Project Title: Understanding Adoption of a Key Soft Cost Reduction Strategy: Modeling Administrative Choices Regarding Streamlined Solar Permitting

FOA Topic 1 Focus Area: Solar Technology Diffusion

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No confidential information is included in this submission.

Project Overview

Background

The time-consuming, costly and heterogeneous residential solar regulations of the roughly 18,000 U.S. “authorities having jurisdiction” (AHJs) are a well-known barrier to the growth of the U.S. residential solar PV market (Burkhardt et al. 2015). To reduce these permitting-related barriers, policy entrepreneurs in local, state, and national government, as well as in non-profits and industry, have developed “streamlined solar permitting” (SSP) policies. However, diffusion of SSP across the country has been uneven (see Tong 2012). Although some AHJs have adopted SSP policies, a greater number remain “potential consumers” of SSP. Additionally, the entities that work to diffuse SSP typically make significant investments of time and resources to customize reforms to the unique political, structural, and operational needs of specific communities. As these investments do not appear to be readily scalable, the idea of standardizing SSP has gained traction with state-level policy makers.

SSP standardization also has drawbacks, as seen by the SSP standardized effort that has been unfolding in California since 2012. The recommendations assembled in California’s 2012 Solar Permitting Guidebook (“Guidebook”), were not adopted as rapidly as had been hoped given the anticipated benefits for AHJ building departments (e.g., increased efficiencies through online applications, proper accounting for staff time through flat permit fee structures, etc.), solar contractors (e.g., reduced administrative costs, higher project throughput), and consumers (reduced prices for rooftop solar PV systems, more certain project duration). The mandated adoption of SSP through California’s 2014 law, AB2188, which requires AHJs to substantially conform to the recommendations of the Guidebook, resulted in more widespread adoption of SSP policies. However, this mandate has not been fully successful; more than 300 of California’s 540 AHJs now comply with the law, although the official compliance deadline was September 30, 2015. This mandated approach is also unlikely to be politically tractable in many markets outside of California and thus alternative strategies are crucial at this time for the continued reduction of solar soft-costs in the U.S.

There are two broad areas of research and development regarding SSP diffusion: on-the-ground field work in solar permitting reform and empirical research on innovation and public policy. For a review of recent practices in the former area, see Tong (2012). For the latter area, see Jordan and Huitema (2014) for an introduction to literature on the sub-national diffusion of climate mitigation policies, a literature that does not yet address SSP diffusion directly. In addition, see Hensler et al. (2005) for a useful primer on the choice analysis techniques the project team plans to apply to SSP diffusion strategy.

The organizations collaborating on this project are leaders in the areas of research and development described above. The Center for Sustainable Energy (CSE) has trained hundreds of solar industry and building department employees through statewide SSP trainings and webinars. The standardized SSP documents developed through CSE’s Rooftop Solar Challenge (RSC) II program were implemented and made available on the websites of approximately 20% California AHJs to date, including some of the largest rooftop solar PV markets in the nation.

The team at Lawrence Berkeley National Laboratory (LBNL) is renowned for empirical research on innovation and public policy in climate and energy technology industries. The project lead at LBNL is Dr. Margaret Taylor, who has dual appointments at LBNL and at Stanford University’s

Precourt Energy Efficiency Center, as well as a decade of experience as a professor of public policy at University of California, Berkeley (UCB). A co-chair of the annual Behavior Energy Climate Change conference since 2013, Dr. Taylor's past research has included a comprehensive assessment of the many policy instruments California has implemented to support solar technology innovation and diffusion since the 1970s (see Taylor 2008), according to multiple indicators of innovative activity, including social network analysis (see Taylor et al. 2007).

Project Goal

The goal of the proposed research project is to supply an alternative strategy to the fully standardized or fully customized approaches described above. Our proposed alternative is a scientifically differentiated SSP "product", developed according to the likely uptake of segments of the potential AHJ "market" for SSP nationwide. The development of this new strategy relies on the premise that SSP can be modeled as a bundle of practices with differentiable attributes and that potential AHJ consumers have heterogeneous preferences for these bundles. This premise allows the project team to apply cutting-edge choice analysis techniques to solar policy diffusion. This novel application of choice analysis is a diversion from past applications in research on consumer behavior and market segmentation.

Through the design, implementation, and analysis of discrete choice experiments, primarily with early adopters/rejecters of SSP in California, this project will statistically relate the SSP adoption decision to team-derived, nationally consistent AHJ characteristics (e.g., solar value proposition, demographics, political variables, proximity to other adopting AHJs, etc.) and team-assessed attributes of available SSP options. Outcomes will include a strategic segmentation of the national AHJ market for SSP and a considered differentiation of the SSP "product" that will both serve to expedite the national diffusion of SSP. To demonstrate the practical usefulness of this research in reducing the soft costs for rooftop solar PV systems, the project will culminate with three "differentiated SSP" adoption case studies conducted in jurisdictions that are new to SSP.

DOE Impact

DOE funding is as essential to the success of this proposed social science-driven effort to diffuse SSP nationwide as it has been to the invention and early diffusion of SSP through such programs as Solar America Cities, RSC I, and RSC II. There is no single entity whose interest is the diffusion of this important permitting reform, although solar PV customers, companies, and AHJ building departments all potentially benefit from the related reduction in transaction costs imposed by local regulation on rooftop solar PV system prices. By funding this project, the DOE will maximize the returns on its previous investments in SSP while working with trusted and experienced partners that otherwise lack the resources to take on an effort of this scope.

Technical Description, Innovation and Impact

Relevance and Outcomes

The proposed project is directly relevant to the goals and objectives of the SunShot SEEDS II FOA. Consistent with the aim of SEEDS II Topic 1 and the purpose of the SunShot program, the proposed project will develop a foundational understanding of the aids and obstacles to the jurisdictional diffusion of SSP practices that reduce a significant soft cost for solar PV installations. By aiding in the diffusion of this policy invention, the project team seeks to enhance the competiveness of U.S. solar energy.[1]

Consistent with other goals of the SEEDS II FOA, the proposed project will advance social science while it works to inform an actionable SSP diffusion strategy nationwide; this reflects the value of partnership between the research and energy practitioner communities. If funded, the project would be a pioneering application of choice analysis techniques involving the jurisdictional consumer of a policy product that would draw on the appraisals of the adopters and non-adopters of the first generation of SSP. If successful, it could serve as a model for related efforts to understand and overcome local jurisdictional barriers to clean energy technology adoption, such as permit reform for advanced energy storage, electric vehicle charging infrastructure and energy efficiency retrofits. In addition, the proposed project will create, organize, and analyze nationally consistent jurisdiction-level data on the solar value proposition, demographics, and other variables of relevance to SSP diffusion across the U.S. The project will make use of existing data on the institutions that shape the solar marketplace, such as the DOE-funded OpenEI Utility Rate database, in order to inform national SSP jurisdictional market segmentation.

