Understanding Streamlined Solar Permitting Practices: A Primer

Draft written by Margaret Taylor, November 17, 2017

Introduction

A significant "soft cost" barrier to the growth of the residential solar PV market is the length of time and cross-jurisdictional inconsistency associated with the process by which PV system installations are built according to code and interconnected to the grid (see Burkhardt et al. 2015 for cost estimates).

The growing response to this problem has been the development of a heterogeneous set of reforms known as "streamlined solar permitting" (SSP) practices. To date, SSP reforms have taken different shapes in different "authorities having jurisdiction" (AHJs), and have been unevenly adopted across the country.

This primer introduces the current landscape of U.S. SSP practices. To provide context for understanding the delays associated with the permitting, inspection, and interconnection process, it starts by reviewing the process by which a rooftop PV system is built to code and integrated into the U.S. electrical grid. In the next three sections, the document discusses important aspects of cross-jurisdictional inconsistency in this process, namely: the spatial distribution of building codes and standards; AHJ implementation issues; and utility interconnection implementation issues. The final substantive section of this document provides an overview of major SSP reforms discussed in the literature. An associated Appendix provides a live link to a synthesis of existing AHJ-level SSP practice data collected nationally, with supplemental information from California, as well as some basic descriptive statistics on this AHJ-level dataset.

The Permitting, Inspection, and Interconnection Process

The permitting and inspection aspects of the rooftop PV system installation process primarily involve interactions between solar installers and building department officials in the locality associated with the proposed project. These building officials are typically interested in ensuring that a rooftop PV system complies with "building, electrical, fire and/or plumbing codes" developed to ensure public health and safety (Stanfield et al. 2013). Less typically, a locality will want to ensure that a proposed rooftop PV system is in alignment with the "requirements of the zoning code and in alignment with broader community planning goals, including those for the protection of design character or historic resources." (ibid.)

The building code compliance process begins as an installer prepares to meet a locality's requirements, either independently or with the aid of locality-provided pre-application resources (e.g., permit application forms, checklists, guidance documents, etc.). The installer then usually submits "in person at the building department office" either a solar-specific or generic permit application, with accompanying documentation "including plans and certain diagrams," as well as an accompanying permit fee (Stanfield et al. 2013). The locality's building department conducts a "plan check," and if this initial review shows that the permit application meets requirements, the installer can begin construction. In most jurisdictions, the locality conducts regulatory oversight via "one or more field inspections," the completion of which are necessary for "final approval of a project and issuance of a permit" (*ibid*.). Field inspections can involve separate or integrated building, electrical, and fire inspections, either only after the solar panels are secured in place or also before they are thus secured (i.e., "in-process" or "rough-in" inspections). The installer is typically present on site when the field inspections occur, usually because this is best for directly answering questions or addressing issues that arise during the inspection, but sometimes because of the additional inducement of local requirements. The final permit is issued either in the field, upon completion of the final inspection, or back in the building department. The installer obtains the final permit either in the field, in-person at the building department, or via electronic or direct mail.

The zoning compliance process, by contrast, is typically less involved. According to Stanfield et al. (2013), “in many cases, compliance with the zoning code is verified at the time the building permit application is filed.” The exceptions are in cases in which solar is not a “permitted use” or when a jurisdiction requires that all projects “undergo design review.” An installer’s actions in response to the first exception include requesting a “special use permit,” a request that requires submitting accompanying paperwork to the local building department. An installer’s actions in response to the second exception include presenting the proposed project “to a specially elected or appointed board that evaluates whether the project complies with the community’s design standards” (*ibid.*).

The interconnection aspect of rooftop PV system installations, in contrast with the permitting and zoning aspects of the process, primarily involves interactions between installers and the utility that serves the locality associated with the proposed project. The utility is interested in ensuring that “new grid-connected generators do not impact the safety, reliability, and power quality of the operation of the distribution and transmission grid” and that costs associated with any necessary system upgrades are recovered (Stanfield et al. 2013). The interconnection process begins with the installer submitting an interconnection application and fee to the utility. According to Stanfield et al. (2013), the utility usually “segregates applications into certain ‘tracks’ depending on their size, location and other characteristics,” with many system applications receiving expedited review because of their small “size (<10kW) and low impact on the utility’s system.” Expedited review is conducted by the utility via a “series of technical screens,” typically does not trigger the need for a more intensive study process or utility system upgrades (particularly in areas of the country with low solar penetration), and generally results in providing the installer with an interconnection agreement.[1] After the installer signs the interconnection agreement and provides “proof that it has received its building permit or other local authorizations,” the utility will often require a field inspection for which the installer need not be present. It is only sometime after the completion of this inspection that a system can “be energized.”

