Local Solar:
International Cost Comparisons
Australia, Germany, United States

Why Do Americans Pay 3 Times as Much as Australians for Rooftop Solar?

Why Don't Americans Have Plug-In Solar, Like Germans Do?

Bill Powers, P.E.,
June Sekera, Beth Woolfolk
Local Power Networks Project

July 2025

Economics in Context Initiative | Global Development Policy Center | Boston University

The Local Power Networks project is supported by
funding from the Rockefeller Brothers Fund and the Rockefeller Family Fund..

Local Solar: International Cost Comparisons
Australia, Germany, United States

Why Do Americans Pay 3 Times as Much as Australians for Rooftop Solar?

Why Don't Americans Have Plug-In Solar, Like Germans Do?

Bill Powers, P.E., June Sekera, Beth Woolfolk

July 2025

Table of Contents

Why Do Americans Pay 3 Times as Much as Australians for Rooftop Solar?	
Summary	1
Determining rooftop solar's financial value for consumers: system acquisition cost and ongoing operational value	3
Factor 1: System Acquisition Cost	3
Factor 2: Operational Value	10
Conclusion	13
Appendix: Solar $/W Cost Comparison	14
Cost of Rooftop and Plug-in Solar PV in Germany	15
Average Rooftop PV Cost for Homeowners	15
Balcony Solar	16
Germany's Solar Package	17

Overview

Siting solar electricity generation close to where it is used is more energy-efficient, can be less expensive than remote centralized generation with its energy-dissipating long-distance transmission system, and avoids the despoilation of large land areas required by utility-scale solar. Australia and Germany have taken steps and enacted policies to foster local solar generation in the built environment, with the result that significant shares of their populations are self-generating their own electricity. These models could be replicated at the local level in the United States, despite the present stance of the US federal government on renewable energy.

In Australia, 33% of homes have rooftop solar; in the United States, only 7% do. Australians pay on average 82¢ per watt (USD) for a 10-kilowatt system; in the US it is $2.53 per watt, three times that of Australia. The high cost of residential rooftop systems in the US can be a deterrent to its widespread deployment here. Our study of Australia's cost structure sought to answer two questions: How is Australia achieving low costs for residential rooftop solar, making it a far better financial proposition there than for Americans? Can these low costs be replicated in the US?

Our investigation found that there is ample opportunity to reduce both soft costs and hard costs of rooftop solar in the US. Public policy in Australia created a high-demand business environment which, in turn, enabled solar installation companies – who then had access to a steady pipeline of customers and minimal customer acquisition costs – to operate on a high-volume business model, spreading their fixed costs over a larger sales base, thereby reducing the cost for each installation, while continuing to pay workers living wages. Such a "wholesale" approach could be taken in localities in the US as part of a local solar saturation strategy. The specific public policy actions that could lower costs through economies of scale are detailed in this report. Getting residential rooftop solar soft costs down in the US could make rooftop solar electricity substantially lower-cost than the grid-delivered electricity it would displace in many parts of the country.

Germany also has aggressively fostered local solar generation, and has gotten the cost of a 10 kW rooftop solar system to $1.52 - $1.69/W (USD). In 2023, 70% of the newly added solar capacity in Germany was rooftop solar. A notable portion of residential solar is small "balcony solar" systems. Also called "plug-in" solar, these systems are becoming increasingly popular among renters and individual apartment owners because of the very low cost and simplicity of installation. These plug-in systems are small (600-800 watts) and can be installed without a professional contractor. They cover only a portion of households' electricity demand, but are affordable, costing as little as 200 Euros ($230 USD), and reduce households' electric bills. In the US, a few companies market plug-and-play solar, but this approach to residential solar generation is in its infancy here.

With models from Australia and Germany to replicate, localities in the United States could significantly increase the ability of Americans to self-generate their electricity. There is a "solar spectrum" of policy and practice choices – from small plug-in systems for individual apartments to whole-neighborhood solar saturation strategies – as laid out in the Blueprint for Local Power Networks. The models in this spectrum could be instituted in the near term at a small scale at the local level, testing and demonstrating approaches that could be implemented nationally later, when the federal government returns to an energy transition, as it surely must, and is seeking models on which to build.

Why Do Americans Pay 3 Times as Much as Australians for Rooftop Solar?

An examination of the cost components in each country

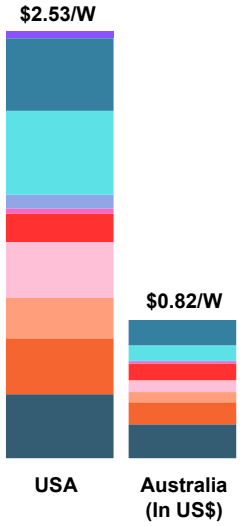
Bill Powers, P.E. and June Sekera[1]

July 2025

Summary

Generating electricity locally, close to where it is used, is more energy-efficient than delivering it from centralized sources over long-distance transmission lines. Local generation can also supply electricity that is more accessible, secure and affordable. These advantages can be obtained by putting solar photovoltaic (PV) systems on the roofs of the buildings where the electricity is used, particularly residences. In Australia, 33% of homes have rooftop solar; in the United States, only 7% do. The high cost of residential rooftop systems in the United States can be a barrier to its widespread deployment here. In the US, buyers of a 10 kilowatt (kW) rooftop system pay an average price of $19,110 with the federal tax credit, and $27,300 without the tax credit[2]. For the same size system, Australians pay, $5,695 (US$)[3] (including the Australian automatic federal rebate).

Fig. 1 Cost per watt of residential rooftop solar US and Australia (in US$) 2023



To compare the value of systems of different sizes and in different countries, most reporting uses an average cost per watt ($/W) metric. In Australia that cost is $0.82/ W[4]; in the US it is $2.53/W,[5,6] three times that of Australia. See Figure 1 and Attachment A.

Those per-watt amounts are reported by the International Energy Agency and, to enable international comparisons, do not factor in the government subsidies offered by either country. But most reporting on residential solar pricing in Australia includes the federal government subsidy because it is "baked in" to the prices installers charge customers. Those reports show a net price to customers of $0.57/W (US$).[7] At the other end of the price spectrum between Australia and the US is the $4.20/W (US$)

---

[1] Technical information, Bill Powers, Professional Engineer. Policy implications, June Sekera, Director, Local Power Networks project.

[2] https://www.energysage.com/local-data/solar-panel-cost/

[3] $9,040 AU$ https://www.solarchoice.net.au/solar-panels/solar-power-system-prices/

[4] IEA, *National Survey Report of PV Power Applications in Australia 2023*, July 2024, Table 11, p. 20. This is the representative cost for an AU 10 kW (direct current) system prior to government subsidies. The $1.30 AU$ is converted to US$: $0.82.

[5] This cost is for an assumed 10 kW direct current (DC) system prior to incentives. See: 1) IEA, *National Survey Report of PV Power Applications in the USA 2023*, July 2024, Table 9, p. 13: https://iea-pvps.org/national_survey/national-survey-report-of-pv-power-applications-in-the-usa-2023/, ". . . average price of 5 – 10 kW residential PV systems = $2.49/W", and 2) EnergySage, *Solar panel cost in 2025*, updated March 25 2025: https://www.energysage.com/local-data/solar-panel-cost/, ". . . the average cost-per-watt across the U.S. is around $2.56/W before incentives."

[6] This paper uses average costs nationally for both the US and Australia. However, there is substantial variability among states and localities across both countries.