Finally, the proposed project will improve the state-of-the art of the literature on policy diffusion while enabling the nascent energy decision science community to build on existing peer-reviewed research. The policy diffusion literature – which has a small sub-area related to climate policy – typically uses qualitative research methods and retrospective analytical techniques like event history analysis to identify factors that make it more likely that a government will adopt a given policy. Such influences are known to include factors both internal to a jurisdiction (e.g., motivation, obstacles, resources, etc.) and external to a jurisdiction (e.g., inter-jurisdictional learning, competition, coercion, etc.) (see Jordan and Huitema 2014). This literature also contains a very small but growing body of research on how the nature and attributes of policies (e.g., relative advantage, complexity, trialability, observability, etc.) can affect diffusion across jurisdictions (ibid.). However, this literature has yet to feature the forward-oriented choice analysis techniques that have allowed marketing researchers, transportation planners, energy forecasters, environmental economists, and others to predict consumer demand and advise product pricing and attribute design, in part because the analogies between policy and product design and diffusion have not previously driven research design.

The successful completion of three main tasks – (1) Keystone Research, (2) Choice Analysis, and (3) Differentiated SSP Application – are defined by their scientific and strategic objectives and sequence of outcomes, with multiple research activities occurring in parallel within a given task. In the Keystone Research and Choice Analysis tasks, the project team will relate the revealed and stated SSP preferences of early SSP adopters and non-adopters to nationally consistent AHJ characteristics, define a manageable number of differentiated SSP “products,” and segment the potential AHJ “market” for these products. In the Differentiated SSP Application task, the project team will operationalize its segmentation and differentiation efforts

[1] Previous research has shown that local regulatory processes impact PV prices both directly, through the recouping of administrative labor and installation fees, and indirectly, as a result of the barrier to entry these processes pose for installers interested in competing in a new solar market (see Burkhardt et al. 2015). The average price impact of local solar regulatory processes has been estimated at between $0.19-0.50/W nationwide, depending on the study (ibid.). There is also significant cross-jurisdictional variation in the price impact of local regulatory processes; a recent assessment of the price impact not only of permitting, but other local regulatory procedures as well, showed the range between the least- and most-favorable jurisdictions for rooftop solar PV to be $0.64–$0.93/W (ibid.).

through the conduct of three case studies in jurisdictions that are new to SSP.

The following paragraphs present the scientific and/or strategic objectives of each task, outline the sub-tasks involved in meeting these objectives, and discuss the final outcomes of each task.

Task 1 – Keystone Research

There are three primary scientific objectives of Task 1, Keystone Research. The first objective is to develop a comprehensive overview of the attributes of SSP in its different forms, both in California and in other states. The second objective is to develop and organize nationally consistent data on the heterogeneous characteristics of AHJs that the team expects will be relevant to SSP adoption, including jurisdiction-level solar value propositions and internal and external factors previously found to be influential to energy policy diffusion in the literature and in the practical experience of SSP implementers. The third objective is to identify early adopters and rejecters of different forms of early SSP, whose revealed preferences will be informative regarding the successes and failures of this policy innovation. Meeting these three objectives will make intellectual contributions, in and of themselves, and will also lay the foundation for the Choice Analysis task.

To develop a comprehensive overview of the attributes of SSP, the team will first conduct an in-depth "best practices" review of the current state of SSP development. This review will focus, in particular, on the lessons-learned, successes, and challenges of major developments in the evolution of SSP, including the RSC I and RSC II projects in California and several other states. Besides reviewing documents related to these projects, the team will engage with key stakeholders involved in the development of the Guidebook and similar artifacts in other states in order to learn from the tacit knowledge of the SSP diffusion community. As this review progresses, the project team will work to complete the second main sub-task involved in accomplishing this Keystone Research objective, which will be to assess how SSP practices can best be coded for attributes and attribute levels of use in the Choice Analysis task.

The development and organization of nationally consistent data on the heterogeneous characteristics of AHJs that the team expects will be relevant to SSP adoption, which will accomplish the second Keystone Research task objective, will require the project team to complete at least two main sub-tasks. In the first sub-task involved in meeting this objective, the team will turn to the policy diffusion literature and past experience with SSP diffusion for guidance to the most important jurisdictional variables to assemble and organize. Possible internal jurisdictional factors identified in the policy diffusion literature include: the jurisdiction's *motivation* for adoption (e.g., salience of the problem the policy addresses, time before the next election, etc.), *obstacles* to adoption (e.g., perceived financial and political costs, low bureaucratic capabilities, etc.), and *resources* available to overcome those obstacles (jurisdiction size and wealth, as well as non-financial resources like connection to policy entrepreneurs and advocacy coalitions). Possible external jurisdictional factors include inter-jurisdictional *learning* (e.g., membership in professional networks, geographic proximity to adopting or rejecting jurisdictions, etc.), which can be helped or hindered by inter-jurisdictional competition and so-called "coercive" forces, through which a stronger peer jurisdiction or a jurisdiction at a higher level (e.g., a state to a municipality) exerts pressure to adopt a policy. Note that according to Jordan and Huitema (2014), certain policy attribute combinations correlate with more rapid policy diffusion: (1) policies of high salience and low complexity; (2) policies with broad political appeal and low complexity; (3) policies that are relatively advantageous and easy to follow; and (4) policies that are observable.

As part of this first sub-task, the team will look back at the previously assembled documentation of past experience with SSP to identify key influences on SSP uptake that link to these factor categories. For example, the key variables that CSE found to be important to SSP uptake in its earlier work with California's AHJs generally map well onto these categories. Internal factors included: (1) climate zone, percentage of rural residents, and political factors (map to *motivation*); (2) government structure, organizational home of the permitting office, and funding mechanism of the permitting office (can map to *obstacles* or *resources*); (3) jurisdictional population and demographics, including income, educational attainment, etc. (map to *resources*); and (4) the relationship between the AHJ and the utility serving the community (maps to *resources*). External factors included the relationships between the AHJ and the International Code Council (ICC), such as any leadership role the AHJ might play in a local chapter (maps to inter-jurisdictional *learning*).

In the second sub-task of the Keystone Research task, the team will operationalize its earlier guidance and begin to collect relevant, nationally consistent, data; these data will be organized using geographic information systems (GIS) software. Note that the most important jurisdictional *motivation* variable the team will assemble will be the solar value proposition, given its relevance to SSP salience. The project team will model and map this using publicly available data, including the DOE-funded: (1) OpenEI Utility Rate database; (2) 'Technical Potential Estimate' for production potential rooftop PV at the zip code-level, maintained by NREL; and (3) the Tracking the Sun Reports system costs maintained by LBNL. Other data of relevance to *motivation*, *obstacles*, *resources*, and inter-jurisdictional *learning* will be drawn from existing public and/or academic databases (e.g., the Berkeley Law Voting Database, the American Community Survey of the U.S. Census, PolicyMap, ICPSR etc.). Careful data collection from government records or stakeholder interviews will also occur if necessary.