Cross-jurisdictional Inconsistency: Building Codes and Standards

As noted in Stanfield (2013), the “time and complexity” of the building permit approval process can “vary by jurisdiction, ranging from a few hours to several weeks.” This section focuses on reasons for cross-jurisdictional inconsistency in U.S. building codes and standards as they relate to PV; in general, these codes address the impact of a proposed PV system installation on structural integrity and fire safety, including the safety of first responders during an emergency. This section focuses, in particular, on the varying role of the State versus the municipality in

[1] For most projects, the application fee is the “only fee associated with interconnection.” According to Stanfield et al. (2013), however, there can be significant costs associated with applications that move through the more intensive study process, with applicants required to “pay for the utility’s study costs as well as any upgrades the utility’s system requires to connect the applicant’s proposed installation.” Interconnection procedures set by utility regulators reduce the cost uncertainty associated with study fees, but upgrade costs “are often not clear until after study has been completed and can sometimes be substantial.”

adopting building codes and the concurrent existence across jurisdictions of building codes based on competing model codes of different vintages (and associated equipment standards, as discussed in footnote 5).

In the U.S., building regulations (also known as building codes or building controls) are rules that a local AHJ adopts and implements in order to "protect public health, safety, and general welfare" as they relate to building construction and occupancy (Ching and Winkel 2012). The major form of policy instrument in building regulation is the building or construction permit, the existence of which certifies that an AHJ has given its "planning permission" or "developmental approval" to a project application for either new construction or significant renovation. The roughly 18,000 U.S. AHJs, which also oversee an estimated 42,000 unincorporated communities, both review plans and inspect project construction, sometimes during or after project completion.

The U.S. building code system evolved from the systems of the European powers that established the first American colonies;[2] these building code systems were able to be more effectively applied to small colonial towns than to the much larger European cities they originated in (Hirt 2014). Colonial cities added their own unique building regulations to the underlying building code system (see, e.g., the 1672 Boston fire-resistant building materials regulations described in Garvin 2002). But these city regulations did not have a widespread impact across the agrarian early U.S.; instead, the problems associated with industrialization and concentrated urban populations that large European cities had faced before colonization only began to occur in the U.S. in the mid-to-late 19th century. According to Hirt (2014), "nineteenth-century American city-building rules were more limited in scope than those in Europe," with the nation's ideological bent toward laissez-faire capitalism focusing the U.S. planning tradition more strongly on "the preservation of property values … [and] creation of 'pure' residential areas."

During the rapidly industrializing second half of the nineteenth century, important federal judicial decisions established two competing concepts regarding the relative powers of U.S. States versus municipalities regarding land use regulation. The first, the Dillon Rule, came out of a judicial decision in *Clinton v Cedar Rapids and the Missouri River Railroad*, (24 Iowa 455; 1868), which restricted the rights of municipalities to those that were either: expressly granted to them in their original State incorporation, "necessarily or fairly implied in" the express granting of incorporation, or somehow "otherwise implied as essential to the declared objects and purposes of the corporation." The second, the Cooley Rule, came out of jurisprudence regarding *People v. Hurlbut*, 24 Mich. 44, 108 (1871), which declared that "local government is a matter of absolute right; and the state cannot take it away." The fifty U.S. States and their associated municipalities are today either under the Dillon Rule, "Home Rule" (i.e., the Cooley Rule), or a combination of the two; for a useful treatment of this topic as it relates to U.S. States, counties, and cities, see Russell and Bostrom (2016).

According to Hirt (2014), "between about 1910 and 1930, the United States changed from a place where the public control of private land and real-estate property consisted only of rudimentary nuisance and building laws to a place where practices related to private land, property, and construction were subject to tight public supervision in hundreds of municipalities around the country." During this period, the two "Standard Acts" of U.S. zoning were

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[2] See, for example, the British building ordinances that were first developed after the Great London Fire of 1666, such as controls for "partywall thicknesses, building heights, and materials" (Ben-Joseph 2015).

established, as were the first two of the three major regional model code standards organizations.[3] These standards organizations – the Building Officials Code Administrators International (BOCA, which was founded in 1915 and was most influential on the East Coast and the Midwest), the International Conference of Building Officials (ICBO, which was founded in 1922 and was most influential on the West Coast and in the middle of the country, including parts of the Midwest); and the Southern Building Code Congress International (SBCCI, which was founded in 1940, and was most influential in the Southeast) – later merged to form the International Code Council (ICC, which was founded in 1994 and is most influential throughout the U.S., with some extra-national diffusion).[4] The ICC develops and maintains model building codes known as the "I-codes."

The role of the ICC, its "legacy" code organizations of BOCA, ICBO, and SBCCI, and other standards organizations (e.g., the National Fire Protection Association (NFPA)) has been to develop and maintain technically sound model building codes that jurisdictions can choose to adopt into law, with or without modifications.[5] The standards organizations accomplish their work through committees of affected stakeholders that update the various codes on roughly a 3-5 year cycle.[6] Local jurisdictions, which have varying technical and financial capabilities, help fund the standards-development process by purchasing an edition of the model codes, paying for code reprints, or contracting to the standards organizations for consulting services. Note that the adoption process usually takes time, as it involves a jurisdiction voting to update the code and train its inspectors accordingly; the ensuing delays can mean that a jurisdiction's implemented

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[3] Although more famous for establishing the Standard Zoning Enabling Act (1922) and the Standard City Planning Enabling Act (1928), the Division of Building and Housing within the National Bureau of Standards, which was established under the leadership of Commerce Secretary (later President) Herbert Hoover, "appointed one committee to write a standard building code" (Knack, Meck, Stollman 1996).

