***Rooftop solar PV: In whose interests ?***

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## Overview

Rooftop solar photovoltaics (PV) have grown around the world and in Australia. A rooftop PV system is now installed on every sixth house in the state of Victoria, Australia. These households typically export at least twice as much rooftop PV output to the grid as they use themselves. Government policy seeks to extend rooftop PV to every third house. While policy support for distributed energy production is politically popular, the industry, some economists and regulators have expressed concern that rooftop PV is privately beneficial but at others’ expense. However the absence of data on customers’ actual prices and volumes, their gross PV production and the amount of their own PV production they use in their own homes, has prevented rigorous assessment of the market and price impacts of rooftop PV. We analyse the electricity bills of 48,677 households of which 7,212 have rooftop PV to estimate the impact of rooftop PV on charges for access to the network, and on wholesale market prices. In the context of revenue cap regulation for network access, we find that residential rooftop solar PV has raised network access charges for all customers by $1.3/MWh. However this was offset five times over by the impact of rooftop PV in reducing wholesale market prices from what they otherwise would have been. While policy support for rooftop PV is often considered to be “middle class welfare”, this analysis finds that all consumers benefit from lower prices attributable to rooftop PV, although larger consumers are likely to have gained disproportionately more. Continued rapid expansion of rooftop PV is likely to be in all consumers’ interests although the arrangements for policy support merit reconsideration.

## Methods

We assess whether rooftop PV reduces prices in wholesale markets more than the increase in prices associated with foregone network use of system income.

To determine the impact of rooftop PV on network charges, we use the model in Mountain and Gassem (2020) to estimate the rooftop PV capacity (in kilowatts) for each of the 7,212 households with rooftop PV, and which form part of a dataset of 48,677 retail electricity bills that were provided to us. These bills were voluntarily uploaded to the Victorian government’s price comparison website over the period from July 2018 to December 2018. Relevant data (such as usage, tariff type and rate, rooftop PV export, feed-in prices, discounts, government concessions, distributor and retailer) are extracted from the PDF files using commercially available software specifically designed to automatically extract information from pdf files (described further in Mountain and Rizio (2019)).

From this we estimate the gross annual solar production for each household. Since the annual rooftop PV production exported to the grid is estimated for each customer based on the data in their bills, it is possible to derive the rooftop PV production used on the premises of those dwellings with rooftop PV. From this we estimate the impact of rooftop solar on the revenues recovered by network service providers through an OLS regression with annual distributor revenue as the dependent variable and the volume of grid purchases (plus rooftop PV-sourced electricity used on the premises for households with rooftop PV), dummy variables for whether the household had a concession, controlled load or rooftop solar, their distributor and tariff type as independent variables. Model diagnostic tests are undertaken to validate the robustness of the findings

To determine the impact of rooftop PV on wholesale electricity markets, in the tradition of “merit order effect” studies (e.g. Würzburg, Labandeira and Linares, 2013; Cludius *et al.*, 2014; Bushnell and Novan, 2018) and following Percy and Mountain (2020) we regressed the half hourly Settlement Price in the Victorian regions of the National Electriicity Market as dependent variable against wind generation, solar (large scale and rooftop PV) generation, demand plus inter-regional exports, gas prices, coal generation capacity, and a dummy to account for monthly fixed effects as independent variables. The data used in the model covered half-hourly intervals from 1st April 2016 to 30th October 2018. Model diagnostic tests are undertaken to validate the robustness of the findings. The coefficient on solar generation in this regression establishes the impact of solar generation on wholesale prices.

## Results

We estimate that in 2019, households with rooftop PV paid $133 per year less in charges for the usage of the electricity network than they otherwise would have if they had not installed PV. For the estimated 420,000 households in Victoria with rooftop solar at the end of 2019, this means distributors recovered AUD56m less income from those households with rooftop PV than they would have, if those households did not have rooftop PV. This translates into network use of system prices that were, on average, around AUD1.3/MWh higher than they otherwise would have been.

With respect to wholesale market impacts we estimate that production by rooftop PV reduced the average annual prices in the National Electricity Market by AUD3.1/MWh in 2017, AUD4.7/MWh in 2018 and AUD6.4/MWh in 2019 from what they otherwise would have been. This translates into an annual impact of wholesale market revenues that were AUD273m lower in 2019 than they otherwise would have been.

## Conclusions

Households that installed rooftop PV reduced their annual electricity bills by AUD510 per year (around 30%) from what they otherwise would have been. Contrary to the common perception, we also find that rooftop PV reduces prices for all consumers since its “merit order effect” in wholesale markets far exceeds the effect it has in increasing prices through the recovery of foregone network use of system income. Since consumption-variant charges are a larger proportion of bills for higher consumption consumers, it is likely that larger consumers capture disproportionately more of the price benefits of rooftop PV production, than smaller consumers.

While our study does not provide a basis to conclude on the relative merits, in economics, of policy support for small distributed PV compared to large centrally-dispatched renewable electricity generation, it can support a conclusion that the expansion of rooftop PV has reduced prices for all consumers. This conclusion is likely to hold unless wholesale market prices decline significantly from their current levels, particularly at the times that rooftop PV produces electricity. Since policy support for rooftop PV is publicly funded, the evidence of electricity price reductions associated with rooftop PV suggests that a share of that support might reasonably be recovered from consumers.

## References

Percy, S. and Mountain, B.R. (2020). *Estimating the merit order effect in a multi-regional market*. (forthcoming)

Mountain, B.R and A. Gassem (2020) *Gaussian process regression in the estimation of rooftop PV production and own use* (forthcoming)

Mountain, B. and Rizio, S. (2019). *Do Victoria’s households leave less money on the table when they switch electricity retailers*? (No. Working Paper 1909). Melbourne. Available at: <https://www.vepc.org.au/working-papers>

Bushnell, J. and Novan, K. (2018) *Setting With The Sun: The Impacts Of Renewable Energy On Wholesale Power Markets*, *Energy Institute WP 292*. UC Davis: Energy Institute at Haas.

Cludius, J. *et al.* (2014) ‘*The merit order effect of wind and photovoltaic electricity generation in Germany 2008–2016: Estimation and distributional implications*’, *Energy Economics*, 44, pp. 302–313. doi: https://doi.org/10.1016/j.eneco.2014.04.020.

Würzburg, K., Labandeira, X. and Linares, P. (2013) ‘*Renewable generation and electricity prices: Taking stock and new evidence for Germany and Austria*’, *Energy Economics*, 40, pp. S159–S171. doi: https://doi.org/10.1016/j.eneco.2013.09.011.