To accomplish the third objective of the Keystone Research task, identifying early adopters and non-adopters of different forms of early SSP whose revealed and stated preferences will be informative, particularly in the Choice Analysis task, the project team will perform three sub-tasks. First, it will identify the full set of jurisdictions that were exposed to the Guidebook and similar artifacts in other states, as measured by their expressed interest in this information (e.g., signing up for outreach activities like webinars that were related to the introduction of the Guidebook, etc.). Second, the team will follow-up to see if the expressed AHJ interest manifested itself in adoption of SSP. If so, the team will label the AHJ as an adopter of SSP, and if not, the AHJ will be labeled as a rejecter of SSP. Third, the team will characterize the adopter and rejecter populations according to the AHJ variables of *motivation*, *obstacles*, *resources*, and inter-jurisdictional *learning* capabilities that will be assembled as part of accomplishing the second objective of Task 1.

The outcomes of meeting the three objectives of Task 1, Keystone Research, will include: (1) the creation of a National Streamlined Solar Permitting Policy Summary Report that will review past and ongoing SSP reform efforts; and (2) groundwork for the Choice Analysis task.

Task 2 – Choice Analysis

There are four scientific objectives of Task 2, Choice Analysis. The first objective is to implement well-designed discrete choice experiments (DCEs) with early adopters and rejecters of SSP that will successfully elucidate revealed and stated SSP preferences. The second objective is to statistically relate the results of the choice experiments to nationally consistent AHJ characteristics. The third objective is to use the results of the choice experiments to differentiate a manageable number of differentiated SSP "products." The fourth objective is to map out a scientific segmentation of the potential AHJ "market" for these products. Meeting these objectives has not only scientific merit, but also strategic value for SSP diffusion, as they provide a scientifically derived blueprint for later solar permitting reform efforts.

Accomplishing all four of these objectives will require the research team to perform several tasks that will facilitate administering the DCEs as part of structured, in-person interviews and then supporting analysis of the DCE results. An in-person interview approach is best suited to obtaining a high response rate from AHJ building department officials and other respondents. It is also an economical approach, as the team can leverage CSE's heavy involvement in two major professional networks of AHJ building department officials, California Building Officials (CALBO) and the ICC, in order to conduct interviews in conjunction with the major meetings of these organizations. The team expects that the interviews will have a hybrid structure that combines open-ended questions, administered face-to-face, with the DCEs, which will be administered using self-completion methods. The sub-tasks that the team will perform in order to facilitate the success of these interviews will include: making final determinations on experimental design well in advance of the meetings; beta-testing the open-ended and DCE materials; obtaining internal review board clearance for the interview design as an exempt protocol; securing a venue for the interviews; recruiting the respondents; and scheduling the interviews. For DCE analysis, among other sub-tasks, the team will need to run appropriate statistical software and coordinate with the GIS data.

A number of issues will have to be considered in the course finalizing experimental design. The first issue involves how to make best use of the revealed preference information the team will have access to as a result of selecting respondents from a pool of early adopters and rejecters of SSP. This revealed preference information is unlikely to be sufficient to quantify the influence of particular SSP product attributes on demand for SSP (i.e., deriving the elasticities for differentiated SSP). The range of SSP attributes the early AHJs had exposure to is likely to have been regionally specific and highly correlated (see Hensher et al. 2005). The revealed preference data is expected to be helpful, however, in quantifying the scale and/or sensitivity of choice responses for use in mapping forecasted demand for differentiated SSP. The second issue involves how best to derive the stated preferences of the respondents in order to develop elasticities for differentiated SSP. In stated preference DCE, hypothetical choices are characterized by attributes and attribute levels, which combine to define different packages that respondents trade between. Among other advantages of this approach are: (1) a likely reduced correlation between SSP attributes; and (2) an ability to test future differentiated SSP products with multiple observations per respondent.

The outcomes of meeting the four objectives of Task 2, Choice Analysis, will include a map of national AHJ market segments and accompanying narrative describing the characteristics of each segment, as well as academic and practitioner literature on the choice analysis, the market segmentation, and the set of differentiated SSP packages identified through the team's research.

Task 3 – Differentiated SSP Application

The main objective of Task 3, Differentiated SSP Application, is to operationalize the AHJ market segmentation and SSP differentiation efforts of Task 2, Choice Analysis, by conducting three Differentiated SSP case studies in new markets. Although this objective is generally a strategic one with regard to SSP diffusion, the team will meet this objective consistent with scientific principles, wherever possible. This aspiration will affect the selection of cases, particularly if cross-case comparison is in order, as well as orient the approach the research team takes to conducting the cases themselves. More than simply working with AHJs that represent various market segments identified in Task 2 to help them adopt Differentiated SSP packages, the team will perform its efforts with an eye to process-tracing (i.e., identifying the causal chain within the jurisdiction that supports the adoption or rejection of SSP) and the use of counter-factual reasoning, particularly in evaluation of adoption and rejection decisions (see Starke 2013 for more on qualitative research tools in policy diffusion).

The sub-tasks involved in meeting Task 3 objectives include: producing a decision-making tool and accompanying grey literature which manifest the Differentiated SSP packages; selecting three test markets to use as case studies for the adoption of Differentiated SSP packages that are representative of the market segments identified in Task 2; working with government agencies and/or non-profits that are active in the test markets to bring the tool and grey literature to the appropriate decision-maker(s) in the case jurisdictions; and document the process of working with the test jurisdictions in order to iterate on the tool and methodology literature.

The outcomes of meeting the objective of Task 3, Differentiated SSP Application, will primarily involve the aforementioned initial and revised decision-making tool and guidebook, as well as related outreach and education efforts (e.g., webinars, trainings, etc.). The team also expects to present findings and distill the lessons learned from this project in academic, industry, and policy forums and in written products for academic and practitioner audiences. Where appropriate, the team may also present on this work as part of regulatory proceedings.

Feasibility

Both CSE and LBNL are leaders in the areas of their respective contributions to the proposed project. CSE is an established leader in efforts to reduce solar market barriers, providing technical, policy and stakeholder engagement expertise to industry stakeholders and policy makers. Through these efforts CSE has developed a proven track record of developing productive relationships with the stakeholders (e.g. solar industry, permitting associations, state and local governments and regulatory bodies) that will be necessary for the success of this project. CSE's past success in the development of the California Solar Permitting Guidebook and involvement in the crafting of AB2188 is evidence of their significant impact in this space. This project also leverages the academic and technical resources of LBNL, UC Berkeley and Stanford University. Margaret Taylor, Ph.D. has a broad interdisciplinary education, with expertise in the fields of engineering, social sciences and environmental sciences that is essential for the successful application of social science methodology to the complex issues involved in streamlined solar permitting reform.

