REGIONAL AND SECTORAL DECARBONIZATION PATHWAYS OF AUSTRIA'S INDUSTRY BY 2040

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Motivation and core objective

Responsible for 24% of global greenhouse gas emissions, the industrial sector faces a fundamental transformation to achieve decarbonized energy systems [1]. Key to this green industrial transformation is the adoption of zero-emission technologies in industrial processes. In particular, the energy-intensive industrial sectors, which account for 70% of industrial GHG emissions, face an urgent need to take action while balancing decarbonization goals and economic competitiveness.

This conference paper contributes to the topic of green industrial transformation with a detailed analysis of the regional and sectoral decarbonization pathways of Austria's industry by 2040. In particular, the work focuses on the production of iron and steel, pulp and paper and non-metallic minerals with emphasis on cement. These sectors together account for annual emissions of more than 16 Mt CO2 in Austria, which is 64% of Austria's industrial emissions and have a cumulated energy demand of 62 TWh, 56% of industry's energy demand in Austria [2]. The core objective of this work is to investigate decarbonization pathways for the selected industrial sectors under the consideration of regional effects such as future fuel availability on the implementation of transition technologies.

The zero-emission technologies (e.g., waste heat recovery, direct reduction iron with hydrogen) investigated are implemented in different parts of the processes and can affect the energy demand and the GHG emissions. At the same time, our analysis differentiates also between GHG from fuel combustion and those from the industrial process itself. In general, different options for the decarbonization of the industrial process can be implemented (e.g., energy efficiency measures, switching from fossil-fuel powered heating processes to other green energy carriers such as electricity, hydrogen or green gases, carbon capture and storage/utilization, and circular economy measures).

Methodology

To study this problem, a linear model is formulated. The objective function is the cost minimization aimed to minimize total costs of the investments $c_{t,s}^{inv}$ into transition technologies, the CO2 costs $C_t^{CO2} * q_{t,s}^{CO2}$ and the energy costs $C_{t,s,carrier}^{fuel} * q_{t,s,carrier}^{dem}$:

$$\min_X z = \sum_t \sum_s \left(c_{t,s}^{inv} + C_t^{CO2} * q_{t,s}^{CO2} + \sum_{carrier} \left(C_{t,s,carrier}^{fuel} * q_{t,s,carrier}^{dem} \right) \right)$$

In this formula, t represents the years from 2020 to 2040, s the individual industrial sites and carrier the type of energy carrier.

The investment decisions into different technologies influence the following parameters:

- The specific CO2 emissions of an industrial site
- The specific energy demand for a carrier of a site whereas the switch from one energy carrier to another means, that the demand of the former carrier simply switches to zero

Moreover, some restrictions concerning the switch to zero-emission technologies are added, for example the future availability of fuel on a specific location. This particular constraint ensures the

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consideration of the regional effects of the decarbonization of the Austrian energy sector on the transition in the industry sector.

To include the future development of the energy network and the industrial processes accurately, data preparation is carried out:

- The development of the Austrian electricity network according to APG's Ten Year Network Development Plan [3] and the development of Austria's gas network according to [4] influence the energy carrier availability on specific locations.
- Research of industrial sites of the examined branches and their annual production of the respective product, which is an exogenous parameter in this analysis.
- Specifics of the technologies installed in industrial sites and transition technologies. These specifics include specific CO2 emissions and specific energy demand. Also, accurate knowledge on the energy flows of the processes is collected.

Preliminary results & conclusion

The first run evaluates the decarbonization of the respective industrial sectors without taking into account the regional energy networks. The second model run considers the network during the time period so that statements can be made on the efficiency of the network development when a decarbonized industrial sector is aimed.

References

[1] M. R. Mobarakeh und T. Kienberger, „Climate neutrality strategies for energy-intensive industries: An Austrian case study“, *Clean. Eng. Technol.*, Bd. 10, S. 100545, 2022, doi: https://doi.org/10.1016/j.clet.2022.100545.

[2] „NEFI_Szenarienbericht_v15_WHY_Design.pdf“. Zugegriffen: 30. November 2023. [Online]. Verfügbar unter: https://www.nefi.at/files/media/Pdfs/NEFI_Szenarienbericht_v15_WHY_Design.pdf

[3] „Planning the future grid - TYNDP“. Zugegriffen: 29. November 2023. [Online]. Verfügbar unter: https://tyndp.entsoe.eu/

[4] „Rolle der Gasinfrastruktur in einem klimaneutralen Österreich“. Zugegriffen: 30. November 2023. [Online]. Verfügbar unter: https://www.bmk.gv.at/themen/energie/publikationen/rolle-gasinfrastruktur.html