SolarAPP+ Performance Review: 2021 Data

Jeffrey J. Cook,[1] Eric O'Shaughnessy,[2] Kaifeng Xu,[1] Sushmita Jena,[1] Minahil Sana Qasim,[1] and Seth Crew[1]

[1] *National Renewable Energy Laboratory*
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National Renewable Energy Laboratory
15013 Denver West Parkway
Golden, CO 80401
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NOTICE

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Executive Summary

Accelerating rooftop solar photovoltaic (PV) deployment has strained the capacity of local authorities responsible for permitting and inspection. Given the ongoing expansion of rooftop PV, a growing number of authorities having jurisdiction (AHJs) and utilities are reforming permitting processes to reduce delays. AHJs could significantly reduce permitting timelines through reforms such as expedited reviews for small-scale systems, online customer portals, and over-the-counter permitting. However, independent reforms do not resolve issues associated with permitting variability across AHJs, and many AHJs lack the resources to implement reforms.

In response to these challenges, the National Renewable Energy Laboratory (NREL) developed the Solar Automated Permit Processing Plus (SolarAPP+) platform, in collaboration with local governments, code development organizations, and industry stakeholders. SolarAPP+ is an online portal through which PV contractors can upload system specifications, have those specifications automatically reviewed for code compliance, and receive instant approval for code-compliant systems. Contractors also receive an inspection checklist to verify installation practices and adherence to approved designs. SolarAPP+ is available to AHJs at no cost.

As of May 2022, NREL has contacted over 1,000 AHJs with significant solar permitting volume regarding the SolarAPP+. Of those, 376 AHJs have expressed interest in the platform. Thirteen AHJs have begun piloting the platform, and nine of these have publicly launched the platform. Our study focuses on 10 AHJs that had begun piloting SolarAPP+ by the end of 2021. In 2021, 102 installers were issued 3,291 permits through the SolarAPP+ platform. In the same year, these same AHJs fully processed 10,820 permits through their conventional permitting systems. We compare permitting timelines through SolarAPP+ to traditional AHJ permitting processes to assess the platform's performance (Figure ES-1).

Figure ES-1. Summary of performance review results

The clearest impact of SolarAPP+ occurs during permit review. Across SolarAPP+ AHJs, the median duration of the period between a permit application and a permit issuance for traditional projects was nine business days. In contrast, because SolarAPP+ instantly issues permits for code-compliant systems, the median permit review time for SolarAPP+ projects was zero days. Automating permit reviews also saves AHJ staff and contractor time associated with developing and reviewing permit applications and revisions. We estimate that automated permit reviews on SolarAPP+ saved around 15–60 minutes per permit, or around 3,300 hours of cumulative staff

time by the end of 2021, roughly the equivalent of adding 1.5 full-time employees across the participating AHJs. Further, the data suggest that automated reviews do not result in downstream delays. SolarAPP+ project inspection times and failure rates are not significantly different from those of projects that underwent manual reviews. Data from seven AHJs suggest that SolarAPP+ projects fail about 17% of inspections, compared to a 27% inspection failure rate among traditional projects.

Based on median timelines, the data suggest that a typical SolarAPP+ project completes the full project timeline (permit submission to passed inspection) about 13 business days before a traditional project. Summing up the estimated impacts across AHJs, we estimate that SolarAPP+ accelerated PV permitting timelines by more than 40,000 days in 2021. Although we do not estimate the market impact of these accelerated timelines, the data indicate that SolarAPP+ deployment could accelerate rooftop PV deployment by reducing AHJ permitting backlogs, reducing AHJ staff time spent on permitting, helping projects interconnect sooner, and freeing up installers to pursue more customers.

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1 Introduction

Rooftop solar photovoltaic (PV) systems are subject to building, electrical, fire, and other local codes in most jurisdictions in the United States. Permitting and inspection ensure that rooftop PV systems comply with all local codes, thus increasing system safety. Further, grid-connected rooftop PV systems are subject to utility requirements for interconnecting to the electric grid.

Accelerating rooftop PV deployment has strained the capacity of local authorities having jurisdiction (AHJs) responsible for administering rooftop PV codes (Cook et al. 2021). Annual rooftop PV deployment increased by roughly a factor of 10 from 2011 to 2021, reaching more than 500,000 systems installed in 2021 (Davis et al. 2022). Rooftop PV deployment is projected to continue to increase substantially and could play a key role in decarbonizing the U.S. electric grid (DOE 2021). Given the ongoing expansion of rooftop PV, a growing number of AHJs and utilities are reforming permitting processes to reduce delays (Stanfield et al. 2012; Fekete et al. 2022). Reforms such as expedited reviews for small-scale systems, online customer portals, and over-the-counter permitting could significantly reduce permitting process durations (O'Shaughnessy et al. 2022). Yet permitting reforms have, to date, occurred in a piecemeal fashion, and many AHJs lack the resources to implement reforms (Parsons and Josefowitz 2020).

In response to these challenges, the National Renewable Energy Laboratory (NREL) developed the Solar Automated Permit Processing Plus (SolarAPP+) platform, in collaboration with local governments, code development organizations, and industry stakeholders. SolarAPP+ is an online portal that allows PV contractors to upload system specifications, have those specifications automatically reviewed for code compliance, and obtain instant approval for code-compliant systems. SolarAPP+ also issues an inspection checklist to verify installation practices and adherence to approved designs. SolarAPP+ is available to AHJs at no cost.

Williams et al. (2022) conducted an analysis of the performance of SolarAPP+ during the pilot phase across five AHJs. This analysis builds on that work, completing a more comprehensive assessment of the performance of SolarAPP+ in its first full year of operation (2021) across all participating AHJs.

2 Background

Most rooftop PV systems are subject to local permitting requirements. Though permitting processes can vary substantially across AHJs and utilities, Figure 1 depicts a typical permitting, inspection, and interconnection process. The process begins when a customer signs a contract with a PV installer. The installer is responsible for initial system design, preparing permit materials, and submitting applications for permits and interconnection approvals. The AHJ reviews these applications, requests revisions as needed, and then issues a permit to build for approved applications. Certain utilities also require interconnection approval before system installation. Once the required permits have been issued, the installer installs the system. Most AHJs require some inspection of the installed system before the system can be interconnected. Once the system passes all inspections and receives utility permission to operate (PTO), the installer can interconnect the system to make it operational.

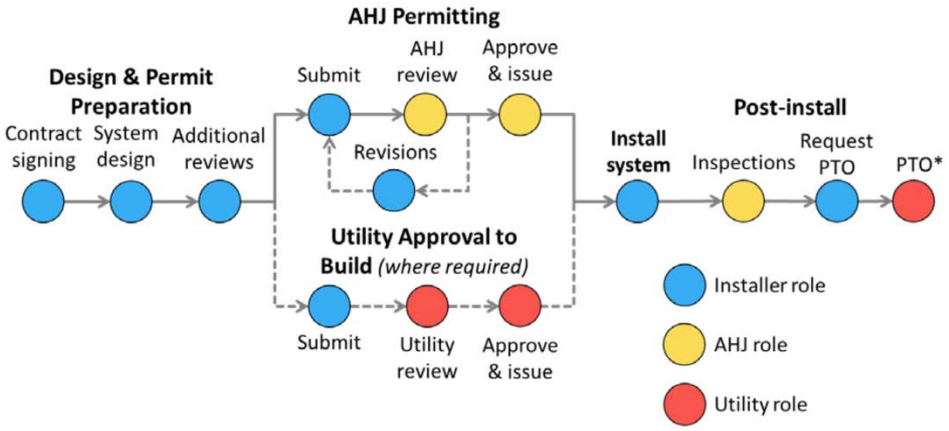

Figure 1. The rooftop PV permitting process

2.1 The Need for Streamlined and Standardized Permitting

Although states often set minimum requirements for building, electrical, and fire codes, AHJs are ultimately responsible for enforcing these codes. Individual AHJs can interpret state codes in various ways, and states often allow AHJs to implement unique local codes (Stanfield et al. 2012). The result is a patchwork of codes that can vary significantly across AHJs. That variability has presented a challenge to the emerging rooftop PV market. Research to date suggests that permitting variation can have both local and global impacts on rooftop PV deployment. By "local impacts," we mean changes in PV deployment in a given AHJ based on the permitting requirements of that AHJ. By "global impacts," we mean impacts on deployment that spill beyond the boundaries of AHJs. For instance, if one AHJ streamlines its permitting requirements, the reforms could have local impacts by increasing deployment in that AHJ and global impacts by increasing deployment in other AHJs. We explore each type of impact in turn.

Permitting variation affects rooftop PV deployment locally by creating differences in compliance costs and delays across AHJs. Burdensome local requirements can significantly increase total system costs (Dong and Wiser 2013; Burkhardt et al. 2015). Variations in local codes can also

explain variations in PV process durations, with burdensome local requirements being associated with longer installation timelines (O'Shaughnessy et al. 2022). Around half of installers report charging higher prices in certain AHJs to offset these compliance costs and delays (Cook et al. 2021). As a result, permitting variation drives variation in local system prices that will, all else equal, cause variation in local deployment levels. Empirical research on these local impacts has produced mixed results. Hsu (2018) finds that streamlined permitting requirements are associated with increased rooftop PV deployment; however, in a similar study, White (2019) finds no statistically significant relationship. Gao (2021) finds that streamlined permitting requirements drive more entrepreneurial activity among PV installers, though that activity cannot be directly linked to impacts on deployment. Cruce et al. (2022) find that most contract cancelations occur before permitting processes have begun, suggesting that cancelations are generally not directly attributable to permitting-associated delays. At the same time, Cook et al. (2021) find that installers rank permitting requirements as the key cause of project delays and cancelations. One potential explanation for these conflicting results is that delays can occur before the permitting process itself officially begins. For instance, installers can incur delays when compiling the necessary paperwork for permit applications (prior to submitting those applications).

Permitting variation is also expected to have global impacts on rooftop PV deployment. These expected global impacts stem from the fact that around half of installers report not differentiating local prices based on local requirements (Cook et al. 2021). Presumably, these installers spread compliance costs over their customer base, meaning that customers living in AHJs with streamlined requirements partly bear the cost burden of requirements in other AHJs. Further, insofar as permitting requirements drive cancelations, installers might recoup cancelation costs through the prices they charge other customers (Cruce et al. 2022). As a result, the costs of permitting variations are at least partly spread out across AHJs. The globalization of compliance costs by some installers could partly explain the mixed results of permit streamlining on PV adoption in studies such as White (2019). If permitting costs are globalized, the impacts of permit streamlining on rooftop PV deployment will spill over across AHJs, thus weakening the measured local effects of delays.