Key risks of the research include a lack of participation from early stakeholders in identifying relevant attributes of solar permitting for use in choice modeling; a lack of participation, particularly by non-adopters, in the open-ended and structured interviews; difficulty in finding associations between jurisdiction characteristics and solar permitting attributes; and difficulty in identifying jurisdiction characteristics in AHJs outside of California. For the participation risks outlined, we believe that CSE's central role in past efforts in California will be particularly helpful, as the organization has built up a significant store of trust and credibility. For the modeling risks, we plan to draw on well-developed techniques, and for the jurisdiction characteristics, we have already identified value proposition datasets and widely used variables in both census demographics and political indices that we expect to draw upon, in conjunction with CSE's geographic information system capabilities. Please note that for manpower to conduct interviews and modeling, we have CSE's resources and the resources of LBNL, UC Berkeley and Stanford at our disposal.

Innovation and Impacts

A systematic study of decision-making in a large number of diverse jurisdictions, as proposed in our research, will reveal patterns that suggest new strategies for streamlined permitting policy design and implementation.

In addition to creating new strategies for solar soft cost reduction, this innovative research will be a significant novel contribution to the field of choice-modeling. Although discrete choice modeling methodology is well-developed and has been applied widely to analyze customer behavior in transportation and marketing fields, applications to institutional decision-making to inform policy design are more limited. Our application of choice modeling to permit reform decision-making will provide an important proof of concept for broader use in the context of local government decision making to adapt to the diffusion of new technologies. A directly related application of methodology would be to the reform of permitting for energy-saving home retrofits, an active effort which faces similar permitting obstacles to rooftop solar.

Workplan

Project Objectives

Achieving widespread adoption of streamlined permitting is an important step in reducing the soft costs of rooftop PV. Important early work by CSE and other RSC teams has made progress enacting SSP reform in a small number of AHJs, particularly in California. However, a more streamlined and efficient diffusion of solar permitting reform is required to reduce soft costs and encourage continued growth of the U.S. solar market. This project will use rigorous social science methodology, discrete choice experiments, to determine the best strategies for SSP reform diffusion. Specifically, this project will result in data-driven recommendations for how to effectively engage AHJs on permitting issues, providing actionable strategies that speak to the unique factors influencing the local government decision-making process. To accomplish this goal, the project will focus on the following objectives:

- Assess the state of SSP reform across the U.S.
- Develop and document nationally consistent data on the characteristics of AHJs relevant to SSP adoption
- Investigate the administrative decision-making process of early SSP adopters in California using a discrete choice modeling framework
- Advance the scientific state of the art by applying discrete choice modeling methodology to a new field; streamlined solar permitting policy
- Develop and implement new methodology to allow for the projection of streamlined permitting adoption nationwide
- Conduct targeted outreach among stakeholders in key markets to share lessons learned

Technical Scope Summary

The work scope and approach to achieving the above objectives is divided into three distinct performance periods where each period encompasses specific project milestones and go/no-go decision points are detailed below:

- In **performance period one**, the project team will accomplish Task 1 and begin Task 2. At the conclusion of this initial period the project team will have completed all background research and experiment preparations can be made to begin the DCE interviews. At the close of performance period one, the team will produce a National Streamlined Solar Permitting Policy Report that will review past and ongoing SSP reform efforts; and a technical brief cataloguing the input data collected and the experimental design required for the choice modeling. A go/no-go decision will be made at this time.
- **Performance period two** encompasses the majority of task 2, Choice Analysis, building on the planning completed in period one to implement and analyze the discrete choice experiments. During the first subtask completed in performance period two, Interviews and Experiment, the project team will conduct interviews with 100-150 representatives at AHJs in California. The first milestone in this subtask is the completion of at least 50 of these interviews and the final milestone is the completion of all scheduled interviews. The second subtask in this performance period is the analysis of the interview transcripts and DCE results. This period will culminate with the completion of the final milestone, which is the successful application of the experimental results to the segmentation of California AHJs.
- In **performance period three**, the outcomes of all previous activities will culminate in conducting outreach and disseminating lessons learned to SSP policy stakeholders. This outreach will begin with the identification of three actively developing solar markets outside of California, in which to target our initial outreach efforts. Once these markets have been selected (milestone 1), the team will engage with early partners in test markets and identify the appropriate channels for dissemination of research findings (milestone 2). In the next stage of outreach the project team will develop a web-based tool and accompanying grey literature to assist stakeholders in crafting SSP policy. These materials will be developed in three stages with accompanying milestones: (1) initial development, (2) beta-testing early partners in test markets and soliciting feedback and (3) implementing changes to produce final tool and literature. Outreach and education efforts will be occurring in tandem with the other activities in this final performance period. There are three milestone periods to track the progress of our planned outreach and education effort: (1) development of a web platform to showcase the results of our research and to feature the SSP planning tool; (2) engagement with a minimum of 10 stakeholders in our test market; (3) highlight the impact of scientific research and outreach in academic and policy papers, at conferences and on our web platform.

Work Breakdown Structure (WBS) and Task Description Summary

Task 1: Background research (M1-M5)

Task Summary: The project team will review existing best practices and lessons learned relating to streamlined solar permitting. This task consists of all background research and preliminary modeling that will be necessary for the subsequent tasks. First, the project team will review the lessons learned from CSE's work on the Guidebook and investigate permitting reform efforts outside of California, focusing on the work of the other RSC awardees. In addition to a review of the academic and policy literature on streamlined solar permitting reform, the project team will engage directly with key stakeholders to gain a comprehensive understanding of the state of streamlined solar permitting reform in key markets throughout the nation.

Task Deliverables:

D1: National Streamlined Solar Permitting Policy Summary Report

D2: Identification of key characteristics of AHJs that are hypothesized to affect streamlined permitting adoption

D3: Map of modeled solar value proposition at jurisdiction level

Task Details: Risks involved in this task include the difficulty obtaining jurisdiction characteristics and potential accuracy issues with publically available datasets (e.g. OpenEI). The project team has experience curating large datasets from multiple sources and employing appropriate quality control strategies, such as a manual confirmation of electric rates from OpenEI in a small random sample. CSE's strong relationships with representatives at local jurisdictions have been used in the past to successfully obtain organizational and physical jurisdictional characteristics (e.g., city council documents, tax accessor data, etc.).

Subtask 1.1: Survey of Best Practices (M1- M2)

Subtask Summary: A summary of information relating to streamlined permitting will be developed through a review of relevant past work and interviews with key stakeholders. The research conducted by the team will build upon the understanding of streamlined solar permitting challenges and best practices documented by CSE in the California Solar Permitting Guidebook.

Subtask Detail: This task contains no significant barriers or risks.

