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Planning of Future Energy Systems focusing on exergy destruction minimization

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Mitigating harmful greenhouse gas emissions, increasing security of energy supply and developing a sustainable society in general are common topics on agenda when talking about future development of mankind. In order to achieve these goals, implementation of renewable energy sources is essential. In order to integrate intermittent power generation such as wind and solar energy, it is important to analyze, understand and plan a transition to low-carbon society. There are many energy planning tools developed for this purpose which focus on different specifics in a certain energy sector or on energy system as a whole. Usual targets in these modelling tools is to minimize socio-economic costs or to reduce the fuel consumption (and consequently to reduce CO2 emissions), using the energy conservation principle (the first law of thermodynamics) during the transformation from primary to end-use energy forms.

However, the second law of thermodynamics, which tells us about irreversibilities of conversion processes, can give us the answer about quality of specific energy form, information which cannot be obtained from the first law of thermodynamics. The concept connected to the second law of thermodynamics is Exergy. Exergy is the maximum useful work which can be obtained from the system by reaching the equilibrium with its environment. Due to the better developed methodology and clearer definition of methods used, a large share of researchers have been focusing on energy analysis, neglecting the beneficial outcome which can be obtained by exergy analysis. Thus, in this paper the authors are presenting the development of novel energy planning tool which focuses on minimizing the exergy destruction within the system. The developed model is a linear optimization tool, having in its initial phase only a few renewable technologies in heating and power sector. The comparison of energy and exergy analysis in energy planning has been shown on imaginary energy system comprising of 15 000 people, living in 7 000 households in Denmark and working in the island mode. Results have shown that a more sustainable energy system can be planned for using the exergy destruction minimization as the goal of planning process, especially the sustainable biomass utilization.