PERMIT POWER

# As Cheap as Our Peers

## How cutting red tape can lower the cost of rooftop solar and offset rising utility bills

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# Table of Contents


| | |
|---|---|
| 03 | Executive Summary |
| 06 | Background: How red tape increases costs |
| 09 | Results |
| 12 | Policy path: making cheap solar possible |
| 14 | Methodology |
| 18 | References |


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Permit Power is a nonprofit organization making it cheap and easy for American families to power their lives. We do research, education, and advocacy to break down the bureaucratic barriers that get in the way of American families installing rooftop solar, home batteries, and other energy upgrades.

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# Executive Summary

In the US, the price tag of residential rooftop solar and batteries is expensive relative to other countries. At a median of $28,000 for a 7 kilowatt (kW) system[1], solar in the US is up to seven times more costly to install than Australia and Germany at $4,000[2] and $10,000[3], respectively, resulting in a difference of $18,000 to $24,000 per project. These prohibitively high costs serve as a significant impediment to adoption, where less than one in ten families in the US have rooftop solar[4] compared to one in three in Australia.[5]

At the same time, Americans are facing a growing energy affordability crisis. Utility bills have risen faster than inflation since 2022[6], and are set to continue to rise as utilities request record increases in rates from regulators.[7] As a result, 1 in 7 households are living in energy poverty.[8] Yet today, most Americans are unable to afford rooftop solar to help them cut their energy costs, even though rooftop solar could reduce electricity bills by over 80 percent.[9]

Bureaucratic barriers are some of the primary drivers of high residential rooftop solar costs. In particular, the onerous rooftop solar permitting, inspection and interconnection processes in many areas in the US can add tens of thousands of dollars in direct and indirect costs to each installation.[10]

## Bureaucratic barriers driving high residential solar costs

## If rooftop solar was as cheap as our peers. By 2040:

**18.2m**
more families installing solar

**$1,600**
average annual bill savings

**$1.2t**
lifetime savings across all households installing solar

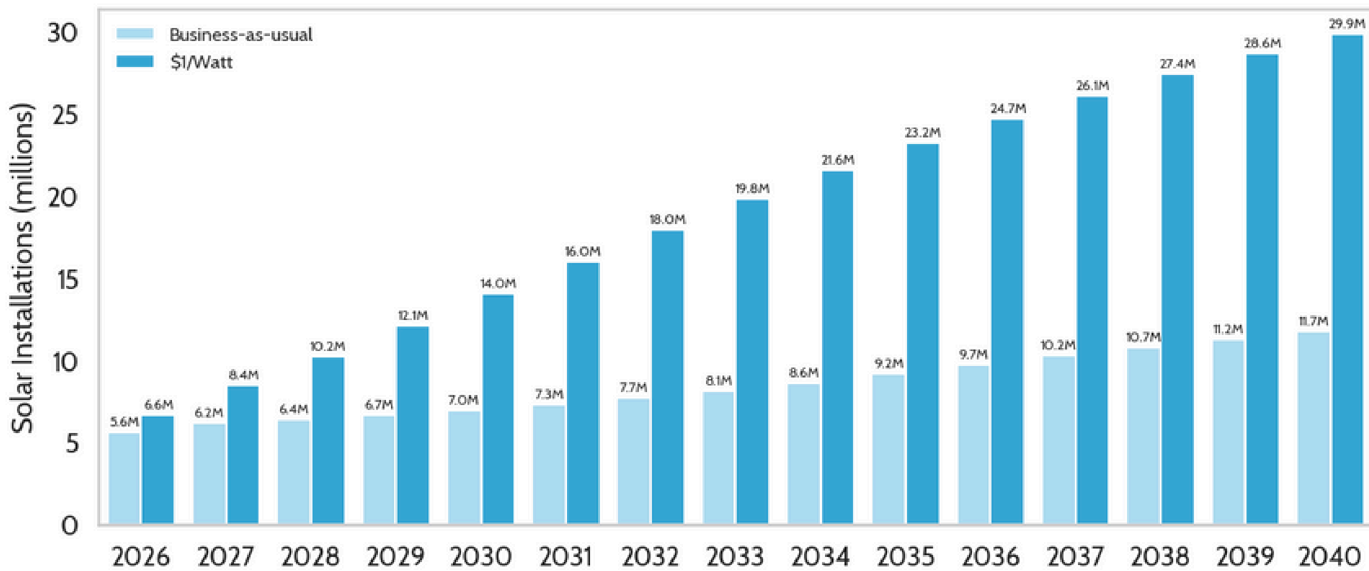
**198.2GW**
more installed residential rooftop solar capacity

With the passage of the One Big Beautiful Bill Act (OBBBA), residential rooftop solar will become even more expensive after the investment tax credit ends in 2027, putting these cost-saving investments out of reach for even more American families. Wood Mackenzie projects residential solar installs will fall by 46 percent through 2030[11]. This market context makes it all the more imperative to find ways to lower costs and enable households to install rooftop solar.

