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A multi-objective energy planning including system exergy efficiency and socio-economic costs

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Abstract

Technical and economic objectives of the energy systems are often competing and improvement of one aspect will probably offset the other objective. Primary energy supply, energy efficiency and CO2 emissions are often the indicators used when evaluating technical aspects of the energy system. However, the above-mentioned indicators have problems evaluating different uses of scarce resources such as biomass in heat only boilers and/or cogeneration plants. In order to deal with the latter and other issues arising from purely focusing on energy efficiency aspects, a multi-objective linear optimization model was developed, encompassing objectives of both minimizing socio-economic costs and exergy destruction within the energy system, with the focus on energy supply. Sønderborg municipality in Denmark was chosen for the case study. Pareto frontier was created for a three alternative scenarios for the year 2029. All scenarios achieved net zero carbon emissions, with the total system costs being lower in different scenarios for 29.2%, 24.8% and 13.9% compared to the officially planned scenario. The net primary energy supply of the municipality in the best scenario was 1,312 GWh, 37.6% lower compared to the reference system of the year 2013.

Keywords: Exergy, Energy planning, Multi-objective optimization, socio-economic costs, zero carbon, Pareto frontier