How Smart Permitting Could Accelerate Rooftop Solar in Colorado

Alexander Gard-Murray
Fellow, *Greenhouse Institute*
Research Affiliate, *Brown University Climate Solutions Lab*

January 31, 2025

BROWN UNIVERSITY | CLIMATE SOLUTIONS LAB

Greenhouse

Credits
Alexander Gard-Murray is a Fellow of the Greenhouse Institute and a Research Affiliate of the Climate Solutions Lab.

The Greenhouse Institute is an independent research institute finding and fighting for solutions to the climate crisis.

The Climate Solutions Lab is housed at the Watson Institute of International and Public Affairs at Brown University, dedicated to creating, learning, and distributing solution-oriented climate knowledge, at Brown and across the world.

Funding
This research was supported by a grant from Permit Power, a national nonprofit conducting research and advocacy to increase the speed and reduce the cost of installing clean energy equipment.

Disclaimer
Statements and views expressed in this report are solely those of the author and do not imply endorsement by Greenhouse, Brown University, the Watson Institute for International and Public Affairs, or Permit Power.

Cover Image
Image of Sunrise at Horsetooth Reservoir, Colorado by Frankie Lopez, available at https://unsplash.com/photos/snow-covered-mountain-during-sunset-UaITS7CCnDE.

Citation
Gard-Murray, A. (2025). “How Smart Permitting Could Accelerate Rooftop Solar in Colorado.” Greenhouse Institute & Climate Solutions Lab. http://www.greenhouse.institute/research/2025/solar_permitting_co/.

Executive Summary

According to the Colorado Energy Office, the state needs to increase its installed solar capacity by a factor of five from its 2022 levels in order to reach its 2040 clean energy goals.[1]

Unfortunately, permitting can be a significant obstacle to rooftop solar. Homes that install solar first need to receive a permit from local governments to begin installation. This can be a lengthy, bureaucratic, costly, and inconsistent process, which can discourage and prohibit families from investing in solar.

> Smart permitting could spur the installation of an additional 32,000–34,000 home solar systems by 2030 and 283,000–329,000 by 2040, an increase of 52–58% above business-as-usual.

This report traces how the current solar permitting process deters families from "going solar," and how streamlining this process using a standardized, online, and smart permitting software platform would help bring solar to more roofs in more neighborhoods. The City and County of Denver have already adopted one such platform, and their experience has already demonstrated significant benefits.

> "Denver's implementation of SolarAPP+ has been a tremendous help in streamlining the adoption of rooftop solar within the city. The new system allows for instant approval of nearly all our residential permits so we can provide customers with quicker installation timelines. [...] We are excited about Denver's embrace of new technology commitment to expanding the number of service offerings eligible for approval in the new system."
>
> *– Ben Long, co-owner of Namaste Solar*[2]

This report models the potential impacts of adopting such a platform across Colorado, and projects that smart permitting could spur the installation of an additional 32,000–34,000 home solar systems by 2030 and 283,000–329,000 by 2040,

[1] CEO (2024).
[2] CPD (2024).

an increase of 52–58% above business-as-usual.[3] These additional rooftop systems could add a combined generating capacity of 210–220 megawatts by 2030 and 1.8–2.1 gigawatts by 2040. In other words, a shift to smart permitting could add roughly double the generating capacity of a typical nuclear power plant.[4]

Making the process of getting solar projects approved more efficient would bring down the costs associated with the permitting process. As these costs get passed on to consumers, lower prices could spur increased demand.[5] As smart permitting cuts through red tape, families buying a new system could save $1,400 on the cost of a new system by 2030, and $3,200–$3,300 by 2040. And that is only the beginning of the savings.

Over the lifetime of the panels, the typical family that "goes solar" as a result of smart permitting could save $30,000 in reduced electricity bills.[6] As electricity prices increase over time, the average family could save $700–$1,300 in electricity bills each year. Adding up the projected ratepayer savings over each system's expected lifetime, the additional families installing solar by 2030 as a result of smart permitting could eventually save a combined $1 billion. By 2040, the expected lifetime ratepayer savings of the additional systems could rise to a combined $8–$10 billion. These projections assume only gradual increases in electricity prices over time: if utilities move forward with substantial rate increases then the value of generating power at home could increase even further.

The increase in rooftop solar systems from smart permitting could cut annual greenhouse gas emissions across the state by 98,000–103,000 metric tons of CO_2 in 2030, and 373,000–434,000 tons in 2040. The cumulative emissions reductions from smart permitting could amount to 210,000–217,000 metric tons of CO_2 by 2030 and 3.3–3.7 million metric tons of CO_2 by 2040. This is equivalent to avoiding the emissions from driving 759,000–780,000 gasoline-powered cars for a year, burning 7.5–7.7 million barrels of oil, or using 150–153 million barbeque propane canisters.

The increase in demand for new solar installations could also create 560–610 jobs across the state by 2030, and 1,600–1,800 jobs by 2040. Higher installation volumes could also mean increased permitting fee revenue for jurisdictions, bringing in $6 million by 2030 and $61–67 million by 2040. Reduced labor required to review all permits could save 199,000–203,000 hours of staff time by 2030 and

[3] The model assumes that the market environment in which residential solar has developed to this point persists. Significant changes to the market, such as the expansion of the Successor Solar Incentive program or cuts to net metering, could expand or shrink the projections.
[4] Office of Nuclear Energy (2021).
[5] The projected cost reductions are derived from assumptions based on samples of the market. The components of a project's cost, which impact the projected cost savings achieved from smart permitting, can vary widely across the industry.
[6] This assumes a 30 year lifetime with 0.5% annual loss in panel capacity (DOE 2021).

826,000–895,000 by 2040, allowing plan reviewers to focus on other priorities, such as permitting new housing.