This report models the additional installations, utility bill savings, and generating capacity that would be realized if decision-makers took action to cut red tape and bring the cost of solar down to where it stands in peer countries. This report finds that, by 2040, total installed prices at levels seen in other countries around the world would yield the following over a business-as-usual scenario:

- 18.2 million more families installing solar – a 155 percent increase
- Annual bill savings of $1,600 for the average family
- An average of $56,000 in savings over the 25-year lifetime of a solar PV system, translating into $1.2 trillion in savings across all households installing solar
- 198.1 GW more installed residential rooftop solar capacity[12]

## Figure 1. Solar adoption almost triples by 2040




To lower the price tag for home solar and realize these benefits, policymakers should streamline the permitting, inspection, and utility interconnection processes, including:

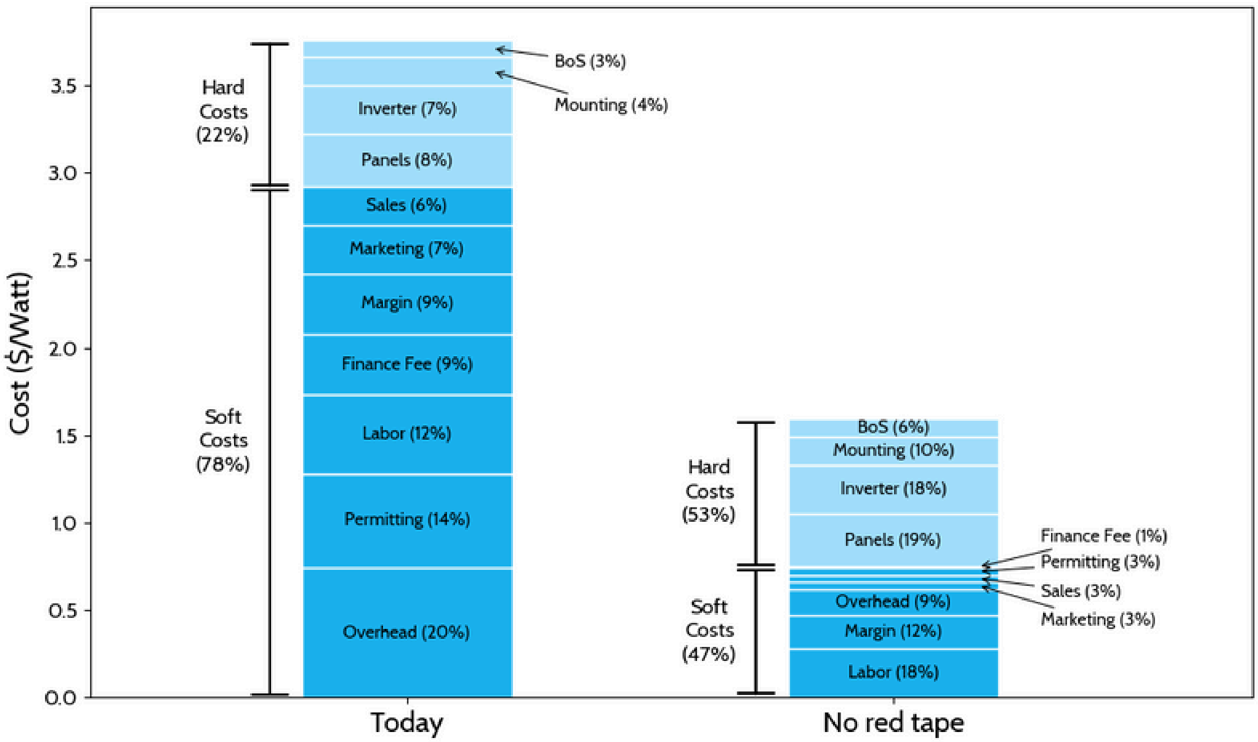
- Adoption of **instant permitting** software or qualified third party permitting to issue instant permits for standard residential solar and battery projects.
- Use of **remote inspection protocols** that allow code compliance to be verified through photos or video submissions for routine residential installations.
- Implementation of **automatic utility interconnection** approvals for qualifying residential systems that use smart inverters and meet established technical screens.
- Updating outdated local government and utility requirements that mandate the installation of unnecessary and expensive hardware, and prevent the use of modern cost-saving technology.

