EVERGREEN ECONOMICS

California Solar Initiative RD&D Program

Process Evaluation

Summary Report

May 11, 2017

Summary

The California State Legislature created the California Solar Initiative Research, Development, Demonstration and Deployment Program (the CSI RD&D Program, or the Program) in 2006 to support the broader California Solar Initiative. The CSI RD&D Program received $50 million to fund research, development and demonstration projects supporting integration of distributed solar photovoltaic (PV) into the California grid, with the longer-term goals of increasing solar technology performance, reducing solar technology costs, and filling technical knowledge gaps in the solar industry.

The CSI RD&D Program design established three target research areas:

- **Grid Integration:** Improving PV integration with transmission and distribution systems (50-65% of funding).
- **Solar Production Technologies:** Supporting commercialization of new photovoltaic (PV) technologies (10-25% of funding).
- **Business Development and Deployment:** Supporting the market and end-users (10-20% of funding).

The CSI RD&D Program funded 37 projects (35 of which were completed) across the three target research areas, with total CSI funding of $38.3 million in addition to $34.6 million in matched funding from the grantees and other sources.

In 2016, Evergreen Economics led a research team consisting of Evergreen Economics, Research Into Action, Dr. Gretchen Jordan, Dr. Varun Rai, and Advanced Survey Design to conduct a process evaluation of the CSI RD&D Program. This theory-based evaluation began with the development of a program logic model that linked the CSI RD&D Program activities to immediate outputs and to longer-term outcomes that were consistent with CPUC policy goals.

Once the Evergreen team identified metrics that would provide evidence of the Program's progress toward its goals, the evaluation team developed a data collection plan to gather information from a variety of different activities:

- ***Review of project data and documentation*** – Collecting and analyzing all relevant program reports, presentations, and project data.
- ***48 interviews with grantees and program managers*** – Obtaining additional information on the projects not included in the original documentation.
- ***15 interviews with industry experts and stakeholders*** – Collecting information on how program activities, products, and knowledge are affecting grid operators, utilities, and regulators.

- ***5 interviews with other solar market actors*** – Collecting information on how project activities, products, and expertise from the Program are affecting the broader solar market.
- ***88 online surveys of solar market actors*** – Collecting additional standardized data on the perception of Program accomplishments from the solar community.
- ***Review of external data/literature*** – Reviewing secondary data and literature to investigate knowledge dissemination of the Program-supported research.

In addition to the data collection and analysis, the Evergreen team completed a related network analysis task to evaluate the knowledge benefits provided to the solar community as a result of Program activities.

Based on these research activities, general conclusions from the evaluation are summarized below.

1. **The Program Manager, Itron, performed very well.** Grantees receiving funds from the Program gave universally positive feedback on Itron. Itron carried out all the required tasks of the Program Manager very competently and implemented the Program in accordance with the original Program design. Itron communicated clearly with grantees and stakeholders throughout the life of the Program, completing each phase –proposal solicitation, project selection, project implementation oversight, and final reporting–with no complaints and with high satisfaction ratings from participants. Itron also played an important and highly effective role in facilitating communication and partnerships within and between projects, as well as with the broader solar community, helping to engage key stakeholders and reduce duplication of efforts.
2. **CSI RD&D projects were mostly successful in making progress toward the long-term policy goals established for the Program.** Demonstration of short-term outcomes that are consistent with the logic model is a positive sign that projects are on a pathway to achieving the longer-term goals established for the Program. Examples of successes for each of the project groups (with details included in the full evaluation report) are summarized below.
    - ***Grid Integration*** was the most successful research area, with 20 completed projects. Important accomplishments for these projects included the following:
        - **Improvement to interconnection requirements.** There are a host of rules and regulations governing the interconnection, operating, and metering requirements for solar generating facilities connected to the distribution system. Eight of these projects conducted work explicitly designed to influence standards or rules relating to interconnection. Specific improvements addressed PV interconnection limits, project screening, and costs and processes for energy storage systems. These changes helped

streamline the review process for interconnection and storage projects, and played a direct role in the improvement to the interconnection process in California.