[7] Solar Choice (AU), *Solar Panel Costs: Solar Choice Price Index*, March 1, 2025: https://www.solarchoice.net.au/solar-panels/solar-power-system-prices/

cost reported by the Lawrence Berkeley National Laboratory LBNL).[8] This LBNL reported cost includes dealer fees and financing charges Americans typically pay, but does not count the 30% tax credit that was available to US residential solar PV buyers. With the tax credit applied, the US net cost would be $2.94 per watt. That cost of solar is about 5 times the average price Australian customers are actually paying. Other countries, like Germany, have also achieved much lower costs per watt than the US. See Annex. Australia appears to have achieved the lowest cost.

How is Australia achieving low costs for residential rooftop solar, making it a far better financial proposition there than for Americans? Can these low costs be replicated in the US? Those are the two questions that we set out to answer. This study was conducted as part of a project to develop a model for Local Power Networks (LPNs) – a solar-based, local mini-grid system for decarbonized electricity generation that is designed to make electricity more secure, reliable, and affordable for people in the US. See the "Blueprint" for LPNs at the project website.

Our investigation found that there is ample opportunity to reduce both soft costs and hard costs in the US. A "wholesale" approach at the local level as part of a local solar saturation strategy could reduce process expenses and hardware costs and create a local high-volume, low-cost economic environment, similar to Australia nationally. This would enable solar installers to substantially reduce costs while continuing to pay workers living wages. In particular, we found that:

- Australia enacted a policy specifically targeted to increase the buildout of small-scale renewable energy generation, like rooftop solar PV systems, and then backed that policy by creating robust financial supports.
- That concerted public policy framework created a business environment that enabled a pricing structure favorable to widespread deployment of rooftop solar. It spurred high demand for local solar PV systems, which, in turn, enabled installers to prosper using a high-volume, low-cost business model.
- "Soft costs" associated with residential rooftop deployment are far lower in Australia. Soft costs include businesses' expenses like marketing/advertising, administrative costs and profit margin. Soft costs also include expenses under the control of public authorities and utilities, such as permitting, inspection and interconnection approval processes. These were aggressively and effectively streamlined in Australia,
- "Hard costs" – for solar modules, inverters and other materials – were reduced in Australia because wholesalers/distributors could streamline purchasing and bulk buy materials, often directly from China,[9] with no tariffs and only nominal taxes, to support the reliable and steady demand for solar hardware.
- These cost savings are passed on to buyers of residential rooftop PV systems in Australia.
- While cost savings in Australia are spurred by federal and state government policy and strong financial supports, state-level financial supports are being curtailed, just as they largely are in the US.

[8] Barbose, Galen et. al. (Aug. 2024) Tracking the Sun, Pricing and Design Trends for Distributed Photovoltaic Systems in the United States; Lawrence Berkeley National Laboratory,

[9] United States Studies Centre, *Should Australia make solar panels? Supply chain security through global engagement*, December 1, 2024: https://www.ussc.edu.au/should-australia-make-solar-panels-supply-chain-security-through-global-engagement.

- The Australian residential rooftop solar "value proposition" is increasingly based on onsite consumption of low-cost rooftop solar to displace much higher cost (4X) retail grid power. This value proposition is also driving greater use of collocated onsite battery storage.

Determining rooftop solar's financial value for consumers: system acquisition cost and ongoing operational value

There are two aspects to the financial viability of residential rooftop solar for an energy consumer: 1) the upfront system acquisition cost, and 2) the ongoing operational value. Below we discuss the upfront installation (acquisition) cost, first in Australia and then in the US, and then turn to ongoing operational value.

Factor 1. System acquisition cost

1.a. Australia Residential Rooftop Solar Pricing

Virtually all residential rooftop solar customers in Australia automatically receive an upfront federal financial incentive that is incorporated into the sale price,[10] so most reports on AU installation costs reflect prices that incorporate this benefit. The subsidies under the program are colloquially called "rebates" but are not rebates in the sense that term is generally used. The subsidies go to installation companies, and those installers pass on the savings in the form of lower prices to customers. The program reduces the price to customers by about 30%. The subsidy is essentially invisible to purchasers of rooftop solar. Australian purchasers do not need to file claims for rebates or tax credits, as in the US.

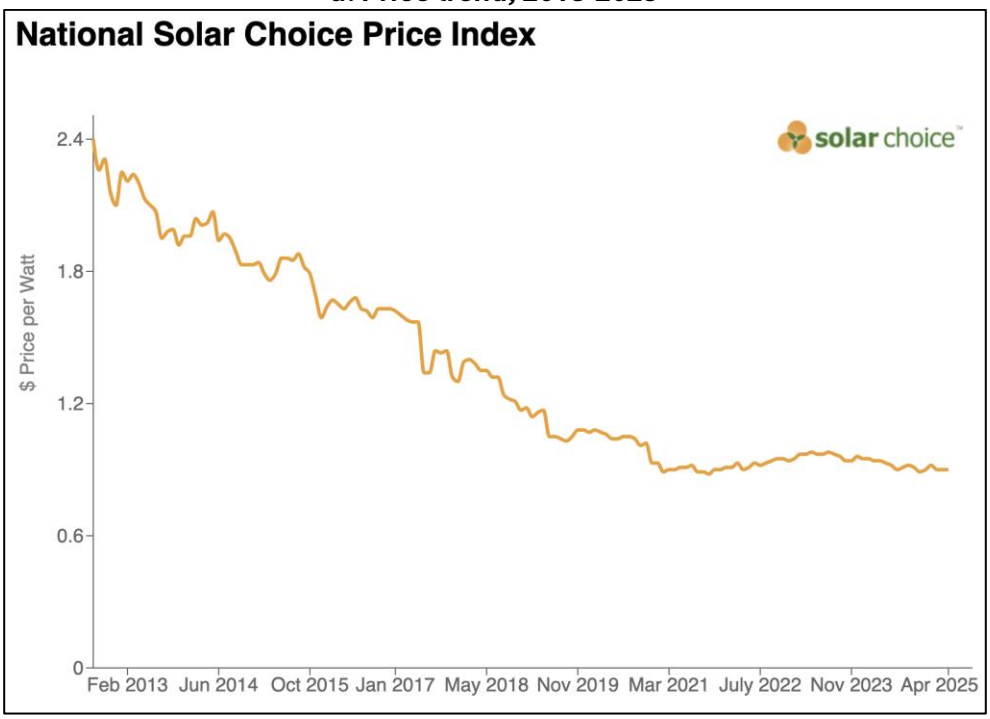
The following discussion uses the price installers charge rooftop solar system buyers (which includes the up-front subsidy).

The Q4 2024 average retail price of an Australian 10 kW_{dc} (10,000 $watt_{dc}$) residential rooftop solar system was approximately $0.90/W (AU$).[11] equivalent to $0.57/W (US$).[12] This pricing has remained stable for the past four years in Australia. As shown in Figure 2a, the installation price of AU residential rooftop systems dropped dramatically and steadily after the creation of the Small Scale Renewable Energy Scheme in 2011.[13] The low prices have been maintained for the last four years, averaging $0.89/W (AU) in February 2021 and $0.90/W (AU) in March 2025. And, as shown in Fig. 2b, the number of AU installations rose steadily after the price decline. Installations peaked around Q4 2020 and Q1 2021, with installation rates holding relatively steady at somewhat reduced levels since 2021.