[4] Today, the ICC maintains the following "I-Codes": the International Building Code; the International Energy Conservation Code; the International Existing Building Code; the International Fire Code; the International Fuel Gas Code; the International Green Construction Code; the International Mechanical Code; the ICC Performance Code; the International Plumbing Code; the International Private Sewage Disposal Code; the International Property Maintenance Code; the International Residential Code; the International Swimming Pool and Spa Code; the International Wildland Urban Interface Code; and the International Zoning Code. Competing building codes include the Comprehensive Consensus Codes (C3), which were crafted by the National Fire Protection Association (NFPA), the International Association of Plumbing and Mechanical Officials, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, and the Western Fire Chiefs Association.

[5] PV equipment standards – which are usually developed by third parties like the safety-science oriented Underwriters Laboratories (UL) or the Institute of Electrical and Electronics Engineers (IEEE, a professional society) – are an important complement to building codes. Equipment standards typically "set eligibility criteria under government-administered incentive programs, or government-led purchasing programs" or serve as "utility-enforced prerequisites for interconnecting to the electric grid." Two UL equipment standards, UL 1703 and UL 1741, are particularly relevant to the testing and certification with the NEC model building code of PV modules and associated PV system components (e.g., inverters, interconnection equipment, rack mounting systems, trackers, etc.), respectively. These UL standards, which are designed to mitigate "mechanical, electrical, and fire hazards," were published under "the American National Standards Institute's (ANSI) accredited process for Standards Development Organizations" (Argetsinger and Inskeep 2017). In addition, the IEEE 1547 consensus standard on PV "articulates the widely adopted standard for interconnecting a rooftop PV system to the electric grid" (*ibid.*) It is this standard that the Energy Policy Act of 2005 set as "the national standard for interconnecting rooftop solar PV systems (and other distributed generation resources) to the grid, and many states and utilities have adopted IEEE 1547 as part of their interconnections standards" (*ibid.*)

[6]Critics of the ICC assert that, at least in the early 2000's, the code development process disproportionately favored the building industry over unions and did not follow a consensus "process accredited by the American National Standards Institute" LeClaire (2005).

code is not the latest available code. In addition, not every jurisdiction adopts every edition of the model building codes, although there is pressure to do so to avoid variance applications by construction industry professionals who operate across jurisdictions.

Cross-jurisdictional Inconsistency: Permit Process Implementation

This section focuses on cross-jurisdictional inconsistency in AHJ code interpretation and implementation. Although the sources of this heterogeneity include the resources and workload of the AHJ and the behavior of its building-related department(s) and staff, we focus here particularly on academic research related to the behaviors related to the code inspection process.

To set the stage for this discussion, it is helpful to define some terms. The earliest sections of the model IBC establish definitions for a building department and building official whose function is to oversee code implementation. IBC Section 103 creates a model "Department of Building Safety," and training material for the IBC provides a useful illustration (see Figure 1). The "building official" is deemed to be the "primary administrator of the code," with duties established in Section 104 of the IBC. Note that although the building official can delegate power to deputies, IBC training material states that "there are many jurisdictions that may only have a one-person department where that person performs administrative, clerical, plan review and inspection duties while other larger jurisdictions may have single or multiple individuals to handle each of these primary functions" (ICC 2015).

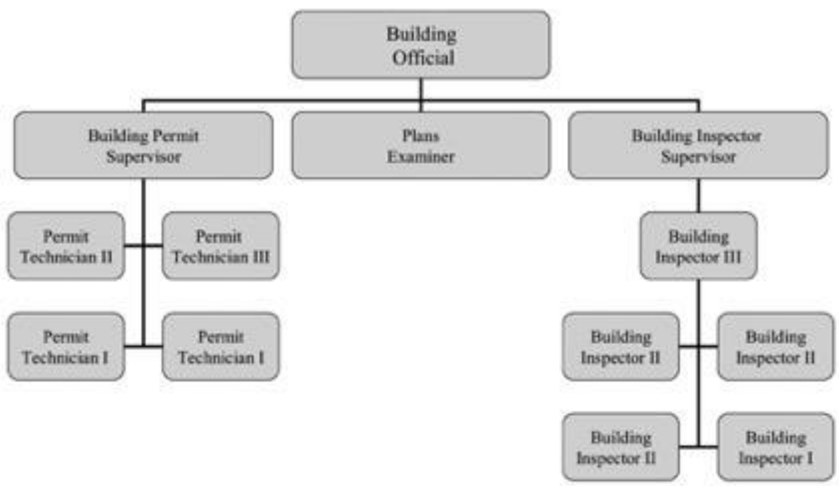

Figure 1: A Model Building Safety Department. *Source*: ICC (2015)

Academic literature on public administration and building regulation has focused on building inspectors as "front line" regulators who undertake many different types of enforcement actions (see, e.g., the building code enforcement practices detailed in Table 1 of May and Burby 1998). According to May and Wood (2003), building inspection "differs in two key respects from other regulatory functions," first with respect to its higher frequency and certainty than in other more staff-limited regulatory areas, and second because "the inspection process is typically viewed by both inspectors and homebuilders as a form of quality control." This is because, "whereas for most regulatory settings inspection is primarily aimed at preventing harms in the first place, building inspection is aimed at identifying and rectifying problems" (*ibid.*).

