How Smart Permitting Could Accelerate Rooftop Solar in Minnesota

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

January 25, 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 Minneapolis skyline through trees by Matt Barton, available at https://unsplash.com/photos/green-grass-field-with-trees-during-daytime-aziCuBOYm4c.

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

Executive Summary

Minnesota has committed itself to achieving a 100% carbon-free electricity grid by 2040.[1] Rooftop solar is a crucial part of achieving these goals.

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 6,100–6,300 home solar systems by 2030 and 54,000–55,000 by 2040, an increase of 60–64% 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.

This report models the potential impacts of adopting such a platform across Minnesota, and projects that smart permitting could spur the installation of an additional 6,100–6,300 home solar systems by 2030 and 54,000–55,000 by 2040, an increase of 64–69% above business-as-usual.[2] These additional rooftop systems could add a combined generating capacity of 50 megawatts by 2030 and 430,000 megawatts by 2040. In other words, a shift to smart permitting could add nearly half the generating capacity of a typical nuclear power plant.[3]

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.[4] As smart permitting cuts through red tape, families buying a new system could save $1,600–$1,900 on the cost of a new system by 2030, and $3,700–$4,400 by 2040. And that is only the beginning of the savings.

---

[1] Olson (2023).

[2] 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.

[3] Office of Nuclear Energy (2021).

[4] 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.

Over the lifetime of the panels, the typical family that “goes solar” as a result of smart permitting could save $52,000 in reduced electricity bills.[5] As electricity prices increase over time, the average family could save $1,200–$2,400 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 $319–$327 million. By 2040, the expected lifetime ratepayer savings of the additional systems could rise to a combined $2.8–$2.9 billion. These projections assume only gradual increases in electricity prices over time: if utilities enact 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 15,000 metric tons of CO_2 in 2030, and 88,000–90,000 tons in 2040. The cumulative emissions reductions from smart permitting could amount to 28,000 metric tons of CO_2 by 2030 and 591,000–607,000 metric tons of CO_2 by 2040. This is equivalent to avoiding the emissions from driving 138,000–142,000 gasoline-powered cars for a year or burning 1.4 million barrels of oil. It would take 593,000–610,000 acres of forest a year to remove the same amount of emissions from the atmosphere.

The increase in demand for new solar installations could also create 484–538 jobs across the state by 2030, and 1,000–1,100 jobs by 2040. Higher installation volumes could also mean increased permitting fee revenue for jurisdictions, bringing in $11–$12 million by 2040. Reduced labor required to review all permits could save 33,000 hours of staff time by 2030 and 37,000–38,000 hours by 2040, allowing plan reviewers to focus on other priorities like 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, Minnesota should ensure that smart solar permitting is widely available.

[5] This assumes a 30 year lifetime with 0.5% annual loss in panel capacity (DOE 2021).

Table of Contents

The Benefits of Residential Solar in Minnesota

Minnesota has seen a boom in demand for residential solar. In the five years between 2017 and 2022, residential solar in Minnesota grew by 397%.[6] Solar PV technology is also crucial to meeting Minnesota's greenhouse gas reduction goals and its target of reaching 100% carbon-free electricity by 2040.[7]

Rooftop solar benefits the grid by reducing the need for costly transmission and distribution upgrades, alleviating stress on the infrastructure, making the overall service more dependable.[8] 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.[9] 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 Minnesota' economy. Solar PV systems can allow residents to cut their bills by $1,200–$2,400 annually.[10] The solar industry, including residential, commercial, and utility scale companies, employs 5,332 people in the state across more than 373 businesses (IREC 2024).

---

[6] Ibid.
[7] Olson (2023).
[8] Fields (2023) and DOE (2023).
[9] Fields (2023).
[10] Price data from EIA (2024a), savings calculated using the NREL System Advisor Model (NREL 2024a).

Bureaucratic Permitting Requirements Deter Families from Going Solar

Unfortunately, permitting can be a significant obstacle to rooftop solar across the North Star State. Homes that install solar first need to receive a permit, which grants permission to begin the installation, from local government. In Minnesota, the permitting process can be lengthy, bureaucratic, inconsistent, and costly, which can discourage and prohibit families from making the investment.[11]

Many cities and counties in Minnesota have their own bespoke processes and requirements for obtaining the permit. Contractors frequently must conduct some or all of the permitting process via mail, phone, or in person, as opposed to online. The in-person component could include attending a monthly township meeting on Sunday night to receive zoning approval. In some jurisdictions, the permit is dependent on a professional engineer approving that the roof is capable of supporting the solar panels, whereas that approval is not required for similar roofs in neighboring jurisdictions. While requirements vary between permitting offices, the requirements within a permitting office can be unclear and inconsistently enforced. Some jurisdictions can be uncommunicative or contentious.[12]

Nationally, 22 percent of residential solar projects that apply for permits are canceled.[13] According to national survey data, installers view the permitting process as the most important cause of customer cancellations.[14] Installers' second most important cause of cancellation is changes in customer finances, a risk that likely increases with project delays.

