RE: Question on Notice from Senator Canavan

Would the cost of distribution network upgrades to support maximum rooftop solar and consumer energy resource capacity result in more than a $100 increase on power bills?

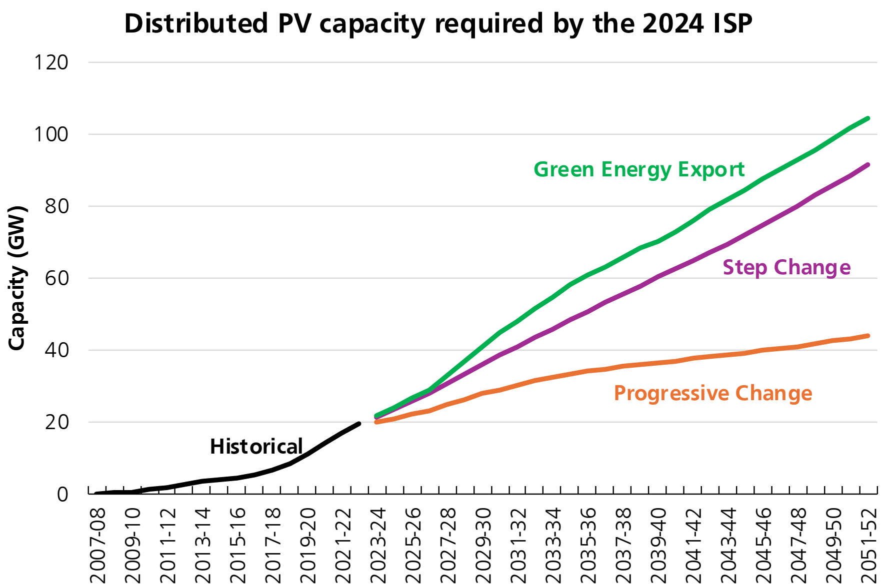
Without home or community batteries, distribution network upgrades to support maximum rooftop solar exports are likely to increase power bills between $47 and $2,525 per year. This assumes that Australia reaches the 80% penetration of rooftop solar specified by the Integrated System Plan (ISP).

Supporting rooftop solar exports is initially cheap or free but becomes very expensive as exports exceed the capacity of the distribution network. AEMO's ISP excludes the cost of these upgrades but assumes a significant expansion of rooftop solar occurs in the coming decades. These costs could vary widely depending on the network, level of rooftop solar penetration, curtailment accepted, and home battery capacity.

The ISP also excludes the capital costs for rooftop solar and home batteries. The 2024 ISP projects an annual installation average of 3.1 GW of new rooftop solar capacity and 9.1 GWh of new consumer battery storage from 20204-25 through 2049-50 under the *Step Change* scenario.[1] The Centre for Independent Studies estimates that the total capital cost of these CERs over this period will amount to $121 billion in net present value terms. This would effectively double the ISP's primary cost figure of $122 billion if they were included.[2]

The cost of distribution network upgrades

The ISP assumes rooftop solar will increase fourfold from 20 GW this year to 86 GW in 2050 under *Step Change*.[3] To enable increased rooftop solar exports and ensure grid stability, substantial capital expenditure will also be needed to upgrade distribution networks.

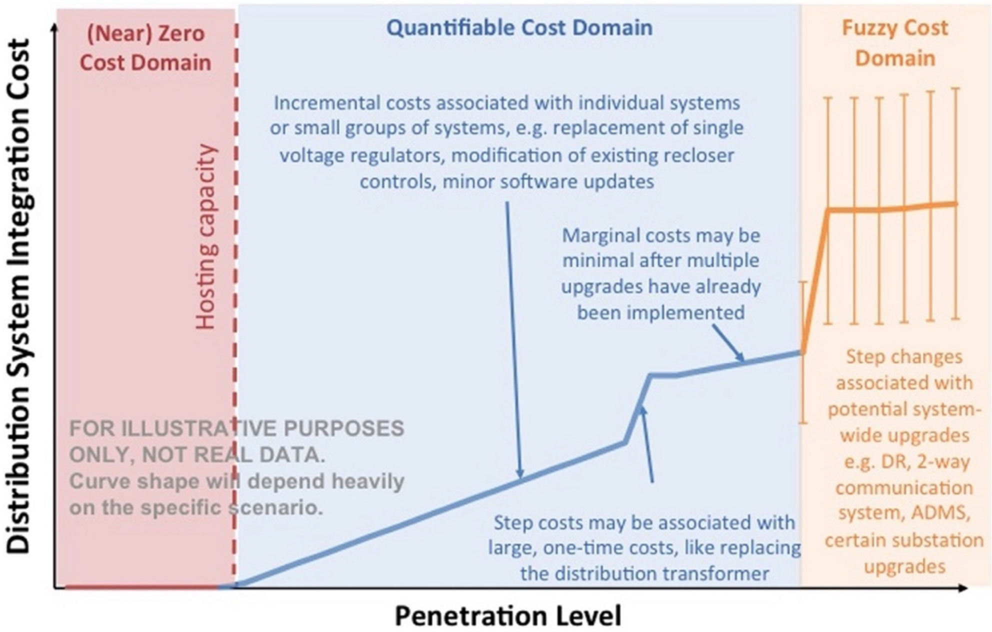


[1] AEMO, Final 2024 ISP results workbook.

[2] See CIS Submission to Select Committee regarding Integrated System Plan Flaws, pp. 9–15.