These and other policies to **cut red tape would provide the foundation to allow costs to fall into line with peer countries and 23 percent of US households to get rooftop solar by 2040** compared to 7 percent today.[13] These additional families adopting cheap solar would see their bills decline by 61% on average, an enduring relief from electricity rates that have risen and are projected to continue rising in many areas of the country.

# Background: How red tape increases costs

**78%** of the total installed cost for residential rooftop solar is soft costs

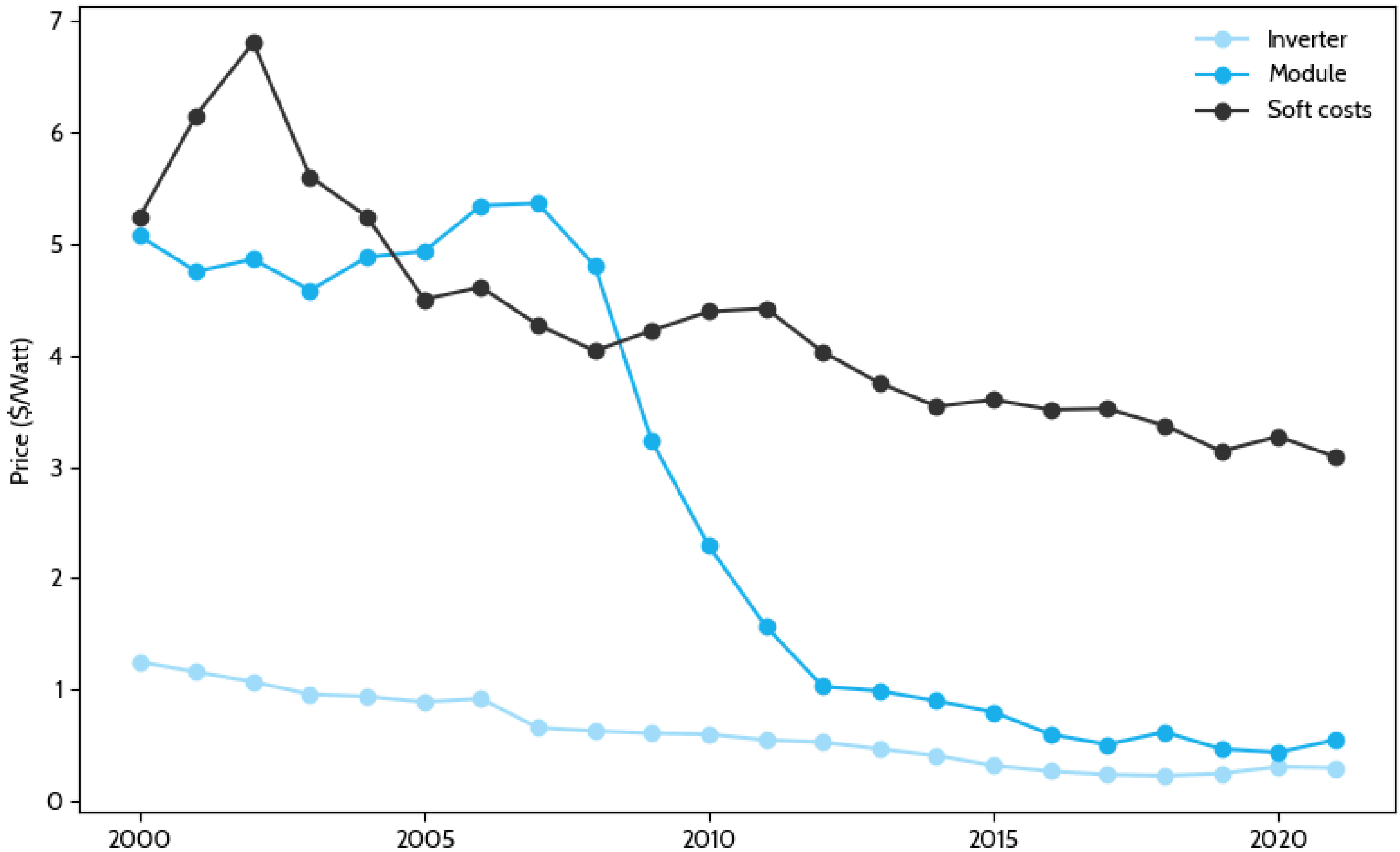
## Figure 2. Residential Rooftop Solar Installation Cost Breakdown[14]




Despite hardware costs falling precipitously in recent decades, the share of U.S. residential rooftop solar system prices attributable to non-hardware components—design, project management, sales, permitting, inspections, and interconnection—has grown.

