Designing PV Incentive Programs to Promote Performance:

A Review of Current Practice

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Project Overview

- **Motivation:** Continued concern about the performance of PV systems (particularly those supported by public/ratepayer-funded programs)
  - Efforts to design PV incentive programs to encourage performance are sometimes undertaken without recognition of the full range of options available

- **Project Scope:** Examine approaches that 32 state/utility PV incentive programs in the U.S. have used to encourage PV performance
  - Including, but not limited to, performance-based incentives

Factors Potentially Affecting PV System Performance

- **Geographic Location**
  - Latitude
  - Climate (cloud/fog cover, ambient temperature, wind)
- **System Design**
  - Panel orientation and shading
  - Inverter sizing
  - Mounting structure
- **Equipment Quality**
  - Accuracy of ratings
  - Impact of actual operating conditions on equipment performance
  - Equipment reliability and durability
- **Installation Workmanship**
  - System faults caused by improper installation
  - Excess losses (e.g., due to undersized wiring)
- **Maintenance**
  - Cleaning, tree-trimming
  - Repair/replacement of failed components

Program Design Options for Encouraging Good Performance

	Performance Factors Potentially Addressed †				
	Geographical Location	System Design	Equipment Quality	Installation Workmanship	Maintenance
Equipment & installation standards			✓	✓	
Warranty requirements			✓	✓	✓
Installer requirements, assessment & voluntary training		✓		✓	
Design standards & administrative design review		✓			
Incentive-based approaches	✓*	✓*	✓*	✓*	✓*
Post-installation inspections & acceptance testing				✓	
Performance monitoring & assessment					✓
Maintenance requirements & services					✓

† The table identifies what are arguably the *primary* performance factors addressed by each program design strategy; many of the program design strategies may address additional performance factors, depending on their design.

* The various incentive-based approaches differ significantly in terms of the performance factors potentially addressed.

Equipment & Installation Standards

- **Most programs require modules and inverters to be UL-listed (pertains primarily to product safety)**
  - UL-listing for modules also requires that output under STC be at least 90% of nameplate rating (*currently the only national standard addressing rating accuracy*)
- **At least one-third of programs also require that inverters meet the IEEE-929 standard** (deals with safety features for utility interconnection)
- **Additional CEC equipment standards:**
  - Inverters must undergo a set of tests according to a specific testing protocol developed for the CEC
  - For its new program (NSHP) the CEC has proposed requiring that module nameplate ratings be established according to the test procedures described in IEC 61215/61646 **and** that nameplate ratings represent the lower end of each module's tolerance band
- **State/local building codes are based on the National Electric Code (NEC)**
  - NEC Article 690 specifically addresses wiring and connections for PV installations
  - Current version of the NEC requires that *inverters* be UL-listed, and the 2008 NEC will require that *modules* be UL-listed as well

Warranty Requirements

Warranty requirements differ in scope and duration:

- **Items covered:** modules, inverters, whole system, installation workmanship
- **Length of coverage:** modules (10-20 yrs), inverters (2-5 yrs), system (2-5 yrs), installation (1-5 yrs)
- **Conditions covered:** breakage/failure, performance degradation
- **Costs covered:** parts and/or labor

Five-year, full warranty covering all major components is the most common requirement [about half of the programs]

- Often includes performance guarantee of <10% degradation for modules/inverters over 5-year warrantee period
- CCEF and RIREF also require longer performance guarantee for modules (<20% degradation over 20 years)

Recently-enacted solar legislation in CA (SB1) will require all ratepayer-funded systems to have a full ten-year warranty

PV Installer Requirements, Assessment, & Voluntary Training

- **Program eligibility requirements for PV installers:**
  - **Licensing requirements** are the most common (e.g., general contractors' license or electricians' license; CA has a solar contractor license)
  - **NABCEP certification** [Maine, Ohio, Austin, Wisconsin] or specific minimum levels of **training and/or experience** [LADWP, SMUD, CCEF, NYSERDA, SDF]
- **Installer performance assessment**
  - Assess the workmanship of participating installers (e.g., through site inspections and/or system performance monitoring)
  - Disqualify or place on probation installers who perform unsatisfactorily
- **Support for voluntary training/certification**
  - Hosting training workshops [LADWP, Nevada, NYSERDA]
  - Financial or other support for installers [NYSERDA activities, WFE grants and higher buy-down incentives for NABCEP-certified installers]
  - Financial support for training and accreditation institutions [NYSERDA]