Up until recently, governments that wanted to implement smart permitting had no choice but to implement it themselves. This could be a costly and complicated task for an individual government to start from scratch, requiring specialist expertise and resources. But the recent launch of multiple smart permitting platforms available at no cost to governments mean that the status quo of slow, manual permitting processes is no longer difficult to escape. For families and the state to realize these benefits, Colorado should ensure that smart solar permitting is widely available.

Table of Contents

The Benefits of Residential Solar in Colorado

Colorado has some of the highest levels of solar potential in the country. The state was among the first to pass a renewable portfolio standard to encourage the development of solar resources.[7] Demand is soaring: Colorado is one of the top ten states for residential solar installations, and residential solar capacity grew by 217% between 2017 and 2022.[8]

Solar photovoltaic (PV) technology is crucial to meeting Colorado's greenhouse gas reduction goals. To meet the state's goal of 100% renewable energy by 2040, the Colorado Energy Office estimates that the state will need to have 11 GW of solar power by 2040, up from 2 GW today. That means a fivefold increase in solar capacity in the next fifteen years.[9]

Rooftop solar also benefits the grid by reducing the need for costly transmission and distribution upgrades, alleviating stress on the infrastructure, making the overall service more dependable.[10] In addition to the everyday benefits achieved by reducing the total demand for electricity, rooftop solar produces the most energy when the grid is most in need – afternoons on hot summer days when families are running their air conditioners.[11] When paired with a home battery, residential solar can provide clean energy to the residence and neighborhood once the sun sets.

Solar electricity makes vital contributions to Colorado's economy. Solar PV systems can allow residents to cut their bills by $700–$1,300 annually.[12] The solar industry, including residential, commercial, and utility scale companies, employs 9,623 people in the state across more than 414 businesses (IREC 2024). Altogether, solar investments in Colorado to date total more than $8.1 billion (SEIA 2024).

Despite the development to date and benefits of residential solar, deployment in Colorado remains far below its potential, tapping only 4.8% of its rooftop generating potential in 2022.[13]

---

[7] SEIA (2024).
[8] Dutzik et al. (2024).
[9] CEO (2024).
[10] Fields (2023) and DOE (2023).
[11] Fields (2023).
[12] Price data from EIA (2024a), savings calculated using the NREL System Advisor Model (NREL 2024a).
[13] Schatz (2024).

Bureaucratic Permitting Requirements Deter Families from Going Solar

Unfortunately, permitting can be a significant obstacle to rooftop solar across the Centennial State. Homes that install solar first need to receive a permit, which grants permission to begin the installation, from local government. In Colorado, the permitting process can be lengthy, bureaucratic, inconsistent, and costly, which can discourage and prohibit families from making the investment.[14]

As of December 2024, according to data available from Ohm Analytics, Colorado has some of the longest permitting timelines in the Western United States, placing it behind many states with no statutory climate goals at all.[15] Statewide, one in ten projects takes more than a month to receive a permit.[16]

Many cities and counties in Colorado have their own bespoke processes and requirements for obtaining the permit.[17] In Fort Collins, for example, installers must first submit solar plans via email and then submit revisions via an online portal. Fort Collins building department has also published a page of file naming conventions based on the project's permitting stage. Arapahoe County has its own guide with formatting requirements. Rifle requires two physical copies of the solar plans as well as one emailed or delivered on a flash drive. Solar installers frequently mention the difficulty of learning about a jurisdiction's specific requirements. Solar permitting can also be held up by requirements unrelated to the health & safety of the solar project itself, like closing outstanding permits for home renovation projects unrelated to solar or getting approval from a homeowners' association before the building office will issue its permit.

[14] Inefficient permitting is also one of the largest barriers to maximizing the impact of grant programs, like the $156 million Colorado was scheduled to receive from the federal Solar for All program for low- and moderate-income communities. At time of writing the future of this program is unclear, following an executive order pausing the program issued by President Trump on January 20, 2025 (Bolster 2025). If this program survives, smart permitting would help Colorado take full advantage of this resource (Steinberg & Richardson 2024, p. 1).
[15] Ohm Analytics (2024). Permitting timelines are determined by the median for each state. Ohm does not have permitting timeline data for five states, and data are limited for some states.
[16] Based on data from Ohm Analytics (2024). The 90th percentile for permitting timelines in the state is 24 business days.
[17] Examples in this paragraph drawn from CoPIRG & Conservation Colorado (2025).

Other permitting challenges include requirements unrelated to the health and safety of the solar system, like requiring the outstanding permits for home renovation projects irrelevant to the solar must be closed and homeowner association approval must be granted before the permitting office provides their approval.

Nationally, 22 percent of residential solar projects that apply for permits are canceled.[18] According to national survey data, installers view the permitting process as the most important cause of customer cancellations.[19] Installers' second most important cause of cancellation is changes in customer finances, a risk that likely increases with project delays.

> *"Why isn't Colorado realizing its rooftop solar potential? Too often, red tape is getting in the way of going solar. Even for straightforward residential solar projects, it can take days or weeks to get local government approval for installation. The processes vary by jurisdiction and can be complex and costly. The additional costs associated with the permitting process can push rooftop solar outside of many homeowners' budgets despite the otherwise falling costs of going solar."*[20]

Permitting barriers directly discourage and prevent families from going solar. Additionally, permitting barriers drive up costs, which further discourage and prevent families from making the investment. The costs of permitting bureaucracy come from both the direct work of preparing, submitting, and revising permit applications and the costs caused in the rest of the installation process by uncertainty and complexity of permitting. These costs include:

- **Permit application preparation:** preparing the permit application requires developing a bespoke set of plans outlining the technical details of the project, tailored to the particular requirements of the jurisdiction. As previously stated, different jurisdictions can have different requirements and processes, and permit reviewers within the same jurisdiction may interpret codes differently.[21]
- **Permit submission:** in many jurisdictions in Colorado, the plans and forms need to be printed out and submitted in person, adding labor and travel time. In the National Renewable Energy Laboratory's SolarTRACE data, 77 out of 173

[18] Cruce et al. (2022), p. 17.
[19] Cancellations during the permitting process itself are rare, but cancellations later in the process are still large, and contractors report permitting as the foremost driver. See Cook et al. (2021).
[20] Schatz (2024).
[21] Compare this with the situation in Germany, where "PV systems have been explicitly exempted from building permission requirements in the model building code" since 1997, "the overwhelming majority of rooftop PV systems have never been subject to any permit requirements placed by local authorities," and "planning and transaction costs related to municipal requirements are generally minimal to non-existent for most rooftop PV installations" (Strupeit 2016, p. 452).

jurisdictions in the state are confirmed to allow online submission of applications, and only 9 jurisdictions in the data offer same-day, in-person permitting. According to these data, only two jurisdictions allow instant online smart permitting (Denver and Bennett).[22]

- **Permitting timelines and delays:** once an installer submits a permit application, they often need to wait weeks or months before receiving the approved permit. As stated above, the median permitting time in Colorado is more than a week, ranking 29th for rooftop solar in the country.[23] While long permitting timelines are a problem on their own, they also can increase project costs by preventing installers from being able to develop the project schedule and manage work crews.
- **Permit revision:** when reviewers identify a problem with an application, installers must spend additional time preparing and submitting a revised application. The back and forth between jurisdictions and contractors can stretch out timelines significantly, as revised applications can end up at the back of the line. The whole process raises costs for both the reviewing agency (which has to revisit the same application multiple times) and families (since the cost of paying installers to revise and resubmit applications drives up the price of the system).[24]
- **Permit fees:** installers must pay a fee to the jurisdiction for review, and may have to pay additional fees for revisions.
- **Overhead:** installers must keep customers updated throughout this process, arranging additional site visits as needed and discussing potential changes in response to rejections, adding communication costs. All of this activity needs to be tracked and coordinated, adding to project management costs.
- **Cancellations:** As previously stated, 22 percent of residential solar projects that apply for permits are canceled,[25] and installers cite the permitting process as the most important cause of the cancellations.[26] Canceled projects drive up the costs for all remaining projects, since deposits (when collected) are rarely enough to cover the lost spending on customer acquisition, project design, permitting, and overhead.[27]
- **Customer acquisition:** customer acquisition includes sales, marketing, and initial system design, and represents the single largest component of solar soft

[22] SolarTRACE (2024). Some jurisdictions are marked “N/A,” so these figures may not be complete.
[23] Ohm Analytics (2024).
[24] Surveyed installers say that inconsistent standards across authorities having jurisdiction cause delays: “interviewees cited inconsistent permitting inspections as a key driver of project delays, given that an installation with the exact same characteristics could pass inspection in one AHJ but fail an inspection in another AHJ” (Cook et al. 2021, p. 156).
[25] Cruce et al. (2022), p. 17 and Ohm Analytics (2024).
[26] According to Cook et al. (2021), cancellation during the permitting process itself are rare, but cancellations later in the process are still large, and contractors report permitting as the foremost driver.
[27] Cook et al. (2021).

costs. The uncertainty of approval timelines creates difficulty for installers to guarantee delivery dates, making sales more difficult. The same negative experiences that drive cancellations can reduce the willingness of customers who do end up installing systems to recommend solar to others.[28] This can increase the cost of acquiring new customers, since peer recommendations are a key driver of solar adoption.[29]

- **Barriers to entry:** permitting complexity can act as a barrier to entry (Dong and Wiser 2013 p. 540). Installers must develop experience with each jurisdiction's rules and how individual reviewers interpret those rules.[30] This increases startup costs for new firms and slows the expansion of existing firms.
- **Installer reactions:** Some installers raise prices in difficult jurisdictions, while others spread the cost across all their customers. Some firms avoid the most difficult jurisdictions altogether, reducing the number of contractors competing for families' business, further driving up costs.

Taken together, all these permitting-driven installation costs raise the price of residential solar in Colorado. Unnecessary and inflated permitting costs create a vicious circle: high upfront prices reduce demand for solar, which drives up customer acquisition costs. Higher customer acquisition costs, in turn, drive up prices for future customers. These effects compound over time, keeping solar more expensive than it otherwise would be.

Generally, the United States has many more permitting and bureaucratic barriers compared to other high-income industrialized countries. As a result, in 2020, the price for a typical residential solar system in the United States was $28,600, while the price in peer countries was $9,000–$16,700.[31] In 2023, the price for a typical residential solar system in the US had actually increased since 2020 to $31,500

[28] One solar installer we spoke with had a third party survey their customers after installation to find out how likely they were to recommend the company. If the installation was completed within 30 days, 70% of customers said that they would recommend the company to others. But once the installation took 120 days, 0% of customers were willing to make a recommendation. Beyond that time, customers were inclined to actively warn others against working with the company.

[29] Wolske et al. 2020.

[30] This could be especially difficult for larger firms trying to develop high-volume, low-cost business models (Overholm 2015). This could also help explain why large national solar firms do not necessarily have lower costs than small firms, despite the potential for economies of scale.