The local and global impacts of permitting variation on PV deployment provide a rationale for standardization and streamlining. Many AHJs have already streamlined their processes through the implementation of online portals, expedited approvals for small systems, or other approaches. O'Shaughnessy et al. (2022) find evidence that such measures effectively expedite PV installation timelines. Yet some AHJs lack the resources to implement such reforms (Parsons and Josefowitz 2020). Further, AHJ-level streamlining does not necessarily reduce permitting variation. The local and global benefits of rooftop PV permitting reform could be maximized through a top-down approach to implement standardized, streamlined processes in as many AHJs as possible.

2.2 SolarAPP+

NREL led the development of the SolarAPP+ platform to address the need for standardized, streamlined permitting. NREL developed SolarAPP+ in a collaborative partnership with industry and the building safety community, with funding from the U.S. Department of Energy. SolarAPP+ is designed to streamline AHJ permitting for a typical residential rooftop PV system

that meets certain eligibility requirements.[1] SolarAPP+ automates the review of eligible systems through the steps illustrated in Figure 2. Based on the application inputs, SolarAPP+ also generates a checklist for inspectors to confirm that the installed system matches the preapproved design submitted to the platform. The SolarAPP+ project formally began in September 2019 with development and testing of the software for alignment with national model codes. NREL piloted the software with five communities in 2021 (Williams et al. 2022). SolarAPP+ was then officially launched in July 2021.

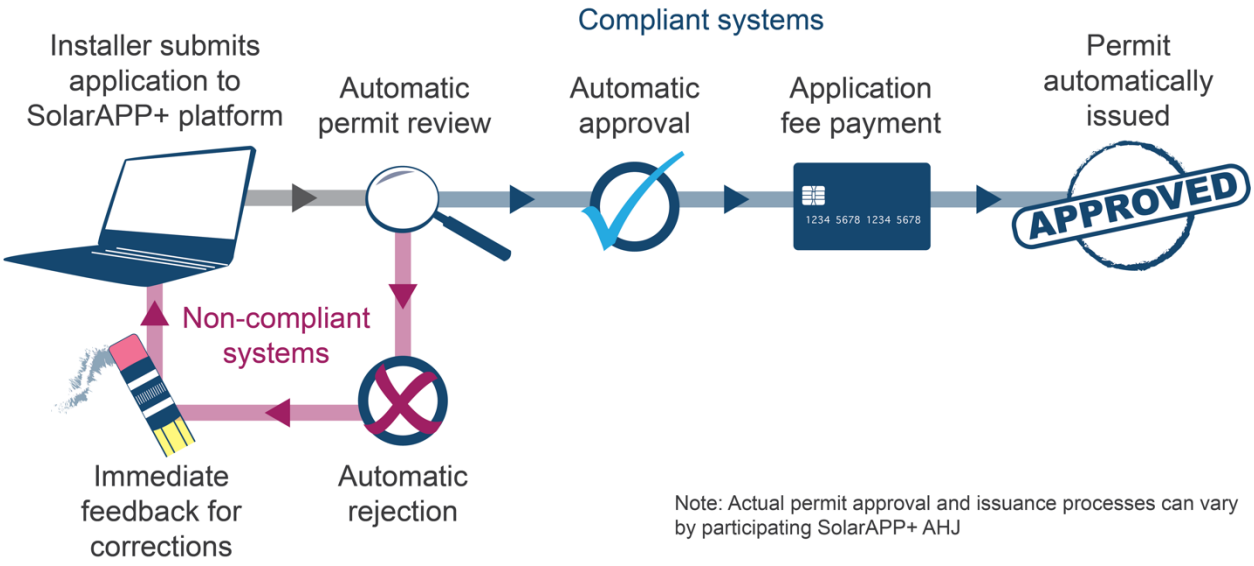

Figure 2. Example SolarAPP+ permit application and approval process

Note: In most AHJs, the fee payment and permit issuance occur via the AHJ's existing permitting system

SolarAPP+ was designed to eliminate permitting backlogs for eligible code-compliant rooftop solar projects. In so doing, SolarAPP+ frees local government staff to work on other, more complex projects (e.g., commercial projects), while providing contractors business certainty regarding when a permit will be received and allowing those contractors to begin work immediately after permit issuance (assuming they have all other necessary approvals, i.e., interconnection approval to build where required).

Williams et al. (2022) evaluated whether the pilot deployment of SolarAPP+ delivered on these stated goals. Key findings include:

- AHJs saved 236 hours on permit and revision reviews.
- SolarAPP+ reduced average permit review times (permit submission to issuance) to less than one day.

[1] For a complete list of the eligibility requirements, see https://help.solar-app.org/article/43-what-types-of-systems-are-not-eligible-for-solarapp-review.

- SolarAPP+ projects had similar inspection durations and passed inspections at similar rates as other projects.

- SolarAPP+ projects were installed and inspected 12 days faster than projects using traditional permitting processes, on average.

This report provides a more comprehensive picture of the overall performance of SolarAPP+ beyond the pilot jurisdictions, including additional insights regarding the slate of projects approved through the platform in participating jurisdictions in 2021. As we shall discuss, our more comprehensive study largely affirms previous results from Williams et al. (2022).

3 SolarAPP+ Implementation

As of May 31, 2022, NREL had contacted over 1,000 AHJs as potential users of the SolarAPP+ platform.[2] Of these, 376 have expressed interest in implementing SolarAPP+.[3] Interested AHJs are geographically distributed throughout the United States and are at various stages in the implementation process (Figure 3). A plurality of AHJs (193) have expressed interest but are still in the process of determining next steps. 124 AHJs have received a SolarAPP+ technical demonstration, 26 AHJs are evaluating and testing SolarAPP+, 20 AHJs are in pilot onboarding, and 13 AHJs have piloted or publicly launched the platform.

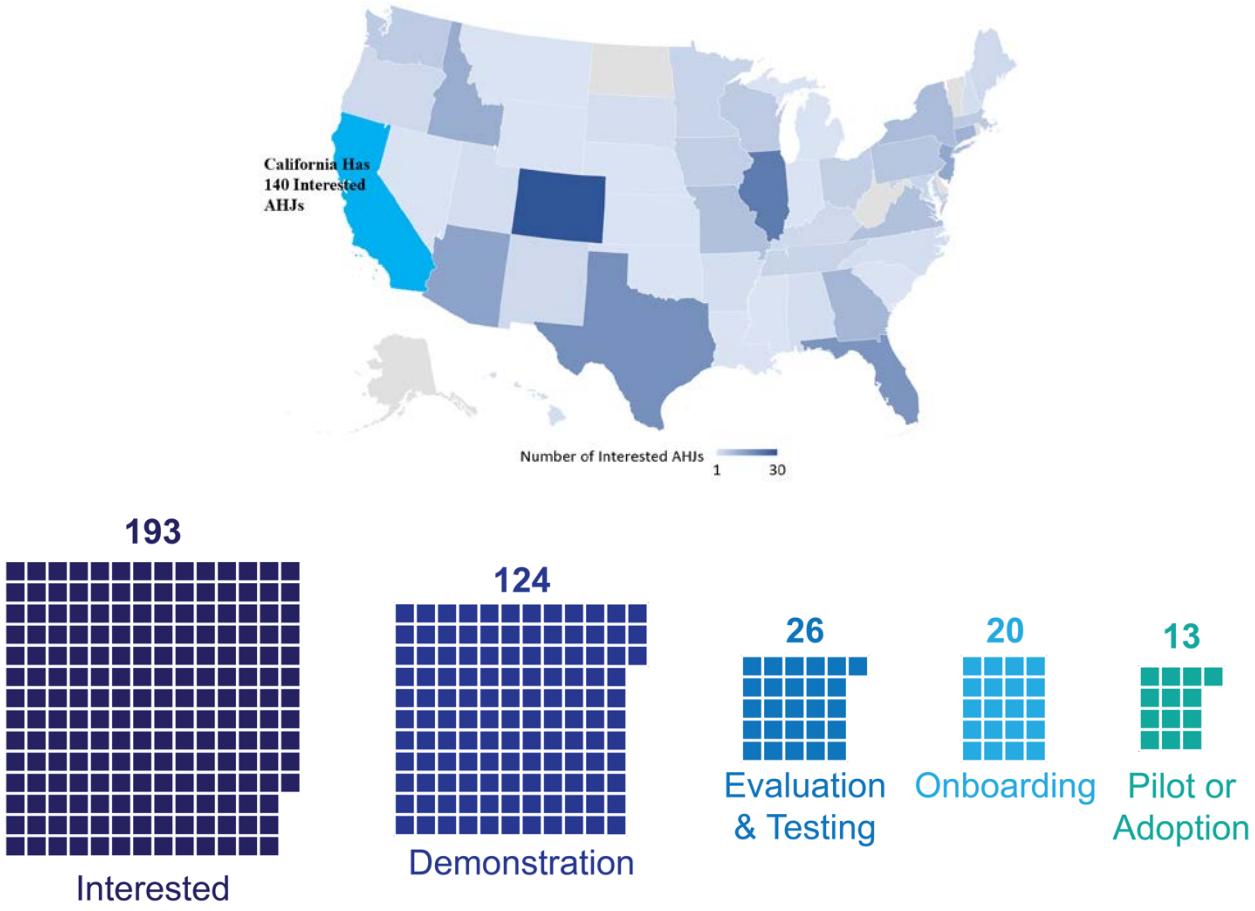

Figure 3. Number of AHJs that have expressed interest in SolarAPP+, by state (top pane), and interested AHJs by adoption stage (bottom pane)

Figure 4 depicts the timelines over which the 13 AHJs implemented the SolarAPP+ platform. The figure is ordered by the timing of the first interaction, with more recent interactions on the top. For example, Pleasant Hill completed the first interaction activity first, in May 2020, whereas Benicia finished this activity in August 2021. Pima County, Pleasant Hill, and Tucson implemented the first phase of the SolarAPP+ pilot in late 2020. Menifee then joined the pilot in

[2] NREL has a goal to contact 1,250 AHJs through 2022.
[3] An expression of interest occurs when an AHJ follows up on an initial contact, and it includes AHJs at any level of implementation: demonstration, evaluation, testing, pilot, or adoption.

spring 2021. These early pilot AHJs helped beta test SolarAPP+ and provided input on functionality and implementation practices, which contributed to longer implementation times than for more recent adopting AHJs. See Williams et al. (2022) for a complete description of and results from these two initial pilot phases. San Ramon, Simi Valley, Sonoma County, and Stockton started pilots in summer 2021. Finally, Benicia and Modesto started pilots in late 2021. Eight of the 13 AHJs have since launched SolarAPP+ for public use by participating contractors. The average time from first interaction to pilot launch was about 170 days, or nearly 6 months. The average time from pilot launch to public launch was about 140 days, or roughly 4.5 months. This study focuses on the 10 AHJs in Figure 4 that had piloted or launched SolarAPP+ before the end of 2021, i.e., excluding Beaumont, Palo Alto, and Pinole, CA.

