CROSS-SUBSIDIES IN ENERGY COOPERATIVE TARIFF DESIGNS

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Overview

Reducing carbon footprint due to sustainability concerns has motivated energy efficiency and replacing fossil fuel-based generation for renewable energy sources, some as distributed decentralized units (D-RES). This decentralized energy generation creates a new paradigm in the electricity grid, that of a conventional energy consumer turned producer (a “prosumer”). Prosumers require an enabler to provide energy use locally and remove unnecessary energy trading with a remote central point. This can be accomplished through forming “microgrids”, which provide the physical infrastructure as well as information exchange platform to control such a system. Microgrids are sometimes managed via an “energy cooperative”, which is a decentralized, democratic coordination method, examples of which exist in Germany (Yildiz et al. 2015).

Energy cooperatives require new tariffs designs for pricing their electricity use. Traditional tariff designs assume passive consumers as end-users, but this assumption does not hold for cooperatives with D-RES volumes. Thus, they require a new tariff design to match electricity supply and demand (Picciariello et al. 2015). Particularly, conventional tariffs designed for passive consumers can cause cross-subsidization, i.e. the subsidizing of electricity use by one group of consumers for another group. In the case of high distributed solar PV generation, there is already evidence from California, US, and New South Wales, Australia, that cross-subsidization probably happens from high-income to low-income households (Borenstein 2015; Simshauser 2016). These studies looked at cross-subsidization under net metering, where consumption and generation is metered as one connection. However, in some jurisdictions generation and consumption are metered and accounted separately. We investigate cross-subsidization amounts in such scenarios.

We investigate cross-subsidization in an energy cooperative developed from household data from Austin, Texas, US. We assume that all cooperative households have a PV panel and their energy generation and consumption is metered separately. We first calculate cross-subsidization under a conventional tariff, drawn from a local municipality utility. We next find cross-subsidization values if the tariff were to match actual electricity costs. Our results show that current tariffs create massive amounts of cross-subsidization, which are probably by-products of the energy efficiency policy baked into the conventional tariff’s design. However, additional cross-subsidization exists, which can be reduced with new tariffs based on hourly metering.

Methods

We use data from the Pecan Street Dataport[1] for the full year of 2016. 150 households contained usable data for this study and were all utilized. These households have separate metering and accounting for PV panel generation and consumption.

Table 1- tariffs used in this study

Tariff	**Energy Costs**	**Capacity Costs**	**Generation Credit**	**Miscellaneous Costs**
Conventional Tariff	Based on consumption tiers, from 7.4 to 15.6 c/kWh[2]	None (Reflected in energy costs)	11.3 c/kWh	Billed separately
“Fixed-Price” Tariff	Flat rate for all hours	None (Reflected in energy costs)	11.3 c/kWh	Billed separately
2-Tiered Time-of-Use (“TOU”) Tariff	High daylight (6:00 to 22:00) prices and low nighttime (22:00 to 6:00) prices, from average ERCOT RTLMP	Separately billed	Energy costs + 2.5 c/kWh renewable energy credit (REC)	Billed separately
“Real Time Pricing” Tariff	Average of ERCOT RTLMP per hour	Separately billed	Energy costs + REC	Billed separately
Actual Delivery Costs	*ERCOT RTLMP*	*Separately billed*	*Energy costs + REC*	*Billed separately*

Electricity costs generally consist of energy costs, capacity costs, and other miscellaneous costs. We assume that the latter depends only on the number of households connected and thus does not depend on tariff design. Currently, these households can be subscribed to Austin Energy’s residential tariff. This tariff is a volumetric tariff based solely

[1] More information at http://www.pecanstreet.org/
[2] Data from https://austinenergy.com/wps/portal/ae/residential/rates/residential-electric-rates-and-line-items

on monthly energy use designed to promote frugal energy consumption. There is also a separate Value-of-Solar credit for solar PV panel owners. To compare, we design a set of additional tariffs that price electricity not only based on energy use, but also capacity use (Table 1). Energy costs were based on ERCOT real-time locational marginal prices (RTLMP) [3]. Capacity costs are assumed as that of a commercial entity of similar size[4]. Lastly, we define cross-subsidizaton for each household as the ratio between electricity costs per annum for a given tariff (c_{tariff}) and the actual electricity delivery costs (c_{real}):

$$C = \frac{c_{tariff} - c_{real}}{c_{real}}$$

The same calculations are also done separately for electricity generation as credits per annum. All tariffs are calibrated to be revenue-neutral.