According to OpenSolar, soft costs account for 78 percent of the total installed cost for residential rooftop solar. The direct fees for permits are a small piece; the larger effects come from costs and delays associated with outdated and cumbersome approval processes, such as varying and convoluted permitting requirements across localities, differing requirements between plan reviewers and inspectors within the same jurisdiction, and unresponsive and bureaucratic utility interconnection processes that can stop projects being turned on for months after they have been completed.

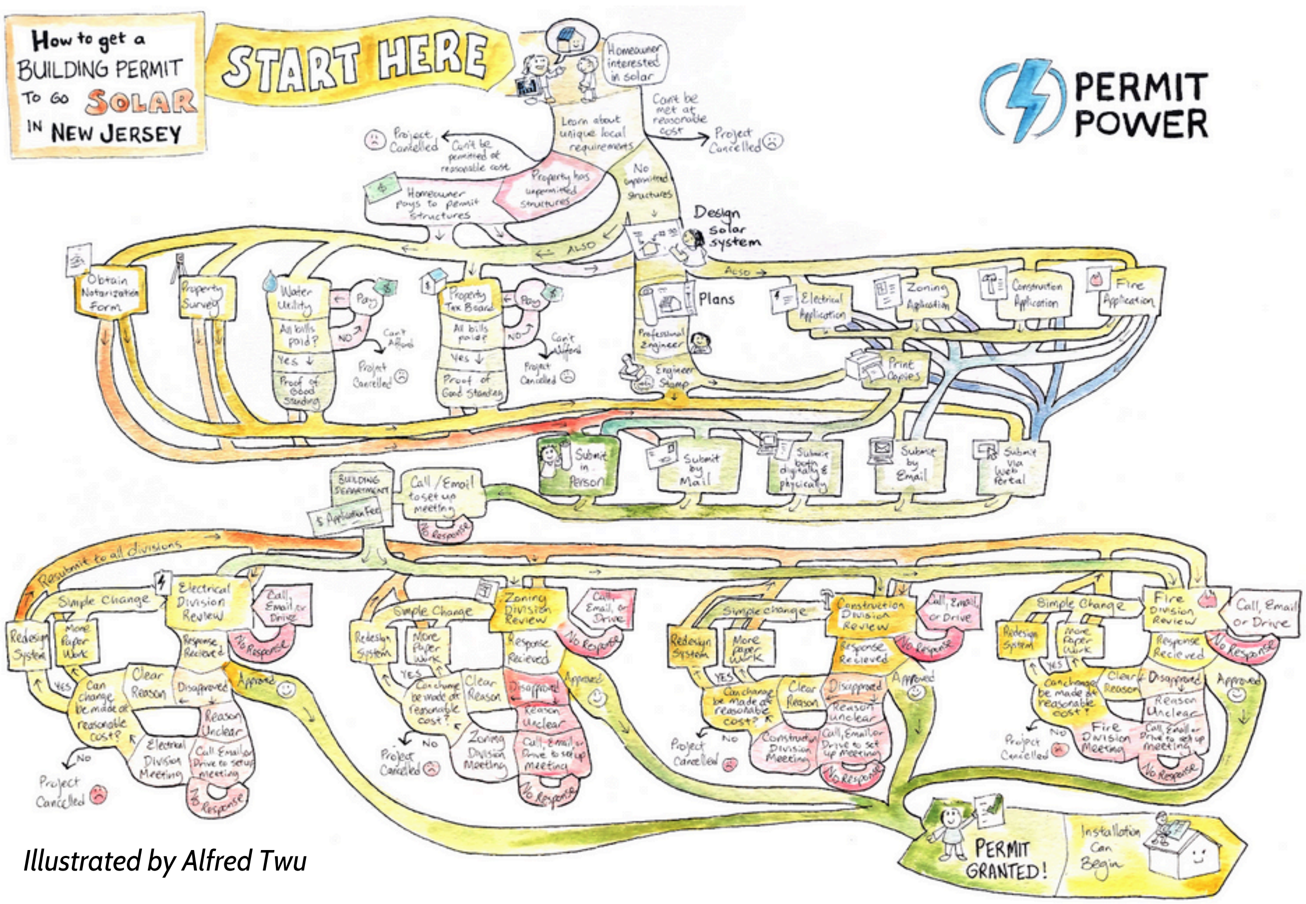
## Figure 3. PV system component prices[15]




These delays lead to cancellations that increase costs for all households aiming to get solar, as installers face higher costs of doing business overall. Indeed, installers report rising cancellations as weeks accrue between sale and construction, with industry data suggesting a roughly **10 percent increase in cancellations for each additional week of permitting-related delay.** [16]