[31] IRENA (2021). 2020 prices were $1.20/W in South Korea, $1.22/W in Australia, $1.38/W in Italy, $1.40/W in Spain, $1.61/W in Germany, $1.84/W in France, and $2.22/W in the United Kingdom. In the same year, prices were $4.24/W in California and $3.52/W in other US states, creating a national weighted average of $3.808/W. Roughly 40% of solar systems in the U.S. are in California (Lyons 2024). Prices for the solar system assume a typical system size of 7.5kW.

despite prices in countries like Australia continuing to decline.[32] The price in Colorado in 2023 was even higher, hitting $35,250 for a 7.5 kW system.[33]

[32] Barbose et al. (2024). The median 2023 price was $4.2/W. Price for the solar system assumes a typical system size of 7.5kW. Note, IRENA (2021) and Barbose (2024) used different methodologies to calculate $/W costs, yielding different $/W figures.
[33] Barbose et al. (2024). The median 2023 price in Colorado was $4.7/W. Note, IRENA (2021) and Barbose (2024) used different methodologies to calculate $/W costs, yielding different $/W figures. Except where noted otherwise, prices in the rest of the report are reported in 2023 dollars.

Smart Permitting Encourages Families to Go Solar

Colorado can reduce permitting barriers and spur residential solar growth by switching to a smart permitting process, allowing families using licensed contractors to get immediate feedback on their projects and receive permits instantly. Overall, smart permitting can eliminate permitting timelines, reduce unnecessary bureaucracy, reduce inconsistencies in permitting processes and requirements, and reduce costs.

Today, both the federal government and private vendors have created software platforms that can instantly review applications and issue permits for residential solar projects. Starting in 2019, the National Renewable Energy Laboratory, a branch of the federal Department of Energy, began working with the building safety community, jurisdictions, and the solar industry to create a smart solar permitting software platform. The resulting platform, SolarAPP+, has been deployed in more than 260 jurisdictions around the country as of January 24, 2025, with more than 59,300 permits issued.[34] There are now also private platforms that can provide permitting automation for residential solar, such as Symbium, which as of January 5, 2025 has launched in 43 jurisdictions.[35]

Smart permitting can eliminate the weeks or months families must wait to receive permission from local government to begin installation. Smart permitting can eliminate both expected delays (e.g., when the permit application is approved within the expected two weeks) and unexpected delays (e.g., when the permit application is expected to be approved within two weeks, but is actually approved in two months). If an installer submits a project that is not up to code, smart permitting software notifies the installer in real time. The installer can then make changes to the plans, resubmit the application, and receive the approved permit instantly. Additionally, smart permitting software can approve revisions instantly, further smoothing the installation process (e.g., if the type of solar panels in the approved plans are no longer available when construction begins, and the installer must submit a revised permit application to the jurisdiction).

Smart permitting can standardize the process and requirements for obtaining permits across jurisdictions. This benefit is most visible when the smart permitting platform in operation is consistent between jurisdictions. However, this benefit can persist between different permitting platforms due to the digitization of the process and

[34] "Over 260" includes both 222 jurisdictions that have fully adopted SolarAPP+ and 44 that are currency running pilots See SolarAPP+ (2024a).
[35] Symbium (2025).

similarities in input fields needed for the systems to automate the code compliance checks.

Smart permitting reduces cancellations in two ways. First, smart permitting reduces the instances in which the permit for the intended design cannot be obtained. Second, smart permitting can eliminate long project timelines and the back-and-forth between the jurisdiction, installer, and homeowner, which frequently cause the homeowner to become exasperated and walk away from the project before installation could otherwise begin.

Smart permitting can significantly reduce the resources, complexity, and uncertainty involved in residential solar projects, which directly reduces the cost of solar. These "first-order" effects include:

- **Simplified submission:** permit automation software accepts applications online, eliminating the need for physical plans and in-person submissions. Standardized portals also allow installers to submit plans through one consistent interface, rather than preparing plans with different details for different jurisdictions.
- **Instant feedback:** software can review plans without human intervention, check code compliance, and mark errors instantly. This allows designers to make necessary modifications during the initial design process, without the need for follow-up visits or repeat trips to the jurisdiction.[36]
- **Standardization:** if many jurisdictions adopt smart permitting, the process becomes more consistent. Even if jurisdictions have different requirements, the use of the same platform minimizes the complexity in working across borders.
- **Enhanced government efficiencies:** because smart permitting systems reduce the need for manual staff review, jurisdictions can do more with the same number of building department staff, or re-assign them to other pressing departmental needs.
- **Shortened timelines:** smart permitting can eliminate wait times and delays for solar projects to be reviewed and approved. In 2023, SolarAPP+ eliminated approximately 142,000 days where a project would have otherwise been awaiting approval at the jurisdiction.[37]
- **Enhanced safety:** software-driven plan review can be more comprehensive and thorough than the process that many jurisdictions are following today. SolarAPP+, for example, which was built in collaboration with codes- and standards-development bodies including the International Code Council,

[36] Our installer interviews suggested that each system engineer could handle 50% to 100% more permit applications if all an installer's sales were in AHJs with smart permitting.
[37] Cook et al. (2024). In 2023, SolarAPP processed 14,072 solar-only permits and 4,834 PV+storage permits (p. 9). For traditional permitting, median permitting timelines are 7 days for solar-only projects and 9 days for solar projects that include storage (pp. 12-13). 14,072 times 7 plus 4,834 times 9 equals 142,010.

National Fire Protection Association, and UL, performs a comprehensive review of relevant electrical, fire, and structural codes, ensuring the proposed system meets safety requirements.[38] SolarAPP+ also stays up to date with new code editions and technologies, avoiding circumstances of plan reviewer error due to delayed training.[39]

- **Easier customer acquisition:** shorter timelines and less uncertainty could produce better customer experiences, which should increase customers' likelihood of recommending their installer to others, lowering customer acquisition costs. Additionally, if installers can guarantee installation timelines with more confidence, that may increase sales at the margin as well.
- **Fewer cancellations:** smart permitting can shorten projected timelines, which provides customers with more confidence in the efficacy of the contractor, and avoid major project revisions, which provides customers with assurance in their investment. These factors can increase customer satisfaction and reduce cancellations, saving installers from spreading the expenses from canceled projects across their remaining customers.
- **Fewer failed inspections:** if automatic review catches errors that manual review would have missed, it can reduce the chance that installed systems fail their inspections. One study found that systems permitted through SolarAPP+ failed inspections in most jurisdictions studied less often than those permitted through existing methods.[40]
- **Reduced overhead:** simpler permitting processes, elimination of paper plans, fewer trips to the site and the jurisdiction, and less correspondence with customers can reduce the need for tracking and coordination, cutting overhead.