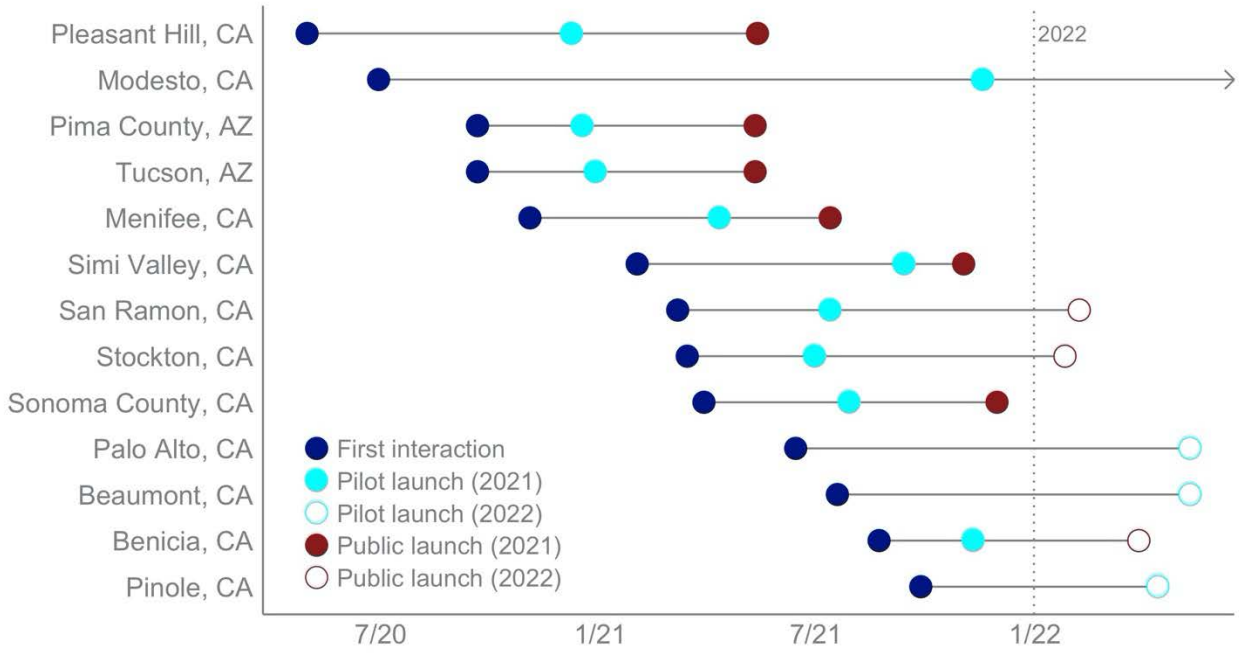

Figure 4. AHJ SolarAPP+ implementation timelines

The characteristics of the 10 SolarAPP+ AHJs in our study sample are summarized in Table 1. The AHJs, while concentrated geographically in Arizona and California, comprise a range of demographic features. The AHJs range in population from 28,192 in Benicia, CA, to 542,629 in Tucson, AZ. Four of the AHJs are classified as economically disadvantaged, where the AHJ median income is less than 80% of the state income. All 10 AHJs have relatively active rooftop PV markets, with over 90,000 systems cumulatively installed through the end of 2020 (Barbose et al. 2021).

Table 1. Characteristics of AHJs Implementing SolarAPP+ in 2021

AHJ	Status	Pop.	Economically Disadvantaged	2021 Traditional Permits[a]	2021 SolarAPP+ Permits[a]	Existing Permit Software	Permit Fee	2021 Traditional Median Permit Review Time (Days)
Benicia, CA	Pilot	28,192	No	NC	5[c]	OpenGov	$415	11[b]
Menifee, CA	Public	102,527	No	1,127	455	Accela (ACA)	$295	6[b]
Modesto, CA	Pilot	215,196	Yes	533	11[c]	eTRAKiT	$300	12[b]
Pima County, AZ	Public	500,804	No	1,946	671	Accela (ACA)	$94	6
Pleasant Hill, CA	Public	33,152	No	249	44	Accela	$235	1[d]
San Ramon, CA	Public	75,984	No	749	134	EnerGov	$450	8
Simi Valley, CA	Public	125,594	No	1,046	182	EnerGov	$450	16
Sonoma County, CA	Public	494,336	No	1,351	30	Accela (ACA)	$450	11
Stockton, CA	Public	320,804	Yes	2,003	93	Accela (ACA)	$300	4
Tucson, AZ	Public	542,629	Yes	1,816	1,682	EnerGov	$99	24

NC = not collected. [a] May include some solar-plus-storage projects. [b] Data collected from SolarTRACE. [c] Due to data collection issues, project numbers in Benicia and Modesto come from a different data source than the other AHJs; the exact number of permits issued in 2021 is unknown. [d] Data based on 2020.

An additional 53 AHJs have explored SolarAPP+ but have delayed implementation due to various adoption blockers. Table 2 summarizes the challenges to SolarAPP+ adoption most frequently cited by interested AHJs. The most common challenge is incompatibility between local requirements and the standardized compliance checks conducted in SolarAPP+. Other common barriers include requests for customized compliance checks, local requirements for reviews unrelated to building and electrical codes (e.g., zoning, planning), and AHJ concerns about automating certain reviews. Though these are the most cited blockers to adoption, AHJs have also stressed that a lack of resource and financial constraints can slow SolarAPP+ adoption and implementation, even when an AHJ is otherwise motivated to adopt the SolarAPP+ platform.

Table 2. Summary of Challenges to SolarAPP+ Implementation

Note: Frequency refers to the number of AHJs who cited each challenge, based on responses from all contacted AHJs still considering adopting SolarAPP+

Challenge	Description	Frequency
Code issue	AHJ must adhere to state or local amendments to codes, which may conflict with the code compliance checks conducted by SolarAPP+.	16
Customization request	AHJ desires SolarAPP+ to be modified to match a statutory/regulatory requirement or help the AHJ meet a certain policy goal.	12
Planning requirements	PV systems in certain AHJs are subject to requirements beyond the electrical and building codes, such as zoning or floodplain regulations.	10
Fire review	Projects that meet specific criteria are subject to fire department or fire district review.	9
Plan sets	AHJ expresses concern that SolarAPP+ automated compliance checks are not sufficient to replace AHJ review of contractor plans.	8
Software transition	AHJ is in the process of transitioning to a new permitting software platform, precluding the incorporation of SolarAPP+ into their current system.	7
Utility specific requirements	Municipal utilities require reviews as a part of interconnection procedures beyond those required for permit approval. SolarAPP+ does not currently address interconnection processes.	6
Human review	AHJ expresses concern about the automation of compliance checks.	5
Administrative fee	Issues related to processing administrative fees in SolarAPP+.	4
Incompatibility with instant workflow	AHJ permitting software cannot issue permits instantaneously (instant workflow is required for SolarAPP+ compatibility).	4
Other software incompatibility issues	AHJ permitting software is incompatible with SolarAPP+ for reasons other than instant workflow.	4
Duplicate permit review	Certain AHJs wish to test SolarAPP+ by requiring contractors to submit duplicate permits through the conventional AHJ review and through SolarAPP+.	4
Liability	AHJ concern over legal liabilities of using SolarAPP+.	2
Payment processing	Issues related to fee collection.	2
Inspection time	Concerns that using the SolarAPP+ inspection checklist creates a time burden for staff.	1

62 of the roughly 1,000 contacted AHJs ultimately decided not to adopt SolarAPP+. Figure 5 depicts the reasons provided by these AHJs. Around half of these non-adopters are satisfied with their existing permitting systems.

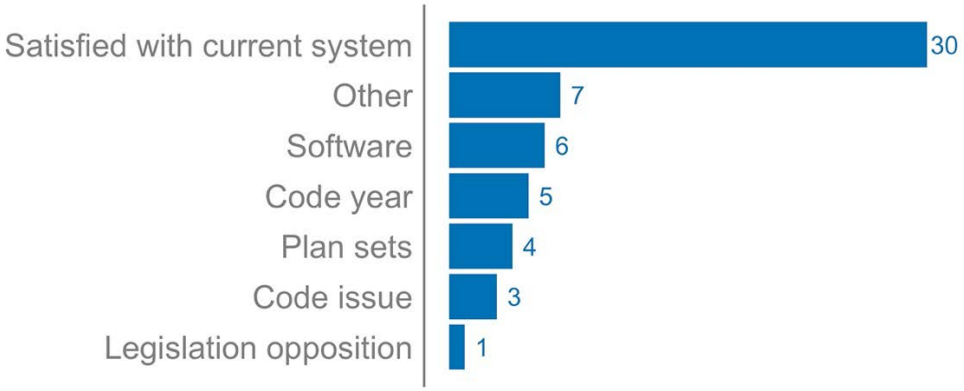

Figure 5. Reasons cited for not adopting SolarAPP+

Note: Figure based on subsample of 56 AHJs that provided reasons for not adoptin SolarAPP+

4 Performance Review

We review SolarAPP+ performance by comparing metrics for projects processed through SolarAPP+ to those processed through traditional AHJ permitting processes. Performance review data were collected from two sources. First, we pulled data directly from the SolarAPP+ software, including data on projects, installers, AHJ adoption challenges, interested AHJs, and detailed project-level characteristics such as system size, module brands, and information on home electrical upgrades (summary statistics for these project-level characteristics are provided in the Appendix). Second, we collected data from the 10 AHJs that had adopted SolarAPP+ by the end of 2021 (see Table 1). These 10 AHJs provided data on SolarAPP+ adoption timelines, permit submission dates, permit issuance dates, permit fees, inspection dates, inspection durations, and inspection failure causes. For some analyses, we used the AHJ-provided dates to calculate durations. All durations reported in days are in terms of business days.