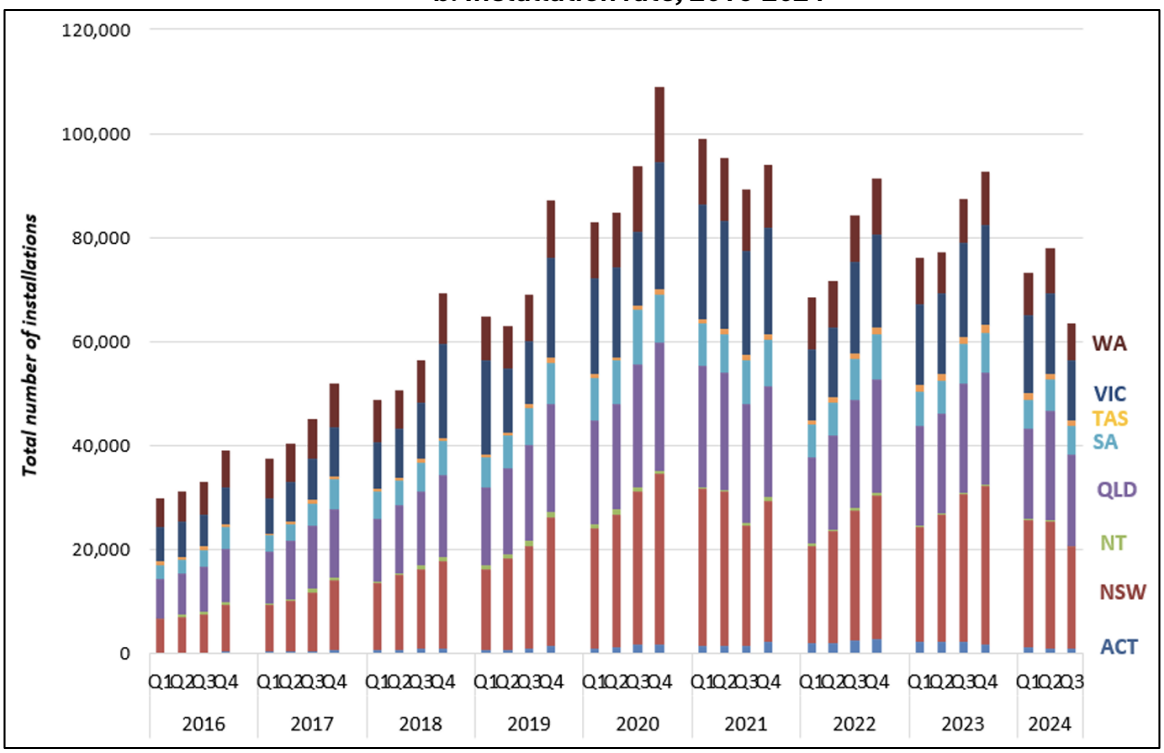
[10] The Small-Scale Renewable Energy Scheme (SRES). Created in 2011, It expires in 2030.
[11] Solar Choice (AU), *Solar Panel Costs: Solar Choice Price Index*, March 1, 2025: https://www.solarchoice.net.au/solar-panels/solar-power-system-prices/. This price includes the upfront incentive, under the Small-Scale Renewable Energy Scheme, which reduces the installed cost by approximately 30%: https://www.solarchoice.net.au/blog/solar-power-system-prices-wollongong-nsw/.
[12] Exchange rate, AU dollar to US dollar, March 28, 2025 = 0.63: https://www.tradingview.com/symbols/AUDUSD/.
[13] https://cer.gov.au/schemes/renewable-energy-target/small-scale-renewable-energy-scheme

Figure 2. AU residential rooftop solar price trend vs number of installations[14,15]

a. Price trend, 2013-2025



b. Installation rate, 2016-2024



[14] Solar Choice website, *Solar Panel Costs: Solar Choice Price Index*, March 1, 2025: https://www.solarchoice.net.au/solar-panels/solar-power-system-prices/.

[15] Australian Energy Council, *Solar Report Q3 2024*, November 7, 2024, Figure 3, p. 5: https://www.energycouncil.com.au/media/kuqbtb15/australian-energy-council-solar-report-q3-2024.pdf.

1.b. Reasons for Low AU Residential Rooftop Solar Pricing[16]

Residential solar in Australia benefits from the well-developed, national financial incentive program, a streamlined permitting and approvals process, and independently funded solar equipment and solar installer accreditation programs.[17,18] There are no tariffs on solar hardware imports. The solar installer industry is very experienced and highly competitive. Profit margins are comparable in AU and the US, but the absolute profit per sale is much lower in AU. Average household system size is in the 9 to 10 kW range.[19]

Significant reasons for low AU residential rooftop solar pricing are:

- **A high-volume business environmen**t. The federal up-front subsidy program, as well as state incentive programs, dramatically increased demand for rooftop solar by making solar economically attractive to customers. This high-demand business environment, in turn, enabled solar installation companies, who then had access to a steady pipeline of customers and minimal customer acquisition costs, to operate on a high-volume business model basis, spreading their fixed costs over a larger sales base, and thereby reducing the cost for each installation.
    - The high-demand, high-volume business environment minimizes marketing and advertising costs normally borne by installers. (Marketing/advertising costs comprise 20-29% of the per-watt installation price in the US).
    - Installers' planning cost is negligible so there is little to no pre-installation down time after an order has been placed.
    - Profit per installation is lower in AU, despite the profit margin percentage being about the same as in the US.[20] The AU businesses' profit margin is applied to systems that are priced at one-third that of US prices. In AU, the higher job volume compensates for less revenue per job.

- **"Soft costs" in AU are much lower than in the US. Process costs are greatly reduced by streamlining and simplification** of permitting, utility/distributor automatic approvals and other aspects of the installation process.[21] Standardized technology platforms further speed up processes and reduce costs:

---

[16] Much of the Information in this section is from Renate Egan, Ex. Dir., and Lauren Ashby of the Australian Centre for Advanced Photovoltaics; personal communication March 2025.

[17] The Australian "Clean Energy Council" maintains lists of solar hardware (panels, inverters, batteries) approved for use in Australia: https://cleanenergycouncil.org.au/industry-programs/products-program. The Clean Energy Council is a not-for-profit, membership-based organization. The Australian government also provides funding to the Clean Energy Council for various initiatives.

[18] The Solar Accreditation Australia (SAA) has operated the Australian solar installer accreditation program since 2024. Previously it was operated by the Australian Clean Energy Council. SAA charges fees for individuals to become accredited as solar installers and designers. The fees cover the costs of administering the accreditation process. SAA is a not-for-profit organization. The Australian Clean Energy Regulator oversees SAA to ensure the integrity of the accreditation process: https://cer.gov.au/.

[19] Australian Energy Council, *Solar Report Q3 2024*, November 7, 2024, Table 3, p. 11.

[20] "Typical" gross margin for solar businesses in AU is 18%.Sunwiz (AU), *Where's the profit in solar businesses?*, August 18, 2021: https://www.sunwiz.com.au/wheres-the-profit-in-solar-businesses/. The US margin is about 17%. IEA, National Survey Report of PV in the USA – 2023, July 2024, Table 11, p. 15. Profit = $0.43/W, total installed cost = $2.53/W. Profit percentage of total installed cost = $0.43/W ÷$2.53/W = 0.17 (17%).

[21] Green Tech Media, *How to Halve the Cost of Residential Solar in the US*, January 5, 2018: https://www.greentechmedia.com/articles/read/how-to-halve-the-cost-of-residential-solar-in-the-us.

