

Combining expansion turbines, heat pumps, and low-temperature solar heat for enhanced primary energy savings in gas pressure regulating stations

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Abstract

According to previous studies, gas pressure regulating and metering stations (GPRMS) in Germany account for a primary energy consumption between 1.4 and 2.0 TWh/a for the preheating of natural gas flowing through. This work assesses the potential of reducing this consumption through the combined use of expansion turbines, heat pumps, and solar thermal collectors. For this purpose, operation data of 57 GPRMS of a German gas network operator are used to design systems combining in different scenarios two and three of these technologies in each GPRMS. Using an in-house model developed in Python the 57 systems are simulated over one year with an hourly time step. The results show a potential for the installation of expansion turbines with a total capacity of 3.57 MW_{el}, leading, combined with the renewable heating technologies, to a reduction of more than 99 % of the original gas consumption for gas preheating. The results are then extrapolated to the whole country using scaling factors, showing a potential for feeding-in between 510 and 1,140 GWh/a of surplus electricity into the grid, on top of the almost complete elimination of the gas consumption for gas preheating. In total, the use of the complete technical potential available would lead to net primary energy savings between 1,710 and 3,650 GWh/a and net CO₂ emissions reductions between 470 and 1,010 kt/a. Overall, this work demonstrates that the combination of expansion turbines and heat pumps technically allows an almost complete decarbonation of the operation of GPRMS in Germany. In addition, significant amounts of electricity could be fed into the grid, especially during the winter months, which would contribute to decarbonise the electricity mix of the country. The amount of electricity fed into the grid can be increased with the additional use of low-temperature solar thermal systems. To exploit this potential in the future, current regulations should be adapted and targeted support programmes launched.

Keywords: Gas pressure regulating and metering station, Expansion turbine, Heat pump, Solar heat for industrial processes, Potential analysis

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