Milestone 1.1: Summary of National Solar Permitting Policy Review (M3)

Subtask 1.2: Data Collection (M1 – M4)

Subtask Summary: The project team will collect community and organizational characteristics of jurisdictions in the projected experimental sample.

Subtask Details: Characteristics of jurisdictions will be obtained from public or academic databases (Berkeley Law Voting Database, U.S. Census American Community Survey, PolicyMap, ICPSR, etc.) where possible and carefully collected from government records or interviews where necessary.

Milestone 1.2: Completed dataset of jurisdictional characteristics with documentation of sources (M4)

Subtask 1.3: Modeling of Solar Value Proposition (M4-M5)

Subtask Summary: The project team will develop a measure of solar value proposition at the jurisdiction level.

Subtask Details: This modeling exercise will make use of several publically available datasets: (1) NREL's 'Technical Potential Estimate' of rooftop PV production; (2) Open EI database of electricity tariffs; (3) LBNL's 'Tracking the Sun' reports of PV system costs.

This modeling exercise will result in a geographic database of solar value proposition within each jurisdiction in California to be used in subsequent tasks. CSE has the technical resources and expertise to carry out modeling with large geo-referenced datasets.

Milestone 1.3: Completed model of Solar Value Proposition at jurisdiction level (M5)

<u>Task 2: Structured Interviews and Analysis (M4-M24)</u>

Task Summary: The project team will conduct interviews with appropriate representatives at sample AHJs. The interviews will focus on uncovering the reasoning underlying the AHJs decision to adopt, or not to adopt streamlined solar permitting in advance of the mandate by AB2188. The structured interviews will comprise two parts: a series of open-ended questions and a stated preference choice experiment. An analysis of interview responses will first provide insight into the preferred design of different packages of streamlined permitting practices by the various market segments defined in Task 1. Additionally, this analysis will inform the forecasting of nationwide demand for these different design packages in the third phase of the project.

Task Deliverables:
D5: Draft script of structured and open-ended interview questions
D6: Presentation of results – a segmentation of local jurisdictions according to the solar value proposition, methodological innovation in discrete choice experiments, and policy and programmatic implications of research – in appropriate academic and regulatory venues

Task Details: Potential obstacles in this task include: engaging participants, particularly non-adopters, in the interviews and potential difficulties in analysis and modeling of results. CSE, through past successful projects engaging local governments and key solar industry stakeholders, has built up significant trust and credibility with California AHJs, which will be employed to recruit interviewees.

Subtask 2.1: Scheduling and Networking (M8-M12)

Subtask Summary: The project team will identify and engage with appropriate representatives (e.g. chief building officials, planning department leads, sustainability officers) at sample AHJs to schedule interviews.

Subtask Details: Recognizing the difficulty in recruiting professionals for interviews, the project team will employ several strategies for success. To recruit interview participants CSE will first rely on their existing relationships with a large number of AHJs. Through their work on the Guidebook, CSE has developed strong relationships with potential interviewees at several jurisdictions in California. Additionally, the project team will leverage CSE's membership in the ICC and existing relationship with CALBO to recruit interviewees and conduct interviews at regional meetings of these organizations when necessary.

Milestone 2.1.1: Identification of appropriate representatives (e.g., chief building inspector, sustainability officer, city planner, etc.) at each AHJ for interviews (M9)

Milestone 2.1.2: Completed schedule of interviews (M12)

Subtask 2.2: Experimental Design and Planning (M4-M12)

Subtask Summary: The project team will develop an experimental design for the DCE according to best practices and formulate and test interview questions.

Subtask Details: The main risks involved in this step are that the experimental design and interview questions will not solicit reliable and valid data that can be analyzed in such a way that the results will be useful for the market segmentation and Differentiated SSP. To overcome these risks, the team will ensure that the interview questions and DCE design will meet the standards of the literature. The team will also test the interview questions and DCEs with a sample of potential respondents, in order to iteratively hone the interview materials.

Milestone 2.2.1: Complete beta-testing of the open-ended and DCE interview questions (M8)

Go/No-Go/Milestone 2.2.2: Successful completion of interviewee recruitment and experimental design, including a draft of the interview script. (M12)

Subtask 2.3: Interviews and Experiment (M13 – M18)

Subtask Summary: Interviews, consisting of open-ended questions and the DCE, will be conducted with representatives from approximately 100-150 jurisdictions.

Subtask Details: The appropriate number of jurisdictions to interview will be determined by the sampling strategy in the experimental design. Best practices, which will be adhered to by the project team, prescribe that the interview component of DCEs should be administered via computer with in-person guidance from the researcher. The project lead, Margaret Taylor, who has significant experience administering DCEs using best practices, will train team members to conduct interviews.

Milestone 2.3.1: Completion of 50 interviews (M15)

Milestone 2.3.1: Completion of all interviews (M18)

Subtask 2.4: Analysis and Segmentation (M19 – M24)

Subtask Summary: The quantitative and qualitative results from the interviews in subtask 2.3 will be analyzed using appropriate methods.

Subtask Details: Discrete choice modeling is used widely in the literature and there are readily available methodological suggestions to counteract the weaknesses in a given research design (e.g., researcher choices on the error distributions and form of utility functions used to make inferences from the ordinal data that results from choice experiments). The team of researchers at LBNL is well versed in this literature and has significant experience in its practical application to the analysis of DCEs.

Go/No-Go/Milestone 2.4: Successful application of the results of DCE to segment jurisdictions and identify relationships between streamlined permitting attribute preferences and jurisdictions' characteristics. (M24)

<u>Task3: Application to New Markets (M22-M36)</u>

Task Summary: The objective of this task is to apply the insights gained from the previous tasks to improve streamlined solar permitting reform efforts outside of California. This objective will be achieved through the design, implementation, and marketing of a decision making tool and accompanying guidebook. These resources will synthesize the lessons learned from interviews, modeling and outreach in the test markets to create actionable suggestions and guidance for streamlined permitting reform stakeholders and policy makers.

Task Deliverables:

D7: Identification and justification of test markets

D8: Web-based tool to guide jurisdictions and other interested stakeholders in crafting streamlined solar permitting

D9: Presentation of lessons learned from application of permitting reform design methodology in test markets in appropriate policy venues

Task Details: A significant risk in this task is that the lessons learned in California will not be applicable in other markets because of differences in jurisdictional characteristics. However, California is an ideal state to conduct solar permitting research that will be broadly applicable. California is a large state with a diverse group of jurisdictions and our experimental design will insure that our results capture the preferences of jurisdictions with a range of characteristics.

Subtask 3.1: Identify Test Markets (M22-M23)

Subtask Summary: The project team will identify three solar markets outside of California to test the application of the methodology developed in task 2.

