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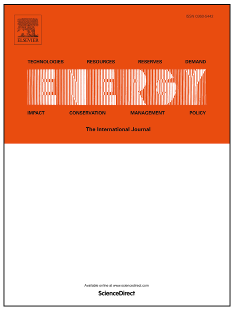

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District Energy Systems: Modelling paradigms and general-purpose tools

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Abstract

Future energy systems will be characterized by large shares of renewable energy sources, high system efficiencies, high flexibility in terms of supply and demand, diverse energy mixes, storage and demand side management options. Simulation is regarded as key method for concept development and assessment as well as for operational optimization to address the growing complexity of these systems and to derive quantitative feedback e.g., as input for decision-support or operational processes. In this paper we present a comprehensive comparison of four widely used general-purpose modelling tools for district scale energy systems, including a detailed discussion of modelling paradigms and co-simulation capabilities. This comparison is based on an extensive literature review, a comprehensive questionnaire that was conducted by tool and library developers, as well as a comparison of pipe model behavior of various libraries against measured data. The results including the experimental data are openly available and can support users in academia and industry with the selection of suitable modelling paradigms and associated tools and libraries.

Keywords: Modelling, Simulation, Co-Simulation, Tools, Energy System, District

1 Introduction

Future energy systems will be characterized by large shares of fluctuating renewable energy sources, high system efficiency and high flexibility in terms of supply and demand, broad energy mixes, storage options and demand side management options [1], [2]. In this context, urbanization and its positive and negative impacts is one of the main drivers, rendering cities as one of the hotspots of all our future energy problems as well as solutions. This fact becomes prominent if one considers the growth of people living in urbanizations of 54 % of the global population in 2014 to more than 66 % in 2050. Consequently, urban energy systems need to undergo significant changes, especially in Europe to meet the EU 2020 and 2030 climate targets (20 % and 40 % GHG emission reductions, respectively) [3].

The concept of a Smart Grid was introduced by Massoud and Wollenberg [4] and it refers to the security, agility, and robustness/survivability of a large-scale power delivery infrastructure that faces new threats and unanticipated conditions. A modern Smart Grid integrates advanced sensing, control methods and integrated communications on a transmission and distribution level. In the early days, this smart concept was defined and applied within a single sector and mainly within the electricity sector. Lund et al. [5] introduced the concept of smart energy systems to identify potential synergies and provide flexibility options for the overall energy system across multiple sectors like electricity,