SUCCESS STORY

K1-MET SusMet4Planet Competence Center of Sustainable Digitalized Metallurgy for a Climate Neutral and Resource Efficient Planet

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USING DIGITAL TWINS FOR CLIMATE-NEUTRAL STEEL PRODUCTION

ASSESSMENT OF DECARBONIZATION PATHWAYS FOR AN INTEGRATED STEEL PLANT USING FLOWSHEET-BASED PROCESS SIMULATION

The steel industry faces the challenge of making its processes more climate-friendly. The traditional blast furnace process, which relies on coal, is to be gradually replaced by CO_2-lean technologies that use electricity and hydrogen, such as hydrogen-based direct reduction (DR) and electric arc furnaces (EAF). This transition significantly affects existing energy networks and leads to increased energy demands.

To explore these changes, a model of the integrated steel mill Linz was developed using the gPROMS simulation platform. This digital twin is based on real measurement data and provides a detailed representation of the plant's energy and gas flows. The various energy flows are shown in the figure below.

The gPROMS simulation software is already being successfully used by Primetals, voestalpine, K1-MET, and TU Wien to improve metallurgical production processes and evaluate more climate-friendly steelmaking methods. For this purpose, a proprietary model library called m.simtop was developed, which provides validated models for iron and steel production.

Based on these and other newly developed models, the digital twin was adapted to various possible future scenarios to evaluate changes in gas and energy networks. The modeled decarbonization pathways include natural gas and hydrogen-based direct reduction, electric arc furnaces, electric smelting furnaces and carbon capture, utilization and storage (CCUS) technologies. For each scenario, the

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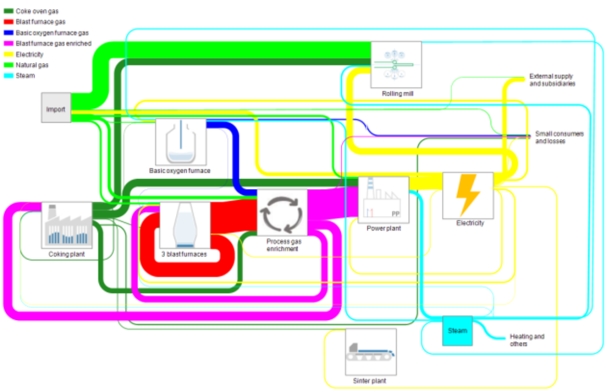
impacts on energy consumption (electricity, natural gas, and hydrogen), the steam network, and operating costs were analyzed.



Energy streams of the current steel mill Linz in MW-streams
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Impact and effects

The simulations reveal a significant increase in energy requirements when transitioning to low-CO_2 steel production, particularly for hydrogen and electricity. This underlines the importance of ensuring broad availability of green electricity and hydrogen at competitive prices. As operating costs shift from fossil fuels to electricity and hydrogen, economic feasibility will depend heavily on energy prices and CO_2 policies.

Furthermore, CO_2 capture and utilization technologies play a key role in reducing unavoidable emissions. Among the options analysed, the combination of amine-based CO_2 capture and catalytic methanation proves to be particularly promising, as it not only removes CO_2 emissions but also reduces dependence on fossil natural gas. The production of synthetic methane contributes to closing the carbon cycle.

This project demonstrates how digital twins and process simulations can support strategic decisions in the steel industry's transition to climate neutrality. The developed process models are also suitable for evaluating decarbonization strategies in other steel plants and carbon-intensive industries.

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