[3] AEMO, Final 2024 ISP results workbook.

Horowitz et al. (2018) helpfully outline three cost domains for integrating rooftop solar: costs are generally minimal when solar penetration is below the hosting capacity; as penetration rises, costs increase, moving from predictable upgrades (like voltage regulation) to less quantifiable, “fuzzy” costs that require complex, system-wide upgrades.[4]



Robert Barr explains that existing distribution networks were typically designed to manage an After Diversity Maximum Demand (ADMD) of 3-5 kVA per customer for incoming power, with newer subdivisions accommodating slightly higher levels around 7 kVA per customer.[5] Barr notes that to manage a broader range, such as 6 kVA per customer for import up to 8 kVA per customer for export, most distribution networks would need substantial upgrades.

With more customers installing rooftop solar systems around 8 kW – and the ISP projecting the average size of new residential solar capacity to reach nearly 12 kW by 2054[6] – the existing distribution network will be pushed beyond its original design limits. To mitigate over-voltage issues and enable solar customers to export their excess solar generation, substantial upgrades to distribution networks will be required. These upgrades may include installing larger transformers, adding voltage regulation equipment, and even reconductoring lines to handle the increased flow of electricity from households back to the grid.[7]

The costs of upgrading distribution systems to integrate rooftop solar vary widely, depending on several factors such as PV penetration levels, the location and clustering of PV systems, feeder characteristics, and the specific equipment required for reliable grid operation. Studies in the US show network upgrade costs per kW of rooftop solar integrated ranging from as low as 0.23 USD/kW to as high as 1,400 USD/kW, with midpoints between 59 and 700 USD/kW (or 90 – 1,060 AUD/kW).[8] This broad variability reflects differences in local network conditions and the types of upgrade solutions needed.

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[4] Horowitz et al. 2018, p. 428.

[5] Robert Barr 2024, *Submission on the 2024 Draft AEMO Integrated System Plan*, p. 14. https://www.epc.com.au/wp-content/uploads/EPC-Submission-on-the-2024-Draft-ISP-20240216-Final.pdf

[6] AEMO 2024, 2024 Forecasting Assumptions Update, p. 23.

[7] Horowitz et al. 2018, ‘Distribution system costs associated with the deployment of photovoltaic systems’, *Renewable and Sustainable Energy Reviews*, vol 90, pp. 420–433.

[8] See literature review in Horowitz et al. 2018 and Gandhi et al. 2022, ‘Levelised cost of PV integration for distribution networks’, *Renewable and Sustainable Energy Reviews*, vol 169.

Currently, about one-third of detached dwellings in the NEM have rooftop solar, and under the ISP's *Step Change* scenario this is projected to exceed half of all detached homes by 2034, reaching 79% by 2050.[9] Nacmanson and Ochoa (2020)[10] estimate that the DNSP-focused network upgrade costs required to accommodate 60% of customers having rooftop solar with no curtailment vary widely, with estimates for rural feeders ranging from 741 to 13,574 AUD per customer in net present value terms and for urban feeders from 1,288 to 31,924 AUD per customer in net present value. Converted to annual costs, this equates to approximately 47 to 886 AUD per year per customer in rural areas and 82 to 2,525 AUD per year per customer in urban settings.[11]

It is reasonable to anticipate costs near the upper end of Nacmanson and Ochoa's cost range for DNSP-led network upgrade to allow for maximum solar export. While their cost estimates are for 60% hosting capacity, the ISP assumes 79% of detached homes will have rooftop solar by 2050, pushing the cost up. Additionally, the study assumes a weighted average system size of 5.18 kW,[12] less than half the 12 kW average assumed by the ISP in 2050.

The cost of alternative solutions

Given that traditional distribution network upgrades are potentially very expensive, alternative approaches like home or community batteries and curtailment strategies have been considered.

Curtailment, however, presents the major drawback of limiting solar customers – especially those without battery storage – from fully utilising their rooftop solar, leading to longer payback periods and diminished incentives to install rooftop solar.

Consumer-installed batteries are therefore often favoured as a solution for managing rooftop solar integration.[13] However, the ISP assumes consumers will install home batteries at their own expense and even relinquish control of these batteries to the grid. This effectively increases the cost of rooftop solar, and may well require additional subsidies to either batteries or rooftop solar to achieve the level of penetration and coordination assumed. Such CER costs, as discussed above, are excluded from the ISP.

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[9] AEMO, 2024 Integrated System Plan, p. 50.

[10] William Nacmanson and Luis(Nando) Ochoa 2020, "Deliverable 5 "Cost Comparison Among Potential Solutions"," in *Advanced Planning of PV-Rich Distribution Networks*, The University of Melbourne. https://www.researchgate.net/publication/346853363_Deliverable_5_Cost_Comparison_Among_Potential_Solutions

[11] Converted to annual costs based on real discount rate of 4.83% and timeframes specified in the paper. The authors examined seven traditional and non-traditional solutions. The solution referenced here — utilising advanced voltage regulation equipment, network augmentation, and optimised inverter settings — is selected given its universal applicability across all feeder types and its focus as a DNSP-led approach, rather than requiring consumers to invest in home batteries or face curtailment measures. This is to answer the question of maximising solar export potential via distribution network upgrades.

[12] Nacmanson and Ochoa (2020, p. 52).

[13] See Gandhi et al. 2022; Nacmanson and Ochoa 2020.