The aggregate impact of permitting alone—counting both direct and indirect costs—was estimated at one dollar per watt for residential systems in 2019 and has not changed much since.[17] With total installed cost estimates ranging from $3 to $5 per watt, this represents 20 to 33 percent of the cost of the system, or $6,000 to $7,000 for an average residential system.[18]

# Evidence from states




*Illustrated by Alfred Twu*

Descriptions of byzantine permitting, inspection, and interconnection processes from states help to demonstrate how bureaucracy increases delays and adds costs:

- **Illinois:** Paper submissions of permitting and inspection documents, sequential approvals across departments, and differing documentation requirements for each local government all serve to delay timelines and drive costs.[19]
- **Minnesota:** In-person submission requirements and monthly township meetings for zoning approval delay the start of construction.[20]
- **New York:** Survey requirements, architectural reviews in certain areas, and restrictive battery practices in some localities impede deployment.[21]
- **Colorado:** Bespoke file-naming conventions and mixed paper/digital formats complicate submissions and lead to increased corrections, resubmissions, and delays.[22]
- **New Jersey:** Sequential approvals across different departments and slow, inconsistent processes lead to cancellations and foregone savings.[23]

# Results

The analysis uses NREL's Distributed Generation Market Demand (dGen)[24] model to translate a change in total installed price into residential rooftop solar and battery adoption over time. The model compares a business-as-usual U.S. residential price of $4 per watt[25] with a peer-country price case of $1 per watt. $1 per watt represents a rough mid-point between recent estimates of prices in Australia[26] and Germany,[27] and serves as an aspirational cost of residential rooftop solar in the US that could be achieved based on a foundation of eliminating red tape. The model calculates system economics based on install costs, estimates market potential based on those economics, and predicts adoption following typical patterns of market growth.

## Top Line Findings

**Under the $1 per watt scenario, the modeling projects:**

- **18.2 million additional residential solar installations**
- **198.1 gigawatts of additional residential PV capacity**
- **46.2 gigawatt-hours of additional residential behind-the-meter batteries,**
- **$245 billion in additional cumulative savings by 2040 compared to the business-as-usual scenario.**

Over the 25-year lifetime of their rooftop solar system, the average family will save $56,000, resulting in $1.2 trillion in savings across all families installing solar.

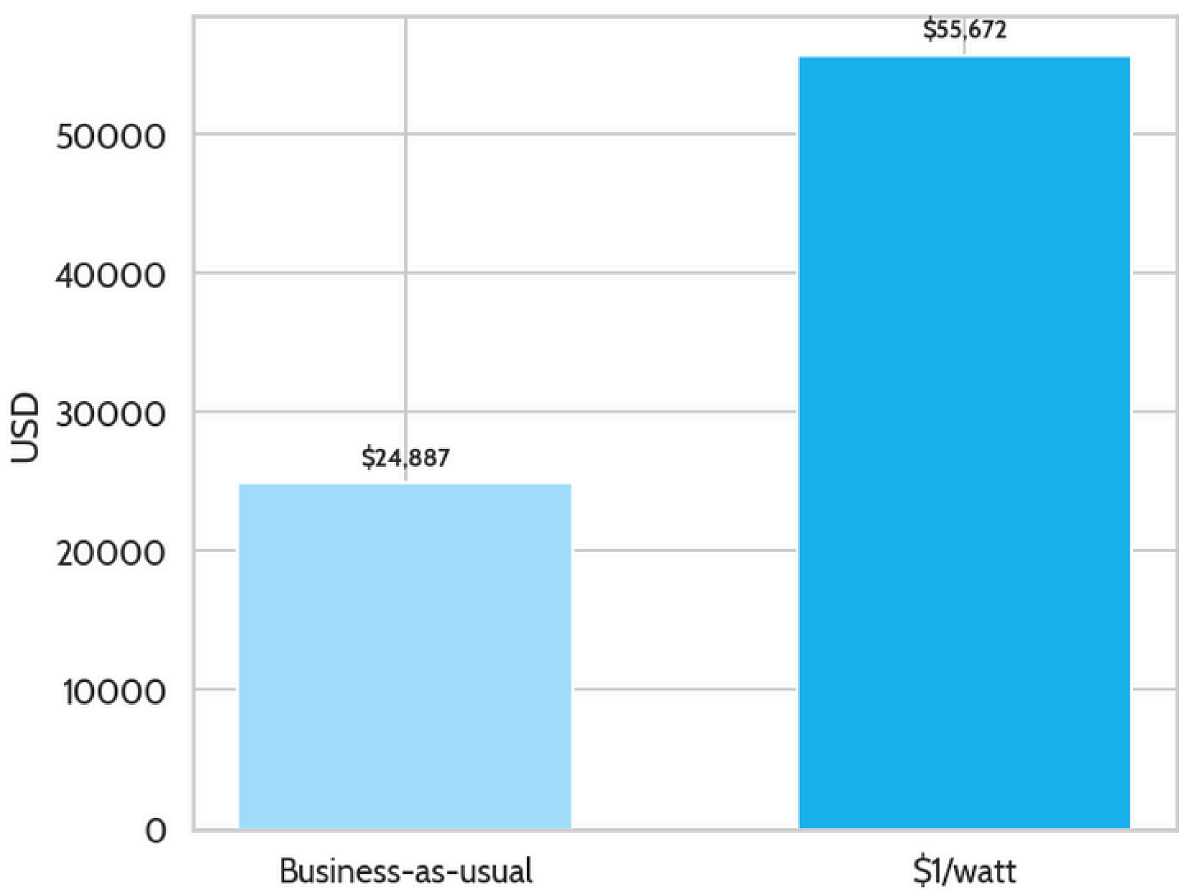
These results indicate that relatively simple bureaucratic reforms can help unlock tens of thousands of dollars in potential savings for households around the country. This is especially relevant in an era where utilities are requesting record rate increases from regulators.