In addition to the above "first-order" effects, over time smart permitting can also have "second-order" effects, which happen in response:

- **Volume effects:** as cost savings are passed to consumers, demand for solar PV systems should increase. This should lower some of installers' fixed costs, like sales and marketing expenses and general overhead, because they can spread them across a higher number of successful projects.
- **New business models:** over the long term, automation can allow solar installers to overhaul their business models to emphasize speed and volume, becoming much leaner operations that earn smaller profit margins but with higher volume. Fully realizing this model would likely require other process simplifications, like making the inspection and interconnection processes more efficient as well.

[38] See SolarAPP+ (2024b) and UL (2024).
[39] SolarAPP+ (2024c).
[40] Cook et al. (2024), p. 20.

Taken together, these second-order cost reductions have the potential to create a "virtuous" circle, in which direct reductions in installer costs gradually bring down prices, leading to increased demand, which allows for further cost reductions through economies of scale, leading to further cost reductions, and beginning the cycle again.

Two jurisdictions in Colorado have already adopted smart permitting: the City and County of Denver and the town of Bennett. The experiences so far have been positive, with one solar installer reporting:

> *"Denver's implementation of SolarAPP+ has been a tremendous help in streamlining the adoption of rooftop solar within the city. The new system allows for instant approval of nearly all our residential permits so we can provide customers with quicker installation timelines. [...] We are excited about Denver's embrace of new technology commitment to expanding the number of service offerings eligible for approval in the new system."*[41]

So far this report has reviewed the benefits of residential solar permit automation in general terms. The next section quantifies the benefits Colorado might expect from automation.

[41] Ben Long, co-owner and utility/permitting coordinator for Namaste Solar, quoted in CPD (2024).

Modeled Impacts of Permit Automation in Colorado

To estimate the impact of smart online permitting in Colorado, this report models how automation could change the costs faced by installers, lower the prices paid by consumers, reduce cancellations, improve the purchasing experience for families, raise the financial appeal of rooftop solar, and increase the number of solar systems installed. It then projects impacts on individual households and on the state as a whole. The full details of the methodology are available in a Technical Appendix.[42]

The model assumes a 6.5kW system with 18 panels (close to the median size of a system in Colorado). To make sure we capture the different environments in the state, the model run is repeated for Colorado's different climate zones. In each climate zone, the population center of the most populous county in the zone is used as the reference point. The utility rates are also taken from that county, and correspond to the most current rates available. The model takes into account the hourly weather and electricity consumption for a typical home in each reference county. The cost modeling is done in Excel and Python, and the performance modeling is done using NREL's System Advisor Model.[43]

The model uses two benchmarks to track the cost of installing residential solar systems. The first comes from the National Renewable Energy Laboratory (Ramasamy et al. 2022) and the second comes from data shared by a major solar installer software platform (OpenSolar 2024). These data are combined to produce a range of estimates. In both cases, the prices are modified from their original national estimates to reflect local prices in Colorado.[44]

The model assumes that the market environment in which residential solar has developed to this point will persist. Significant changes to the market, such as the expansion of the Successor Solar Incentive program or cuts to net metering, could change outcomes either positively or negatively. The model also assumes that cost reductions for installers will gradually be passed on to consumers as the market adjusts, and that these cost reductions will drive increased consumer demand. While the model is grounded in real cost data, it is important to note that individual project cost components can vary significantly between companies and markets.

---

[42] The Technical Appendix is available at http://www.greenhouse.institute/research/2025/solar_permitting_co/.
[43] NREL (2024a).
[44] Prices are adjusted from national values to Colorado values using Regional Price Parities (BEA 2024).

The results suggest that if Colorado rolled out smart permitting statewide beginning in 2026, it could have major impacts on solar deployment. By 2030, an additional 32,000–34,000 families could go solar compared with a business-as-usual scenario. As contractors reconfigure operations to take full advantage of the simplifications and efficiencies of smart permitting, the model projects installations could take off even faster. By 2040, the model suggests that Colorado could have 283,000–329,000 more residential rooftop solar systems than we would currently expect. This is a 52–58% increase over business-as-usual installations. It is equivalent to roughly two gigawatts of additional generating capacity, twice as much as a typical nuclear reactor. In other words, Colorado families would add more generating capacity than 1.8–2.1 nuclear power plants—without building any new nuclear power plants.[45]

All these additional solar systems could produce major savings for families. As smart permitting cuts through red tape, families buying a new system could save $1,400 on the cost of a new system by 2030, and $3,200–$3,300 by 2040. These savings are independent of state or federal incentives and financing arrangements that can further reduce the price of a new system.

Savings could continue to accumulate over the lifetime of the system, as solar generation can reduce electricity bills significantly. New solar systems last 30 years without significant performance drops, and can continue to operate longer (though parts of the system may need to be replaced).[46] But even if the model assumes that systems are replaced entirely after 30 years, the savings over that time dwarf the upfront costs of the system. The model suggests that a typical 6.5kW system could cut the average family's annual electricity bills by $700–$1,300 depending on the location of the system and the year of operation. This is equivalent to a monthly bill reduction of $59–$112.[47] Over a 30-year system lifetime, these savings could amount to $30,000, much larger than the typical cost of a system.