May and Burby (1998) provides some very interesting insights into cross-jurisdictional variation in inspector enforcement philosophy in the paper's attempt to better understand "the underlying structure of choices that agencies make to bring about compliance" with building codes. In a nationally representative survey of city and county building code enforcement agencies, the authors established a set of indices corresponding to different actions undertaken in 819 local governments and "identified in the enforcement literature: standardization and supervision, deterrent enforcement, technical assistance, discretionary enforcement, and use of incentives."

The authors also developed a two-dimensional characterization of inspector enforcement styles that was consistent with the literature in "calling attention to the degree of formalism (the systematic dimension) and cooperativeness (the facilitative dimension) in regulatory enforcement." In the May and Burby (1998) schema, the systematic dimension "loads highly on agency use of standardized rules and supervision of field inspectors, use of deterrent enforcement techniques, and use of technical assistance" and variation along this dimension reflects variation "in the degree to which agencies undertake enforcement in an orderly way," ranging "from a highly structured agency role involving much standardization, deterrent approaches, and technical assistance to a less-structured role involving a more haphazard approach." This variation in systematic enforcement "can be largely accounted for by factors that comprise the bureaucratic and problem contexts" with the major factor being work loads: "as work loads increase, agencies cope by adopting formal procedures and systematic approaches to enforcement" (May and Burby 1998). Meanwhile, the facilitative dimension "loads highly on the use of discretionary enforcement and incentive practices" and variation along this dimension "involves the role of the agency in easing compliance," ranging "from much use of discretion and incentives to an absence of those practices." Variation in facilitative enforcement "can be largely accounted for by factors that comprise the political environment," with greater roles for elected officials in the code enforcement process tied to increased "pressure to be more accommodating in dealing with contractors and builders." (*ibid*.).

Figure 2 displays the results of cluster analysis of the enforcement behavior philosophy of the 819 local government respondents to the survey administered in May and Burby (1998), according to the systematic and facilitative dimensions of this behavior, as determined through "principal component analysis for which the scales for each dimension indicate relative scores."

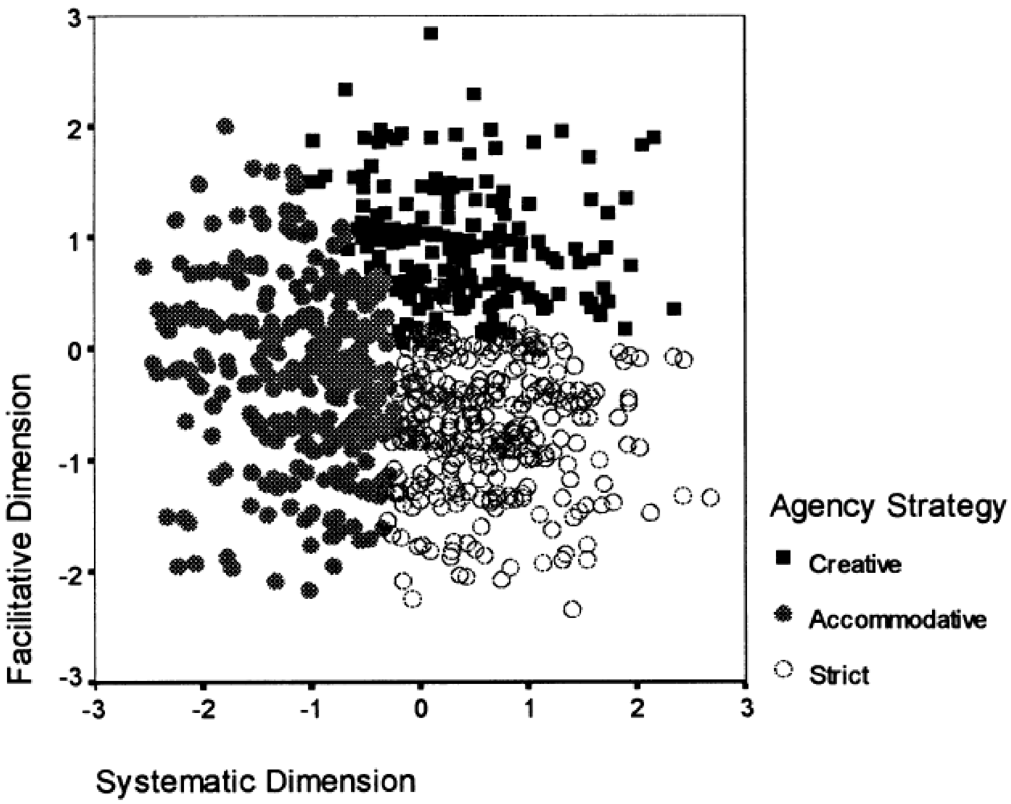

Figure 2: Cluster analysis results of local government code enforcement behavior. *Source*: May and Burby (1998)

