INCREASING RENEWABLES IN ENERGY COOPERATIVES LEADS TO HIGHER CROSS-SUBSIDIES, DEPENDING ON TARIFF

Mohammad Ansarin; Rotterdam School of Management, Erasmus University, Netherlands; ansarin@rsm.nl
Yashar Ghiassi-Farrokhfal; Rotterdam School of Management, Erasmus University, Netherlands; y.ghiassi@rsm.nl
Wolfgang Ketter; University of Cologne, Germany; ketter@wiso.uni-koeln.de
John Collins; University of Minnesota, MN, United States; jcollins@cs.umn.edu

Overview

Renewable energy sources are replacing fossil fuel-based energy sources for electricity generation. In many regions, distributed RES (D-RES) are installed by end users who were previously passive consumers of electricity. These new consumer-producers, or "prosumers", often trade their energy use and generation with a managing aggregator. This aggregator can be organized by an energy cooperative. The prosumers' electricity trade is often facilitated through tariff subscriptions, similar to before. However, traditional tariffs designed for passive consumers are often incapable of adequately matching costs to revenues for grids with many prosumers. Hence, many distribution grid utilities have witnessed significant cross-subsidization (i.e. the undue transfer of costs from one prosumer to another) within their population (Picciariello et al. 2015). Many energy cooperatives have shown a momentous growth of D-RES in the past years and face a similar issue. Hence, an oft-asked question within past literature is "what kind of tariff is best in a high D-RES grid?".

Practically speaking, tariffing electricity is dependent on how it is measured. Electricity metering opens up two main considerations: (1) whether to use advanced metering infrastructure (AMI) and (2) whether generation and consumption should be treated separately (FiT metering) or not (Net metering).

In this article, similar to (Picciariello et al. 2015), we investigate the effect of increasing D-RES penetration on the cross-subsidization of various commonly-used or -discussed tariffs within an energy cooperative. Compared to their work, our study includes a more comprehensive set of tariffs. In addition, we compare net and FiT metering based on tariff cross-subsidies (Table 1). We vary D-RES installations from zero members to all members owning solar photovoltaic (PV) panels. We find that cross-subsidies increase as D-RES installations increase for the traditional tariffs (e.g. the flat-rate tariff).

Methods

We use data from the Pecan Street Dataport (more information at http://www.pecanstreet.org/) for the full year of 2016. This data was narrowed down to 144 households from Austin, TX, USA, with solar PV generation and consumption data. The household population was checked for heterogeneity with other datasets of household consumption patterns from the Austin, TX, area.

Table 1 - Tariffs used in this study. Generation is credited separately only for the FiT tariffs, and is credited along with energy costs for the Net tariffs.

Tariff	Metering	Energy Costs	Capacity Costs	Generation Credit
Conventional	FiT, traditional	Based on consumption tiers, from 7.4 to 15.6 c/kWh[1]	None (reflected in energy costs)	11.3 c/kWh
"Fixed-Price"	FiT and Net, traditional	Flat rate for all hours	None (reflected in energy costs)	11.3 c/kWh
2-Tiered Time-of-Use ("TOU")	FiT and Net, AMI	High daylight (6:00 to 22:00) prices and low nighttime (22:00 to 6:00) prices, from average ERCOT RTLMP	Billed separately	ERCOT RTLMP average per hour + 2.5 c/kWh renewable energy credit (REC)
"Real Time Pricing"	FiT and Net, AMI	ERCOT RTLMP average per hour	Billed separately	Energy costs + REC
Demand Charge	Net, AMI	ERCOT RTLMP average per hour	Household maximum net demand per month	Energy costs + REC
Actual Costs		*ERCOT RTLMP*	*Billed separately*	*Energy costs + REC*

Electricity delivery costs mainly consist of three parts: energy costs, capacity costs, and miscellaneous costs (e.g. billing, accounting). Since miscellaneous costs are equally levied among the households and do not contribute to cross-subsidization, they are ignored in this study. Energy costs mainly depend on the amount of energy used by a household at each time and the market price of electricity. The latter data was fetched from the Electricity Reliability Council of Texas' (ERCOT) Real-Time Locational-Marginal Prices (RTLMP) for the Austin, TX, load zone.[2]

[1] Data from https://austinenergy.com/wps/portal/ae/residential/rates/residential-electric-rates-and-line-items
[2] Data from ERCOT.com

Capacity costs mostly depend on the maximum amount of net demand of the entire grid over a long time horizon, i.e. one year or more. Here, we take this time horizon as one year and use costs from a local electricity distributor, Austin Energy, for a commercial or industrial entity to calibrate capacity costs.[3] In addition to costs, prosumers require payment (credits) for their produced electricity. These payments are typically subsidized in some manner by local or regional government to promote RES uptake. Here, we assume an extra 2.5 c/kWh is given above real-time local market prices for generation, similar to (Rábago et al. 2012).