Across all the additional families installing solar, the savings could be quite significant. The roughly 32,000–34,000 additional systems installed by 2030 could produce $23 million in savings that year. By 2040, 283,000–329,000 additional systems could produce annual savings of $220–$255 million. Adding together all the savings over the modeled 30-year lifetime, the additional systems installed by 2040 because of smart permitting could produce a combined $8.5–$9.8 billion worth of savings for Colorado families.

By replacing electricity that households would otherwise buy from the grid, and generating excess electricity that can be sold to other households, these additional

[45] Office of Nuclear Energy (2021).
[46] This is a conservative assumption since new systems often produce power for 30-35 years or more (DOE 2021).
[47] Figures do not match perfectly between annual and monthly savings due to rounding.

solar installations could also significantly reduce emissions in the Centennial State. An average family installing solar could cut emissions by 3 metric tons of CO_2e per year in 2030 and 1.3 tons in 2040.[48] That's the equivalent in 2030 of burning 340 gallons of gasoline or 3,300 pounds of coal. It would take 3 acres of U.S. forests a year to sequester the same amount of emissions.[49]

Summing up all the additional systems, by 2030 Colorado families could collectively avoid 98,000–103,000 metric tons of CO_2e emissions each year compared to business as usual. That's equivalent to taking 23,000–24,000 gasoline-powered cars off the road. By 2040, annual emissions savings could expand to 373,000–434,000 metric tons of CO_2e. It would take 374,000–435,000 acres of U.S. forests to sequester the same amount of carbon. Families would need to divert 32–37 million trash bags of waste from landfills to recycling every year to achieve the same emissions reduction.

Looking again at the modeled 30-year system lifetime, the additional systems installed by 2040 because of smart permitting could eventually save 14–17 million metric tons of CO_2e. That's roughly the equivalent of shutting 4 coal-fired power plants for a year. To achieve the same emissions reductions through cutting fuel usage, the state would need to reduce fuel consumption by 33–38 million barrels of oil, 658–764 million home barbeque propane canisters, 1.6–1.9 billion gallons of gasoline, or 15.9–18.4 billion pounds of coal. It would take a forest 22–25% the size of Colorado a year to sequester the equivalent amount of carbon dioxide.

Jurisdictions could see benefits at building departments as well. Smart residential solar permitting could save 826,000-895,000 hours of staff time at building departments through 2040, allowing plan reviewers to focus on other priorities, such as permitting new housing.[50] Additionally, the increased volume of solar installations could mean more revenue in the form of permitting fees. The model suggests that fee revenue through 2040 could increase by a cumulative $93–$111 million dollars.

All these additional panels could also increase the number of jobs in solar installation in Colorado. Even though smart permitting would reduce the total labor hours needed to install solar panels on an individual house, the increase in overall demand is projected to more than make up for more efficient project timelines. The model suggests that Colorado could have more than 690–730 additional residential solar installation jobs by 2030, and 1,500–1,600 more residential solar jobs by 2040, an increase of 45%–49% above current residential solar employment.

---

[48] The size of the avoided emissions is lower in 2040 because the grid is assumed to be getting cleaner over that time, which reduces the emissions impact of residential solar. The Cambium model we use to calculate avoided emissions reflects state policies to enforce cleaner grids through mechanisms like renewable portfolio standards (Gagnon et al. 2024).
[49] These emissions comparisons and those that follow are calculated using the EPA Greenhouse Gas Equivalencies Calculator (EPA 2024).
[50] Cook et al. (2024).

Data from the EIA suggests that batteries paired with residential solar systems are currently uncommon in Colorado.[51] As costs for batteries fall or if energy tariffs are reformed, this figure could well increase. Were Colorado families to install home batteries at the same rate as California families, then the increased demand for solar as a result of smart permitting could deliver between 0.2 GWh of new battery capacity by 2030 and 2 GWh by 2040.[52] This could insulate families from potential energy tariff changes, as well as generate further carbon emissions reductions which are not modelled in this report.[53]

[51] EIA (2024b).
[52] This assumes an average battery size of 10 kWh (Fields & Walker 2024) and a California battery attachment rate of 69% (Palmere 2024). In the state's "Optimized 100" scenario, Colorado has 7.6 GW of battery capacity by 2040 (CEO 2024).
[53] Battery uptake is likely linked to the prices utilities pay for solar exported to the grid by families. While it is beyond the scope of this paper, if utilities were to reduce the rates they pay for such exports then batteries could help limit the financial impact of that change.

Policy Recommendations

Given the expected benefits, all families in Colorado should have the opportunity to install rooftop solar with a permit obtained via a smart process. Fortunately, state policymakers have started creating a program to encourage streamlined solar permit applications, the Automated Permit Processing For Solar (APPS) grant. The application window is currently open. The sooner communities apply for and receive these funds, the sooner the benefits of smart permitting will start to accrue.

There are also other bureaucratic barriers to solar adoption, particularly around building inspection, utility interconnection, and homeowner association approvals. Though these are beyond the scope of this report, finding ways to lower these barriers while maintaining installation quality and grid balance would also likely speed up solar installation and bring down solar prices. Colorado leaders, jurisdictions, and utilities should look for ways to minimize unnecessary delays and costs here as well.

References

Ardani, K., Barbose, G., Margolis, R., Wiser, R., Feldman, D., & Ong, S. (2012). "Benchmarking Non-Hardware Balance of System (Soft) Costs for U.S. Photovoltaic Systems Using a Data-Driven Analysis from PV Installer Survey Results." DOE/GO-102012-3834, 1059144; p. DOE/GO-102012-3834, 1059144. https://doi.org/10.2172/1059144.