This cluster analysis prompted May and Burby (1998) to develop a new typology of jurisdictions according to the enforcement strategy categories of "strict," "creative," and "accommodative." Agencies in the strict enforcement strategy category: "reflect a philosophy that is highly systematic and low in facilitation"; "typically use twice as many enforcement practices of all types as agencies in the accommodative category"; and on average "employ greater degrees of field supervision and a slightly wider range of technical assistance practices than agencies employing a creative strategy." Agencies in the creative enforcement strategy category: "reflect a philosophy that is moderately systematic and high in facilitation"; "typically use twice as many enforcement practices of all types as agencies in the accommodative category"; and on average employ "much greater use of flexible enforcement and incentive practices." Agencies in the accommodative enforcement strategy category: "reflect an enforcement philosophy that is unsystematic but average in facilitation" and exhibit a "lower degree of enforcement effort in comparison to the other categories."

In a later paper focused on inspector enforcement style as it relates to the knowledge level of builders and to builder compliance with code, May and Wood (2003) focused on residential homebuilders in fourteen randomly selected jurisdictions considered to be representative of a mix of different sized cities and approaches to code enforcement in western Washington, as supplemented by field observations of the interactions between inspectors and homebuilders in four of the fourteen jurisdictions. Potentially useful findings from this paper with respect to SSP practices include the factors the authors found to be relevant in fostering voluntary code compliance – namely builder knowledge of code provisions and quantity of homes built, but not builder experience as measured in years – and the factors they found to be relevant to creating shared expectations between builders and inspectors about compliance, namely repeated interactions and consistent inspector signals. In particular, homebuilders "value clarity in expectations, consistency in procedures, and the benefit of the doubt when deficiencies are found," with a general preference "to have a single inspector assigned for the course of a project." Meanwhile, May and Wood (2003) stated that "inspectors know they are likely to interact with the same builders again, and they know builders can make life difficult for them by going over their heads. Under such circumstances, it is far better to get along than to get tough, especially given that inspectors are concerned about their reputations with homebuilders." In the field observations conducted by the authors, "inspectors appeared to get tough when they felt that homebuilders were far off the mark in compliance levels," usually "when homebuilders were not present" at the time of inspection. Two other findings from May and Wood (2003) appear to be potentially relevant to SSP practices. First, the authors found that "builders who report high levels of code knowledge and rate inspectors as cooperative" generally had the fewest code deficiencies. Second, the authors interpreted their findings "to suggest that cooperative relationships enhance compliance for more knowledgeable homebuilders but do not necessarily enhance compliance for less knowledgeable homebuilders."

Cross-jurisdictional Inconsistency: Interconnection

This section focuses on cross-jurisdictional inconsistency in the interconnection process. This process is included in SSP reform discussions for two reasons. First, it is a major source of the delay seen in some localities with respect to getting rooftop solar PV systems energized. Second, it involves coordination with different actors in SSP practice development, namely installers and building department officials, and considerable inconsistency in the interconnection process has been observed by these actors. This section provides some context on how interconnection processes are established, the extent of waiting time for PV energization associated with the interconnection process, and the main aspects of the interconnection process that have been highlighted for SSP reform.

Interconnection processes are established by a locality's serving utility, as guided by relevant regulation. In general, the State Public Utility Commission (PUC) that oversees a given utility sets the basic outline for grid interconnection procedures, which may follow a model introduced by the Federal Energy Regulatory Commission (FERC) (see Stanfield 2013).[7] Some local variation in this system is introduced based on the ownership structure of the utility, however, as other than investor-owned utilities (IOUs), which serve at least three-quarters of U.S. load, most utilities (e.g., publicly-owned utilities, rural cooperative utilities, etc.) are not subject to PUC regulation. Additional cross-jurisdictional variation is introduced by factors that are either utility-specific (e.g., how efficiently the utility processes applications internally, the extent of the renewable application workload) or location-specific (e.g., if the proposed installation is on a circuit with heavy renewable penetration already) (*ibid.*).

Barnes et al. (2016) reports on some very useful data regarding the delays associated with the interconnection process, as experienced by PV installers who responded to surveys in "the 100 utility service territories with the most net-metered residential PV customers," according to 2015 data compiled by the U.S. Energy Information Administration (EIA). Table 1 compiles and arranges the delays reported in Barnes et al. (2016) for 2014 and 2015, according to the full

[7] According to Stanfield (2013), in some States, state-level statutes govern interconnection procedures.

interconnection process as well as its two component parts, namely the pre-construction review to issue the interconnection agreement, and the post-construction delay associated with inspection and the utility's issuance of a "permission to operate" (PTO). In general, Barnes et al. (2016) found that utilities took longer to deal with the full interconnection process in 2015 over 2014, "although the delay increases were much more significant for PTO than for pre-construction applications."

