SQUARING THE SUNNY CIRCLE? BALANCING DISTRIBUTIVE JUSTICE OF POWER GRID COSTS AND INCENTIVES FOR SOLAR PROSUMERS

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Overview

Solar prosumers are about to revolutionize the power sector. Self-consumption of locally generated power increasingly challenges the ability of utility companies to recover costs of their distribution grid. As prosumers can avoid part of the grid costs under the volumetric grid tariff, costs are distributed differently among customers (Eid et al., 2014; Ruester et al., 2014). The scope of PV bill savings of solar prosumers particularly depends on the applied grid tariff design and types of net metering (Darghouth et al., 2011, 2014; Darghouth et al., 2016; Eid et al., 2014). Adjusting the grid tariff sets off a reinforcing feedback loop that increases the attractiveness of solar investments, but also leads to a distribution effect between solar prosumers and conventional consumers. The issue of cost recovery of distribution grids with solar prosumers is subject to a controversial political debate. The question is: How to recover distribution grid costs without hampering the diffusion of solar power? Frequently, a capacity tariff is discussed as a potential solution (Costello & Hemphill, 2014; Eid et al., 2014). In this study, I investigate the scope of the distribution effect and the deviation from the cost causation principle of grid consumers, solar prosumers and solar prosumers with storage. Furthermore, I test currently discussed alternative grid tariff designs.

Methods

I present a System Dynamics simulation model designed to understand the interactions and assess the competing goals of distributive justice and incentives for solar prosumers. The simulation model is designed, calibrated and simulated for the particular circumstances of the utility company of Berne (Switzerland) BKW Energie AG. The conceptual model framework of Kubli and Ulli-Beer (2016) was used as a basis, but was refined to a more realistic representation of the diffusion processes in the power system. The simulation model contains four major feedback processes – the cost recovery feedback loop, the peer effect, the probability of investor-roof match and the scarcity effect. Simulation results are evaluated for distributive justice along two measures: the distribution effect and the deviation from the cost causation principle. The diffusion of solar prosumers indicates the effectiveness of the tariff design in respect to achieving climate policies goals.

Results

The simulation results indicate a strong diffusion of solar prosumers in all simulated scenarios. Storage appears to play a crucial role in the analysis of the cost recovery of distribution grids. Prosumers with storage diffuse widely among the consumer groups. The base run, a scenario assuming unbundling of power generation and distribution with a net purchase and sales policy, leads to an increase of the volumetric grid tariff caused by self-consumption of 9%, with an installed base of PV of 358 MW in 2050 (Figure 1). In the case of the utility BKW Energie AG, conventional grid consumers would pay 13.5 CHF per year more due to the distribution effect. Net metering provides stronger slightly incentives for consumers to adopt the prosumer concept, but is less attractive for additional storage installation. Under the net metering policy, a much larger distribution effect arises, reaching a level of 25% in 2050 (Figure 1).

Alternative grid tariff designs were tested for their impact on the diffusion of self-consumption concepts, the distribution effect and deviation from the cost causation principle for the different consumer groups. The flat tariff prevents a self-consumption induced increase of the grid tariff, but lowers the attractiveness of self-consumption and hinders diffusion. The PV capacity expansion under the capacity tariff is smaller than in the base run, but sets incentives for consumers to invest and adopt a behavior that reduces peak demand. The capacity grid tariff successfully reduces the deviations from the cost causation principle, as consumers pay for the effectively needed connection size. Nevertheless, the capacity tariff still increases due to self-consumption diffusion, as the grid infrastructure already exists and has to be amortized. Therefore, the distribution effect, which considers historic costs, still increases, indicating that conventional grid consumers pay more than they would if there was no self-consumption. Considering that consumers can invest in a peak demand optimized behavior, by shifting demand and adjusting the storage management, the distribution effect increases to a level only slightly lower than under the volumetric grid tariff.

Conclusions

Overall, these findings confirm that a distribution effect occurs under the volumetric grid tariff with unbundling, but it is moderate in scope. Results highlight the importance of the tariff design induced investment incentives for solar prosuming. Changes in the attractiveness of the self-consumption concepts have a strong effect on the system development through their diffusion. A capacity tariff can reduce deviations from the cost causation principle of solar prosumers and incentivizes investments in decentralized storage solutions to reduce peak demand. Nevertheless, also the capacity tariff causes a distribution effect. Achieving perfect distributive justice while incentivizing solar prosumers seems impossible – like squaring a circle.

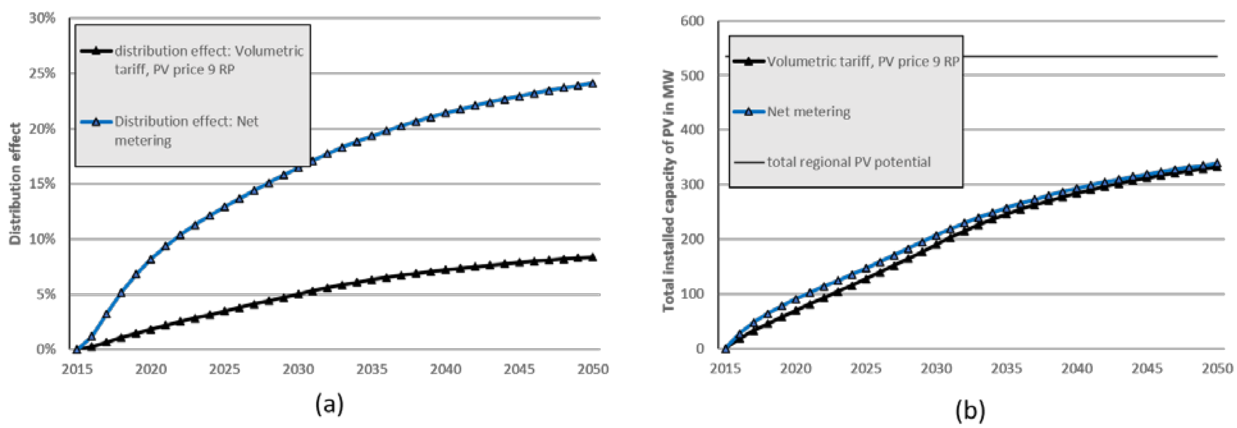

Figure 1: Distribution effect (a) and the installed capacity of PV (b) under the base run and the net metering scenario

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