- **Software products.** Across the 20 projects with Grid Integration components, there were over 30 outputs that included commercialized software packages, modeling methodologies, open source modeling tools, data collection tools, and databases. Grantees developed several software products that improve resource visibility, provide more accurate prediction of generation, and allow grid planners to model economic value of planned solar generation resources. Improvements in these areas add to overall system reliability, particularly in situations with high penetration PV.
- **Improved modeling tools.** Aside from specific software applications, several projects developed modeling tools and methodologies that can be adopted or integrated into existing utility planning and operations tools. These included tools for solar irradiance forecasting, generation forecasting for individual systems and fleet systems, distribution system models, and economic value modeling tools. Each of these can be used to improve system reliability through more accurate prediction of solar generation and optimal siting of generation resources.
- **Inverter system enhancements.** Advanced smart inverters are communication-enabled inverters that can improve communication between distributed solar resources and the grid. Improvements to inverter systems can greatly increase the penetration of PV and other renewable energy on the grid. Key accomplishments by the Program in this area included demonstration projects of advanced smart inverters, technical reports providing guidelines and inverter settings, and studies to develop optimal control methods.
- **Permanent demonstration sites.** The Grid Integration research area accounted for six demonstration sites. Examples of these projects include demonstrations of battery packs, a showcase home for Zero Net Energy homes and their integrated technologies, a training facility, and a field demonstration of a PV penetration modeling tool.

- The ***Solar Production Technologies*** research area had a total of 12 projects, with varied success. While most of these projects met all their stated objectives, some either did not meet their objectives or invested in technology that proved not to be viable in the market at present. Significant accomplishments with this research area included:
  - A project between SolarCity and Tesla demonstrating new battery technology and control systems that led directly to development of the Tesla PowerWall product, which was predicted to have in excess of 168 MWh in sales ($44 million in revenue).

    - A project by Sunlink involving seismic testing and design automation of solar mounting units. This led to Sunlink developing new software to improve design and reduce costs of mounting products, as well as a new startup company that created automated design software.
- The ***Business Development and Deployment*** research area included 10 projects and had the least success, both in terms of achieving the stated project goals as well as in demonstrating short-term progress on key metrics. There were positive contributions from this group, however, including two technology projects that did develop business models and strategies that have proved successful. These have helped support expansion of cost-competitive solar technologies, either by reducing costs or increasing value of the solar and storage technology to owners and utilities.

3. **The Program resulted in a substantial amount of knowledge benefits**. The creation and dissemination of knowledge benefits may be the most important metric of success when evaluating a research program. By this measure, the CSI RD&D Program was very successful and took an essential step toward achieving its longer-term program goals. Key examples of successful knowledge benefits include the following:
    - **The Program research has been widely cited.** A primary knowledge benefit is the degree to which research results are cited in the related literature, as this reflects its potential value outside the Program. In this regard, the Program has been very successful, with 395 total citations to date. Among the 153 papers and reports publicly released by Program teams, 26 have been cited at least one time.
    - **Collaborative team dynamics led to significant follow-on research, with more than 40 enduring partnerships resulting from the Program**. Continued research activities combined with new and sustained partnerships are positive effects of the Program and provide another solid indicator that the Program is on a pathway to achieve its longer-term policy goals. As a result of the Program, a variety of partnerships were formed among team organizations, between team organizations and stakeholders, and between team members and market actors.
    - **The Program design led to the selection of teams committed to knowledge transfer.** Most teams went beyond the minimum knowledge exchange activities required by the Program, and many created additional knowledge dissemination opportunities by releasing resources freely to the public and by developing demonstration sites. Teams identified direct stakeholder engagement, non-Program webinars, and conference presentations as the most effective knowledge exchange methods.