Permitting barriers directly discourage and prevent families from going solar. Additionally, permitting barriers drive up costs, which further discourage and prevent

[11] Inefficient permitting is also one of the largest barriers to maximizing the impact of grant programs, like the $62.4 million Minnesota 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 Minnesota take full advantage of this resource (Steinberg & Richardson 2024, p. 1).
[12] Kienbaum et al. (2025)
[13] Nationally, 22 percent of residential solar projects that apply for permits are canceled. (Cruce et al. 2022, p. 17). Data from Ohm Analytics (2024) on 903 applications in 15 jurisdictions in Minnesota show an average of 27% for the cancellation rate.
[14] 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).

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.[15]
- **Permit submission:** in many jurisdictions, the plans and forms need to be printed out and submitted in person, adding labor and travel time, especially in rural areas where the distance to the local permitting office may be significant.
- **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 Minnesota is more than a week, ranking 23rd for rooftop solar in the country.[16] 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).[17]
- **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.

[15] 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).
[16] Ohm Analytics (2024).
[17] 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).

- **Cancellations:** As previously stated, 22 percent of residential solar projects that apply for permits are canceled,[18] and installers cite the permitting process as the most important cause of the cancellations.[19] 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.[20]
- **Customer acquisition:** customer acquisition includes sales, marketing, and initial system design, and represents the single largest component of solar soft 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.[21] This can increase the cost of acquiring new customers, since peer recommendations are a key driver of solar adoption.[22]
- **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.[23] 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 Minnesota. 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.

---

[18] Cruce et al. (2022), p. 17 and Ohm Analytics (2024).
[19] 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.
[20] Cook et al. (2021).
[21] 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.
[22] Wolske et al. 2020.
[23] 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.

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.[24] In 2023, the price for a typical residential solar system in the US had actually increased since 2020 to $31,500 despite prices in countries like Australia continuing to decline.[25]

[24] 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.
[25] Barbose et al. (2024). The median 2023 national price was $4.2/W, as was the median price in Minnesota. 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.

Smart Permitting Encourages Families to Go Solar

Minnesota 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.[26] In 2024, the Minnesota legislature passed and the governor signed SF4942, which, among other provisions, created an incentive program for jurisdictions to adopt SolarAPP+.[27] 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.[28]

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).

---

[26] "Over 260" includes both 222 jurisdictions that have fully adopted SolarAPP+ and 44 that are currency running pilots See SolarAPP+ (2024a).
[27] See Article 6, Section 46 of S.F. 4942 (State of Minnesota 2024).
[28] Symbium (2025).

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 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.[29]
- **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.[30]

[29] 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.
[30] 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.

- **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, National Fire Protection Association, and UL, performs a comprehensive review of relevant electrical, fire, and structural codes, ensuring the proposed system meets safety requirements.[31] SolarAPP+ also stays up to date with new code editions and technologies, avoiding circumstances of plan reviewer error due to delayed training.[32]
- **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.[33]
- **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

[31] See SolarAPP+ (2024b) and UL (2024).
[32] SolarAPP+ (2024c).
[33] Cook et al. (2024), p. 20.

higher volume. Fully realizing this model would likely require other process simplifications, like making the inspection and interconnection processes more efficient as well.

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.

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

Modeled Impacts of Permit Automation in Minnesota

To estimate the impact of smart online permitting in Minnesota, 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.[34]

The model assumes a 7.9kW system with 22 panels (close to the median size of a system in Minnesota). To make sure we capture the different environments in the state, the model run is repeated for Minnesota 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.[35]

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 Minnesota.[36]

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.

[34] The Technical Appendix is available at http://www.greenhouse.institute/research/2025/solar_permitting_mn/.
[35] NREL (2024a).
[36] Prices are adjusted from national values to Minnesota values using Regional Price Parities (BEA 2024).

The results suggest that if Minnesota rolled out smart permitting statewide beginning in 2026, it could have major impacts on solar deployment. By 2030, an additional 6,100–6,300 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 Minnesota could have 54,000–55,000 more residential rooftop solar systems than we would currently expect. This is a 64–69% increase over business-as-usual installations. It is equivalent to roughly 430,000 megawatts of additional generating capacity, a little less than half as much as a typical nuclear reactor. In other words, Minnesota families would add more generating capacity than half a nuclear power plant—without building any new nuclear power plants.[37]

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 $1,600–$1,900 on the cost of a new system by 2030, and $3,700–$4,400 by 2040. By 2040 the upfront cost savings for Minnesota families could reach $418–$472 million. 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).[38] 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 7.9kW system could cut the average family's annual electricity bills by $1,200–$2,400 depending on the location of the system and the year of operation.[39] This is equivalent to a monthly bill reduction of $102–$198.[40] Over a 30-year system lifetime, these savings could amount to $52,000 for an individual family.[41]