- Permitting and commissioning are managed by the installer, primarily with software and apps. It is a lean process, including receipt by the installer of the federal government subsidy and interaction with the electricity distribution company to approve interconnection.
- For most residential installations, there is a largely automatic interconnection approvals process. There is blanket pre-approval for rooftop PV systems below a specified inverter size, generally 10 kW or less.[22]
- Installers can quote remotely. The homeowner can decide, place an order within a week, and have the work start nearly immediately.
- A simple installation is completed in a day.

Achieving low soft costs is significant because more than half of the U.S. system installation cost involves soft costs, including marketing, labor, general and administrative (G&A), permitting, and interconnection approval. How to achieve low soft costs in the US is discussed in Section 1.d. below.

- **Hardware costs are minimized**.
  Australian installation companies charge customers substantially less than American companies for hardware (panels, inverters, etc.). In part, this is because of a lack of tariffs on panels and other hardware imports and a focus on more competitively-priced[23] quality equipment from China to compete effectively in the AU solar market.

  In addition, shipping and travel costs are minimized -- Australia has a well-established network of small installers, plus a number of larger state-based or national solar hardware distribution companies who sub-contract to local installers to do the actual installation. The distributors maintain hardware stock, which reduces or eliminates potentially costly delays for installers in sourcing hardware. In AU the wholesalers have largely standardized on a limited number of equipment manufacturers and models, which enables them to get lower prices.

1.c. Residential Solar Costs in the US

In all reporting, residential rooftop solar is more expensive in the US than in AU. But there is significant variation among sources reporting on the US cost. At the high end, a 2024 study by Lawrence Berkeley National Laboratory reported the average US cost of residential solar at $4.20/W_{dc}$. Other sources reported lower amounts: Wood Mackenzie (2024) -- $3.36/W_{dc}$; National Renewable Energy Lab (2024) -- $3.15/W_{dc}$; and Energy Sage (2025) -- $2.56/W. The International Energy Agency (IEA) study noted earlier determined an average US cost of $2.53/W_{dc}$.[24] The differences occur, in part, because some rooftop price estimates are modeled costs and others are reported costs.

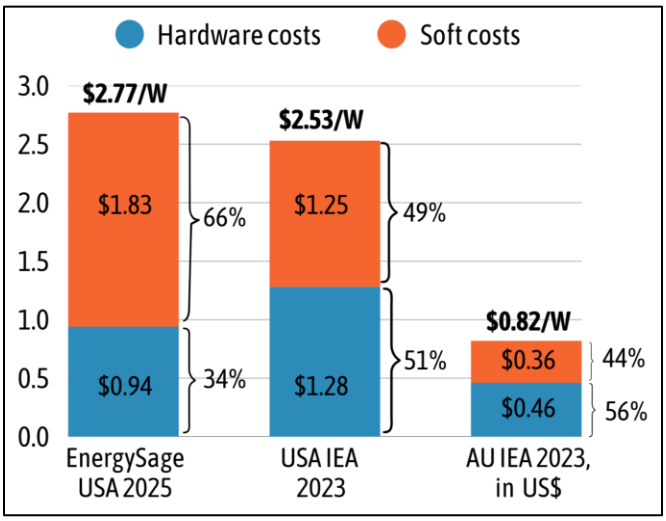
In addition, there are differences in what expenses are included in the cost per watt calculation. For example, the LBNL study factored in dealer fees and financing charges, which can add 5 to

[22] Solar Choice, *Solar system size limits: How much does your local network allow?*, August 8, 2024: https://www.solarchoice.net.au/learn/design-guide/solar-system-size-limits-by-network/.
[23] Quality problems can arise with the lowest-priced equipment, but the extent to which this may be occurring in Australia is unclear.
[24] The cost shown in the report is $2.57, but there is an addition error. The components costs total to $2.53.

50% to the overall reported cost. Other price projections do not include these fees. As explained below, dealer fees could be eliminated and financing cost significantly reduced or eliminated via a local "solar saturation" strategy.

Figure 3 shows the cost of US and AU systems reported by EnergySage and the IEA. Of particular interest – in terms of ways to reduce system costs in the US – is that half or more of the US expense is "soft costs," including marketing, labor, and general and administrative (G&A) costs.

Figure 3. Comparison of US and AU residential rooftop solar hardware costs and soft costs, US$/W$_{dc}$



The three dominant US soft costs are: marketing, profit, and installation labor. These three soft costs account for 43% of the installed cost of the US system. US hardware costs by themselves exceed the entire installed cost of an AU residential rooftop solar system, as shown in Figure 3.

The cost per watt is a frequently reported metric, and represents the installed cost of a system. It does not, however, provide the information needed to understand the cost of electricity *generation* from a system, nor to calculate the difference between that cost and the cost of the grid electricity it is displacing. For those purposes, the metric typically used is the "Levelized Cost of Energy" (LCOE). The LCOE compares the annualized cost of the system to its annual electricity production to determine a unit cost of electricity production from the system. The LCOE provides a standardized basis for comparing generation costs in different locations and countries, and for comparing the production cost of rooftop solar to that of grid-supplied electricity.

The LCOE of the representative US residential rooftop solar system in Figure 3, with an installed cost of $2.53/W (from the IEA study noted earlier), without incentives and financed over 30 years at 4% interest,[25] would be $0.096/kWh.[26] The average cost of grid-delivered electricity in the US is $0.16/kWh.[27] So, the displaced electricity is $0.06/kWh more expensive than the self-generated electricity, making for a moderately positive value proposition for onsite consumption from a rooftop solar array.

[25] These are the financing terms used in the NREL, *2022 v2 Annual Technology Baseline Workbook* for rooftop solar They are also terms that a municipal or co-op utility could likely obtain to finance a wholesale/saturation rooftop deployment project.
[26] NREL, *2022 v2 Annual Technology Baseline Workbook*, tab: Solar – PV Dist. Res, Class 3 LCOE 2024 "Conservative" and 2029 "Moderate", July 21, 2022.
[27] This average $0.16/kWh value includes both the wholesale energy cost and the grid delivery cost ("poles and wires" cost).

Using as an example a representative real-world rural electric cooperative with an average delivered wholesale energy cost of approximately $0.085/kWh,[28] the displaced co-op wholesale energy would be less costly than the rooftop-generated electricity at $0.096/kWh and not a good value proposition. But if the installed cost of rooftop solar were brought down to $1.20/W (as projected by the US National Renewable Energy Laboratory for 2028/2029), the LCOE would be $0.046/kWh.

The $0.046/kWh cost of rooftop solar generation is substantially lower than the example rural cooperative's $0.085/kWh wholesale energy cost and comparable to the current AU residential rooftop solar LCOE (with incentives) of US $0.05/kWh.[29] **In sum, getting residential rooftop solar soft costs down in the US could make rooftop solar electricity substantially lower-cost than the grid electricity it would displace in many parts of the country.**

1.d. Viable Approach to Achieving AU Residential Rooftop Solar Pricing in the US

Low AU residential rooftop solar pricing can be approximated in the US in utility territories where the utility itself, or the local government, can take actions to substantially reduce both soft and hard costs. The following types of actions could be taken:

Create a high-volume solar rooftop business environment, which was done at a national scale in Australia, but do it at the local level here. A municipal utility or electric co-operative can institute a local area solar saturation strategy, targeting a community or a neighborhood on a single substation feeder line,[30] for example, and then incentivize and enable all or most customers on the feeder line to have rooftop solar. Financial supports for rooftop solar could be provided, in the case of public utilities, by issuing low interest rate revenue bonds. Bond proceeds would be used for bulk purchasing of equipment and for other actions to lower the cost of individual rooftop solar systems. Customers would continue to make monthly payments for electricity. However, the monthly payments would be used to pay down the bond money used to install the system. The monthly payments for solar power under this approach would, as a policy requirement, be lower than the amount the customer would otherwise be paying for grid electricity.