Subtask Details: To insure that the implementation strategies and outreach materials developed in Task 3 are broadly useful, test markets will be chosen such that they mirror the nation as a whole as much as possible. Early support for the work in this task has been provided from NYSERDA, California Energy Commission, Massachusetts DOER, etc.

Milestone 3.1.1: Complete selection of test markets (M23)

Milestone 3.1.2: Begin engagement with key early partners in test markets to identify future channels for dissemination of research findings (M22-23)

Subtask 3.2: Tool Development (M25-M30)

Subtask Summary: Synthesize lessons learned from interviews and modeling to create a web-based tool and accompanying guidebook to assist AHJs in crafting new SSP policy.
Subtask Details: CSE has significant experience creating educational and outreach materials and engaging policy stakeholders. The project team will use that experience, combined with input from early users in the beta-testing phase, to produce a tool that is widely useful.
Milestone 3.2.1: Develop web tool and guide (M25-M27)
Milestone 3.2.2: Beta-test web tool and guide with early partners in test markets and solicit feedback (M27-28)
Milestone 3.2.3: Implement changes to produce final tool and guide (M28-30)

Subtask 3.3: Outreach and Education (M25-M36)

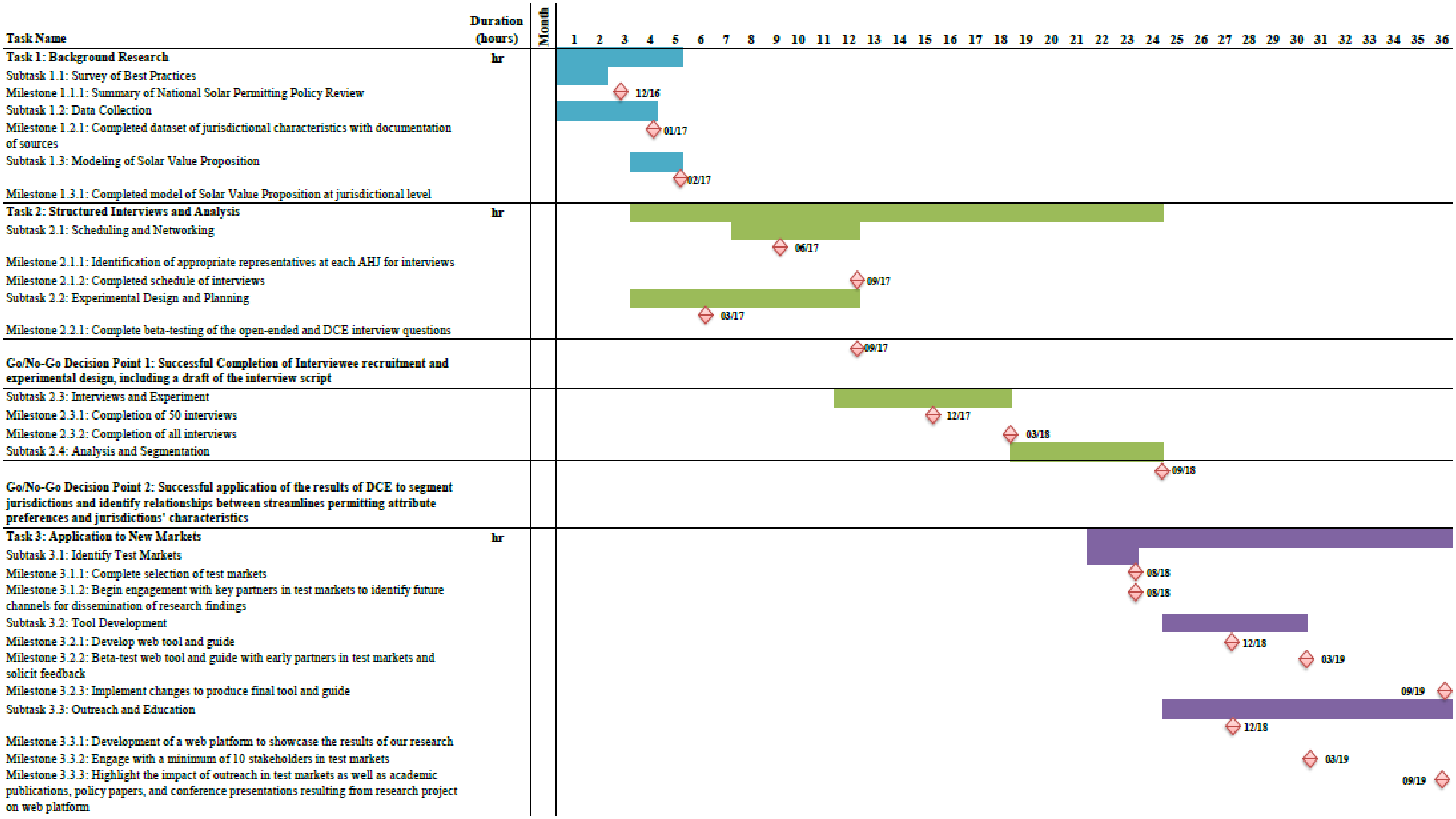
Subtask Summary: The project team will engage with state energy offices, non-profits, state and local governments to produce roadmap to guide permit reform efforts in test markets. The resources developed in this task will be presented at industry events, policy forums, and conferences. CSE will develop and deliver trainings and webinars on the decision-making tool developed in subtask 3.2.
Subtask Details: Acknowledging the potential difficulties in engaging directly with state policymakers, the project team will employ several outreach strategies to hedge risks determine the stakeholders most receptive to our resources. CSE will take leverage existing relationships with regional solar associations, non-profits, and state energy offices.
Milestone 3.3.1: Development of a web platform to showcase the results of our research (M27)
Milestone 3.3.2: Engage with a minimum of 10 stakeholders in test markets (M25-M30)
Milestone 3.3.3: Highlight the impact of outreach in test markets as well as well as academic publication, policy papers, and conference presentations resulting from research project on web platform (M36)

Milestone Table

Milestone Summary Table							
Recipient Name:		Center for Sustainable Energy					
Project Title:		Understanding Adoption of a Key Soft Cost Reduction Strategy: Modeling Administrative Choices Regarding Streamlined Solar Permitting					
Task #	Task/Subtask Title	Milestone Type	Milestone	Milestone Description (Go/No-Go Decision Criteria)	Milestone Verification Process	Anticipated	Anticipated
1.1	Survey of Best Practices	Milestone	1.1.1	Summary of National Solar Permitting Policy Review	Team provide report of current SSP policy efforts in U.S.	M3	Q1
1.2	Data Collection	Milestone	1.2.1	Completed dataset of jurisdictional characteristics with documentation of sources	Team will collect and organize all data needed for research project	M4	Q2
1.3	Modeling of Solar Value Proposition	Milestone	1.3.1	Completed model of Solar Value Proposition at jurisdiction level	Map of solar value proposition at jurisdiction, documented methodology supplied to DOE	M5	Q2
2.1	Scheduling and Networking	Milestone	2.1.1	Identification of appropriate representatives at each AHJ for interviews	Team will conduct networking and outreach to identify best representatives for interviews	M9	Q3