Barbose, G., Darghouth, N., O'Shaughnessy, E., & Forrester, S. (2024). *Tracking the Sun: Pricing and Design Trends for Distributed Photovoltaic Systems in the United States, 2024 Edition.* National Renewable Energy Laboratory. https://emp.lbl.gov/sites/default/files/2024-08/Tracking%20the%20Sun%202024_Report_0.pdf

BEA (2024). "SARPP Regional price parities by state." U.S. Bureau of Economic Analysis. https://www.bea.gov/tools.

Bolster, J. (2025). "Amid Paused Solar Funding, EPA Floats Workforce Reductions." *Inside Climate News*. https://insideclimatenews.org/news/31012025/amid-paused-solar-funding-epa-floats-workforce-reductions/.

CoPIRG & Conservation Colorado (2025). *Removing Permitting Barriers to Home Energy Production in Colorado*. Forthcoming.

CEO (2024). *Pathways to Deep Decarbonization in Colorado's Electric Sector by 2040: An Analysis of Colorado's Energy System in Meeting the State's Clean Energy Goals.* Colorado Energy Office & Ascend Analytics. https://drive.google.com/file/d/1-0bU7_rDCgpNfI859zryE1BtLe2Ecgti/view?usp=drive_link.

CPD (2024). "Denver bringing more residential solar projects to market faster." Denver Community Planning and Development. https://denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directory/Community-Planning-and-Development/CPD-News-and-Events/CPD-News/2024/SolarAPP-Press-Release-2024.

Cook, J., Akar, S., Chang, D., Fensch, A., Nissen, K., O'Shaughnessy, E., & Xu, K. (2024). *SolarAPP+ Performance Review (2023 Data)*. National Renewable Energy Laboratory. NREL/TP-6A20-89618. https://www.nrel.gov/docs/fy24osti/89618.pdf.

Cruce, J., O'Shaughnessy, E., & Cook, J. (2022). "Evaluating the Impact of Residential Solar Contract Cancellations in the United States." National Renewable Energy Laboratory. NREL/TP-6A20-80626. https://www.nrel.gov/docs/fy22osti/80626.pdf.

DOE (2021). "End-of-Life Management for Solar Photovoltaics." Department of Energy Solar Energy Technologies Office. https://www.energy.gov/eere/solar/end-life-management-solar-photovoltaics.

DOE (2023). "5 Benefits of Residential Solar." Department of Energy. https://www.energy.gov/energysaver/articles/5-benefits-residential-solar.

DOE (2024). "How Much Power is 1 Gigawatt?" Department of Energy, Office of Energy Efficiency & Renewable Energy. https://www.energy.gov/eere/articles/how-much-power-1-gigawatt.

Dong, C., & Wiser, R. (2013). "The impact of city-level permitting processes on residential photovoltaic installation prices and development times: An empirical analysis of solar systems in California cities". *Energy Policy*, 63, 531–542. https://doi.org/10.1016/j.enpol.2013.08.054.

Dutzik, T., Ham, A., & Neumann, J. (2024). "Rooftop solar on the rise: Small solar projects are delivering 10 times as much power as a decade ago." Environment America, Frontier Group. https://publicinterestnetwork.org/wp-content/uploads/2024/02/Rooftop-Solar-on-the-Rise-2024.pdf.

ECB (2023). "Currency Converter." *ECB Data Portal*. https://data.ecb.europa.eu/currency-converter.

EIA (2024a). "Table 5.6.A. Average Price of Electricity to Ultimate Customers by End-Use Sector, by State, July 2024 and 2023." *Electric Power Monthly*. Energy Information Administration. https://www.eia.gov/electricity/monthly/epm_table_grapher.php.

EIA (2024b). "Form EIA-861M (formerly EIA-826) detailed data." Energy Information Administration. https://www.eia.gov/electricity/data/eia861m/.

EPA (2024). Greenhouse Gas Equivalencies Calculator. Environmental Protection Agency. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

Fields, S. (2023). "How solar benefits the electricity grid." EnergySage. https://www.energysage.com/electricity/how-solar-helps-the-grid/.

Fields, S., & Walker, E. (2024). “Solar battery cost: Why they're not always worth it.” EnergySage. https://www.energysage.com/energy-storage/how-much-do-batteries-cost/.

Enkhardt, S. (2024). “Residential PV prices in Germany drop 25% within 12 months.” *PV Magazine*. https://www.pv-magazine.com/2024/10/24/residential-pv-prices-in-germany-drop-25-within-12-months/.

Fuhs, M. (2023). “Germany’s average residential PV prices rose by 10% to €1,557/kW in Q2.” *PV Magazine*. https://www.pv-magazine.com/2023/06/22/germanys-average-residential-pv-prices-rose-by-10-to-e1557-kw-in-q2/.

Gagnon, P., Sanchez Perez, P.A., Obika, K., Schwarz, M., Morris, J., Gu, J., & Eisenman, J. (2024). “Cambium 2023 Scenario Descriptions and Documentation. National Renewable Energy Laboratory. NREL/TP-6A40-88507. https://www.nrel.gov/docs/fy24osti/88507.pdf.

IREC (2024). Colorado: Solar and Clean Energy Jobs. Interstate Renewable Energy Council. https://irecusa.org/colorado-solar-and-clean-energy-jobs/.

IRENA (2021). Renewable Power Generation Costs in 2020, International Renewable Energy Agency, Abu Dhabi. https://www.irena.org/publications/2021/Jun/Renewable-Power-Costs-in-2020.

Lyons, M. “America Exceeds Five Million Solar Installations Nationwide,” Solar Energy Industries Association. https://seia.org/news/5million/.

McCoy, M. (2023). “The State(s) of Distributed Solar — 2023 Update”. Institute for Local Self-Reliance. https://ilsr.org/articles/the-states-of-distributed-solar-2023/.

