INVESTMENT PLANNING AND OPTIMIZATION OF URBAN AND RURAL HYBRID ENERGY SYSTEMS

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Overview

The key question of planning energy infrastructure for energy supply companies is whether to invest in new plants or maintain and optimize operation of existing power plants, energy grids and to implement also innovative technologies on the demand side. Based on this question, energy supply companies and local/ regional governments have to consider alternative solutions across traditional supply and demand sectors and make plans for the total integrated energy infrastructure (Bakken et al. 2007).

Until now, energy infrastructure e.g. electricity, natural gas and heat grids are planned and operated usually independent from each other. This is not least due to the implementation of unbundling rules in competitive energy markets, where market participant maximizes it individual benefits and profits. Due to this reason the full potential is not necessarily fully exploited of both power plant portfolio and grid energy operation. Therefore synergies as long as they are compatible with the implemented regulations and market rules, are envisaged in this paper.

Methods

This work develops an optimization model to minimize the energy system's total costs. The method uses a steady-state power flow model and optimizes to the cost-minimal investment. It is based on the multi-grid approach and the modelling of energy hubs according to (Schulze 2010; Kienzle 2011; Geidl 2007). Energy hubs are a simplification of an urban or rural area (i.e. it is an abstraction of a spatial area). An energy hub is characterized by a production capacity, energy consumption and storage capacity. Different energy hubs are connected by grids. Mathematically, energy hubs are formulated by a multidimensional linear system. These predefined energy sources are grid conducted energy sources (e.g. electrical, natural gas and heat grid) as well as stationary energy sources (e.g. coal or biomass).

The proposed model is formulated as a mixed-integer linear optimization problem which minimizes investment and operation costs. The existing energy infrastructure as well as different systems of energy hubs are modelled and compared by costs over a period of time (typically 20-40 years into the future). The work does not present an empirical study of a test region but shows the model's functionalities via test cases.

Results and Conclusions

The expected results of the investigated cases shall indicate optimal investment strategies differentiated by technology, energy carrier, supply/demand pattern, and others. It also determines the optimal technology portfolio and optimal investment trajectory as well as the optimal dispatch of existing and new power plants over the predefined planning horizon. Energy prices are used, among others, as sensitivity parameters. E.g. it will be shown that a high dynamic in energy price increases the risk of an investment in production facility and grid infrastructure.

References

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