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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