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Reducing industrial steam system temperatures to enable the utilisation of low-temperature heat sources –A review of the (Upper) Austrian industry

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The decarbonisation of industrial process heat must be promoted in all industrial sectors, as it depicts a crucial role in the corporate transformation. Rosenow et al. (2024) emphasize the significant role of heat processing in industrial energy consumption, accounting for approximately 66 % of the total industrial energy demand within Europe. As up to 77 % of this energy is derived from non-renewable sources, the need for action to decarbonise the industrial heat supply is evident.

While companies from the energy-intensive industry (EII) (Iron and steel production, non-ferrous metals, non-metallic minerals, chemicals and petrochemical, paper, pulp and printing) face major challenges due to their affiliated high energy consumption, solutions have already been outlined in this field. Regarding Nurdiawati and Urban (2021) supply side measures (such as electrification, alternative energy carriers, carbon capture and utilisation (CCUS) or energy efficiency measures) and demand-side measures (reusing or recycling of products to lower overall material intensity) are considered viable methods of the utmost importance for the transition of EII companies. Next to technological solutions, proper energy management plans can contribute to energy efficiency savings of up to 6 % for companies from the EII and up to 13 % for entities belonging to the non-energy-intensive industries (NEII) (Thollander & Palm, 2015).

The non-energy-intensive industry (consisting of wood and wood products, construction, textile and leather, food, beverages and tobacco, machinery and transport equipment, as well as all other non-specified industrial branches) accounted for 36,7 % of the total final energy consumption in Europe in the year 2022 (eurostat, 2022). Smaller and medium entities (SME) of the NEII are characterised by a lower ratio of energy related costs (usually 1- 3 % of the production costs, whereas EII representatives can easily succeed a 10 % share) (European Commission, 2022). Businesses from the NEII are usually bound to limited economic and workforce-related flexibility, leading to a lower grade of defossilisation-related measures (König et al., 2020). Therefore, a novel approach to lower overall steam system temperatures of corporations from the NEII with the aim to lower overall fuel usage and allow for a higher share of low-emission technologies to supply heat demand is proposed.

The aim of the paper is, firstly, to show that decarbonisation of process heat, particularly within non-energy-intensive industries, is significantly hindered by the prevailing tendency to operate steam systems at temperatures higher than necessary. Secondly, to highlight that current corporate strategies indicate this issue is unlikely to change, and thirdly, to explain the necessity of implementing temperature reductions in a manner that aligns with energy efficiency principles and non-fossil energy sources. To present the status quo, an empirical analysis was conducted on 20 production companies in Upper Austria between 2020 and 2022 as part of various research projects and proposals. These investigations focused on evaluating the feasibility of process heat supply through predominantly local, low-energy technologies.

To present the status quo, 20 Upper Austrian production companies were analysed in the years 2020-2022 as part of research projects or research proposals. Analyses were carried out to determine whether a process heat supply with (mainly local) low-energy technologies was possible.

Emphasizing the importance of lowering steam system temperatures to facilitate the integration of low-emission technologies in both NEII and EII sectors, one-quarter of the analysed companies belonged to the EII group. This underscores the significance of low- to medium-temperature heat demands within EIIs, where over 20 % of industrial heat consumption in the chemical and petrochemical industries, and more than 30 % in the paper, pulp, and print industries occurs at temperatures below 100 °C (Puschnigg et al., 2021).

Relevant company data from prior research projects and proposals were collected, focusing on existing heat

supply temperatures, current heat supply technologies, and (thermal) peak demand management. Due to confidentiality constraints, only the respective industrial sectors and descriptions of process heat systems can be disclosed.

By integrating generic research findings with company-specific insights, this study aims to provide conclusions for industry representatives and policymakers contributing to the effective design and implementation of future projects and funding schemes. Additionally, an evaluation of various approaches to lower steam temperatures - predominantly based on empirical data and supplemented by generic research findings - will be presented to support the increased adoption of low-carbon technologies.

Ultimately, despite the exploration of alternative supply options, two key observations can be made: (i) Gas boilers continue to be the standard choice for planned capacity expansions across all companies previously relying on gas-fired systems. Therefore, (ii) a reduction in process temperatures –and thus the precondition for enabling low-emission alternatives –does not appear to be a feasible approach for related entities. This cumulates in a lock-in effect, reinforcing the dependency on high process temperatures and fossil energy sources. Furthermore, the short-term focus of regulatory frameworks and the absence of targeted funding mechanisms for low-emission technologies intensifies this lock-in effect, limiting the adoption of critically important decarbonisation measures (Anderson et al., 2023).

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