- **Bulk-buy hardware**: modules, inverters, panel mounting materials, other electronic equipment and batteries. Bulk purchasing alone can reduce solar system hardware costs by one-half.[31] A publicly-owned utility or co-op can eschew any markup on the hardware they bulk-buy and furnish for system installation.
- **Standardize systems**. Offer customers ("members" in the case of co-ops) a standard PV system and battery. As with Southwest Airlines' original strategy of buying one model of

[28] Representative rural electric cooperative example.
[29] The representative rural coop "all-in" retail residential rate is ~$0.22/kWh. This includes the cost of owning and operating the local distribution grid and the cost of wholesale energy delivered over the distribution grid. $0.085/kWh is the wholesale energy component of that all-in retail rate.
[30] Distribution substations typically have four "feeder" circuits. These feeder circuits loop through neighborhoods and business districts to supply power to customers. A typical feeder may have hundreds, or even thousands, of individual customers.
[31] 2023 IEA US 5-10 kW panel cost is $0.38/W. Wholesale panel cost in US is $0.12 - $0.18/W. See: https://a1solarstore.com/wholesale-solar-panels.html

airplane, this can elicit bulk-buy discounts, and reduce installation cost. It can also reduce operating and maintenance costs.

- **Standardize installation practices to increase efficiency and reduce installation labor cost while paying workers a living wage**. Australian solar installers often complete the installation process in a single day and are paid a fixed fee for installation based on per project "industry typical" installation labor cost. Australian installation labor cost has historically been about one-third less than US installation labor cost on per kW installed basis.[32] Solar installation workers in AU receive a living wage.[33]
- **Design the standard system at a capacity that meets the needs of most participants in the network**. This will maximize self-generation for self-consumption in the targeted community or neighborhood.
- **Simplify and streamline permitting and interconnection** to reduce processing time and expenses. Stipulate the system size and solar panel and inverter elements that can be automatically approved.
- **Eliminate or minimize interconnection fees** for residential PV systems connecting to the distribution grid.
- **Institute an independent certification authority** for solar installers and hardware. This would establish a pool of pre-certified installers and pre-certified hardware. This will make the installer selection and hardware verification processes more efficient and faster.
- **Certify and pre-approve experienced solar installer firms** to install the systems.
- **Minimize marketing and advertising costs installers would otherwise have to bear**. Creating a high-volume business environment for participating installers will, in effect, eliminate or minimize marketing and advertising costs, which typically make up 20% to 29% of the per-watt cost for US residential rooftop systems.

  Offer low-cost financing to households, so that they can avoid the high costs of dealer fees and commercial loans. The Lawrence Berkeley National Laboratory estimates that those expenses can add 5 to 50% to the cost of a rooftop solar system. On-bill financing tied to the meter is one way to achieve this objective. Under this type of financing, customers continue to pay an electric bill at a rate lower than they previously paid for grid electricity, while at the same time, they pay off their rooftop solar system.

There are two frameworks within which low-cost residential solar could most effectively be achieved in the US: (1) a not-for-profit utility environment and (2) a local solar-saturation strategy.

Utility environment

The residential rooftop solar cost reduction strategy described above is most applicable to public or not-for-profit electric utilities in the US. The reason for this is the focus of public and not-for-profit electric utilities on low rates and high reliability. In contrast, private monopoly utilities have

[32] Aurora Solar, *Lessons From Down Under: Ways to Lower PV Solar Soft Costs*, 2019: https://aurorasolar.com/blog/lessons-from-down-under-ways-to-lower-pv-solar-soft-costs/.

[33] Average base salary, solar installers AU, April 2025 ~$109,125 AU$, which is ~$68,700 US$, and ranging from $117,300 US$ to $47,200 US$: https://au.indeed.com/career/solar-installer/salaries.

an interest in expanding conventional infrastructure to increase profits. This has resulted in private monopoly utilities generally being averse to mass adoption of residential rooftop solar.

Saturation strategy

A local solar saturation strategy that increases demand and creates a high-volume business environment at the local level, similar to what Australia has done at the national level, could reduce both soft costs and hardware costs. As part of the saturation strategy, a bulk customer base can be generated by implementing the rooftop solar project as an "opt-out" program. An "opt out" program structure is routinely used by utilities to achieve high levels of adoption for new programs. "Opt-out" means that all customers are automatically enrolled in the program but can affirmatively "opt out" of the program if they chose to do so.

A critical requirement of a rooftop solar program, to minimize the number of opt-outs, would be to assure that the customer rooftop solar production cost is significantly less than the grid power being displaced so customers see a clear economic benefit.

For the saturation strategy to be effective, a simple and straightforward financing mechanism that is open to all and that reduces customers' financing cost must be available. This could take the form of "on-bill" financing – a common mechanism in the electric utility sector. However, an uncommon version of this mechanism is meter-based billing – a model in which the meter at the customer site is the entity billed, not the individual customer "behind" the meter. Billing in this manner makes the credit history of owner/renter irrelevant. All that matters is that the bill is consistently paid. This financing model is being used in Hawaii's GEM$ program.[34] Rental properties can be accommodated by utilizing meter-based financing. Meter-based financing is designed on the actuarial analysis and experience that electric customer bill payments are a reliable and secure debt repayment stream. This repayment approach eliminates the problem of individuals with less than good credit ratings, who typically do not qualify for financing, being excluded. To this end, the GEM$ program in Hawaii has a specific focus on rental properties serving lower-income customers.

Factor 2. Operational value

As noted earlier, there are two primary factors in calculating financial value of a rooftop solar system for an electricity consumer: 1) the upfront system acquisition cost, and 2) the difference between the generation cost of electricity from the rooftop solar system and the cost of the grid power that is being displaced. Section 1 discussed the acquisition cost. In this section we discuss the second factor -- operational value.

The operational value for consumers of solar self-generation is derived in two ways: 1) the savings if the self-generation cost is less than the cost of grid power; and 2) compensation, if any, from exporting excess rooftop solar power to the grid through "net metering" or "net billing" programs in the US and feed-in-tariff (FIT) programs in AU. In both the US and in AU, compensation from exports to the grid have been a crucial aspect in the historic value calculus of a rooftop system. However, export compensation under these programs is declining in both countries. We discuss here the implications of this declining compensation.

[34] Hawaii Green Infrastructure Authority, Green Energy Money $aver (GEM$) On-Bill Program, webpage accessed March 20, 2025: https://gems.hawaii.gov/participate-now/for-homeowners/.

In net-metering[35] in the US (and FIT in Australia), surplus power generated from a rooftop solar system is automatically sent to the grid[36] and the utility compensates the customer for these "exports" at the retail grid power rate. In both the US and AU, this form of compensation is done under state-authorized programs.

In both the US and AU, the compensation amounts for exports to the grid are being reduced, in some cases drastically. In AU the FIT had been set as high as 0.60/kWh AU$ ($0.38/kWh US$) in the past. But the FIT rate is being steeply reduced in most parts of AU, to levels of $0.03 or $0.04 per kWh (AU$), and at some times of the day, the FIT is negative. In California, which represents half of residential rooftop solar in the US, compensation for exports to the grid was approximately $0.40/kWh under net metering. But in mid-2023, the rate was steeply reduced under the new "Net Billing Tariff" (NBT).[37] The export price a California residential rooftop solar owner receives under the NBT is currently in the range of $0.02 to 0.03/kWh. The implementation of the NBT tariff has resulted in a sharp decline in California residential rooftop solar installations.[38]

In an environment in which net billing (US) and the FIT (AU) are providing little to no revenue for rooftop solar exports, the calculus of the financial value of rooftop solar systems is, in both countries, less reliant on compensation for exports and more reliant on the value of self-generation for self-consumption.

