NET METERING SCHEME FOR SOLAR ENERGY: HOW ARE COSTS AND BENEFITS DISTRIBUTED BETWEEN HOUSEHOLDS WITH AND WITHOUT SOLAR PANELS?

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Overview

Solar panels are crucial in the transition from a fossil-based to a renewables-based energy system. A widespread policy to foster their adoption by households is net metering (Dufo-López and Bernal-Agustín, 2015). The latter scheme allows households with grid-connected solar panels to feed their excess electricity production to the grid at retail prices. Specifically, net metering usually involves one meter, and the electricity costs for the households are based on the yearly difference between consumption and own generation. This policy has been shown to be one of the most cost-effective (Darghouth et al., 2011; Londo et al., 2020) and easier to implement (Duke et al., 2005) measures to incentivize residential solar panel adoption.

The net metering scheme has a negative effect on electricity prices, because more production from renewables in a given hour implies a lower wholesale price of electricity in that hour (so-called merit order effect), as well as a positive effect, as retailers may charge more to offset the costs of supplying electricity to households with solar panels. Moreover, net metering implies that the burden of electricity bill levies is disproportionately larger for households without solar panels. However, the distribution of these effects between households that install solar panels (henceforth, PV households) and those that do not (non-PV households) has rarely been addressed in previous literature. The present study aims to fill this gap and provide policymakers with a more complete toolset to evaluate and mitigate the inequality between households due to the net metering scheme.

Thus, we develop a model to measure the effect of net metering on households statically and to capture the dynamic effects of retailer (i.e. tariff adaptation) and government (i.e. tax rate design) behavior. We employ this model to investigate whether there are systematic differences in the size of these effects between households with and without solar panels and the drivers of these differences. Then, we conduct a scenario analysis to infer what retail choices and policy changes may mitigate the cross-subsidies of electricity costs and taxes. Our analysis also provides insights into the international differences in scheme designs and distributional effects as we compare the net metering scheme applied in the Netherlands to those in Spain and Italy, as these countries apply this policy in slightly different formats.

Methods

We identify three main channels through which net metering affects households' utility bills, which have only been considered separately by the previous literature. Firstly, net metering incentivizes residential solar energy production, which negatively affects the hourly wholesale price of electricity when the sun is shining through the merit order effect (Mulder, 2023). Secondly, net metering implies that retailers need to sell the excess electricity produced by PV households on the market, in hours when the wholesale price is lowest, and they need to supply electricity to PV households when the wholesale price is highest. Yet, retailers are only compensated for the annual difference between PV households' generation and consumption. Thus, net metering forces retailers to spread their costs differently (Satchwell et al., 2015), which may lead to higher retail rates and to cross-subsidies from non-PV to PV households (Clastres et al., 2019; Kim et al., 2023). Lastly, energy taxes are generally dependent on electricity consumption, which implies that PV households contribute considerably less than similar non-PV households to the government budget (Londo et al., 2020). In response to this, the government may either raise the tax rates, which disproportionately negatively affect non-PV households, or include a fixed portion next to the variable tax rate, which would decrease the inequality in contributions between PV and non-PV households. However, the latter option would reduce the incentive for households to use less energy, which usually is the main motivation behind such energy taxes.

Having established these three channels, we develop a model for the net benefits of households based on the economic analysis of the electricity wholesale and retail markets and the net metering regulation in the Netherlands, Italy, and Spain. The net benefits depend on the retail and wholesale electricity prices, the energy levies, and the network costs. We obtain data on these variables from the ENTSO-E Transparency Platform and the national energy regulatory authorities and we conduct interviews with retailers to infer their pricing response to net metering. On the basis of this model, we estimate the distribution of the net benefits of net metering between PV and non-PV households both statically and over time accounting for government and retailers' behavior. Furthermore, we conduct a scenario analysis to identify the government and retailers' choices that may mitigate the cross-subsidies.

Results

Our preliminary results, using Dutch data from 2019, show that the merit order effect (MOE) reduces the retailer's cost for non-PV households, yet it increases that for PV households. Indeed, as visible in Figure 2, the retailer earns revenues from selling the excess electricity generated by PV households, however, this excess generation only occurs when the sun is shining, implying lower revenues due to the MOE. Moreover, we obtain tentative estimates of the total electricity bill for households, as presented in Figures 3 and 4. We assume perfect competition in the retail market such that the variable tariff imposed by the retailer is the sum of its costs per unit of electricity supplied. This results in a small cross-subsidy from non-PV to PV households, yet this effect varies depending on the size of the MOE and of the excess generation from PV households. We also compute the tax rate that would yield the same tax revenues as a situation without residential solar PV production, as we expect governments to raise tax rates to keep a constant budget. The contribution to this budget by PV households is significantly smaller than that by non-PV households.

