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PHD THESIS

Title

Self-consumption of solar electricity - Profitability for consumers and market diffusion of PV + battery systems in the residential sector

Abstract

The market diffusion of self-consumption technologies, such as photovoltaic and battery systems, is an important aspect in the transition towards a sustainable energy system. Most studies, which address this issue, focus solely on economic aspects and neglect the influence of individual electricity consumption behaviour and consumer preferences on the individual benefit of a self-consumption system. Yet, preferences and behaviour have a significant impact on the market uptake of new technologies, as can be seen in the current sales figures of batteries for the purpose of self-consumption enhancement. In my PhD thesis, a market diffusion model is developed that is based on 415 individual electricity load profiles, which define the homeowners' consumption behaviour. Further, individual heat pump and electric vehicle profiles are used to address the effect of the new technologies on self-consumption of each consumer. In addition, the results of a market survey are included to explicitly model different user groups and map their varying willingness to pay.

This interdisciplinary combination of technical modelling of PV production, and electricity consumption as well as data on consumer behaviour and preferences in the developed model, holistic understanding of the market diffusion of self-consumption technologies can be achieved. By analysing different individual households in detail and aggregating the resulting findings onto the level of the residential sector, a profound knowledge on the preconditions of the market formation, uptake and potential in the case of PV self-consumption is attained. In my work, I found that in the early stages of the market diffusion, the high willingness to pay of the innovative households is decisive for the market formation. In the medium to long term, the electricity and battery prices as well as the adoption rates are the main driver for the installation of battery enhanced self-consumption systems. Although the diffusion of electric vehicles and heat pumps affects the market for PV + battery system, their share among the entire population of households is currently small and will only have a significant effect on the market potential in the medium term.

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PROFESSIONAL EXPERIENCE

since 09/2013	Research Associate at Fraunhofer Institute for Systems and Innovation Research ISI, Karlsruhe, Germany
03/2017 – 05/2017	Visiting Researcher at the Build Environment Energy Systems Group, Uppsala Universitet, Sweden
10/2011 – 07/2013	Tutor for Mathematics for Engineers at the Dep. for Mathematics for Engineers, Universität Bayreuth, Germany

EDUCATION

since 12/2014	PhD Student at the Chair of Energy Economy and Application Technology, Technical University of Munich
10/2008 – 06/2013	Studies of Environmental Engineering (focus on Energy Sciences) at Universiät Bayreuth, Germany, Degree of Diplom-Ingenieurin (German Master equivalent)
08/2012	Summer School on Energy Economy at the Federal University of Novosibirsk, Russia
08/2010 – 01/2011	Study abroad at the Federal University of Santa Catarina (UFSC), Brazil

RESEARCH INTERESTS

- Analysis and modelling in the field of electricity demand forecast, energy efficiency and demand-side-management
- Analysis and modelling of the decentralized self-consumption

PUBLICATIONS AND CONFERENCE PRESENTATIONS (selected)

Klingler, A.-L. (2017): Self-consumption with PV + Battery systems: A market diffusion model considering individual consumer behaviour and preferences. In Applied Energy (2017) 205C: 1560-1570, DOI: 10.1016/j.apenergy.2017.08.159.

Klingler, A.-L., Teichtmann, L. (2017): Impacts of a forecast-based operation strategy for grid-connected PV storage systems on profitability and the energy system. In: Solar Energy (2017) 158C: 861-868, DOI: 10.1016/j.solener.2017.10.052.

Klingler, A.-L., Schuhmacher, F. (2017): Residential photovoltaic self-consumption: Identifying representative household groups based on a cluster analysis of hourly smart-meter data, Accepted for publication in: Energy Efficiency

This project has received funding from the European Union's Horizon 2020 research and innovation programme [GA-No. 691685].

Klingler, A.-L., Elsland, R., Boßmann, T. (2017): Where are the electricity load hot spots in 2035? A load curve analysis considering demographic and technological changes, 14th International Conference on the European Energy Market (EEM), 6-9 June 2017, Dresden. DOI: 10.1109/EEM.2017.7981993.

Boßmann, T.; Elsland, R.; Klingler, A.-L.; Catenazzi, C; Jakob, M. (2015): Assessing the Optimal Use of Electric Heating Systems for Integrating Renewable Energy Source. In: Energy Procedia (2015) 83: 130-139.

Klingler, A.-L., Gnann, T., Michaelis, J. (2017): The impact of charging infrastructure on the load shift potential of electric vehicles; Presented at IAEE Conference; 03-06 September, 2017; Vienna, Austria.

Klingler, A., Schuhmacher, F., Wohlfarth, K. (2016), Identifying representative types of residential electricity consumers – a cluster analysis of hourly smart meter data, 4th European Conference on Behaviour and Energy Efficiency (Behave2016), Coimbra.

Klingler, Anna-Lena; Marwitz, Simon (2016): Can residential self-consumption contribute to load reduction in low-voltage grids? 14. Symposium Energieinnovation, 10.-12.02.2016, Graz/Austria

Elsland, R.; Klingler, A.-L.; Degner, P.; Oswald, Y.; Wietschel, M. (2015): Are current regionalisation approaches sufficient to decompose electricity demand? – A German case study, 10th Conference on Energy Economics and Technology (ENERDAY), Dresden

Chudej, K., Klingler, A.-L. (2014): Optimal control of a 3D flight of a Hang-Glider through a thermal. ENOC 2014, 8th European Nonlinear Dynamics Conference, 6.-11.7.2014, Vienna/Austria.

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