2.1	Scheduling and Networking	Milestone	2.1.2	Completed schedule of interviews	Tentative interview schedule and risk management plan will be provided	M12	Q4
2.2	Experimental Design & Planning	Milestone	2.2.1	Complete beta-testing of the open-ended and DCE interview questions	Team will	M8	Q3
2.2	Experimental Design & Planning	Go/No-Go	Decision Point 1	Successful completion of recruitment and experimental design; draft of interview script	Interview script draft, experimental design outline provided to DOE	M12	Q4
2.3	Interviews & Experiment	Milestone	2.3.1	Completion of 50 interviews	Team will complete 50 interviews	M15	Q5
2.3	Interviews & Experiment	Milestone	2.3.2	Completion of all interviews	Team will complete all interviews	M18	Q6
2.4	Analysis & Segmentation	Milestone	2.4.1	Report of DCE initial findings	Team will produce a brief report of early qualitative findings of interviews	M21	Q7
2.4	Analysis and Segmentation	Go/No-Go	Decision Point 2	Segment jurisdictions and identify relationships between SSP attribute preferences and jurisdictions' characteristics	A map of segmented jurisdictions based on SSP attributes will be produced	M24	Q8
3.1	Identify Test Markets	Milestone	3.1.1	Complete selection of test markets	Select three states for outreach	M23	Q8
3.1	Identify Test Markets	Milestone	3.1.2	Engagement with key early partners and identify channels for dissemination of research findings	Project team will network in three new markets to develop outreach plan	M23	Q8
3.2	Tool Development	Milestone	3.2.1	Develop web tool and guide	Team will develop materials showcasing research findings	M27	Q9
3.2	Tool Development	Milestone	3.2.2	Beta-test web tool and guide with early partners in test markets and solicit feedback	Outreach materials will be tested with early stakeholders to maximize effectiveness	M28	Q10
3.2	Tool Development	Milestone	3.2.3	Implement changes to final tool and guide	Project team will produce final outreach materials	M30	Q10
3.3	Outreach and Education	Milestone	3.3.1	Development of a web platform to showcase the results of our research	CSE will develop a web platform to showcase educational materials and publications	M27	Q9
3.3	Outreach and Education	Milestone	3.3.2	Engage with a minimum of 10 stakeholders in test markets	Project team will engage with a minimum of 10 stakeholders (non-profits, policy assoc., energy offices, etc.)	M30	Q10
3.3	Outreach and Education	Milestone	3.3.3	Highlight the impact of outreach in test markets in academic publications, policy papers, and conference presentations	Project team will highlight impact of outreach efforts and lessons learned on web and at appropriate conferences and regulatory venues	M36	Q12

Project Schedule



Project Management

The project team will follow a phased lifecycle approach to project implementation that establishes clear stages and processes for achieving project objectives and completing project deliverables. CSE will define project activities and the resulting deliverables, and when appropriate, assign temporal qualifiers to activities and deliverables to ensure project schedules are manageable and that project stakeholders are aligned on scope and schedule expectations early on in the life of the project.

With support from CSE's finance team, the project manager will track project performance and distribute monthly cost reports, including monthly spend plans and monthly performance measure schedules, for budget tracking and reporting variance to the DOE. The project team will use monitoring and evaluation tools including Gantt charts and milestones to monitor schedules and custom reporting templates to monitor performance and progress toward goals.

The project team will manage project risk by ensuring that project risks are known, communicated, and accepted as they move though the phases of project delivery. The project team and its partners will work together through each phase of project delivery to manage risks. The project team will identify potential risks, develop mitigation strategies, execute a risk response plan and evaluate the effectiveness of such approach.

Project Team Members and Roles

The following table identifies project team members by name and specific responsibilities.

Table 1. Project Team Roles

Organization	Primary Role	Work to be Performed
Center for Sustainable Energy	• Overall Project Manager • Oversight, Quality Control • Budgeting and Reporting • Coordination with Building Permitting Officials • Dissemination of Lessons Learned to Stakeholders	• Lead project management including partner coordination • Lead engagement of permitting officials and AHJs • Lead development of roadmap to guide future permit reforms • Lead project impacts and lessons learned report development and dissemination
Lawrence Berkeley National Laboratory	• Subcontractor • Research Lead	• Develop research methodology • Analyze data

Technical Qualifications and Resources

Project Team Qualifications and Expertise

CSE is an independent, 501 (c)(3) national nonprofit organization, with 20 years' experience working to accelerate the adoption of clean energy and energy efficiency technologies through energy market transformation program design and implementation, workforce training, technical consulting and policy innovation. CSE's on-the-ground experience and subject-matter expertise, developed through the management of large-scale state and regional clean energy programs, has cemented its reputation as an essential collaborator and facilitator among regulators, local governments, and the contractor communities.

The **Project Manager** will be Marcus Gilmore, who leads CSE's administration of DOE's SunShot program, working to expand awareness, effectiveness and use of the virtual net metering tariff and stimulating solar adoption within the multitenant market. He is a leader in engaging local governments and solar industry stakeholders throughout California to facilitate the adoption of expedited solar permitting processes for small rooftop PV systems. Additional experiences include managing a CSE program that has contributed to significant improvements in the solar PV interconnection and incentive application process for the largest municipal utility in the US and coordinating AHJ engagement for an HVAC permit streamlining study funded by the California Energy Commission. The project team will also draw on CSE's breadth of knowledge in the clean energy sector, leveraging a diverse and experienced 130-person staff of energy planners, engineers, program implementers, equity specialists and research and policy analysts.

Don Hughes will serve as **Technical Advisor** for permitting. Don is a leading expert regarding solar photovoltaic system permitting, inspecting and codes and standards. With over 30 years of combined experience as an electrician, electrical inspector and chief electrical inspector he has provided AHJ perspective to the leaders in the effort to facilitate wide scale adoption of solar PV, including the DOE EERE, California State Governor's Office of Planning and Research, Interstate Renewable Energy Council and Underwriter's Laboratories. The CSE project team will also be supported by Christina Machak, **Research Analyst**. Christina has a background in scientific and engineering research and quantitative modelling, and has experience conducting research in academic lab and industry settings. She specializes in research design, statistical analysis and GIS, including creating map-based applications for outreach and education.