The degree of data completeness across performance metrics varied by AHJ. For instance, data on permitting volumes were available from all 10 AHJs, but complete data on permit review durations were only available for eight AHJs. The distinct samples used for each analysis are identified in the figure captions.

Finally, the term *SolarAPP+ project* to refers to any PV system that was entered into SolarAPP+ by a contractor. All SolarAPP+ projects are issued preapproved system plans, but only some projects are automatically issued a permit via the SolarAPP+ platform, depending on the SolarAPP+ integration pathway chosen by the AHJ. The projects that do not receive a permit within SolarAPP+ receive their instant permit from the AHJ after the AHJ uploads the SolarAPP+ preapproved system plans in the AHJ's online permitting system. The term *SolarAPP+ permits* to refers to both permits automatically issued on the platform and those that were confirmed as issued by the AHJ.

4.1 AHJ Permit Volume

In 2021, 102 contractors submitted 3,490 projects and completed 2,017 revisions (including revisions during inspection) on these projects within the SolarAPP+ platform across 10 AHJs (Figure 6, Figure 7). Complete permit data are available for 3,291 of these 3,490 projects.[4] All performance analyses are based on this subsample of 3,291 permits. Participating installers reflect a range of characteristics and installation volumes, confirming that the SolarAPP+ platform is not used exclusively by specific types of installers (Figure 8). The data suggest that significant shares of installers participate in SolarAPP+. For instance, data from Barbose et al. (2021) suggest that around 68 installers operated in Tucson in 2020 (the latest year with available data). Although more installers were likely active in Tucson in 2021, the comparison suggests that around half of installers in Tucson used SolarAPP+.

[4] The discrepancy between the two samples mostly reflects projects that were submitted to SolarAPP+ in 2021 but had not been issued a permit by the end of 2021. The N = 3,291 subsample includes all permits reflected in Table 1 and Figure 6 except those in Benicia and Modesto, for which we have project data but no confirmed permit data.

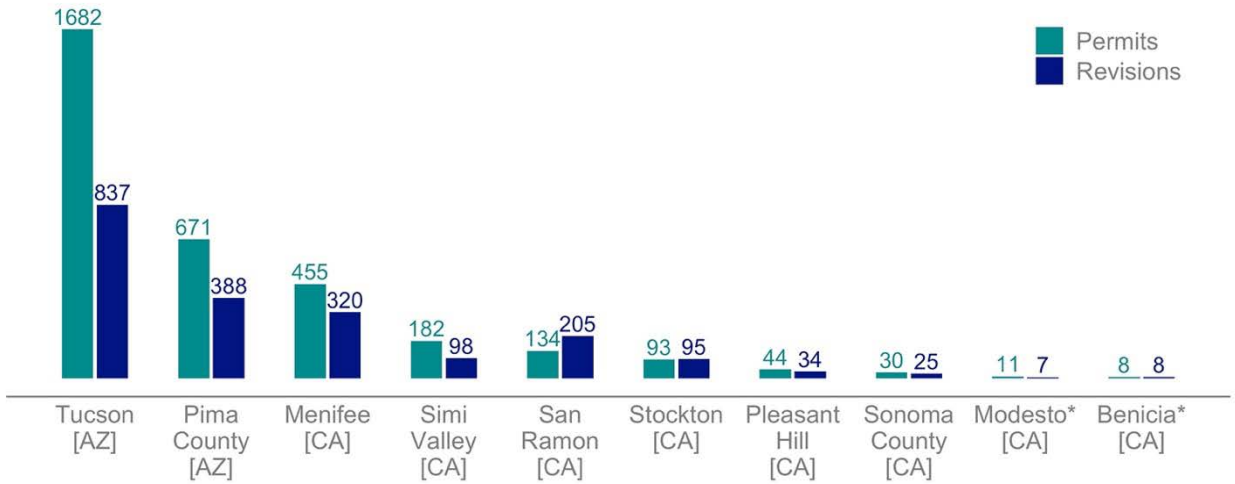

Figure 6. Number of SolarAPP+ projects and revisions by AHJ (2021)

*Permit estimates for Benicia and Modesto come from a different data source than the other AHJs; the exact number of permits issued in 2021 is unknown

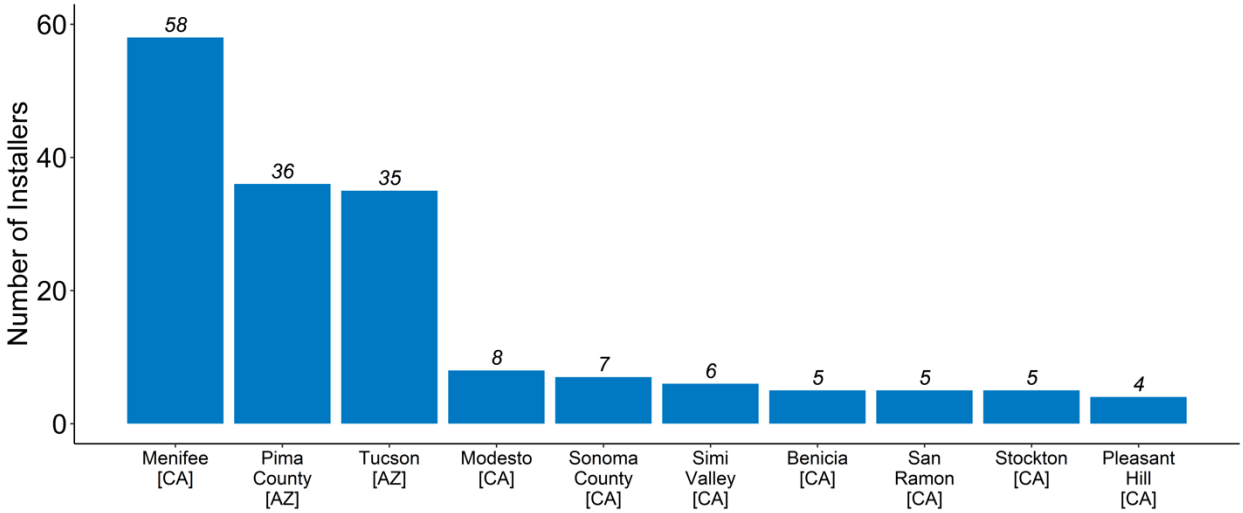

Figure 7. Number of installers using SolarAPP+ by AHJ (2021)

Note: The total number of contractors that have submitted projects through SolarAPP+ is 102; some contractors work in multiple AHJs

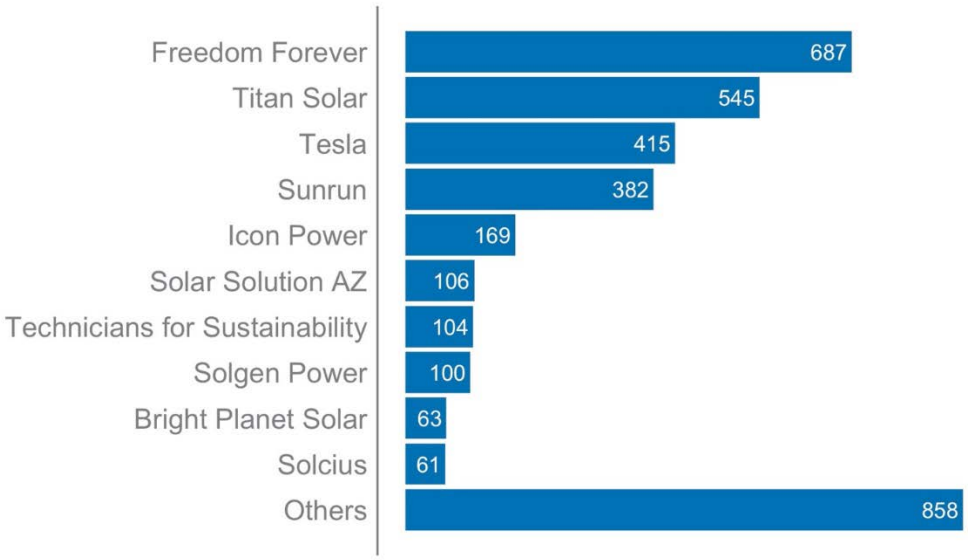

Figure 8. Number of SolarAPP+ projects by participating installer (2021)

Note: This figure reflects all projects submitted to SolarAPP+ in 2021 (N = 3,490)

Figure 9 depicts SolarAPP+ permit volume penetration—meaning the percentage of permits that were processed through SolarAPP+—before and after the public launch in six AHJs. On average, SolarAPP+ penetration rates increased from 9% during pilots to 37% after SolarAPP+ launched across the six AHJs. Tucson has the highest post-launch SolarAPP+ permit volume penetration rate at 62%.

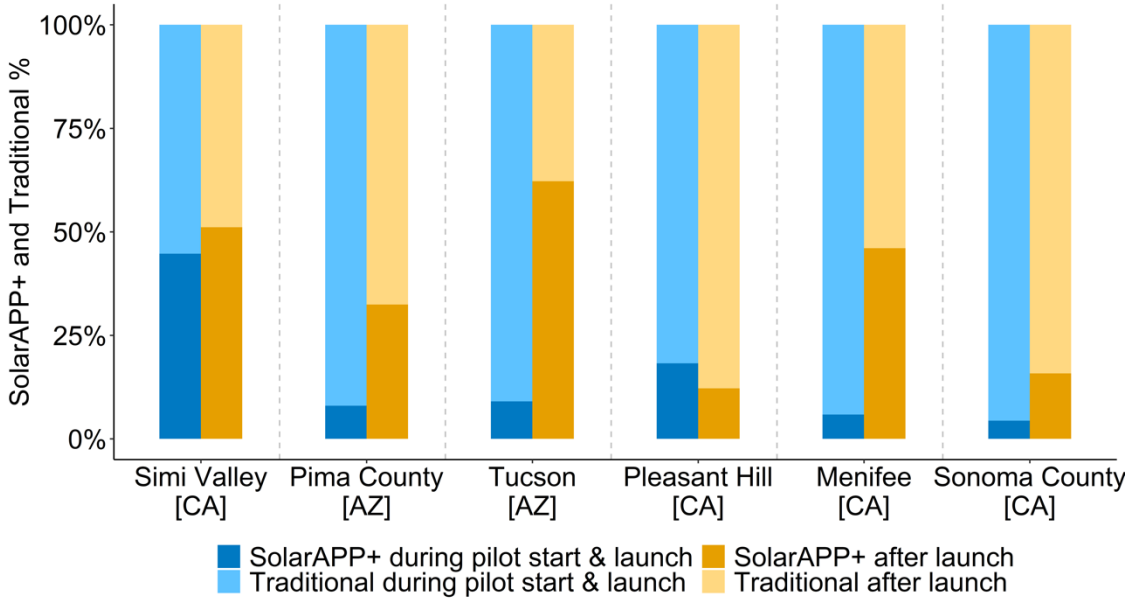

Figure 9. Percentage volume of permits issued with SolarAPP+ before and after public launch by AHJ (2021)

Note: Figure excludes four AHJs that had not publicly launched SolarAPP+ by the end of 2021. Sonoma County post-launch rates are based on a single month (December 2021).