Minimum Design Standards & Administrative Design Review

- **Minimum design standards may be specified in terms of measurable design parameters [10 programs]**
  - **Orientation** (e.g., south-facing, tilt angle within designated range)
  - **Shading** (e.g., max. hours of shading or no obstructions within designated range)
- **Minimum design standards may also be specified in terms of estimated annual energy production [7 programs], either...**
  - **On an absolute basis** (min. kWh per installed kW), or
  - **Relative to an "ideal" reference system** (e.g., at least 70% of kWh produced by an optimally oriented system with no shading, at the same location)
- **Specialized tools may be required to demonstrate compliance with minimum design standards** (e.g., shading analysis tools, PV simulation software)
- **Administrative design reviews may supplement or substitute for minimum design standards**
  - The most detailed reviews incorporate pre-installation site inspections and/or use of outside consultants to assess project specs

Incentive-Based Approaches

- **Performance-Based Incentive (PBI):** incentive payment is based on actual system output [3 programs currently offering a PBI; CA moving toward PBI for large systems]
- **Expected Performance-Based Buydown (EPBB):** incentive payment is provided up-front, based on expected annual output under average climatic conditions
  - Can account for factors whose influence on performance can be estimated up-front (geographic location, panel orientation, shading, mounting structure)
  - **Option 1:** $/kWh incentive based on estimated annual output [WFE, LADWP]
  - **Option 2:** $/kW incentive prorated based on the ratio of the system's expected output to that of an "ideal" reference system [10 programs]; may incorporate a "dead-band" within which full incentive rate is provided
- **Incentive holdbacks:** a portion of the incentive is held-back over some operational period (e.g., 6-12 mos.) and paid only if acceptable performance is demonstrated [CCEF]
- **Improved rating conventions:**
  - **Module ratings at PTC** rather than STC [8 programs]
  - **Stipulated AC rating** based on rated inverter efficiency [7 programs]
  - **Verified AC ratings** based on short-term monitoring data [Tucson Electric, Salt River Project]

Post-Installation Inspections & Acceptance Testing

- **Approx. half of the programs conduct post-installation inspections for all projects and pay incentives only after successful inspection**
  - CEC, MTC and Vermont conduct post-installation inspections only for a sample of projects
- **However, the depth of the inspection process varies widely**
  - Often, it is quite cursory (i.e., just to check that system matches the application)
  - Several programs check for code compliance (given lack of experience by building inspectors)
  - Several programs conduct (or require that the installer conduct) acceptance tests, which involve a set of on-site measurements to determine if output is within expected range

Performance Monitoring & Assessment

- **Most programs require separate metering of PV output, with varying technical requirements**
  - Nine programs require revenue-grade kWh meters for some or all projects (possibly because of PBI and/or REC sales)
  - Most others require only +/-5% accuracy (which can often be met by inverter's internal meter)
- **Performance monitoring & assessment by the program administrator requires a data collection/reporting process**
  - Most programs with metering requirements require customers to report it, although several programs collect data through site visits or remote communications
  - Frequency of data collection varies from monthly to annually; duration varies from one year to ongoing
- **A few programs conduct follow-up inspections**
  - After one year [SDF], on an ongoing annual basis [TEP and UPS], or whenever monitoring data indicates potential performance issues [SMUD]
- **To facilitate monitoring & assessment by the customer, programs may provide or require:**
  - **Customer information, education, and training** (e.g., energy production estimates, training on how to conduct performance assessment)
  - **Enabling technologies** (e.g., "customer-friendly" metering, web-based information and diagnostic tools)

Maintenance Requirements & Services

- **RIREF's 2004 RFP for non-residential projects imposed requirements on project contractors**
  - Contractors required to provide maintenance services and scheduled inspections for at least five years
  - Contractors required to train facility staff on performance assessment and routine maintenance
  - Proposals evaluated, in part, on the quality of maintenance and training services to be provided
- **TEP and UPS provide maintenance services, themselves, free of charge**
  - Need for repair determined through ongoing, annual inspections

Recommendations

1. **Identify critical performance issues**
2. **Build customer knowledge and capabilities** to more fully capture the incentive for performance provided by net metering and warranties
3. **Ensure that applicable codes are followed and enforced through direct or indirect approaches** (e.g., training of installers & building inspectors, required inspection sign-off)
4. **Consider following California's lead on warranty requirements**
5. **If a more rigorous module rating standard is developed** (nationally or in California)**, consider requiring that modules meet that standard**

Recommendations (cont.)

6. **Consider using AC capacity rating conventions based on module PTC and CEC's inverter efficiency ratings** (if a stipulated rating is used to calculate incentive payments)
7. **Consider how best to support NABCEP certification** (e.g., requiring it, helping certified installers differentiate themselves, offering financial or other forms of support)
8. **Incorporate acceptance testing into the post-installation inspection process** (and/or require that installers do it)
9. **Consider structuring incentives as an EPBB and possibly moving to a PBI for large projects**
10. **Employ minimum design standards if EPBBs or PBIs are not used** (preferably based on estimated energy production)

For more information

Download the report:

http://eetd.lbl.gov/ea/emp/reports/61643.pdf

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