The financial calculus that makes solar self-generation in AU work now is low-cost residential rooftop solar electricity production that displaces much higher cost grid power.

The primary value of an AU residential rooftop solar system on an ongoing, operational basis is the delta between the low generation cost of the rooftop solar system and the relatively high cost of retail grid power that is being displaced onsite.[39] This price relationship is shown in Table 1. The AU Levelized Cost of Energy (LCOE) in Table 1 assumes a 100% financed system with 10-year financing at 5% interest.

In AU, a nominal price is paid for exports to the grid, under the state FIT programs, as shown in Table 1. The FIT is adjusted annually and is rapidly declining in AU due to the abundance of solar power on the grid in daytime hours.[40] AU customers are now encouraged to add batteries to enable continued self-consumption in the evening hours.[41]

---

[35] "Net-metering" means that the electricity the rooftop solar customer imports from the grid (nighttime) and exports to the grid (daytime) are compensated at the same retail rate.

[36] In this example it is assumed there is no onsite battery storage to store surplus solar generation.

[37] Net billing" means the solar customer pays retail rates for imported power drawn from the grid and is paid wholesale rates for solar power exported to the grid.

[38] Wood Mackenzie/SEIA, *US Solar Market Insight – 2024 Year in Review, Executive Summary*, March 2025, p. 12. "Despite a 45% year-over-year contraction due to the net billing transition, California continued to lead the residential solar state rankings in 2024."

[39] Solar Choice, *How is Solar Energy used? Self-consumption explained*, September 12, 2024: https://www.solarchoice.net.au/learn/design-guide/solar-self-consumption/.

[40] ABC News (AU), *Solar feed-in tariffs plunge up to 99.93% in 15 years as market saturates,* March 15, 2025: https://www.abc.net.au/news/2025-03-16/australian-solar-feed-in-tariffs-have-plunged-99-per-cent/104986534.

[41] Ibid.

Table 1. 2024 AU residential rooftop solar levelized cost-of-energy (LCOE) vs cost of grid power and value of FIT[42]

AU location	All values in US $/kWh		
	10 kW system cost (LCOE)	retail grid electricity price	Compensation from solar exports (FIT)
Adelaide	0.06	0.26	0.05
Brisbane	0.05	0.20	0.05
Canberra	0.05	0.16	0.06
Melbourne	0.06	0.20	0.03
Sydney	0.06	0.22	0.04
Perth	0.06	0.20	0.04

As Table 1 shows, Australians with rooftop solar in the listed locations derive far greater value from the displacement of grid electricity than from the compensation they receive from the FIT for exports to the grid.

Notably, the retail grid electricity prices in the AU locations are comparable to rates electricity customers are paying in California, New York, Massachusetts and other New England states. In some US states, rates are even higher than what Australians are paying, making rooftop solar an even more attractive value proposition if US installation costs are brought down.

In California, the new NBT compensation rate is at a level comparable to the new AU FIT compensation rate. So, with California's high average electricity price of $0.31/kWh, this would make low-cost rooftop solar even more attractive in that state.

Net Billing and Its Implications for the Financial Viability of Local Solar Generation

There are two important implications of the declining value of rooftop solar exports –

- The increasing importance of self-generation for self-consumption
- The increasing value of the Local Power Networks approach

Self-generation for self-consumption

As customer compensation for exports is drastically reduced in the US and in Australia, the calculation of the value proposition of rooftop solar changes. Exporting to the grid loses much or all of its financial value to the customer. Instead, the value of rooftop solar increasingly is found from "self-consumption" – making maximum onsite use of the electricity generated from the rooftop solar system rather than exporting surplus power to the grid for little or no compensation. This, in turn, has other implications such as the increasing need to bring installation costs down, as discussed throughout this paper, and the increasing importance of battery storage so that solar owners can self-supply when the sun goes down.

[42] Australian Energy Council, *Solar Report Q3 2024*, November 7, 2024, Table 4, p. 13.

Local Power Networks (LPN) Model – The Increasing value of the LPN approach

The declining value of exporting to the grid and the benefit from adding storage creates an environment in which the Local Power Networks (LPN) model becomes increasingly useful and valuable. LPNs do not rely on net metering. The network operates in an auto-supply or "islanded" mode most of the time, with no power flowing to or from the wider grid for extended periods, as managed by the LPN operator to optimize value for LPN members. Rather than sending excess power to the grid, households' excess electricity is sent to a local battery array that serves the LPN members. The network does not rely on being compensated for exporting to the grid. Its focus is on maximizing self-generation for self-consumption. Moreover, for renters and for homeowners who cannot afford batteries, who lack rooftop solar systems or whose systems are too small to meet their load, the LPN "Reservoir",[43] with its network-level PV generation and energy storage capacity (available to serve all members of the network), can make self-consumption viable for many people who would not otherwise have access to inexpensive solar power.

Self-consumption is most viable when solar generation is paired with electricity storage, generally by means of home battery storage. But batteries add cost, generally from a low of $6,000 to an average of $10,000 in the US for an 11 to 12 kWh battery.[44] Recognizing this, and with the intention of supporting self-generation for self-consumption, AU is now planning to subsidize home batteries in the amount of $4,000 (AU$) (equal to $2,500 US$) per household. In the US, there has been a 30% tax credit for home batteries. Even as that is eliminated by US federal legislation, the upfront cost of storage for individual customers can be borne by the LPN in the form of a community-level battery array, purchased and owned by the network, serving all LPN members.

Conclusion

This paper examines how Australia is achieving low costs for residential rooftop solar and how these low costs can potentially be replicated in the US.