4.2 AHJ Permit Review Impacts

Permit review durations refer to the time (in business days) between a permit submission and permit issuance. We compared permit review durations for SolarAPP+ and traditional projects to evaluate the platform's performance during the review stage (Figure 10). The median permit review time for traditional projects across AHJs was nine days.[5] The median AHJ-level permit review time ranged from one day in Pleasant Hill, CA, to 24 days in Tucson, AZ. In contrast, the SolarAPP+ platform issues permits immediately for code-compliant applications, meaning that the median permit review duration for SolarAPP+ projects is zero days.

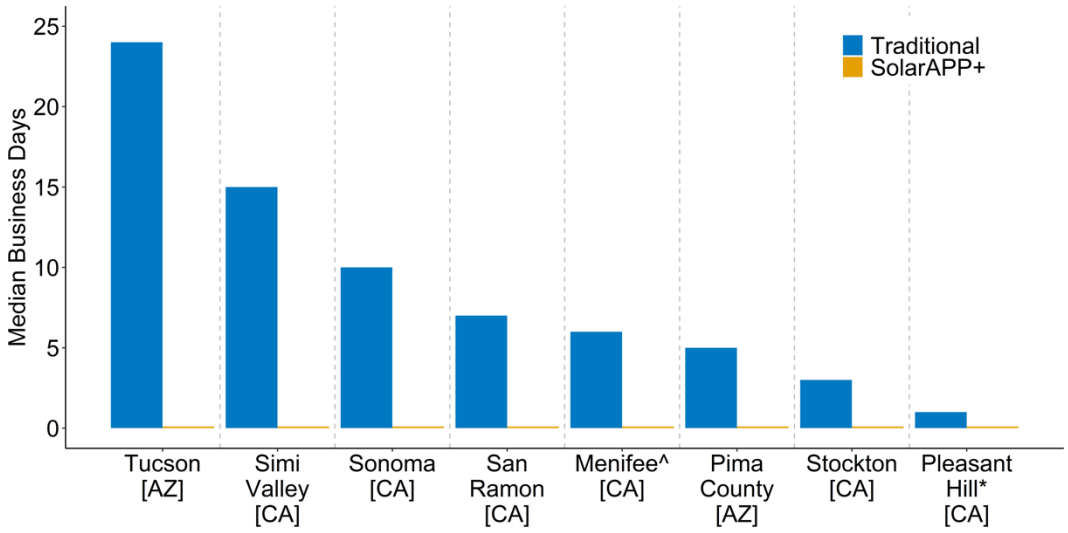

Figure 10. Median permit review times

Note: Benicia and Modesto were excluded because these AHJs began pilots late in 2021. ^2021 permit issued data unavailable; values are based on 2021 SolarTRACE data. *2021 data unavailable; values are based on 2020 data.

In addition to reducing permit review durations, the SolarAPP+ platform reduces AHJ staff review time by obviating the need for individual permit reviews. The net impact of SolarAPP+ on staff time is influenced by both the time savings from permit reviews and the time required to implement SolarAPP+. AHJs reported spending about 47 hours, on average, to implement the SolarAPP+ platform. The majority of this time was associated with pilot meetings and software development (Figure 11). AHJs reported involving one to five staff members to lead SolarAPP+ implementation.

[5] Based on feedback from AHJs, these durations reflect timelines for a single permit entry, i.e., they do not include revisions, allowing for an apples-to-apples comparison with SolarAPP+ durations for code-compliant systems. The median estimate excludes Menifee and Pleasant Hill, for which 2021 duration data were not collected.

Figure

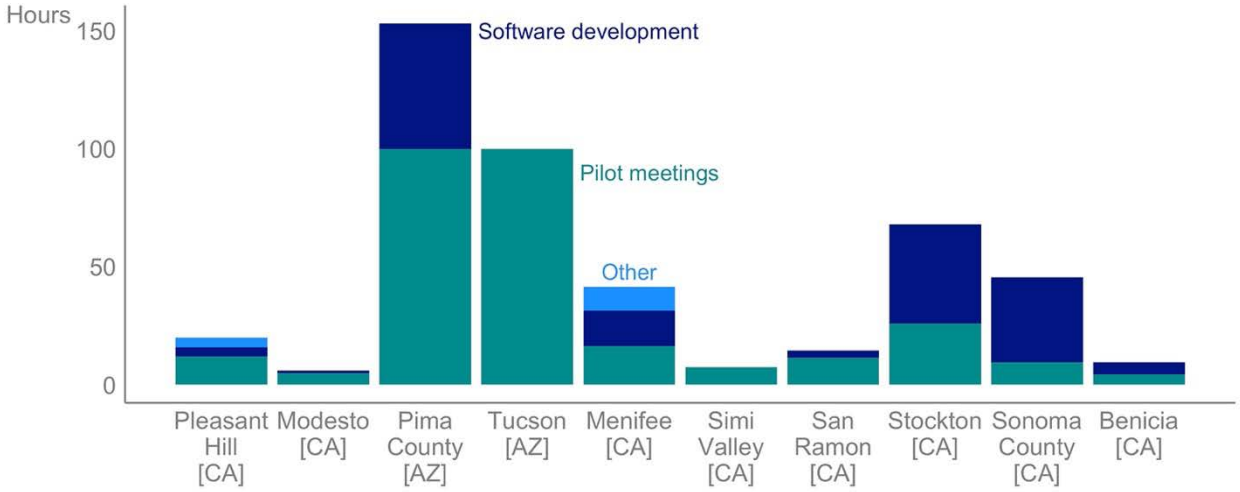

Figure 11. AHJ staff time to implement SolarAPP+

Note: Figure ordered by first interaction dates

According to feedback from the AHJs, manual permit reviews require around 15–60 minutes of staff time. Figure 12 depicts the estimated AHJ staff time saved by automating permit reviews on the SolarAPP+ platform, assuming reviews take 15–60 minutes.[6] For Tucson, a relatively large AHJ, we estimate that automated permit reviews freed up around 1,600 hours of staff time during the study period, roughly the equivalent of adding a full-time employee to AHJ staff. For most AHJs, the staff time savings significantly exceed the staff time spent on implementing the SolarAPP+ platform. These estimates suggest that most AHJs have already recouped the staff time investment in launching SolarAPP+ through staff time savings from automated permit review. Across the eight AHJs with available data, we estimate that SolarAPP+ required a combined 466 hours of staff time to implement but has already saved about 3,300 hours of cumulative staff time through automated permit reviews.

[6] We assume every revision must go through AHJ reviews. Benicia and Modesto are excluded from the permit and revision time saving analysis because we did not collect their permit data. The SolarAPP+ implementation durations for these two AHJs are 9.5 hours and 5 hours, respectively.

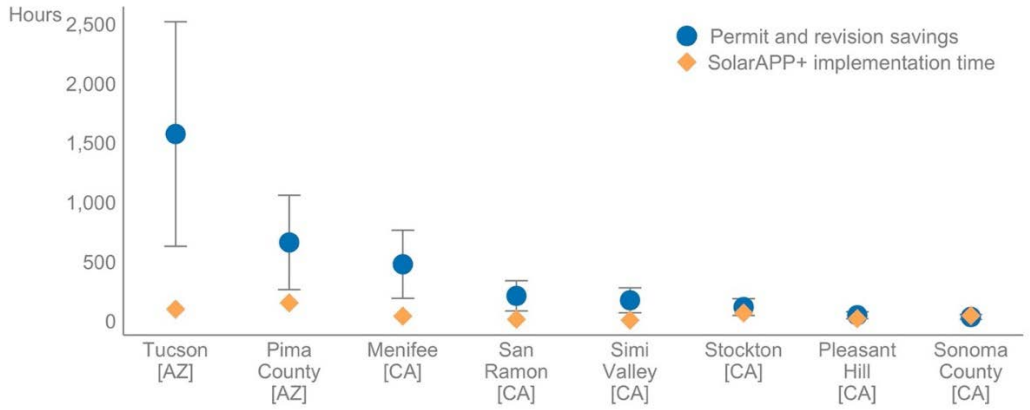

Figure 12. Estimated AHJ staff review time savings (to date) from SolarAPP+ permit processing

Note: The lower and upper bounds of the bars represent staff time savings assuming each review takes 15 and 60 minutes, respectively, while the points represent the middle of the range (37.5 minutes), based on AHJ-provided estimates of permit review time.

As shown in Table 1, all 10 AHJs charge fees for permits processed through their conventional permitting systems. These fees range from $94 to $475 per permit. SolarAPP+ charges an administrative fee of $25 to the contractor in addition to any existing AHJ fees. Permit fees are collected to cover building department plan review and inspection related activities among other costs germane to construction in the AHJ. Comparatively, the SolarAPP+ fee is used to operate, maintain, and expand the SolarAPP+ software. Adjusting AHJ permitting fees often requires a fee review process that can take several months to implement. Some SolarAPP+ AHJs have or are considering reducing or eliminating the plan review fees charged on SolarAPP+ permits. Pima County and Tucson both adjusted their permit fees for SolarAPP+ permits to eliminate the plan review portion of the fee, given that the SolarAPP+ software now performs that service. This resulted in a $6 net permit fee reduction in those two AHJs (after accounting for the SolarAPP+ $25 fee) compared to traditional projects, generating an estimated $14,118 in permit fee savings across those two AHJs in 2021. Subsequently, Simi Valley has completed its solar permit fee review for SolarAPP+ and starting July 1st, 2022, Simi Valley will waive its plan review fee of $155.41 for SolarAPP+ projects (a $130.41 net savings). Other AHJs are also considering revisions to their permitting fee structures, but changes have not yet been made.

4.3 AHJ Inspection Impacts

Inspection duration refers to the time (in minutes) taken to inspect an installed system. Figure 13 shows average inspection durations for SolarAPP+ and traditional projects. Inspection durations are comparable for both project types, suggesting that expedited permitting via SolarAPP+ has a negligible impact on inspection times downstream.

