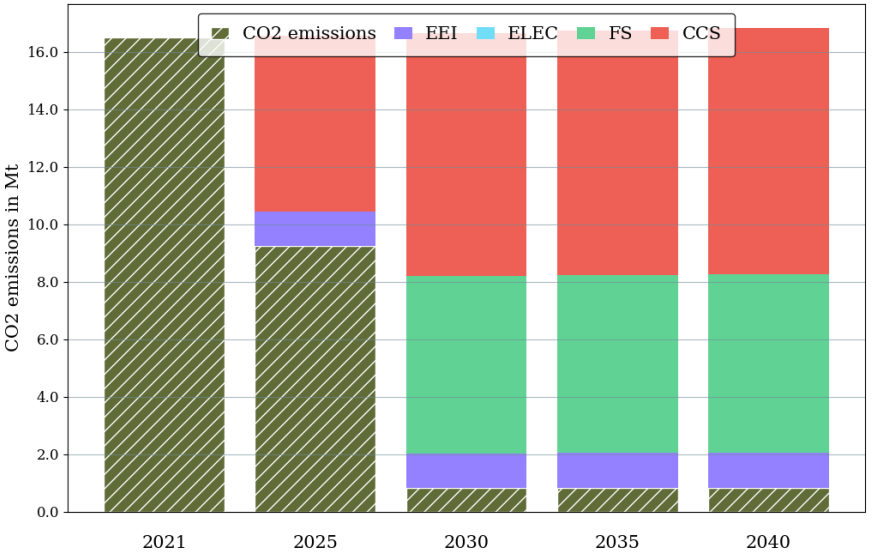
Import ratio (hatched) of the energy carrier demand (solid).

CO2 emission reduction

CO2 emissions and their **reduction potential** by each pillar (Energy Efficiency Improvement, Electrification, Fuel Switch, Carbon Capture) in MtCO2eq



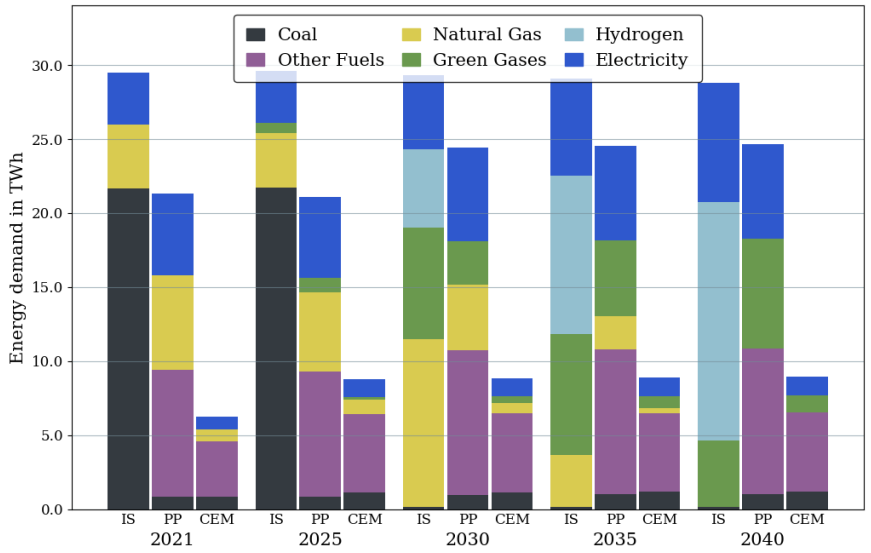
Scenario Import



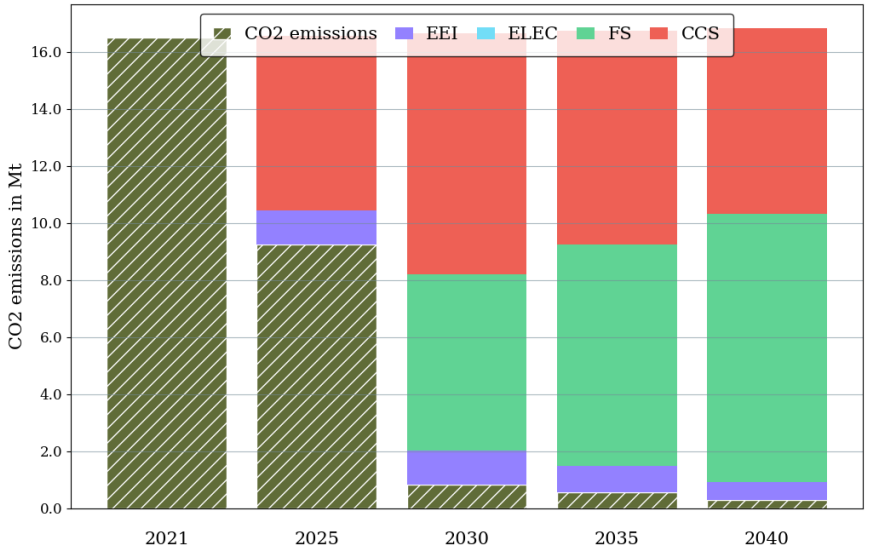
Scenario National

National scenario – domestic obligation

Case: The industry is obliged to use domestically produced H2.



The energy demand of Iron&Steel, Pulp&Paper and Cement industry in Austria.



CO2 emissions and their reduction potential.

Key takeaways

- Decarbonization pathways in the industrial subsectors.
  - **Iron & Steel** is switching to **Direct Reduction Iron** either with Natural Gas or Hydrogen
  - **Pulp & Paper** is being **electrified** or switched to **green gases**
  - **Cement industry** is using **Amine Scrubbing** to capture carbon emissions
- Switch to hydrogen only at low hydrogen prices and supportive regulatory frameworks
- **Availability of grid infrastructure** has a significant impact, because the amount of an energy carrier in the system and domestic production changes economic viability.
- Techno-economic modeling approach of **optimized investment decisions** into transition technologies in line with results of literature sources.

Future work

- Increase number of industrial subsectors in the model
  - For example chemical and petrochemical sector to consume captured CO2
- Include revenues to increase flexibility of the model
- Focus on circular economy and recycling of products as it is crucial for decarbonization in different subsectors
- Research on material flows to increase coupling between subsectors but also for efficiency analyzises in a site
- Information about processes can be further enhanced
  - Heterogenous product palettes
  - More detailed modelling of recycling of energy or material

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