Abstract

In an era of increasing energy demand, it is crucial to develop methods that account for both the complexity of energy systems and their impact on the natural environment. Identifying appropriate tools is particularly important in the context of ongoing climate change and the need for more sustainable resource management. In response to these challenges, the PhD thesis ***Thermo-Ecological Cost assessment for renewable energy systems*** proposes new applications of the Thermo-Ecological Cost (TEC), enabling a comprehensive assessment of energy systems.

The research was conducted in several stages, encompassing different implementations of the Thermo-Ecological analysis. The main focus of the study was on renewable energy sources: wind turbines, solar energy systems (photovoltaic panels, solar collectors, and hybrid photovoltaic-thermal PV/T systems), a biogas-fuelled cogeneration engine, and heat pumps (ground- and air-source). The analysis also considered the possibility of electricity storage. In the first stage, the application of TEC analysis was developed for a single system, the PV/T system.

Subsequently, a microgrid based on renewable energy sources was designed. The analysis of the energy systems' operation was based on real meteorological data for the selected location. The designed grid was a multigeneration system producing electricity, heat, and useful cooling, corresponding to the real demand profiles for each energy service. In the next stage, the operation of the described microgrid was evaluated using TEC analysis, initially focusing on electricity production. In the final stage, the analysis was extended to include heat and cooling.

The results demonstrated that TEC analysis enables a cross-sectional assessment of energy systems. Compared to other commonly used indicators, such as energy efficiency, it better reflects the system's environmental impact. Furthermore, it allows for a clear assessment of the systems' influence on resource depletion and incorporates a broader environmental context. This makes TEC a tool suitable for analysing energy systems in the face of global challenges such as climate change and resource degradation.

Another important conclusion from the conducted analyses is the applicability of TEC in the design and study of microgrids. It allowed for the selection of energy source configurations that minimize non-renewable resource consumption while ensuring the best energy stability. The results also indicated that conventional methods, such as Thermo-Economic Analysis (TEA), may incorrectly suggest the benefits of systems that intensively utilise external resources. The application of TEC provided a significantly more accurate evaluation of systems in terms of sustainable resource use and offered valuable guidance for designing stable grids.

The presented research contributes to the advancement of knowledge in sustainable design of energy systems based on renewable sources. TEC analysis was adapted and expanded as a tool enabling a comprehensive assessment of systems' impact on non-renewable resources. The results also provide a basis for practical applications, indicating optimal configurations of renewable energy mixes and supporting the design of sustainable grids.