GRID FINANCING STRATEGIES IN THE DEATH SPIRAL: A SIMULATION BASED ANALYSIS OF GRID TARIFF DESIGNS

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Overview

Renewable energies, especially photovoltaics (PV), have started a trend towards a decentralization of energy systems (European Parliament's Committee on Industry, 2010; Verbong & Geels, 2007). With decreasing levelized costs of energy of new renewable energies, self-consumption concepts become increasingly attractive and have even reached grid parity in some countries already (Schleicher-Tappeser, 2012). So called "prosumers" (households that are producers and consumers at the same time) start to replace grid consumers, conducting self-consumption with their locally produced electricity by the PV plants (Kesting & Bliek, 2013). Since complete autarky cannot be reached with a PV plant for a household, prosumers still consume electricity from the main grid. This on-going diffusion of self-consumption concepts is significantly influenced by the interplay of network externalities within the system, such as learning from peers, altering the perceived utility by households of the investment into decentral generation (Kubli & Ulli-Beer, 2016). The increasing penetration of photovoltaic significantly contributes to the creation of a more sustainable power supply in Europe (IRENA, 2015) and is considered and supported in many nations by governmental energy strategies. Nevertheless, such decentralization dynamics also lead to multiple challenges in the energy system. New investors enter the energy market (Helms et al., 2015), utility companies are forced to adjust their business models and grid operators face technical as well as financial challenges. The presented paper will be focusing on the financial challenges of grid operators caused by decentralization trends of the electricity system.

Current electricity transmission and distribution systems frequently apply a tariff structure based on the consumed electric work. With rising numbers of prosumers the income of grid operators declines due to the self-consumption by the prosumers. Prosumers consuming their own power require less energy from the central power supply system, but still use the services of the distribution grid operators to cover their electricity needs, respectively get them transmitted to the location of the demand, in times when the PV system is not generating sufficient electricity. As a result, with increasing diffusion of self-consumption concepts, it might become necessary to increase grid tariffs in order to compensate for losses, as the current grid tariffs will no longer cover the grid costs. In return higher grid tariffs increase the incentive for households to invest into a self-consumption concept, since this allows avoiding the grid tariff costs to some extent. This cycle of adapting tariffs for grid usage leading to higher attractiveness of prosuming has a reinforcing character and is often called "death spiral" (Costello & Hemphill, 2014; Felder & Athawale, 2014). The adjustment of the grid tariff potentially leads to a cross-subsidization within the financing of the grid, as conventional consumers implicitly subsidize consumers with self-consumption. Through the adjustment of the grid tariff due to the distributional effect conventional consumers have to pay more for the same consumption, while prosumers contribute less to the coverage of the fix costs driven costs of the grid. This situation raises many questions: is a new grid tariff design necessary to put an end to this vicious circle, to cover grid costs and protect grid operators from a decline in their incomes? What is the magnitude of the cross-subsidization among electricity consumers? What are the appropriate incentives for both to promote investments into new renewable energies and for running decentralized facilities in a grid-friendly way? And how is decentralized storage going to influence this setting?

Existing research addresses the diffusion of self-consumption concepts in dependence of the grid tariff (Darghouth et al., 2014; Schleicher-Tappeser, 2012), the adaption of grid tariffs and utility regulation in general (Ruester et al., 2014). The circular aspect and the developments over time of the death spiral are usually only addressed in qualitative discussions. Our research aims to address the feedback process of the death spiral in a system dynamics simulation framework. We follow the two research questions: "What are the long-term impacts of the death spiral on the decentralisation dynamics under different grid tariff designs?" and "Which grid tariff design minimizes the de-solidarization effect among consumers and maximizes the renewable energies penetration in the energy system?".

Methods

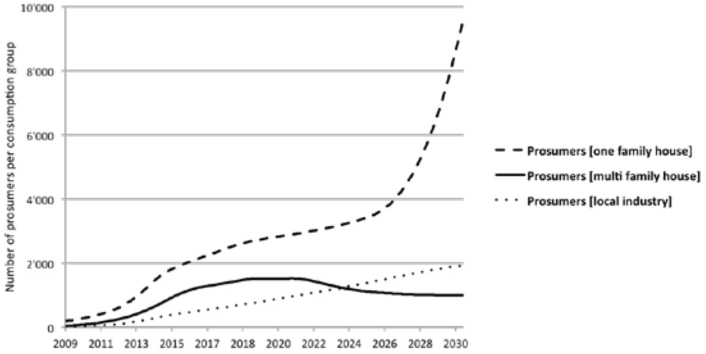
The research questions are investigated by means of the generic System Dynamics simulation model TREES (transition of regional energy systems) (Kubli & Ulli-Beer, 2016) that was enhanced to answer the above mentioned grid tariff questions. The model is calibrated to four different regions and finally simulated and analyzed for the case of the supply area of the utility company of Bern in Switzerland.

The model distinguishes between three consumption concepts: standard grid consumption, prosumers systems and advanced prosumers with a storage unit. The diffusion of the consumers within these three consumption concepts are determined by three feedback loops, which where deduced from the network theory literature: learning theory feedback loop, scarcity feedback loop and the death spiral feedback loop. The death spiral feedback loop can be varied in its particular effect and strength by applying different grid charge tariff designs. The currently applied tariff based on electric work can be exchanged with a) a flat rate tariff, charging the consumers based on an annual fixed price for the grid connection, b) a capacity tariff based on the maximum peak demand in the year and c) a dynamic grid tariff, which is applying a time-varying price depending on the consumption characteristics of the consuming unit. The simulation time period covers the years 2009 until 2030.

Results

The model was simulated for the four different tariff designs, considering realistic estimations for the development of PV costs and overall grid costs developments until 2030. Our preliminary results for the BKW supply area are presented in Figure 1. The simulation results clearly highlight that all other tariff designs than the work tariff lead to a significantly lower penetration of PV plants, as for the simple reason that the prosumer system does not reach the same level of attractiveness without the option to avoid a part of the grid costs. Despite the resulting lower attractiveness, we see that the prosumer concepts experiences a take-off in the later phase of the simulation. The analysis of the cost distribution among the different consumption concepts and the different consumption groups (one-family houses, multi-family houses and industry) concludes that there exists no single best tariff system which perfectly reflects the caused costs of all consumption concepts and groups at the very same time.

Figure 1: Simulation of the diffusion of porsumer concepts under a electric work grid tariff



The full text version of this paper will present the analysis and results in more detail, particularly discussing the advantages and disadvantages of the tariff design and their impact on the diffusion of self-consumption concepts and the distributional effects of the grid tariff design.

Conclusions

Integrating the two elements of the death spiral – namely the tariff adjustment due to increasing penetration of self-consumption concepts and the increased incentives for investments into self-consumption concepts due to tariff adjustment – in a simulation framework led to the following conclusions: the diffusion of solar PV systems will still develop on a moderate level for several years before having a take-off. Alternative grid tariff designs can cause a delay in the PV take-off. None tested alternative grid tariff designs can achieve a perfectly fair distribution of the caused grid costs. Consequently, further tariff designs or mixes of tariff designs have to be considered.

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