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Modeling and simulation of the valorization of waste heat from hydrogen production in industrial applications

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Abstract

Aim and approach

Lately, there has been a notable surge in the momentum surrounding green hydrogen as a mean of reducing carbon emissions in challenging sectors like industrial activities (such as ammonia production and steel manufacturing) and heavy-duty mobility. To achieve this goal, the focus is being directed towards existing water electrolysis technologies. However, the current efficiencies of these systems are still limited to a range between 60 and 70% (amounting to over 30% in wasted heat). Currently, there is a lack of comprehensive studies exploring the potential synergies between hydrogen production centers and the utilization of thermal energy in various industrial applications. In that context, this paper aims to examine how the heat generated by electrolyser systems can be valorized in industrial applications.

Scientific innovation and relevance

One of the scientific breakthroughs of this research concerns the modeling and simulation of electrolyzer behavior. Through the utilization of Aspen Custom Modeler and Dynamics, the electrolyser's performance was simulated across different operational scenarios. These simulation outcomes were subsequently fed to a second inhouse simulation tool developed by CRIGEN to evaluate potential industrial uses for harnessing waste heat.

Preliminary results and conclusion

The study explores using electrolysis waste heat for industry, considering temperature needs, power range, and fluctuations. Utilizing this heat depends on process temperatures and managing temperature fluctuations caused by changes in electrolyzer power consumption. Various industries with sub-70°C heat needs were examined. Some suitable sectors for waste heat use include dairy pasteurization, malting preheating, bioreaction steam, metal treatment baths, plastic metallization, paper steam, and greenhouse heating. Also, waste heat could aid Multi-effect Desalination (MED).

Additionally, a cost analysis compared steam production using electrolyzer waste heat to different upgrading methods—high temperature heat pumps (HTHP), mechanical vapor recompression (MVR), and heat transformers (HT). Findings show economic viability hinges on capacity factors and electricity costs. E-boilers (EB) consistently proved more cost-effective than heat pump-heat transformer combos. For steady heat demand and higher

capacity industries, high temp heat pumps and vapor recompression seem more cost-effective, further supported by higher power prices.

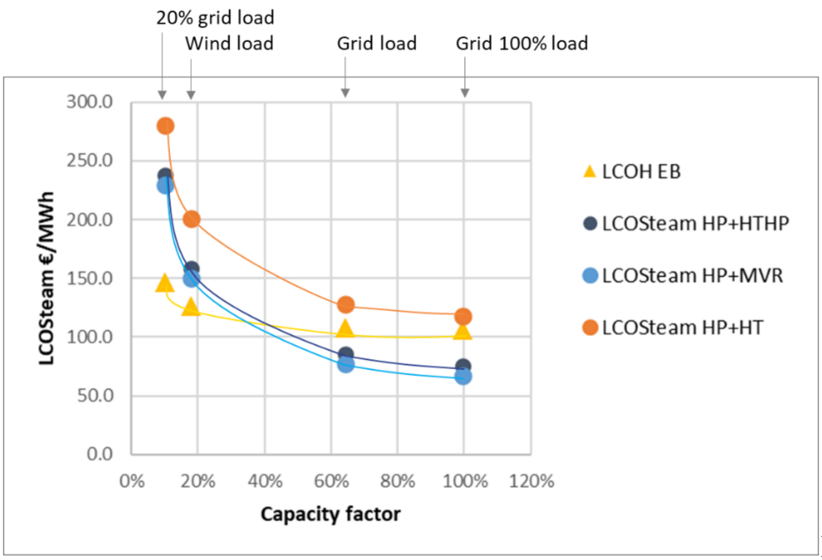

Figure 1 : LCOSteam depending on the capacity factor for the different scenarios studied (cost of electricity assumption 100€/MWhe, EB : electric boiler, HP : heat pump, HTHP : high temperature heat pump, HT : heat transformer, MVR : mechanical vapor recompression)

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