Since 2022, utility rates have increased faster than inflation[28], which exceeded 12 percent between 2022 and 2024.[29] Additionally, in the first half of 2025, utilities requested $29 billion in rate increases[30], which will translate into sharply higher costs for families in the months and years that follow. The Energy Information Administration (EIA) forecasts that rates will be 18 percent higher in 2026 relative to 2022[31], a price shock that can be mitigated with affordable rooftop solar.

## Improved household economics

This magnitude of bill savings is enabled by vastly improved project economics for individual households. By 2040, one dollar per watt residential rooftop solar costs yield average payback periods of less than six years, while in the business-as-usual case, average payback periods remain high at 13 years. In addition, households installing solar will save $31,000 more in bills over the 25-year lifetime of their systems by 2040, after taking into account the upfront cost of the system.

### Figure 4. Net lifetime savings per household installing solar




Rooftop solar is more economically beneficial in states with higher electricity prices, like California and New York, leading to some of the lowest payback periods by 2040 in the modeling. Aside from shorter payback periods, on average, a family installing solar and batteries will see their annual bills decline 61% by 2040.

# Peak demand reductions

Widespread adoption of residential rooftop solar and batteries can help mitigate evening spikes in electricity demand from the residential sector. By storing excess electricity generated from solar panels during the day, batteries enable households to reduce their consumption from the grid in the evening when demand in the residential sector is typically at its highest, contributing to overall reductions in peak demand.

This analysis finds that, if home batteries continue to be paired with rooftop solar at the same rate as they are today, **the additional solar and battery capacity reduces residential sector peak demand by about 21 GW in 2040.** These results demonstrate that distributed solar and batteries can make a substantial contribution to peak demand reduction, supporting reliability and capacity adequacy, and helping reduce costs for all ratepayers.

Certain states, such as Texas and California, see higher battery adoption and thus higher peak demand reductions. Specific dynamics within these states incentivize greater battery adoption and manifest in higher attachment rates.

### California

In California, recent reductions in compensation for electricity generated from solar panels have incentivized self-consumption from home batteries to avoid retail electricity purchases during periods with higher prices. This has led to 66 percent of rooftop solar systems in California being installed with a battery between the second quarter of 2024 and the first quarter of 2025.[32]

### Texas

In Texas, the ability for residential households to participate in virtual power plants (VPP), or aggregations of home batteries across many households that can then be used as a reliable source of power, is more widespread. Households are compensated for their participation in VPPs. This, coupled with periods where the compensation for exporting electricity generated from panels and stored in home batteries to the grid can exceed $1 per kWh, leads to over 30 percent of rooftop solar systems in Texas being installed with a battery over 30 percent over the same period.

Peak demand reductions are important because increases in peak load drive spending on the electricity transmission and distribution infrastructure that all households will pay for through higher electricity rates. Electricity provided at peak times is also the most expensive. To the extent that adoption of rooftop solar and batteries can reduce peak loads, additional infrastructure investments can be minimized, purchases of expensive peak electricity can be avoided, and upwards pressure on future electricity prices can be reduced.