Across all the additional families installing solar, the savings could be quite significant. The roughly 6,100–6,300 additional systems installed by 2030 could produce $7 million in savings that year. By 2040, 54,000–55,000 additional systems could produce annual savings of $72–$74 million. Adding together all the savings over

---

[37] Office of Nuclear Energy (2021).
[38] This is a conservative assumption since new systems often produce power for 30-35 years or more (DOE 2021).
[39] These projected savings are likely to be lower than those for systems installed through 2024, as they reflect the end of the state's net metering program starting in 2025.
[40] Figures do not match perfectly between annual and monthly savings due to rounding.
[41] Note again that the operational and installation savings presented here do not include federal or state-level incentives and financing options which could bring down the purchase price below the expected savings projected here.

the modeled 30-year lifetime, the additional systems installed by 2040 because of smart permitting could produce a combined $2.8–$2.9 billion worth of savings for Minnesota 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 solar installations could also significantly reduce emissions in the North Star State. An average family installing solar could cut emissions by 2.4 metric tons of CO_2e per year in 2030 and 1.6 tons in 2040.[42] That's the equivalent in 2040 of burning 185 gallons of gasoline or 1,800 pounds of coal.[43]

Summing up all the additional systems, by 2030 Minnesota families could collectively avoid 15,000 metric tons of CO_2e emissions each year compared to business as usual. That's equivalent to taking 3,400–3,500 gasoline-powered cars off the road. By 2040, annual emissions savings could expand to 88,000–90,000 metric tons of CO_2e. It would take 88,000–90,000 acres of U.S. forests to sequester the same amount of carbon. Families would need to divert 7.5–7.6 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 2.3–2.4 million metric tons of CO_2e. That's roughly the equivalent of shutting 6 gas-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 5 million barrels of oil, 262–268 million gallons of gasoline, or 2.6 billion pounds of coal.

Jurisdictions could see benefits at building departments as well. Smart residential solar permitting could save 141,000-143,000 hours of staff time at building departments through 2040, allowing plan reviewers to focus on other priorities, such as permitting new housing.[44] 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 $11–$12 million dollars.

All these additional panels could also increase the number of jobs in solar installation in Minnesota. 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

[42] 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).
[43] These emissions comparisons and those that follow are calculated using the EPA Greenhouse Gas Equivalencies Calculator (EPA 2024).
[44] Cook et al. (2024).

suggests that Minnesota could have more than 480–540 additional residential solar installation jobs by 2030, and 1,100–1,400 more residential solar jobs by 2040, an increase of 51%–58% above current residential solar employment.

Data from the EIA suggests that batteries paired with residential solar systems are currently uncommon in Minnesota.[45] As costs for batteries fall or if energy tariffs are reformed, this figure could well increase. Were Minnesota 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 0.37–0.38 GWh by 2040.[46] This could help insulate families from rate changes, as well as generate further carbon emissions reductions and electricity bill savings which are not modelled in this report.[47]

[45] EIA (2024b).
[46] This assumes an average battery size of 10 kWh (Fields & Walker 2024) and a California battery attachment rate of 69% (Palmere 2024).
[47] 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 Minnesota should have the opportunity to install rooftop solar with a permit obtained via a smart process. The expected upfront costs of implementation are moderate and should ultimately pay off for the government and the people of Minnesota. To that end, in 2024, the Minnesota legislature passed and the governor signed SF 4942, which, among other provisions, created an incentive program in the Department of Commerce for jurisdictions to adopt SolarAPP+.[48] The Department of Commerce should devote resources to ensuring the program, slated to launch by March, 2025, is a success. State policymakers should also consider requiring permitting authorities to adopt smart permitting. The sooner this process succeeds in Minnesota, the sooner the benefits 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. Minnesota leaders, jurisdictions, and utilities should look for ways to minimize unnecessary delays and costs here as well.

[48] See Article 6, Section 46 of S.F. 4942 (State of Minnesota 2024).

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/.

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.

Kowalski, E. “Solar power soars in Minnesota.” Environment Minnesota. https://environmentamerica.org/Minnesota/center/articles/solar-power-soars-in-Minnesota/.

IREC (2024). Minnesota: Solar and Clean Energy Jobs. Interstate Renewable Energy Council. https://irecusa.org/minnesota-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.

Kienbaum, K., Behrsin I., & Farrel, J. (2025). “Overcoming Permitting Barriers for Rooftop Solar in Minnesota.” Institute for Local Self Reliance.

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/.

Olson, J. (2023). “Minnesota’s 100% clean electricity law explained.” Fresh Energy. https://fresh-energy.org/minnesotas-100-clean-electricity-bill-explained.

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/.

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). “Minnesota State Solar Overview.” Solar Energy Industries Association. https://seia.org/state-solar-policy/minnesota-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.

State of Minnesota (2024). *S.F. 4942.* Article 6, Section 46. https://www.revisor.mn.gov/bills/text.php?number=SF4942&version=latest&session=ls93&session_year=2024&session_number=0.

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