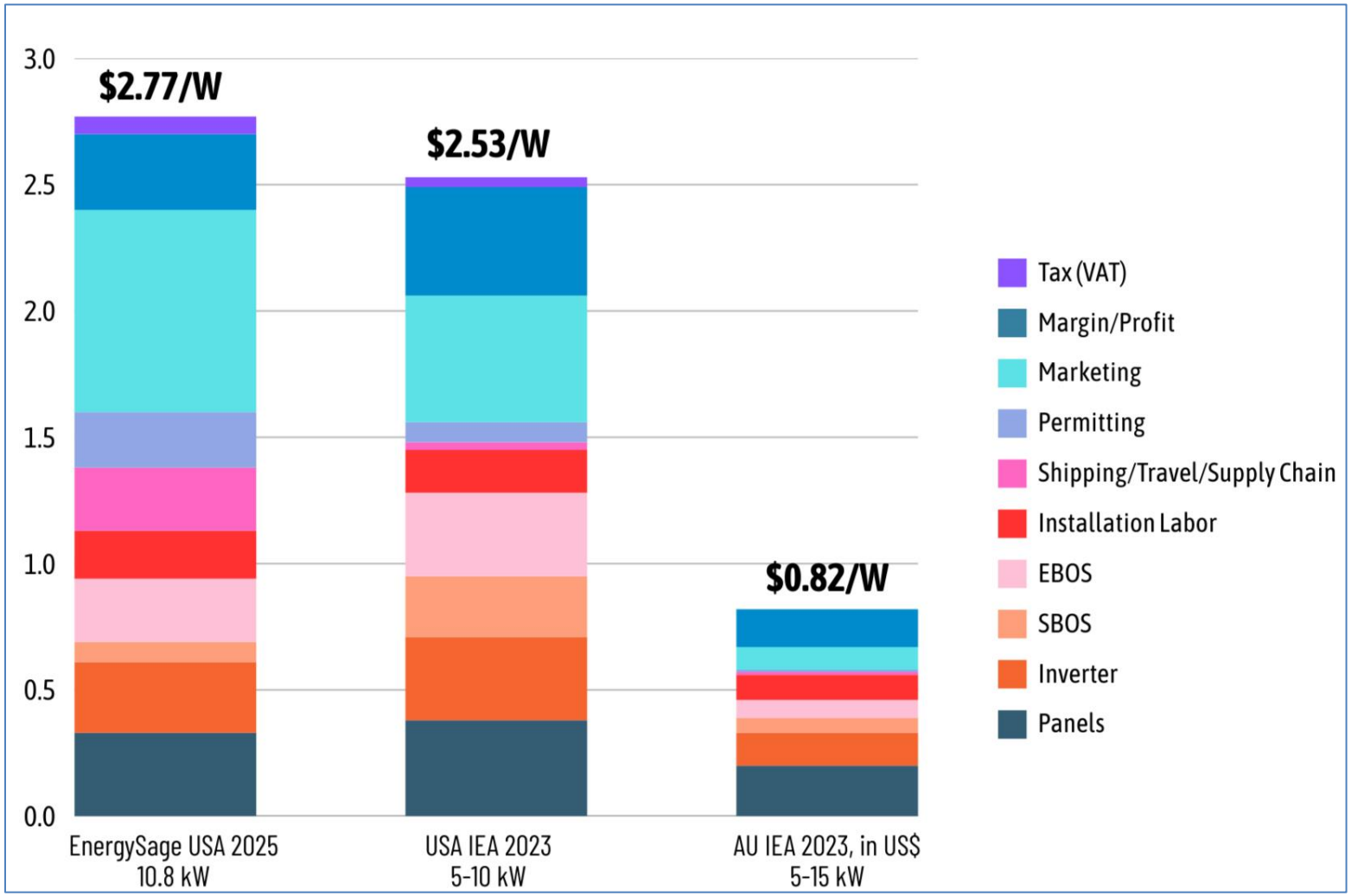
Australia, a country with a standard of living comparable to the US, is installing residential rooftop solar systems at approximately one-third the US cost on average using essentially the same hardware.

The low-cost AU residential rooftop solar cost structure can potentially be replicated in public and not-for-profit electric utility territories in the US by taking advantage of these utilities' ability to bulk buy hardware using low-cost financing, and their concomitant ability to create the conditions to substantially reduce the soft costs of residential rooftop solar installation.

[43] See the Blueprint for Local Power Networks at https://www.bu.edu/eci/2025/01/01/6553/ .
[44] TeraHive, *How Much Solar Batteries Cost for Homeowners in 2025*, 2025: https://www.terahive.io/blog-posts/how-much-do-solar-batteries-cost.

Attachment A

Solar $/W cost comparison
USA residential (2), AU residential in US$



Sources:

EnergySage (USA) https://www.energysage.com/local-data/solar-panel-cost/
USA IEA 2023 https://iea-pvps.org/national_survey/national-survey-report-of-pv-power-applications-in-the-usa-2023/
AU IEA 2023 https://www.energysage.com/local-data/solar-panel-cost/

Annex

Cost of Rooftop and Plug-In Solar PV in Germany

Beth Woolfolk, Manager of Renewable Energy Planning and Policy; A Climate to Thrive

July 2025

Introduction

Germany currently has over 2 million rooftop solar systems installed nationwide. These sources contribute approximately 20% of the country's total electricity production[45]. In 2023, 70% of the newly added solar capacity came from rooftop solar installations, with 6.5 GW coming from homeowner arrays specifically. Pairing generation with battery storage has become increasingly common. In 2023, 80% of new rooftop solar projects were installed with batteries, and by the end of that year, 40% of all residential rooftop systems in Germany were paired with batteries[46] As of 2023, 10% of all German households had adopted solar. A notable portion of residential solar comes from small 600-800 watt plug-in "balcony solar" systems.[47] In 2024, for every five solar arrays installed in Germany, at least two were plug-in PV[48].

The success of Germany's rooftop solar adoption is due to the "Solar Package," which refers to a set of policies and regulations aimed at promoting the use of solar energy within the country. These policies include feed-in tariffs (FiT), investment incentives, interconnection priority, research and development support, and energy storage support. The Solar Package is not a result of a single law but has evolved through several legislative measures, which include the Renewable Energy Sources Act (Erneuerbare Energien Gesetz or EEG), the Energy Industry Act (EnWG), and the Climate Action Programme.

Germany's combination of strong government policies, competitive market environment, technological advancements, and cultural embrace of renewable energy have enabled the country to achieve significantly lower rooftop solar installation prices compared to the U.S.

Average Rooftop PV Cost for Homeowners

The average cost for a 10 kW rooftop system (2023) ranges between $15,160 to $16,850.

Figure 1. Germany's Cost per Watt of Installed Rooftop Solar [49]

2010	2017	2019	2023
E3,50/W ($4.66/W)	E1,60/W[50] ($1.81/W)	E1,45/W ($1.62/W)	E1,40[51]- E1,56/W ($1.52 to $1.69/W)

[45] Federal Ministry for Economic Affairs and Energy, 2023

[46] Fraunhofer ISE 2023 Solar Report, page 21

[47] Fraunhofer ISE 2023 Solar Report, page 19

[48] Solar_Power_Europe_Plug_in_Solar_PV_Briefing_Paper_20250312_V02_6dbb591d88.pdf (page 21)

[49] *Source: gruenes haus* The price development of photovoltaics (until April 2025), currency calculated based on exchange rate each year.

[50] The price development of photovoltaics (until April 2025), currency calculated based on exchange rate each year.

[51] Fraunhofer ISE 2023 Solar Report, page 9

The average rooftop solar system costs less than 30% of the German average income ($58,176[52]), while the same array can cost over 40% of the average income ($66,621[53]) in the U.S.

Germany has been able to achieve these low prices by forcing soft and hard costs down through policies mandated by the EEG.

Soft costs, such as labor, marketing, and administrative expenses, are generally lower in Germany due to streamlined processes and competitive market dynamics. In the U.S., these costs can be significantly higher due to regulatory complexities and varied local requirements by utility companies. Germany has simplified its permitting and administrative processes for solar installers applying for grid interconnection, reducing the time and cost associated with getting solar systems approved and installed.[54] This contrasts with the often complex and fragmented permitting systems in the U.S., where costs can vary significantly by region.

Hard costs, including solar panels, inverters, and mounting systems, are lower in Germany because, as of 2018, there are no additional import tariffs beyond those required by the EU on components produced in China and Southeast Asia. In contrast, the U.S. has imposed a variety of tariffs on imported solar panels since 2012.[55] While the U.S. tariffs increased some domestic manufacturing capacity, it was not substantial enough to offset reduced imports or to substantially lower the cost of domestic solar production. The shifting U.S. policies and ongoing trade tension have led to higher import costs, resulting in market uncertainty in the U.S., and higher prices for customers. [56]

While more expensive than imported solar components, Germany's long history of manufacturing, particularly in precision engineering and technology, has led to the domestic production of high-quality PV systems. Over several decades, the country has made significant investments in research and development to advance solar technology and production. Germany's Federal Ministry of Economics and Climate Protection (BMKW) heavily invests in solar manufacturing research and development (R&D) as well as production[57]. The BMKW allocates significant funding for research institutions and universities and provides subsidies to solar manufacturing companies that prioritize R&D. The BMKW facilitates collaborative R&D projects between academic institutions, industry, and government agencies. The BMKW also invests in upgrading the infrastructure and facilities of research centers and manufacturing plants. This includes funding for state-of-the-art equipment and laboratories that enable researchers and manufacturers to experiment with new materials and processes, the ultimate breakthroughs in solar technology. The high demand created by Germany's "Solar Package" has allowed innovative manufacturers to achieve economies of scale. Several PV companies have partnered to begin developing vertically integrated manufacturing capacity.

