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Editorial

Special Issue on Advanced Applications for Smart Energy Systems Considering Grid-Interactive Demand Response

A.H.M.E. (Angèle) Reinders [1,2]

[1] Department of Design, Production and Management, Faculty of Engineering Technology, University of Twente (UT), PO Box 217, 7500 AE Enschede, The Netherlands; a.h.m.e.reinders@utwente.nl

[2] Energy Technology Group, Department of Mechanical Engineering, Eindhoven University of Technology (TU/e), PO Box 513, 5600 MB Eindhoven, The Netherlands

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1. Introduction

The continuous growth of our fossil fuel demand for energy consumption and the related increase in CO_2 emissions [1,2] are essential motivations to conduct research on smart energy systems which are able to reduce the emission of greenhouse gases. Namely, to strengthen the global response to the threat of climate change, as stated by the Paris Agreement of the United Nations [3], the global temperature increase should stay below 2 °C, or, preferably below 1.5 °C. Because fossil fuel-related CO_2 emissions for energy purposes have increased consistently over the last 40 years, reaching 69% of global GHG emissions in 2010, an urgent transition to more sustainable, smart energy systems is required to stay below this temperature threshold of 1.5 °C. This sustainable energy transition will involve a huge effort by a varied group of stakeholders, including policymakers, industry, business developers, the public, engineers and also scientists. In this context, societal acceptance, technological development, and suitable market design are vital to realizing this goal. In particular, this applies to sustainable, smart energy systems at a human scale, which can be found in households and in neighborhoods, where people live and interact with their energy systems. These sustainable energy systems are called smart grid households or smart grid pilots if they are integrated into a neighborhood.

Each of the nine chapters in this book relates to this framework and was previously published in a Special Issue of the journal *Applied Sciences* on 'Advanced Applications for Smart Energy Systems Considering Grid-Interactive Demand Response'. As such the chapters in this book report interdisciplinary research results that combine technical, social, environmental, and economic aspects of sustainable, smart energy systems. For this Special Issue, authors were invited to submit manuscripts covering applied research on smart energy systems, smart grids, smart energy homes, smart energy products and services, and advanced applications thereof, in the context of demand response and grid interactions. Therefore, in this book, interesting results are presented based on the evaluation of real-life cases, energy pilots, prototypes of smart energy products, as well as end-user surveys and interviews.

2. Three-Layer Model for Assessments of Residential Smart Grids

This book presents an important framework, called the three-layer model, for the evaluation of a smart grid environment [4]. This three-layer model comprises three specific categories, or 'layers', namely, the stakeholder, market, and technology layers. Each layer is defined and explored, using an extensive literature study regarding their key elements, their descriptions, and an overview of the findings from the literature. The assumption behind this study is that a solid understanding of each of the three layers and their interrelations will help in a more effective assessment of residential smart grid pilots in order to better design products and services and deploy smart grid technologies in networks. Based on this review, it is concluded that, in many studies, social factors associated with smart grid pilots, such as markets, social acceptance, and end-user and stakeholder demands, are most commonly defined as uncertainties and are, therefore, considered separate from the technical aspects of smart grids. As such, it is recommended that, in future assessments, the stakeholder and market layers should be combined with the technology layer so as to enhance interaction between these three layers, and to be able to better evaluate residential smart energy systems in a multidisciplinary context.

3. Empowered Users

The active involvement of users in smart grids is often seen as key to the beneficial development of smart grids. In her chapter, Van Mierlo [5] investigates the diverse assumptions about how and why users should be active and to what extent these assumptions are supported by experiences in practice. This chapter presents the findings of a systematic literature review on four distinctive forms of user involvement in actual smart grid projects: demand shifting, energy-saving, co-design, and co-provision. The state-of-the-art knowledge reflects a preoccupation with demand shifting in the actual smart grid development. Little is known about the other user roles. More diversity in the types of projects regarding user roles would improve the knowledge base for important decisions defining the future of smart grids.

4. Indicators for Good System Design

Another chapter [6] frames the impact of various smart grid technologies, to provide a transparent set of indicators for the performance assessment of residential smart grid demonstration projects. The analysis comprises an evaluation of measured energy data of 217 households from three smart grid pilot projects in the Netherlands and a public dataset with smart meter data from 70 households as a reference. The datasets were evaluated for one year and compared, to provide insights into technologies and other differences based on seven key performance indicators, giving a comprehensive overview of system performance: monthly electricity consumption (100–600 kWh) and production (4–200 kWh); annually imported (3.1–4.5 MWh) and exported (0.2–1 MWh) electricity; residual load; peak of imported (4.8–6.8 kW) and exported (0.3–2.2 kW) electricity; import simultaneity (20–70.5%); feed-in simultaneity (75–89%); self-sufficiency (18–20%); and self-consumption (50–70%). It was found that the electrification of heating systems in buildings using heat pumps leads to an increase in annual electricity consumption and peak loads of approximately 30% compared to the average Dutch households without heat pumps. Moreover, these peaks have a high degree of simultaneity. To increase both the self-sufficiency and self-consumption of households, further investigations will be required to optimize smart grid systems.

5. Conclusions

In this book, the reader will further find interesting information about the design of smart energy products [7], about the transaction mechanism for energy pricing for prosumers [8], about ancillary services from residential heat pumps on the reserve market [9] and more. As such, we can conclude that this book provides an interesting overview of concurrent research on innovations into sustainable, smart energy systems, which is essential and indispensable for lowering the energy-related CO_2 emissions of our society. We wish our readers a good, inspirational reading experience.

Conflicts of Interest: The author declares no conflict of interest.

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