Table 1: Varying delays in rooftop PV energizing due to the interconnection process. *Source*: Author's compilation from data reported in Barnes et al. (2016)

	2014	**2015**
Full Interconnection		
Average time utilities took to process (days)	46	67
Median wait time (days)	36.5	62
Pre-Construction		
Average waiting period, per application (days)	12	13
Median waiting period (days)	14	18
Range of average waiting period (days)	0 (SDG&E, PG&E, SCE) to 120 (Hawaii Electric Co.)	1 (Ameren Illinois) to 75 (Maui Electric Co.)
Permission to Operate		
Average waiting period, per application (days)	24	45
Median waiting period (days)	28	45
Range of average waiting period (days)	2 (Colorado Springs Util.) to 94 (Intermountain Rural Elec. Assoc.)	1 (ComEd in Illinois) to 154 (Western Mass. Elec. Co.)

In addition to installer surveys, Barnes et al. (2016) also conducted interviews with installers and utility interconnection staff to identify factors that contributed to delays and "best practices for streamlining the interconnection process while maintaining grid safety and reliability." Barnes et al. (2016) identified nine main areas for reform, with associated best practices. These reform areas related to: (1) application systems and content, which involves method of application delivery and processing, administration and workflow application content and clarity, and incentive program design and administration; (2) consolidation of pre- and post-construction approval; (3) timelines; (4) consistency; (5) communications and transparency; (6) local jurisdiction coordination; (7) expedition of meter exchange; (8) grid capacity transparency; and (9) preparation for increased DG penetration.

SSP Practices

This section provides an overview of major SSP reforms discussed in the literature. The focus here is on the motivation for SSP reform and on how SSP practices relate to the sources of delay and cross-jurisdictional inconsistency discussed in this document. More detail on specific reforms that have been undertaken by AHJs across the nation is provided in the Appendix, which provides a live link to a synthesis of existing AHJ-level SSP practice data collected nationally, with supplemental information from California. The Appendix also provides some basic descriptive statistics on this AHJ-level dataset.

SSP reform has primarily been driven by the solar industry, either directly, by installers and other industry stakeholders, or indirectly, particularly by the pressure that growing solar demand and grid penetration have placed on building departments and electrical grids in certain parts of the country.[8] Installer customer acquisition and retention can be negatively affected by delays associated with the locally varying building code permitting and inspection process, which can range "from a few hours to several weeks" (Stanfield 2,013), and the interconnection process, which are well documented in Barnes et al. (2016) (see Table 1, above). In addition, compliance with locally varying permitting requirements and interconnection processes can add additional administrative costs to installers, potentially affecting their profitability. For building departments and utilities, the "patchwork of permitting requirements and processes nationwide" contributes to their receipt of incomplete or error-containing applications from installers; such low quality applications can negatively impact what can already be heavy workloads in organizations that may already be staff-constrained (Stanfield 2013).

SSP reforms that particularly work to reduce cross-jurisdictional variation in building codes include reforms to model building codes, related equipment standards, and standard design criteria.[9] Focusing here on model building codes, according to Argetsinger and Inskeep (2017), the model I-codes that are most applicable to rooftop solar PV systems are the current versions of the International Residential Code (the IRC, which applies to "detached one- and two- family dwellings and townhouses three stories or less") and the International Building Code (the IBC, which applies to all other buildings and structures).[10] Additional relevant model codes include the International Fire Code (IFC) and the National Fire Protection Association's (NFPA's) NFPA 1 Fire Code and National Electrical Code (NEC, which is also known as the NFPA 70 Code). Note that certain States have instituted their own codes. A useful example is the "Oregon Solar Installation Specialty Code" (OSISC) which has been included in the "Oregon Structural Specialty Code and is applied in conjunction with Oregon's Electrical Specialty Code" (Argetsinger and Inskeep 2017). Part of the OSISC sets minimum structural requirements for the installation of PV components and support systems.

The OSISC also addresses building department implementation issues through an expedited review process and through "guidance for how AHJs should process building permit applications and determine fees" (Argetsinger and Inskeep 2017). The "prescriptive pathway to expedite permitting" (with a flat fee) under the OSISC is limited to installation applications that meet design criteria related to "building type, roof structure, and material requirements," "loading requirements," "height restrictions," and "positive attachment to the roof structure (rather than

[8] Other important stakeholders include government actors at different levels of federalism and policy advocates who are not tied to the industry.

[9] Standard design criteria signal to installers "that a PV system will be approved if it is designed to code, thereby reducing the uncertainty, time, and costs associated with additional engineering studies or re-doing an incomplete or incorrect permit application" (Argetsinger and Inskeep 2017). The advantage of standard design criteria for AHJs, however, is to help AHJs with less "extensive experience with solar" to understand whether a system meets code.