Balcony Solar

Balcony solar systems, also known as plug-in PV, are becoming increasingly popular among renters and individual apartment owners within German cities, because of their low barrier to entry and flexibility.

---

[52] Average gross monthly earnings - German Federal Statistical Office
[53] National Average Wage Index in the United States for 2023
[54] Germany's 2022 renewables and efficiency reforms | Clean Energy Wire
[55] Tracking US solar imports—and the impact of tariffs
[56] Study: Solar Tariffs Cause Devastating Harm to U.S. Market, Economy and Jobs – SEIA
[57] Germany seeks proposals for 10GW of solar PV manufacturing

These plug-and-play systems are small (600-800 watts) and tend to only cover up to 30% of a household's electrical usage. However, they are very affordable, costing as little as 200 EUR for the smallest systems, and can be installed without a professional contractor. Higher-cost plug-in (2000+ EUR) systems also have 1-5 kW of battery storage integrated. In many cases, users can take their systems when they move. Over half of Germany's population live in rented accommodations[58], so developing a distributed solar ownership pathway in which all people can participate is critical to meeting the country's energy goals.

By the end of 2024, more than 780,000 balcony solar systems were officially connected and registered to the German network regulator's Core Energy Market Register (MaStR).[59] However, some estimates are as high as 4 million installations, most of which are not yet registered.[60] While grid operators worry about transparency and visibility, models show that balcony solar has limited interaction with the grid as most of the electricity generated is "self-consumed" behind the meter.

In 2024, Germany passed legal amendments allowing apartment owners and tenants to install solar systems up to 2000 watts on their balconies. These reforms make it difficult for landlords and apartment owner associations to block balcony solar installations without exceptional justification.

Germany's Solar Package

The elements outlined below created a favorable ecosystem for the growth and affordability of solar energy systems.

Zero Value-Added Tax Rate: Germany has a standard Value Added Tax (VAT) rate of 19%, which is applied to most goods and services. However, Germany adopted a zero VAT for single-family residential and commercial solar and battery systems up to 30 kW. This has a significant impact on the system's upfront cost.

Low-Interest Loans: The Kreditanstalt für Wiederaufbau (KfW) is a government-owned development bank that offers several loan programs aimed at promoting energy efficiency and the use of renewable energy. The KfW Renewable Energy Program offers low-interest loans of up to 20 years for the installation of solar and battery systems.[61] As of May 2025, individuals can apply for loans with 3.76% annual percentage rate (APR).[62]

In addition to nationwide incentives, German states often offer their own loan programs to encourage solar adoption. These government-backed loans significantly lower the initial investment required for solar installations. In the U.S., financing costs add a significant amount to the overall cost of investing in rooftop solar.

Feed-in Tariffs (FiT): This program was introduced through the EEG in 2000. FiT guarantees a 20-year fixed payment for electricity generation that is fed back to the grid from rooftop solar installations. This guaranteed payment is designed to ensure a stable return on investment for solar energy producers and has been a cornerstone of Germany's rooftop solar adoption. In 2000, the FiT program was launched

[58] EU: Germany the highest proportion of rental tenants - German Federal Statistical Office
[59] Bsw_factsheet_solar_pv_eng.pdf (May, 2025)
[60] Solar_Power_Europe_Plug_in_Solar_PV_Briefing_Paper_20250312_V02_6dbb591d88.pdf (page 6)
[61] Energy and environment | KfW
[62] Renewable Energy Standard (270) | KfW

with relatively high rates to incentivize early adoption, and rates remained high until 2006 to sustain momentum and encourage participation. Between 2006 and 2010, rates decreased incrementally each year as technology costs declined and the market matured. It was during this time that Germany's solar deployment saw significant growth due to the confidence provided by the program. Between 2010 and 2015, the FiT was reduced substantially, a policy response in recognition of large reductions in the cost of solar panels.

As solar increased, storage and load management became a priority. Beginning in 2019, Germany began to focus on self-consumption and energy efficiency. This shift influenced the structure of the FiT, and the rates were set to encourage the integration of storage solutions. The FiT rate reduction, coupled with the decline in battery storage costs and legislative reforms, led to 80% of new residential rooftop solar systems being installed with battery storage[63].

Figure 2. Germany's Average Small Rooftop Solar Feed-in Tariff Rate[64]

2015	2020	2023
$.16/kWh	$.12/kWh	$.09/kWh

Figure 3. Germany's Cost per Kilowatt of Battery Storage[65]

2010	2015	2020	2023
6,000 EUR/kW	1900 EUR/kW	1200 EUR /kW	1200 EUR/kW

Berlin – Supports for Local Solar[i]

In addition to the 0% VAT federal support, cities and states throughout Germany have offered millions of euros in subsidies to install rooftop, thermal, and balcony solar systems. The best example comes from Germany's capital, Berlin, which launched its SolarPLUS subsidy program in 2022 as a core part of its Masterplan Solarcity. Berlin's SolarPLUS program subsidizes energy storage up to 15,000 EUR, solar installations up to 15,000 EUR, and up to 65% of project preparation costs like roof surveys, feasibility studies, and tax consultation for individuals and businesses. Additionally, until March of 2025, SolarPLUS provided Berlin residents with up to 500 EUR per household for the purchase of plug-in solar devices with a capacity of up to 800 watts. In March of 2025, Berlin's SolarPLUS funding reduced its subsidy for plug-in solar devices to 250 EUR due to the steep reduction in system prices. Berlin's effort has dramatically increased local solar adoption. According to the Masterplan Solarcity 2023 Report, Berlin increased its annual installed solar capacity by 40%, nearly double the national average increase of 21%. The state of Berlin also leads the country in terms of installed capacity per square kilometer. Berlin's SolarPLUS program has served as a model for other cities and states throughout Germany.

[63] Storage capacities grew by 50 percent in 2024 | German Solar Industry Association

[64] EN2024 ISE Study Levelized Cost of Electricity Renewable Energy Technologies, $/kW calculated based on each years EUR to USD exchange rate. The FiT is calculated based on the amount of electricity generated and the market price of electricity. Each German state has its own program/rate, however all state programs are based on the federal program.

[65] The price development of photovoltaics (until April 2025)

[i] Berin information: sources:

-Solar power from the balcony: subsidy program starts Friday – Berlin.de

-Solar incentives for end-users in Germany | Enact

-Smart Cities World - Solar power - Berlin launches SolarCity 2025-30 masterplan

-Solargesetz Berlin* Vom 5. Juli 2021 (Berlin Solar Law, July 2021)

-SolarPLUS funding programme - Berlin.de

-SolarPLUS - Photovoltaic Funding for Berlin - IBB Business Team GmbH

- Solarcity Berlin Monitoring-Bericht 2023, Senatsverwaltung für Wirtschaft, Energie und Betriebe (Solarcity Berlin Monitoring Report 2023, Senate Department for Economic Affairs, Energy and Public Enterprises)