# Policy path: making cheap solar possible

## Policy Options

The policy path to cheap solar and batteries focuses on streamlining the bureaucracy that impedes residential adoption of solar and batteries. First, enable instant online permitting for standard residential systems. A rules-based plan check issues a permit immediately when the design meets code, while non-standard projects continue to a manual review. Local governments using SolarAPP+ report fewer back-and-forth cycles and faster starts, reducing median permitting timelines by over two weeks, or 31 percent.[33]

Second, allow remote inspections of completed projects using structured photo or video evidence for routine items. This can reduce repeat visits and truck rolls while reserving in-person time for higher-risk jobs.

Additionally, standardize inspections to focus on components most important for safe operation of the solar and battery system. This approach addresses common friction points documented in state reports, such as sequential approvals across departments and varying document requirements, without reducing safety.

Third, streamline interconnection for standard residential projects to require that households only or processed in parallel with permitting and standard systems can receive permission to operate without extended queues. Pursuing interconnection approval concurrently with permitting and inspection shortens timelines and reduces cancellations linked to long waits after installation.

## Pathway to cheap solar and batteries

1. Enable instant online permitting
2. Allow remote inspections
3. Streamline interconnection

## Industry changes

These policy reforms can have a material impact on the bureaucratic barriers to residential rooftop solar adoption, but they must be coupled with industry changes to realize more complete cost compression.

Providers have to redesign sales and delivery around digital, self-serve, low-touch motions that the above policies enable. As an example, a report by Tesla on soft costs of residential solar installs points to reductions of $0.57 per watt achievable through customer acquisition and labor improvements—$0.30 from AI implementation that halves commissions and automates project communications, $0.08 from education and transparent, up-front pricing that grows the qualified funnel, $0.09 from tighter install productivity targets, and $0.10 from safety engineering that reduces insurance burden.[34]

Beyond direct soft-cost savings, making rooftop solar and home battery installations cheap and fast unlocks system-wide benefits this analysis does not fully monetize. Distributed generation reduces the cost drivers behind rising retail rates—generation, transmission, and distribution—by shaving peaks, easing transmission congestion, and deferring local capacity upgrades, especially when paired with batteries that make energy available in high-value hours.

Cheaper rooftop solar also improves the economics of electrification: heat pumps, heat pump water heaters, and electric vehicles can utilize midday solar production, cutting household bills. Batteries add resiliency by keeping critical loads powered during outages and, through neighborhood programs or microgrid arrangements, can support nearby homes and essential services.

At the system edge, these resources help serve new loads—from data centers and advanced manufacturing to new housing—without waiting on long-lead central infrastructure. And because solar displaces fossil generation at the margin, particularly peakers, it reduces local air pollution and carbon emissions in communities that often bear the highest exposure. Taken together, these public benefits strengthen the case for policy implementation that cuts red tape impeding solar adoption, even when they are not fully captured in a per-watt cost ledger.

# Methodology

## Building energy simulations

The foundation of NREL's dGen model is a set of approximately 25,000 building energy simulations sampled from NREL's ResStock database that statistically represent all US households.[35] Each simulation uses location-specific building attributes, weather data, and socio-economic characteristics to model energy consumption for all household end-uses over all 8760 hours of a typical meteorological year. Each simulation also represents the universe of households that can potentially adopt solar based on their roof area, azimuth, tilt, occupancy status, and tenure, with only single-family and small multi-family, owner-occupied homes included. Simulated energy consumption is then calibrated using real world load profiles drawn from utility data. Building and socio-economic characteristics are primarily drawn from the American Community Survey (ACS) Public Use Microdata and the Energy Information Administration's (EIA) Residential Energy Consumption Survey (RECS). More information on ResStock's building energy simulations can be found on NREL's ResStock page and related publications.[36]

## Rooftop solar system size and performance

Each building energy simulation utilized by dGen represents between 3,000 and 7,000 households in the real world. Within dGen, rooftop solar system configurations are sized for each building energy simulation to yield the configuration with the highest net present value (NPV). System performance and bill impacts are simulated using NREL's System Advisor Model (SAM)[37], which takes as inputs system size in kW, efficiency in kW per square foot, annual PV degradation, and economic inputs such as total installed costs, utility tariffs, debt fractions of total installed cost, loan interest rates, loan terms, inflation rates, taxes, any incentives, and discount rates to model the hourly generation of a rooftop solar system, resulting electricity bill savings, net present value, and system payback. dGen utilizes Python's SciPy optimize library to search over solar system sizes that vary between 80% and 125% of a given building energy simulation's maximum load to find the NPV-maximizing configuration.