[10] The latest editions of the IRC and IBC have solar provisions detailed in CESA (2017). These provisions include IRC "Solar-Ready Provisions" in an optional Appendix U that AHJs can elect to adopt." Note that a "solar ready" building is one that is "easy to add" a rooftop solar PV system to in the future. Adding PV to such buildings "substantial cost savings" compared to retrofitting other buildings for PV.

ballasted systems)" (Argetsinger and Inskeep 2017). In conjunction with this expedited permit review pathway, the "Building Code Division within the Oregon Department of Consumer and Business Services created a checklist for installers to easily determine eligibility" (*ibid.*). The Interstate Renewable Energy Council (IREC), which published "an overview of permitting and inspection best practices" made "implementing an expedited permit process" like the OSISC's its second highest recommendation (out of nine). Note that system size and systems that meet "a standard set of design criteria" are the main eligibility requirements for expedited permitting pathways discussed in the literature (Argetsinger and Inskeep 2017).

Beyond the OSISC, several States have put together comprehensive guidance on SSP building permitting-related reforms, including California, Connecticut, Massachusetts, New Hampshire, and New York (Argetsinger and Inskeep 2017). In California, a law (AB2188) required that the State's AHJs comply with the State's guidance on SSP by September 20, 2015.

Eight other SSP practices are less about standardizing processes across jurisdictions than they are about offering specific suggestions to a given AHJ on how it might improve the administration (i.e., the efficiency and/or effectiveness) of its permit review process. First is the suggestion that an AHJ take on an online permit review process, "not only for PV systems but globally across all areas of the AHJ's permitting authority" (Argetsinger and Inskeep 2017). An online process can involve one or more of several features (e.g., application submission, signature provision, etc.). Second is the suggestion that an AHJ provide "clear, publicly available, easily accessible information about solar permitting and inspection processes" online so that AHJs can easily access this pre-application material. This reform, and a third reform championed by IREC for AHJs to adopt a "Model Inspection Checklist" (see Stanfield and Hughes 2013), are probably particularly well-matched to the insights of the academic research reported on above regarding enforcement behavior. Pre-application information and information on the contents of an inspector checklist is probably of greatest value in providing installers with a clear regulatory signal, although they are also probably more valuable to AHJs that rate higher on the dimension of systematic enforcement philosophy than to AHJs that rate higher on the dimension of facilitative enforcement philosophy. A fourth administrative reform is the suggestion that an AHJ provide various process-relevant time restrictions, ranging from reducing "the time period between permit application and approval, and project completion and inspection" to establishing a "standard processing window to increase process certainty for contractors" (Argetsinger and Inskeep 2017). IREC's 2013 recommendations (which also included online permit review, pre-application information provision, and time limits for turnaround and inspection appointment windows) also included a fifth, sixth, and seventh administrative reform suggestion, namely: do not require community-specific licenses; eliminate excessive inspections; and train permitting staff in solar. Finally, an eighth administrative reform suggestion is that permitting fees be "reasonable," in IREC's usage. This can be interpreted in different ways. The OSISC, for example, provides "guidance for how AHJs should process building permit applications and determine fees, including a flat fee for prescriptive pathway applications" (Argetsinger and Inskeep 2017). Other permitting fee suggestions include setting them to not exceed "the administrative cost of processing" the solar permit to avoid "unfairly" penalizing new PV systems and to consider standardizing and reducing permitting fees, "particularly for more uniform system applications" (*ibid.*).

Finally, we turn to SSP practices related to the grid interconnection process and the nine main aspects of that process that Barnes et al. (2016) identified for reform, which were enumerated above. Barnes et al. (2016) provides a considerable amount of detail on the results of the authors' interviews with installers and utility interconnection staff, sorting respondent remarks according to the relevant aspect of the interconnection process of interest.[11] The main SSP reforms the authors recommend can be broken down into three categories: reforms that involve State-level planning; practices involving the provision of pre-application information; and administrative reforms that an individual utility can undertake.

There are three major State-level SSP reforms suggested in Barnes et al. (2016). First, the authors suggest that PUCs "incorporate a strategy for accommodating increasing interconnection applications as part of larger distribution planning and grid modernization processes." In alignment with this recommendation, they mention that SolarCity, "one of the nation's leading DG [distributed generation] providers," has proposed an "Integrated Distribution Planning framework, characterized as an intermingling of improvements to interconnection, planning, sourcing, and data-sharing processes." Second, Barnes et al. (2016) recommends that utilities, regulators, and AHJs work together to "standardize application procedures, requirements, and forms across different jurisdictions" (Barnes et al. 2016). IREC has developed a model interconnection process that could aid in standardization, in a similar effort to its work aiming to standardize building inspection for PV through the development of a model inspection checklist. Barnes et al. (2016) notes, however, that there are underlying reasons for cross-jurisdictional variation in interconnection procedures: "for example, in New York, Con Ed has a highly networked grid structure, whereas other utilities have primarily radial structures. For some utilities, islanding is the biggest concern when interconnecting DG, and for others, voltage issues are more prominent." The third State-level reform suggested in Barnes et al. (2016) is interesting in that it considers the connection between the design of incentive programs for solar PV and wait times for interconnection. A number of academic papers have documented the consumer procrastination effect in incentive uptake; Barnes et al. (2016) directly links consumer behavior patterns around PV incentive uptake to "boom-or-bust application periods" that pose sudden and very heavy workload for interconnection offices. The authors recommend that state policy-makers design incentive programs with "long-term step downs or gradual funding disbursements" rather than "'stop-and-go' incentive programs" or uncertain policies and/or incentive programs.