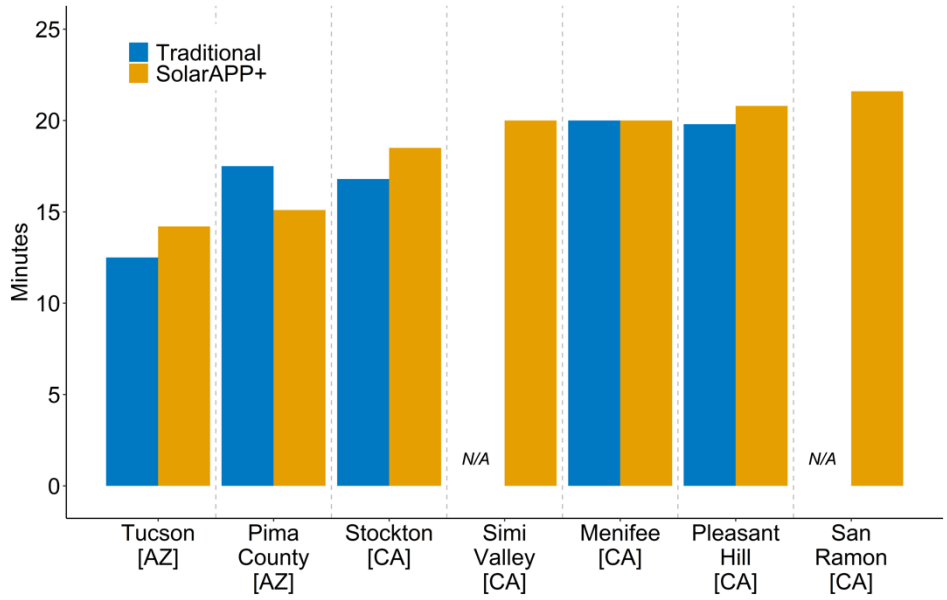

Figure 13. Average inspection time (in minutes) for SolarAPP+ and traditional projects

Note: Sonoma County is excluded because fewer than 10 inspections were performed by the end of 2021; data on traditional inspections for Simi Valley and San Ramon were not available. No SolarAPP+ projects were inspected in Benicia and Modesto in 2021.

Figure 14 depicts inspection failure rates for traditional and SolarAPP+ projects across seven AHJs with available data. In this performance review, we define inspection failure rate as the percentage of projects that failed at least one inspection. This approach differs from the methodology used in Williams et al. (2022), who calculated the failure rate based on the number of failed inspections out of the total inspections conducted. The two methods yield similar results. This project-level calculation yields a total SolarAPP+ inspection failure rate of about 17% across the seven AHJs, similar to the 19% inspection failure rate estimated by Williams et al. In comparison, the traditional project inspection failure rate was about 27% across the same seven AHJs. Due to the relatively small sample sizes for the failure rate estimates, confidence intervals are shown in Figure 14 to reflect uncertainty.

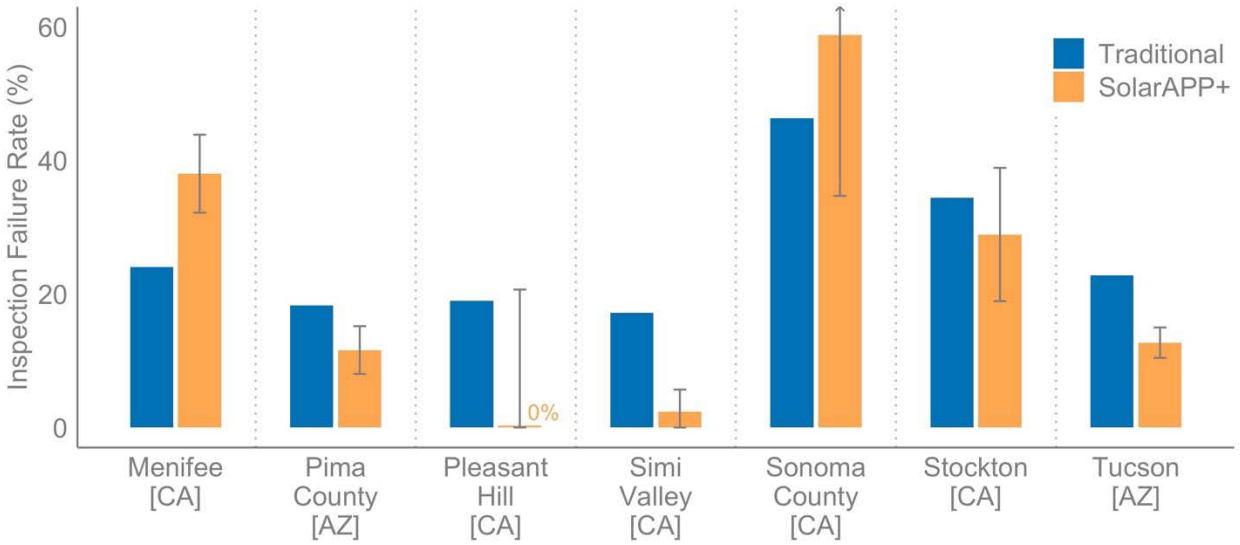

Figure 14. Inspection failure rates by AHJ (2021)

Note: Lines refer to 95% confidence intervals based on sample sizes. The observed SolarAPP+ inspection failure rate for Pleasant Valley was 0%, so confidence intervals for Pleasant Valley were built based on the inspection failure rate across all AHJs of 17%. The confidence interval for Sonoma County extends beyond the axis of this chart.

SolarAPP+ inspection failure rates are significantly lower than traditional failure rates in three of the seven AHJs, meaning that the upper bounds of the confidence intervals are lower than traditional failure rates. In Tucson, the AHJ with the largest sample size and thus the most reliable estimate, the inspection failure rate for SolarAPP+ projects is about 10 percentage points (±2) lower than for traditional projects. Menifee and Sonoma County show higher SolarAPP+ inspection failure rate point estimates, though Menifee was the only AHJ where the difference was statistically significant (i.e., the entirety of SolarAPP+ inspection failure rate confidence interval was higher than the traditional inspection failure rate). Across all seven AHJs, SolarAPP+ projects failed about 17% of inspections, compared to 27% of traditional projects, suggesting that SolarAPP+ projects have failed inspections about 37% less frequently than traditional projects.

In addition to tracking the volume of SolarAPP+ inspection failures, we also tracked the reasons for inspection failure (Figure 15). The most common reasons were work quality issues and rescheduling, which cannot be mitigated by SolarAPP+ implementation. In contrast, approximately 18% of known inspection failures could have been addressed by the contractor before the inspection, namely, ensuring that the installed project matched what was approved in SolarAPP+ (12%) and ensuring that the checklist was on site at the time of inspection (6%). If an as-built change is needed, the contractor can submit revisions through SolarAPP+ instantly and on site. As contractors gain familiarity with the product, these types of failures may be reduced.

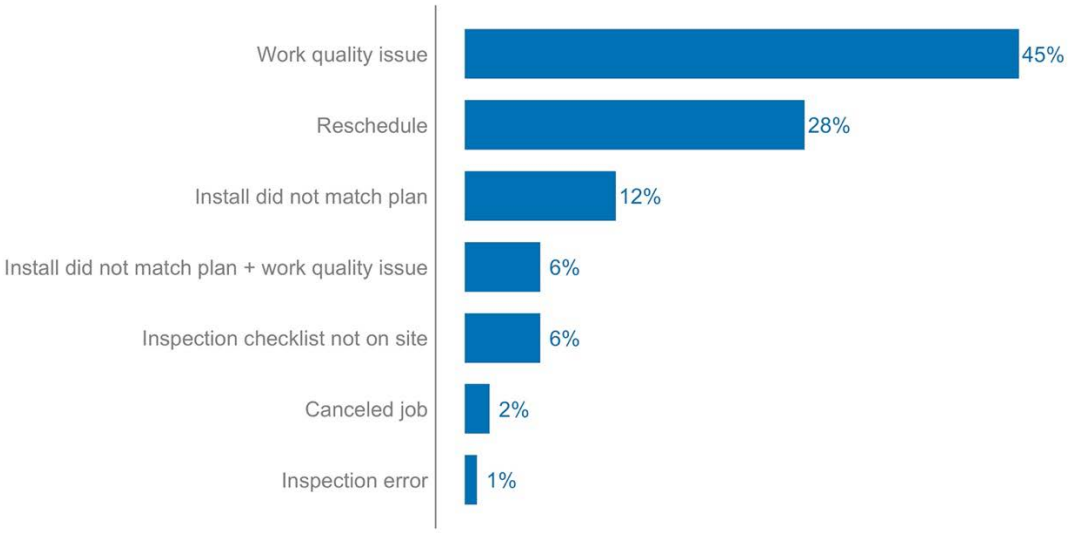

Figure 15. Known reasons for inspection failures among SolarAPP+ projects

4.4 Solar Adoption Timeline Impacts

In the previous two sections, we explored the impacts of SolarAPP+ at specific stages of the solar adoption timeline. Here, we explore the full timeline impacts of SolarAPP+ from permit submittal to final inspection. Figure 16 compares median project times from permit submission to passed inspection for SolarAPP+ and traditional projects across all AHJs. Median project times are shorter on the SolarAPP+ platform in every AHJ. Across all AHJs in 2021, median project times were 13 days shorter for SolarAPP+ projects than for traditional projects (32 days compared to 45 days). This estimate is similar to results from Williams et al. (2022), who found that projects were installed 12 business days faster than those installed via the traditional process for the five pilot AHJs.