## Technology diffusion based on economics

Based on the total installed price input into the model, the optimal configuration estimated by dGen will shift to maximize the NPV of the system. dGen converts these changing project-level economics into adoption over time using a Bass diffusion process. For each building energy simulation (which in turn represents thousands of households in the real world), dGen first translates the project-level economics into a maximum market potential: the fraction of similar households that would ultimately install solar if the given project economics stayed fixed. The specific economic metric used is system payback, which is mapped to maximum market potential from curves drawn from empirical studies.[38] This step sets the ceiling for adoption among the households represented by each building energy simulation.

The model then governs the pace of movement toward that ceiling with a Bass S-curve for technology adoption. Two parameters in the S-curve's mathematical function influence this pace: an "innovation" term (capturing early adopters who move based on economics alone) and an "imitation" term (capturing adopters who move as rooftop solar systems become visible in the peer group). After each year and associated input installed price changes, dGen recomputes economics, updates the maximum market potential, and advances diffusion for every representative building energy simulation. The result is an S-shaped path in which adoption is slow at first, accelerates as visibility rises, and tapers as the representative household approaches its maximum share over time.

Because project economics change over time (for example, as total installed price falls or electricity prices rise), the model must move from one adoption trajectory to another without creating artificial jumps. dGen does this by finding the "equivalent year" on the new trajectory defined by the S-curve—the point that yields the same cumulative market share achieved so far—and then stepping forward one modeling interval from that point. In practice, this means an improvement in economics raises the ceiling and steepens the S-curve, but the adoption path remains continuous rather than spiking in the year of change. dGen also enforces a "no backsliding" rule: cumulative market share cannot fall from one step to the next.

## Battery energy storage

After dGen has determined the number of households that will install solar in a given year, the model assigns battery energy storage based on average state-level battery attachment rates between the second quarter of 2024 and the second quarter of 2025, weighted by the number of battery installations in each quarter. Battery attachment rates are drawn from Ohm Analytics data.[39] Batteries are sized according to fixed ratios relative to the rooftop solar system: battery power in kW is equal to the rooftop solar system size in kW. Battery energy storage in kWh is equal to twice the rooftop solar system size in kW. After sizing, the model simulates behind-the-meter dispatch for those households assigned batteries to capture bill savings and peak demand reductions. The model does not take into account VPPs, wholesale market participation, capacity payments, ancillary services, or explicit resilience value for batteries.

## Modeled scenarios

Given the above framework, this analysis models two scenarios: business-as-usual, where prices start at $4 per watt and decline at the same rate as NREL's 2024 Annual Technology Baseline for residential rooftop solar[40], and the peer-country price scenario, where prices start at $1 per watt and decline two percent per year thereafter. $4 per watt represents the median installed price according to Lawrence Berkeley National Lab's *Tracking the Sun*[41] data for the year 2024.

In both scenarios, residential rooftop solar project economics were evaluated based on 70 percent debt financing, an interest rate of seven percent, a discount rate of five percent, and an inflation rate of 2.5 percent. The investment tax credit under 25D is applied to rooftop solar in 2026 and 2027 in this analysis. Electricity rates are assumed to increase by three percent annually through 2040.

## Bill savings

Each building energy simulation in dGen is assigned a specific utility tariff based on the county associated with the simulation.[42] The tariff is applied to the hourly profile for each simulation under the business-as-usual and $1 per watt scenarios. The hourly charges are aggregated to the annual level, and the difference between the annual aggregations plus the value of all electricity exported to the grid represents the utility bill savings. Export compensation is calculated at an hourly level using county-level hourly wholesale electricity prices prepared by Sun et al. (2025)[43] based on data from the EIA. For each household adopting solar and/or batteries, PySAM projects forward the annual utility bill savings for the 25-year lifetime of the system, taking into account inflation and increases in electricity prices. As "cohorts" of households represented by each building energy simulation adopt solar and batteries over time, the model carries forward their savings based on the projected annual savings output by PySAM.

## Peak demand reductions

To calculate peak demand reductions, the model first aggregates the hourly load profiles at the state level under the business-as-usual scenario and the $1 per watt scenario, subtracting any self-consumption from the solar and battery system to produce a net hourly load time series. Batteries are assumed to charge exclusively from rooftop solar generation. The hour with maximum demand from the residential sector in GW is then identified for each state in the business-as-usual scenario. The model then subtracts the demand in GW from the same hour in the $1 per watt scenario state-level net hourly load time series to produce a reduction in peak demand. This describes the reduction in coincident peak for the residential sector alone; the peak hour at the system level may differ from that of the residential sector, depending on electricity consumption patterns in the commercial and industrial sectors, though the residential sector usually drives peak electricity consumption at the system level.

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