Results

We find that there is significant cross-subsidization under the conventional tariff. This is mainly as a result of volumetric tariffing based solely on electricity use, designed to discourage excess consumption. Compared to a flat rate with similar revenue, this tariff creates heavy cross-subsidization (Figure 1, top). However, this is often from high energy users to light energy users. Thus, such cross-subsidization is not the main discussion topic here.

Next, we compare cross-subsidization between the flat-rate, TOU, and RTP tariffs. For consumption, the TOU tariff greatly reduces the cross-subsidization already and there is minimal gains from implementing an RTP tariff (Figure 1, middle). However, for generation, credits change drastically between the TOU tariff and RTP tariff (Figure 1, bottom). This is because the TOU tariff contains two tiers, one of which is the only one used by generation, which is only active at daytime. Hence, it appears as a flat-rate tariff for generation.

Conclusions

Reducing the cross-subsidization of a flat-rate tariff requires updating metering and accounting from a monthly period to an hourly period, and also separating capacity costs from energy costs. The Cross-subsidization can be mostly mitigated with an RTP tariff. Cross-subsidization amounts are also much lower than previously found in net metering scenarios (Simshauser 2016; Borenstein 2015).

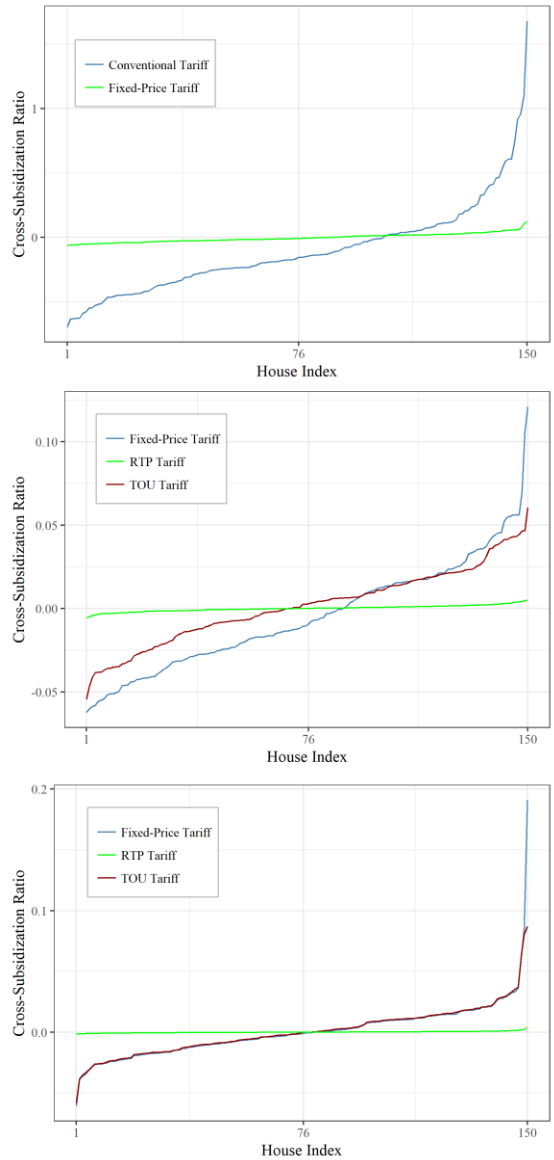

Figure 1 - Cross subsidization spread for consumption (top and middle) and generation (bottom) per household, sorted from lowest to highest values.

References

Borenstein, Severin. 2015. “The Private Net Benefits of Residential Solar PV: The Role of Electricity Tariffs, Tax Incentives and Rebates.” Working Paper 21342. National Bureau of Economic Research. http://www.nber.org/papers/w21342.

Picciariello, A., J. Reneses, P. Frias, and L. Söder. 2015. “Distributed Generation and Distribution Pricing: Why Do We Need New Tariff Design Methodologies?” *Electric Power Systems Research* 119 (February):370–76. https://doi.org/10.1016/j.epsr.2014.10.021.

Simshauser, Paul. 2016. “Distribution Network Prices and Solar PV: Resolving Rate Instability and Wealth Transfers through Demand Tariffs.” *Energy Economics* 54 (February):108–22. https://doi.org/10.1016/j.eneco.2015.11.011.

Yildiz, Özgür, Jens Rommel, Sarah Debor, Lars Holstenkamp, Franziska Mey, Jakob R. Müller, Jörg Radtke, and Judith Rognli. 2015. “Renewable Energy Cooperatives as Gatekeepers or Facilitators? Recent Developments in Germany and a Multidisciplinary Research Agenda.” *Energy Research & Social Science* 6 (March):59–73. https://doi.org/10.1016/j.erss.2014.12.001.

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[3] Data from http://www.ercot.com/content/cdr/html/hb_lz

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