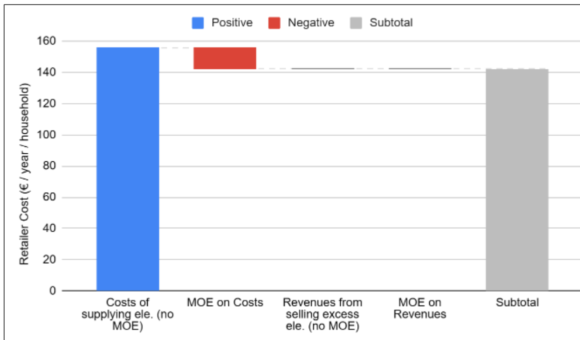

Fig. 1: Retailer costs for non-PV households (tentative results for the Netherlands in 2019).

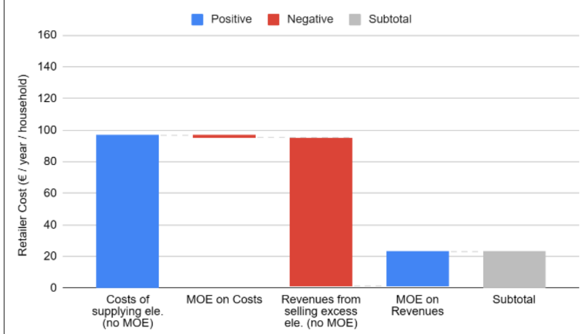

Fig. 2: Retailer costs for PV households (tentative results for the Netherlands in 2019).

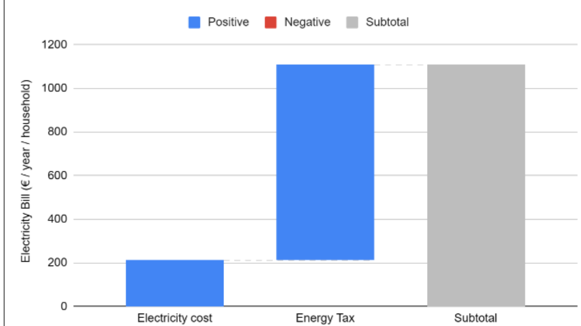

Fig. 3: Electricity bill for non-PV households (tentative results for the Netherlands in 2019).

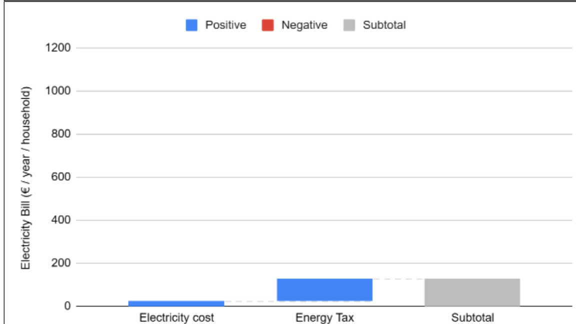

Fig. 4: Electricity bill for PV households (tentative results for the Netherlands in 2019).

Conclusions

Our preliminary findings suggest that non-PV households benefit from net metering though lower wholesale costs due to the MOE, yet, these benefits are much smaller than the costs of extra taxes. We expect our complete analysis to provide more insights into the possible mitigation strategies for this inequality between PV and non-PV households as well as into the effect of wholesale price variation and geographical characteristics on this inequality. Overall, this study aids policymakers in reducing the inequality across households caused by net metering and improving this policy's design, which is crucial to achieving a fair and sustainable energy transition.

References

Clastres, C., Percebois, J., Rebenaque, O., & Solier, B. (2019). Cross subsidies across electricity network users from renewable self-consumption. *Utilities Policy, 59*, 100925.

Darghouth, N. R., Barbose, G., & Wiser, R. (2011). The impact of rate design and net metering on the bill savings from distributed PV for residential customers in California. *Energy Policy, 39(9)*, 5243-5253.

Dufo-López, R., & Bernal-Agustín, J. L. (2015). A comparative assessment of net metering and net billing policies. Study cases for Spain. *Energy, 84*, 684-694.

Duke, R., Williams, R., & Payne, A. (2005). Accelerating residential PV expansion: demand analysis for competitive electricity markets. *Energy policy, 33(15)*, 1912-1929.

Kim, J., Baek, K., Lee, E., & Kim, J. (2023). Analysis of Net-Metering and Cross-Subsidy Effects in South Korea: Economic Impact across Residential Customer Groups by Electricity Consumption Level. *Energies, 16(2)*, 717.

Londo, M., Matton, R., Usmani, O., van Klaveren, M., Tigchelaar, C., & Brunsting, S. (2020). Alternatives for current net metering policy for solar PV in the Netherlands: A comparison of impacts on business case and purchasing behaviour of private homeowners, and on governmental costs. *Renewable Energy, 147*, 903-915.

Mulder, M. (2023). *Regulation of Energy Markets: Economic Mechanisms and Policy Evaluation* (Vol. 80). Springer International Publishing.

Satchwell, A., Mills, A., & Barbose, G. (2015). Regulatory and ratemaking approaches to mitigate financial impacts of net-metered PV on utilities and ratepayers. *Energy Policy, 85*, 115-125.