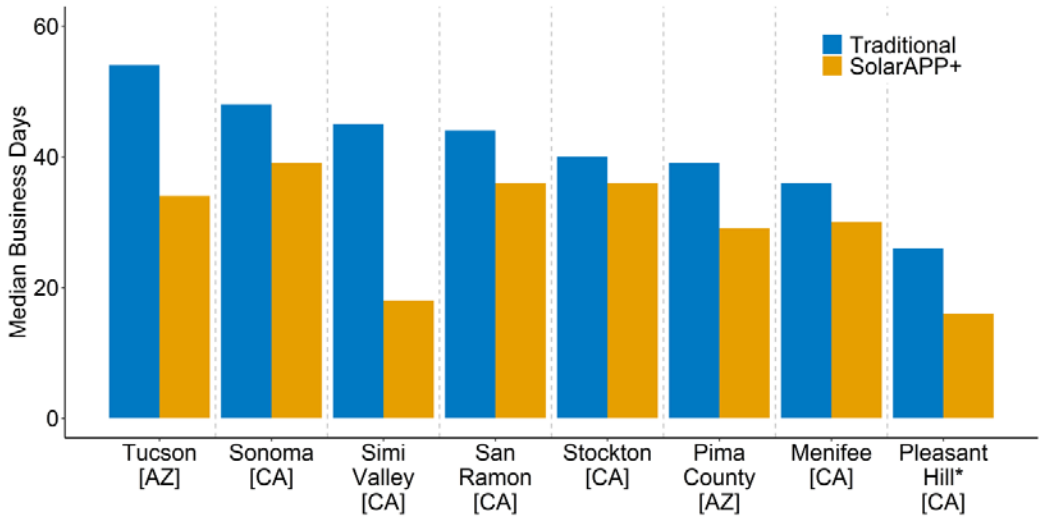

Figure 16. Median project time from permit submission to passed inspection by AHJ (2021)

Note: Benicia and Modesto are excluded because the pilots began in late 2021. *Pleasant Hill traditional permit data for 2021 were unavailable; values are based 2020 data. Pleasant Hill SolarAPP+ values are

based on 2021 pilot data.

The difference in the median project time between SolarAPP+ and the traditional process is an approximation of the cumulative impact of SolarAPP+ and does not control for potential differences between applications submitted through each process. For instance, it is possible that installers that use SolarAPP+ may navigate permitting processes more or less quickly than other installers. Additionally, projects that are ineligible for SolarAPP+ submission may require longer traditional review. Potential differences between the SolarAPP+ and traditional project groups could cause misleading deviations between SolarAPP+ and traditional process durations. Further, the estimated differences in the 10 AHJs are not necessarily representative of the potential impacts of SolarAPP+ in other AHJs. It is possible that these 10 AHJs had more or less efficient traditional permitting processes than an average AHJ prior to implementing SolarAPP+. For these reasons, the reported impacts should be considered approximate impacts of SolarAPP+ on AHJ permitting process durations.

Figure 17 depicts the estimated cumulative impact of the SolarAPP+ platform for the eight AHJs with available data. The cumulative impact is mostly a function of the number of permits processed. As a result, the cumulative impact is largest in Tucson, where we estimate that the SolarAPP+ platform accelerated permitting timelines by more than 30,000 days by the end of 2021.

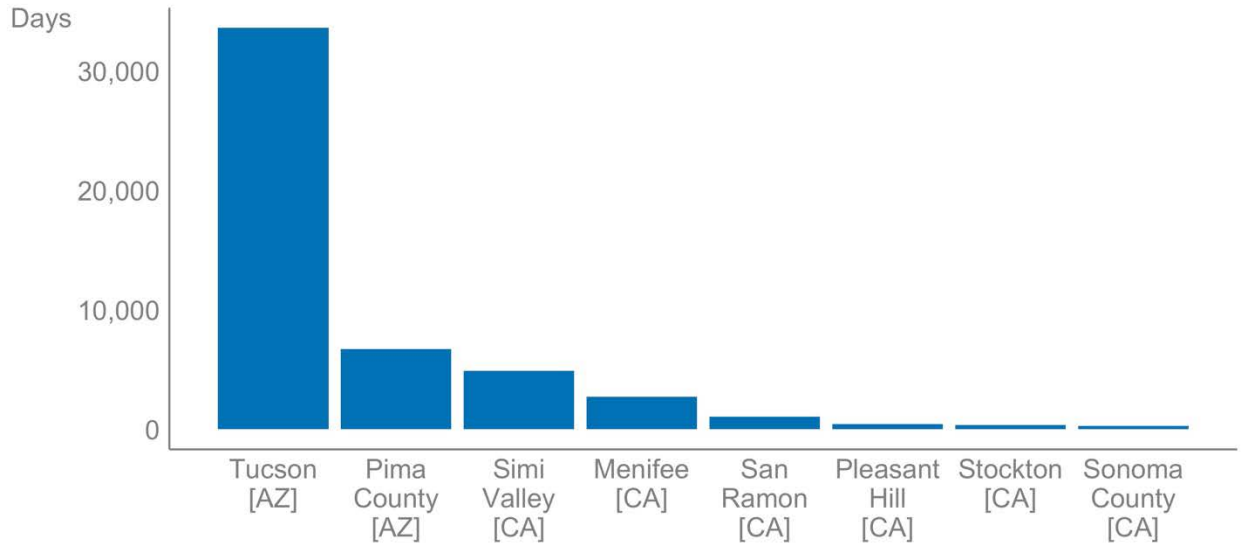

Figure 17. Cumulative estimated acceleration of project timelines (permit submission to passed inspection) across AHJs

Note: Benicia and Modesto are excluded because pilots began in late 2021.

4.5 SolarAPP+ Solar and Storage Pilot

In 2021, based on stakeholder demand, SolarAPP+ was updated to include the option to deliver instant permits for solar PV systems that are installed in tandem with certain lithium-ion battery

storage products. To date, eight AHJs have begun piloting solar and storage permitting with SolarAPP+, for a total of 241 projects permitted across three participating contractors (Table 3).[7] NREL will evaluate the performance of SolarAPP+ in relation to solar and storage projects in a future performance review.

Table 3. Summary of Permits Issued for Solar-Plus-Storage Projects

AHJs	Number of Projects	Number of Contractors
Simi Valley, CA	80	3
San Ramon, CA	58	1
Pima County, AZ	33	2
Tucson, AZ	28	2
Pleasant Hill, CA	16	1
Sonoma County, CA	13	1
Menifee, CA	8	3
Stockton, CA	5	1
Total	**241**	**3**

[7] SolarAPP+ has limited participating contractors to four during the initial piloting phase. Of these, three have submitted projects. The fourth has been unable to participate because the battery storage equipment they install is not compatible with SolarAPP+ in the participating AHJs, given seismic requirements.

5 Summary

NREL developed the SolarAPP+ platform in collaboration with other industry stakeholders to address the growing need for expedited and standardized rooftop PV permitting. By May 2022, NREL had contacted over 1,000 AHJs as potential users of the SolarAPP+ platform. Our study focuses on the 10 AHJs that had at least begun piloting SolarAPP+ by the end of 2021. In 2021, in these 10 AHJs, 102 installers processed 3,490 projects on SolarAPP+.

The clearest impact of SolarAPP+ occurs during permit review. Across SolarAPP+ AHJs, the median duration of the period between a permit application and a permit issuance for traditional projects was nine days. In contrast, the median permit review time for SolarAPP+ projects was zero days.

Automated permit reviews saved AHJ staff or contractor time by eliminating the need to manually review the permits. We estimate that automated permit reviews on SolarAPP+ saved around 3,300 hours of cumulative staff time by the end of 2021, the equivalent of adding about 1.5 full-time employees to the participating AHJs. Further, the data suggest that automated reviews do not result in downstream delays. SolarAPP+ project inspection times are not significantly different from those of projects that underwent manual reviews. Data from seven AHJs suggest that SolarAPP+ projects are less likely to fail inspections than traditional projects.

Based on median timelines, the data suggest that a typical SolarAPP+ project completes the full permitting and inspection process about 13 days before a traditional project. This result is similar to results during the pilot study, which found that SolarAPP+ projects completed the full process about 12 days before traditional projects (Williams et al. 2022). Summing up the estimated impacts across AHJs, we estimate that SolarAPP+ accelerated PV permitting and inspection timelines by more than 40,000 days by the end of 2021. Although we do not estimate the market impact of these accelerated timelines, the data indicate that SolarAPP+ deployment could accelerate rooftop PV deployment by reducing AHJ permitting backlogs, helping projects interconnect sooner, and freeing up installers to pursue more customers.

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Appendix. SolarAPP+ Project Design Characteristics

The SolarAPP+ platform provides a new data source for rooftop PV system characteristics. In this Appendix, we describe SolarAPP+ system characteristics and discuss how SolarAPP+ projects compare to the broader rooftop PV market.

System Size

The median system size for SolarAPP+ projects is 6.6 kW, ranging from 0.3 to 23 kW (Figure 18). The system sizes are comparable to sizes in the broader rooftop PV market, as indicated by the 6.5-kW median for systems installed in 2020, estimated by Barbose et al. (2021).

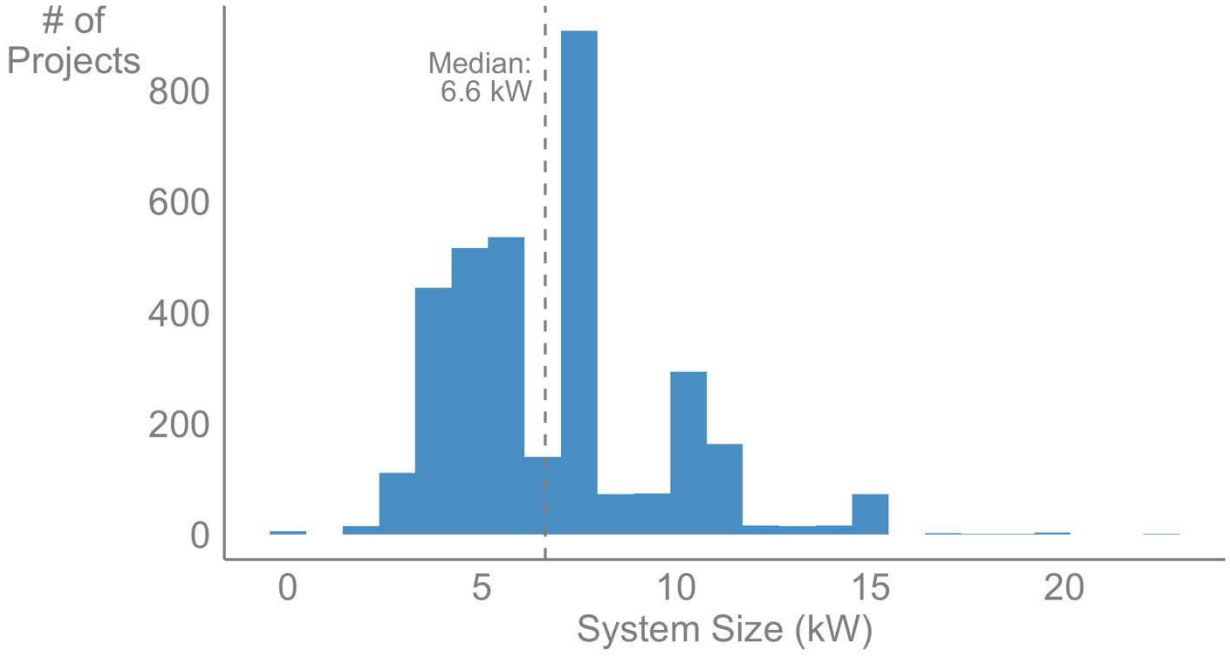

Figure 18. SolarAPP+ system size (kW) distribution

Modules and Inverters

Figure 19 depicts the distribution of module brands used in SolarAPP+ projects. Module brands largely reflect installer preferences and contractual agreements with module manufacturers. The SolarAPP+ module distribution is both similar and distinct from the module choices of other installers. For instance, data from EnergySage (2022) show that Silfab, Renewable Energy Corporation (REC), and LG modules are similarly popular among other installers. At the same time, SolarAPP+ projects use Hanwha Q Cells more frequently than other installers but use Panasonic and SunPower modules less frequently than other installers.