Lawrence Berkeley National Laboratory's Energy Technologies Area performs analysis, research, and development leading to better energy technologies and reduction of adverse energy-related environmental impacts. ETA carries out its work through the support of the U.S. Department of Energy (the Area's primary sponsor), other federal entities, state governments and the private sector. Alan Meier, Ph.D., **Co-Principal Investigator,** is a Senior Scientist in the Building Technology and Urban Systems Division at LBNL and faculty researcher at the Energy Efficiency Center at the University of California, Davis. Dr. Meier's research has focused on understanding how energy is transformed into useful services and the opportunities to use energy more efficiently. His research on standby power use in appliances—1% of global CO2 emissions—led him to propose an international plan to reduce standby in all devices to less than 1 watt. Other research topics include energy use of consumer electronics, human behavior related to thermostats and other energy-saving actions, and international policies to promote energy efficiency.

Margaret Taylor, Ph.D., **Co-Principal Investigator and LBNL Project Lead,** is internationally respected for her empirical research on innovation and public policy in climate and energy technology industries. Dr. Taylor currently holds dual appointments at LBNL and at Stanford University's Precourt Energy Efficiency Center. Dr. Taylor currently co-chairs the annual Behavior Energy Climate Change conference and serves on the Advisory Board both of Applied Solutions, a national non-profit that shares best practices regarding sustainability amongst local governments, and of the Sloan Foundation's Energy and Environment Program. Dr. Taylor's past research has included a comprehensive assessment of the many policy instruments California has implemented to support solar technology innovation and diffusion since the 1970s; this work employed multiple methods, including patenting activity, network analysis, and the conduct of multiple structured interviews, to assess the outcomes of these instruments on innovative activity.

Project Team's Existing Equipment and Facilities

CSE has ample resources to support successful completion of the project. CSE staff has access to numerous collaborative spaces in each of its California offices; all of our office locations are equipped with video conferencing technology and cloud-based collaboration services. These resources will support efficient project team communication with partner organizations throughout the state and the DOE. CSE's Research and Analysis team has demonstrated expertise using the following software and programming languages: (1) ESRI ArcMap for GIS analysis and map production, (2)ESRI ArcServer and QGIS with PostgreSQL and PostGIS extensions for managing geodatabases, (3)R, Stata, and Python for conducting statistical analysis, (4) JavaScript and Tableau for creating web-based data visualizations and interactive maps. The equipment and facilities the LBNL project team has access to include: a variety of statistics software licenses; the UCB library system and its databases; recording equipment for interviews; excellent support staff; and an efficient internal review board.

Relevant, Previous Work Efforts and Demonstrated Innovations

CSE's technical assistance and solar market development project expertise and previous work efforts and innovations include:

- *Lead organization on two SunShot Rooftop Challenge Programs (I and II) in CA, including coordination work on the Governor's Solar Permitting Taskforc*e – CSE convened solar stakeholders to address soft cost barriers to PV in the largest market in the U.S. Work included technical assistance services to over 63 jurisdictions across CA and publication of the Governor's Solar Permitting Guidebook. These efforts resulted in more uniform, rapid and transparent permitting and interconnection processes across CA.
- *Technical lead for DOE Solar Energy Evolution and Diffusion Studies grant* – CSE supports the development of predictive model of individual and aggregate solar technology adoption.
- *Project lead for DOE Solar Market Pathways grant* – CSE is collaborating with industry stakeholders to develop a replicable model for deployment of virtual net metering that will result in increased awareness and understanding of the virtual net metering tariff and increased adoption of the tariff on multi-metered, multitenant properties in CA and beyond.
- *Administrator of the Multifamily Affordable Solar Housing Program (MASH)* – CSE administers MASH for SDG&E territory, which provides incentives to offset costs of installing solar PV systems on multifamily affordable housing buildings in California.
- *Administrator of the California Solar Initiative Program (CSI)* – CSE administers CSI for SDG&E territory, the solar rebate program in California that helps businesses, public agencies and homeowners lower their energy costs through the use of solar technologies.
- *Program implementor of the California Energy Commission HVAC Permit Compliance & Financing Pilots* – CSE engaged local government and industry stakeholders to develop best practices for streamlining residential HVAC alteration permit processes and compliance.

Time Commitment of Key Team Members to Support Project

As the prime applicant, CSE will lead 45% of the proposed activities. As project partners, LBNL will support 55% of the proposed work plan. The co-Principal Investigator, Alan Meier, will spend approximately 5% and Co-PI Margaret Taylor (LBNL) will spend approximately 25 % of her time working on this project over the three year period. Project Manager Marcus Gilmore will spend approximately 25% of his time working exclusively on this project over the three year period. Don Hughes (CSE) will spend roughly 15% of his time advising the project.

Resumes- See appendix for key participating team member resumes.

Services to be Provided by DOE/ NNSA FFRDCs and GOGOs

LBNL will lead experimental design and data analysis for the project. LBNL will play a more secondary role on Task 1 and Task 3, however, while it will play the primary role in Task 2.

Letters of Commitment and Support - See appendix for Letters of Commitment and Support.

Multi-Organizational Collaboration

As outlined in the above project management section, CSE will be the project lead, responsible for all deliverables and project outcomes, budgeting and reporting to the DOE. CSE will implement a subcontractor agreement with our proposal partner LBNL for their portion of the overall scope of work. The proposed organization structure supports CSE's project management best practices allowing for clear and streamlined communications with the DOE, as well as delineation of project responsibilities by support staff and subcontracting partner LBNL.

As this research aims to accelerate and maximize diffusion of residential solar energy throughout the U.S., intellectual property will be structured to advance this goal. The project team will disseminate the research findings through conferences and publications as well as through other relevant stakeholder, industry and technical forums.

Communication Plan: CSE will coordinate weekly check-in meetings with LBNL to assess progress towards contract deliverables, and to ensure quality of work products and the timely completion of milestones. Weekly meetings will be supplemented with half day quarterly team meetings, to discuss strategy, progress and any needed revisions to scope. CSE will lead the project effort, while integrating substantial input from LBNL researchers on their respective areas of expertise. Team meetings will provide an opportunity to share data and research findings gleaned from the surveys and interviews, as well as allow for team collaboration on reports, plans, and outreach strategies. Roles and key tasks are summarized in the table below.

Name	Project Role	Work to be Performed
Center for Sustainable Energy		
Tim Treadwell	Technical Advisor	Oversight and quality control to ensure work is completed at the highest level of quality and timeliness
Marcus Gilmore	Project Manager	Day-to-day project leadership; communication/coordination with DOE and LBNL; engage building permitting officials and AHJs
Benjamin Airth **Don Hughes**	Technical Advisors	Provide technical guidance on solar permitting Engage AHJs and building officials; disseminate knowledge
Christina Machak	Research Analyst	Lead CSE's research and data analysis activities
Lawrence Berkeley National Laboratory		
Alan Meier **Margaret Taylor**	Co-Principal Investigator	Lead choice analysis experimental design; data analysis
Christopher Payne **Ryan Wiser** **Galen Barbose** **Anna Spurlock**	Research Scientists	Research support: solar PV market research; extensive solar market data sets; organizational behavior, econometrics and research methods