The tariffs we use can be categorized based on their metering infrastructure requirements. For some tariffs, we investigate differing implementations of both Net and FiT metering. We calibrate these tariffs based on the data described before, along with residential tariffs from Austin Energy (titled "Conventional" in Table 1). All tariffs were calibrated to be revenue-neutral. Finally cross-subsidization C for each household is defined as the "costs transfer" (i.e. the tariffed costs per annum c_{tariff} minus the real costs per annum c_{real}) divided by the real costs per annum, as $C = \frac{c_{tariff} - c_{real}}{c_{real}}$.

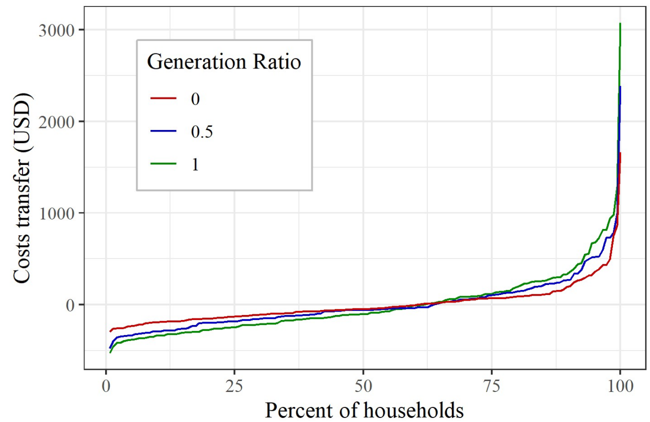

Figure 1 - Costs transfer sorted from low to high for the Flat-rate FiT tariff for multiple generation ratios.

Results

Our analysis results in multiple conclusions, of which we report two here. First, We find that as the ratio of households with generation units increases, cross-subsidies between households also tends to increase (Figure 2). The median costs transfers per household for the Flat-rate FiT tariff increase from 100.10 USD to 217.66 USD; as a ratio, the median cross-subsidization increases from 13.8% to 71% of the annual electricity bill (Figure 1 and Figure 2). In comparison, median costs transfer values for the FiT TOU and RTP tariffs are much lower at 7.5 and 0.52 USD, respectively.

A second interesting observation is that the DC tariff's cross-subsidies are not significantly affected by generation volume. In the DC tariff, capacity costs are retrieved from a demand charge dependent on the maximum monthly net demand of households (Table 1). With increased generation, these values are similarly reduced across households over time, and thus their share in cross-subsidy creation will remain the same. However, the overall cross-subsidies are small compared to that of the tariffs that depend on traditional metering, i.e. the Flat-rate FiT and Net and the Conventional tariffs (Figure 2).

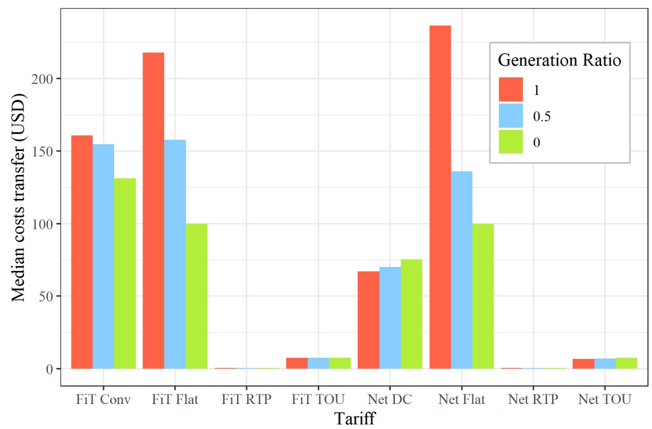

Figure 2 - Median costs transfers for all tariffs in this study per generation ratio.

Conclusions

Tariff design is a careful balancing act of multiple considerations. One of these considerations is economic efficiency, which we have attempted to quantify here with cross-subsidization. The traditional flat-rate and volumetric tariffs seem to no longer be suitable from this standpoint for electricity trade with residential households. However, how to balance economic efficiency with sending suitable economic signals for energy efficiency and demand side management is an open issue. While a Demand Charge is best for sending suitable net demand reduction signals, it increases cross-subsidies for capacity costs. The Time-of-Use pricing has much lower cross-subsidies, but sends very rough, and problematic in the long run, economic signals. The RTP tariff is the benchmark for tariffing energy and capacity costs, but the information signal is hard to decode and act on by end users. A suitable tariff design would balance the economic efficiency requirements of the grid with these signalling considerations.

References

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Rábago, Karl R., Leslie Libby, Tim Harvey, Benjamin Norris, and Thomas Hoff. 2012. "Designing Austin Energy's Solar Tariff Using a Distributed PV Value Calculator." In *Proceedings of World Renewable Energy Forum*.

[3] Data from https://austinenergy.com/ae/commercial/rates/commercial-electric-rates-and-line-items