The pre-application information that the authors of Barnes et al. (2016) recommend that utilities provide not only serve an administrative function, but also align with psychological insights. Barnes et al. (2016) recommend that utilities put online: grid capacity maps or data; pre-application studies (e.g., on circuit capacity and identified system upgrade needs, etc.); "interconnection queues with clear project status information"; and "regular interconnection timeline performance reports" (note that the publication of this information is implied in the authors' recommendation that these reports be required by regulators). All of this information, but particularly interconnection queues, align with psychology studies on the perception of wait times. In the context of public transit delays, for example, public information on the cause of a delay and on when the delay is expected to end can significantly reduce the perception of the

[11] As a reminder, the highlighted topic areas related to: (1) application systems and content, which involves method of application delivery and processing, administration and workflow application content and clarity, and incentive program design and administration; (2) consolidation of pre- and post-construction approval; (3) timelines; (4) consistency; (5) communications and transparency; (6) local jurisdiction coordination; (7) expedition of meter exchange; (8) grid capacity transparency; and (9) preparation for increased DG penetration

length of a delay.[12] Barnes et al. (2016) note that there are several benefits of requiring utilities to report interconnection timeline data including: "improv[ing] utility-customer relationships; allow[ing] regulators to identify barriers to meeting policy goals, allow[ing] installers to better utilize their assets and set more realistic expectations for customers, and provid[ing] advocates with the data needed to press for better processes."

Finally, Barnes et al. (2016) identifies several administrative reforms that individual utilities can undertake to reduce interconnection delays. These include: improvements to applications; organizational issues; ways utilities might combine aspects of the interconnection process; and timeline restrictions. Suggested application improvements, which generally aim to reduce staff time, include: online, automated application systems; online payment options; and the repeal of "wet signatures." Suggested organizational improvements include: ensuring that "appropriate staff time and resources are allocated to interconnection departments especially where application numbers are rising"; changing application procedures and requirements to better "take into account utility employee workflow and administrative procedures"; changing systems and processes in order to "facilitate better communication between customers, installers, and utility staff;" and considering the meter exchange (i.e., swapping one-way for bidirectional meters) part of PTO earlier in the interconnection process to ensure that delays are not generated by issues such as inventory control. Suggested ways that utilities might combine aspects of the interconnection process include: building "automatic screening for grid reliability and penetration issues" into online application systems; and combining interconnection applications with PTO. This latter reform could build on the experience of California's IOUs, which allow solar installers to use their online maps "to determine where specific substations and feeders can accommodate additional solar without the need for additional studies." This eliminates the need for pre-application approval and expedites the installation process for "standard-design residential systems interconnecting to non-congested grid locations." Suggested timeline restrictions include: establishing deadlines for specific aspects of the interconnection process (e.g., interconnection application receipt, application review, meter exchange, and PTO approval, as IREC has suggested) and creating financial penalties for failure to meet deadlines, as Massachusetts has done.

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[12] Another aspect of public transit wait time research that could be beneficial in the context of interconnection delays but does not currently seem to be in the mix of SSP recommendations is the value of a public apology by the delaying agency – in addition to information provision – in reducing consumer perception of wait time length.

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Appendix

This spreadsheet combines information on the diffusion of SSP practices from across the country. It combines information from the first and second U.S. Department of Energy (DOE) Rooftop Solar Challenges, as captured in the NREL-maintained SM3 datasets, as well as information on the compliance of California AHJs with AB2188: https://docs.google.com/spreadsheets/d/19DVGAQZgUAp8a-dCejyR-PWlv_FHFFVCfbYblWaDA-0/edit?usp=sharing

In this spreadsheet, detailed jurisdiction-level data is available for 281 jurisdictions, which we refer to here as "AHJs."

Some insights from this spreadsheet include:

- 94% of AHJs allow installers to obtain an application online;
- 25% of AHJs allow online application submissions;
- The average response time between application submission and AHJ decision is distributed as follows (for the 94% of AHJs for which data is reported):
  - Less than 3 days for 51% of AHJs;
  - 4-5 days for 23% of AHJs;
  - 6-10 days for 15% of AHJs; and
  - More than 10 days for 6% of AHJs
- 49% of AHJs do not have streamlined processes for solar PVs, while 47% do (4% did not report);
- Average total fees are distributed as follows (for the 85% of AHJs for which data is reported):
  - Less than $250 for 53% of AHJs;
  - $251- $500 for 31% of AHJs; and
  - Greater than $500 for 1% of AHJs
- For 81% of AHJs, there is no communication between the utility and the jurisdiction regarding inspection requirements and on-site inspection times for the permit inspection and interconnection inspection
- The time for interconnection application completion is distributed as follows:
  - Less than 2 days for 5% of AHJs;
  - 3 – 5 days for 20% of AHJs;
  - 6 - 10 days for 59% of AHJs;
  - More than 10 days for 8% of AHJs
- 48% of AHJs do not have a State or local law that protects a property owner's rights to install solar systems on their property, while 44% do