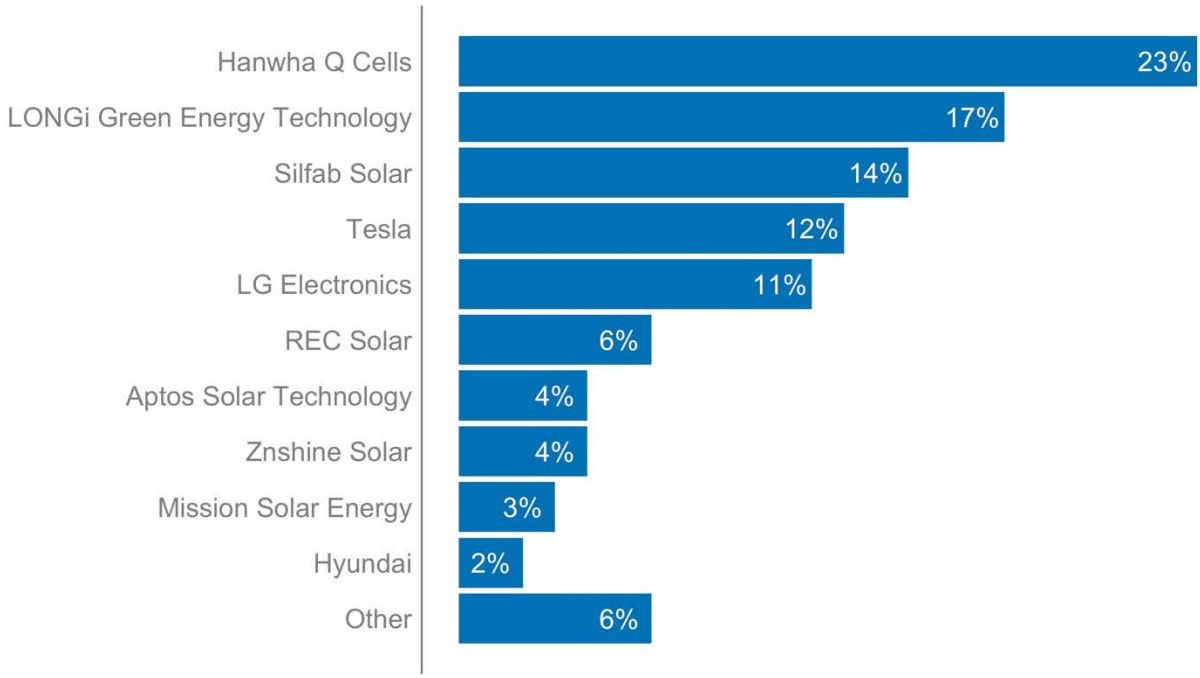

Figure 19. Module brand shares in SolarAPP+ projects (N = 3,490)

About 83% of SolarAPP+ systems include module-level power electronics, specifically DC optimizers (59%) and microinverters (24%). That share is slightly less than the estimated residential market-wide share of 94% (Barbose et al. 2021).

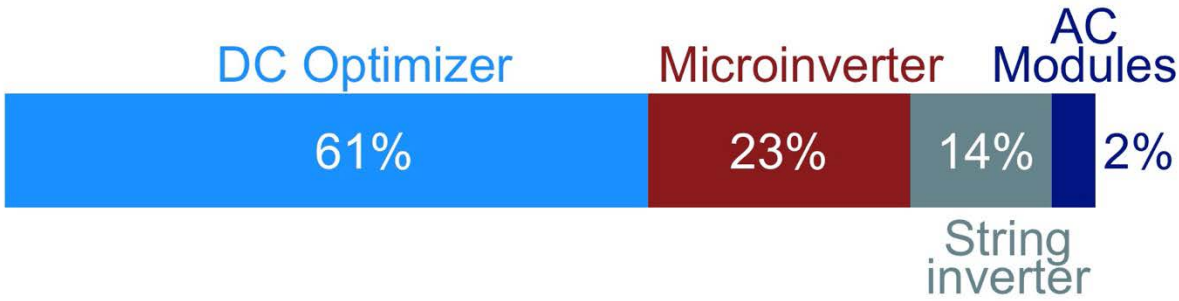

Figure 20. Inverter characteristics of SolarAPP+ systems

Figure 21 depicts the distribution of inverter brands used in SolarAPP+ projects. Around 81% of SolarAPP+ projects use SolarEdge or Enphase brand inverters, similar to the share of those brands estimated by EnergySage (2022).

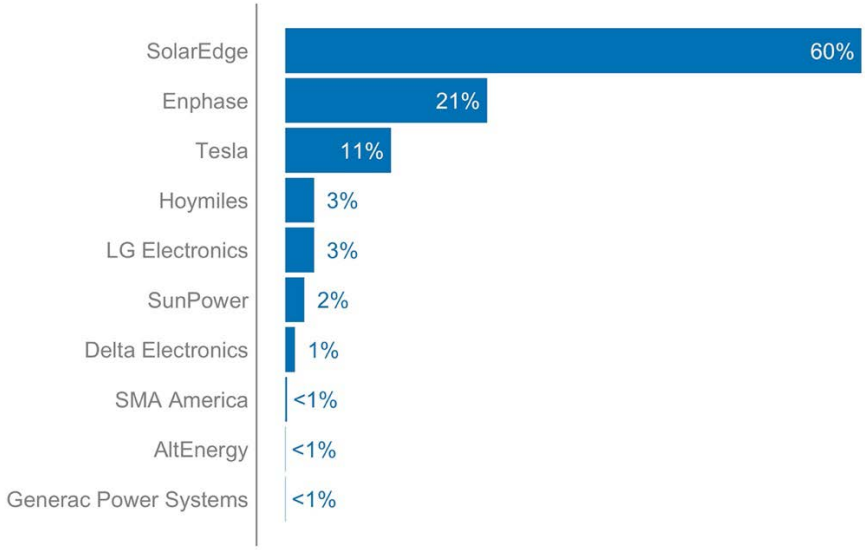

Figure 21. Inverter brand shares in SolarAPP+ projects (N = 3,490)

Home Electrical Upgrades and Interconnection Methods

Residential PV system installations can require upgrades to home electrical systems in certain cases. About 18% of SolarAPP+ permits were associated with a main panel upgrade (Figure 22). Further, about 11% of permits were associated with derating (reducing) the power limits of the home's main breaker, required in cases where the PV system could cause the home to exceed amperage limits set by the local utility. All PV systems require setting an amperage limit above which the system is automatically disconnected from the grid. SolarAPP+ service disconnect limits ranged from 100 amps (14% of systems), 125 amps (5%), 150 amps (3%), 175 amps (9%), to 200 amps (69%). Finally, most SolarAPP+ systems are connected to the grid using the 120% rule, meaning that the installed system amperage cannot exceed the home meter's safety limit by more than 20%.

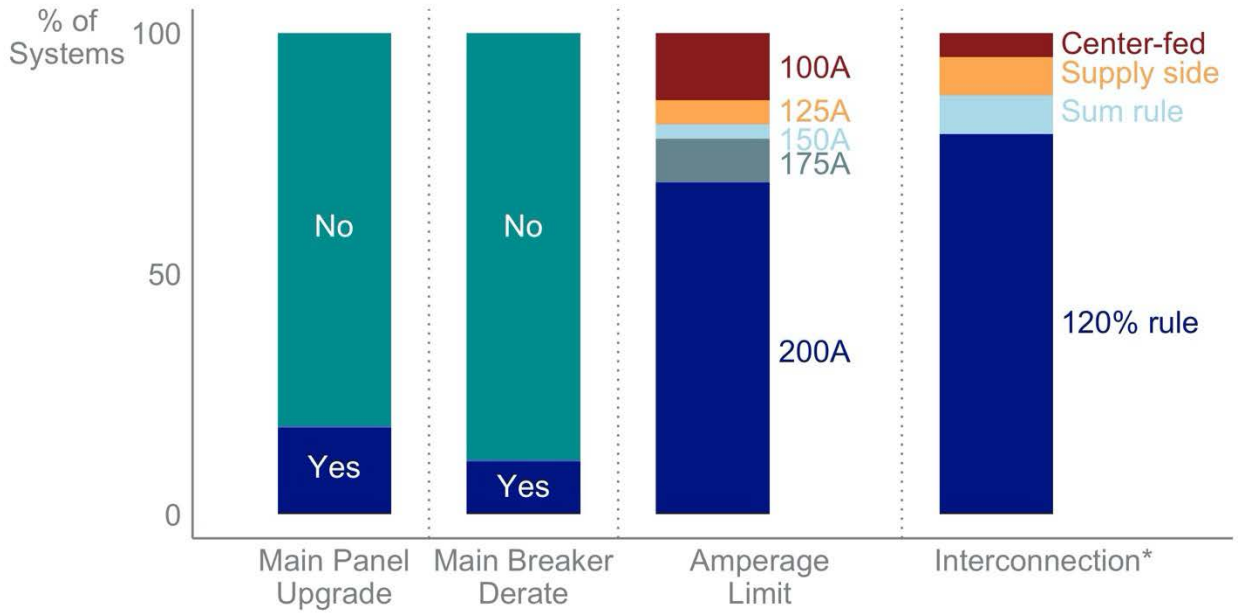

Figure 22. Electrical upgrade features of SolarAPP+ systems

*Sum rule = sum of breaker rule; supply-side = supply-side connection; center-fed = 120% rule on center-fed panels