McGarvey, S. (2023). “Why are US distributed solar customer acquisition costs still on the rise?” *Wood Mackenzie*. https://www.woodmac.com/news/opinion/why-are-us-distributed-solar-customer-acquisition-costs-still-on-the-rise/.

Minneapolis Fed (2024). *Inflation Calculator.* Federal Reserve Bank of Minneapolis. https://www.minneapolisfed.org/about-us/monetary-policy/inflation-calculator.

NREL (2024a). *System Advisor Model Version 2024.12.12*. National Renewable Energy Laboratory. https://https://sam.nrel.gov.

NREL (2024b). *Solar Time-Based Residential Analytics and Cycle time Estimator (SolarTRACE).* National Renewable Energy Laboratory. https://gosolarapp.org/solarTRACE.

NREL (2024c). "2024 Annual Technology Baseline." National Renewable Energy Laboratory. https://atb.nrel.gov/.

Office of Nuclear Energy (2021). "How Much Power Does A Nuclear Reactor Produce?" Department of Energy. https://www.energy.gov/ne/articles/infographic-how-much-power-does-nuclear-reactor-produce.

Ohm Analytics (2024). "Clean Code." https://cleancode.ohmanalytics.com/.

Overholm, H. (2015). "Spreading the rooftop revolution: What policies enable solar-as-a-service?" *Energy Policy*, 84, 69–79. https://doi.org/10.1016/j.enpol.2015.04.021.

Palmere, M. (2024). "Behind-The-Meter Distributed Generation Forecast Updates." California Energy Commission. https://www.energy.ca.gov/sites/default/files/2024-12/Behind-The-Meter_Distributed_Generation_Forecast_Updates_ada.pdf.

Ramasamy, V., Zuboy, J., O'Shaughnessy, E., Feldman, D., Desai, J., Woodhouse, M., Basore, P., & Margolis, R. (2022). *U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks, With Minimum Sustainable Price Analysis: Q1 2022* (NREL/TP-7A40-83586). National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy22osti/83586.pdf.

Ramasamy, V., Zuboy, J., Woodhouse, M., O'Shaughnessy, E., Feldman, D., Desai, J., Walker, A., Margolis, R., & Basore, P. (2023). *U.S. Solar Photovoltaic System and Energy Storage Cost Benchmarks, With Minimum Sustainable Price Analysis: Q1 2023* (NREL/TP7A40-87303). National Renewable Energy Laboratory. https://www.nrel.gov/docs/fy23osti/87303.pdf.

Ros, A. J., & Sai, S. S. (2023). Residential rooftop solar demand in the U.S. and the impact of net energy metering and electricity prices. *Energy Economics*, 118, 106491. https://doi.org/10.1016/j.eneco.2022.106491.

Rosen, T. & Scarr, A. (2024). "Electric bills are set to increase in June for 65 million Americans. Here's why." Environment America. https://environmentamerica.org/center/articles/electric-bills-are-set-to-increase-in-june-for-65-million-americans-heres-why/.

Schatz, K. (2024). “More Rooftop Solar for Colorado, Less Red Tape.” CoPIRG Foundation. https://pirg.org/colorado/foundation/articles/more-rooftop-solar-for-colorado-less-red-tape/.

Seel, J., Barbose, G. L., & Wiser, R. H. (2014). “An analysis of residential PV system price differences between the United States and Germany.” *Energy Policy*, 69, 216–226. https://doi.org/10.1016/j.enpol.2014.02.022.

SEIA (2024). “Colorado State Solar Overview.” Solar Energy Industries Association. https://seia.org/state-solar-policy/colorado-solar/.

SolarAPP+ (2024). “Where is SolarAPP+ Available?” https://help.solar-app.org/article/108-where-is-solarapp-available. Accessed January 24, 2025.

SolarAPP+ (2024b). “How does SolarAPP+ execute the code compliance check for various components of a system before issuing a permit?” https://help.solar-app.org/article/262-how-does-solarapp-execute-the-code-compliance-check-for-various-components-of-a-system-before-issuing-a-permit.

SolarAPP+ (2024c). “Benefits of the SolarAPP+ Online Permitting Software.” https://www.nrel.gov/docs/fy24osti/90815.pdf.

Steinberg, E., & Richardson, C. (2024). *Top 5 Barriers to Implementation for Solar for All,* Realize 2050. https://www.realize2050.com/solar-for-all-webinar-and-white-paper https://docsend.com/view/qzg3tmhaww3je4em

Symbium (2025). “In which cities and counties can I use Symbium to secure an instant solar permit?” Accessed January 4, 2025. https://symbium.com/faq/rooftop_solar_ess/in-which-cities-and-counties-can-i-use-symbium-to-secure-an-instant-solar-permit.

UL (2024). “SolarAPP+ permit tool for residential solar & storage.” https://code-authorities.ul.com/about/inspection-resources-for-code-authorities/solarapp-permit-tool-for-residential-solar/.

Wolske, K. S., Gillingham, K. T., & Schultz, P. W. (2020). Peer influence on household energy behaviours. Nature Energy, 5(3), 202–212. https://doi.org/10.1038/s41560-019-0541-9

Acronyms

CO_2e	CO_2-equivalents
$mTCO_2e$	Metric Tons of CO_2-equivalents
$MMTCO_2e$	Million Metric Tons of CO_2-equivalents

W	Watt	1 W
kW	Kilowatt	1000 W
kWh	Kilowatt-hour	1000 Wh
MW	Megawatt	1,000,000 W
MWh	Megawatt-hour	1,000,000 Wh
GW	Gigawatt	1,000,000,000 W
GWh	Gigawatt-hour	1,000,000,000 Wh