Solar American Board for Codes and Standards

2010 Gap Analysis Final Report

July 12, 2010

Summary

The Solar America Board for Codes and Standards (Solar ABCs) 2010 Gap Analysis process was a formal review of the current state of the major codes and standards that bear on PV. The process identified major gaps that exist in the current work on codes and standards. These were then prioritized and developed into a strategic plan for the activities of the Solar ABCs for Year 4 and future years. Wherever possible, Solar ABCs will address the highest priority activities. Solar ABCs will also recommend others to address some of the important remaining activities.

From topics suggested by stakeholders, the Solar ABCs Steering Committee identified the following high priority topics to be addressed and placed them in this order.

Highest Priority Topic

- Follow-up Research on Flammability Issues

Second Highest Priority Topics

- Ground Fault Protection Improvements to Prevent Fires
- Standards for PV and Energy Storage
- Connection Issues of PV to the Smart Grid
- Guidelines for Utility Inspections of PV Systems

Third Highest Priority Topics

- Training for Installers and Fire Officials
- Develop operation and maintenance best practice guidelines including periodic safety-targeted inspection programs for Bypass-Diode Failures
- National Model Fire Guidelines
- Model Building Codes (ICC)
- Extend Expedited Permitting Guidelines to More Small Systems
- Develop Permit Guidelines for Large Systems
- Accuracy of Electro-Mechanical Meters
- Time-of-use Rate Structures

The following topics are recognized as being high priority, but the Solar ABCs will defer any work on these topics until further research or work at national labs is complete:

- Inverter Qualification Standard
- Standards for Power Conditioning and DC-DC- Converters
- Standards for High Penetration Solar

Solar ABCs recommends that, if possible, DOE fund the following task outside of the Solar ABCs as this task requires more resources than Solar ABCs currently has available.

- Web-based Code Official Training

The following topics are also recognized as high priority, but other organizations are working on the tasks already:

- Testing for Firefighter Safety (Underwriters Laboratories)
- Large Generator Interconnection Standards (Federal Energy Regulator Commission)

The Solar America Board for Codes and Standards (Solar ABCs) is a collaborative effort among experts to formally gather and prioritize input from the broad spectrum of solar photovoltaic stakeholders including policy makers, manufacturers, installers, and consumers resulting in coordinated recommendations to codes and standards making bodies for existing and new solar technologies. The U.S. Department of Energy funds Solar ABCs as part of its commitment to facilitate widespread adoption of safe, reliable, and cost-effective solar technologies. For more information, visit solarabcs.org

Introduction

The Solar America Board for Codes and Standards (Solar ABCs) Gap Analysis process reviewed the current state of the major codes and standards that bear on PV, identified major gaps that exist in the current work on codes and standards and prioritized these to become a strategic plan for the development of the Solar ABCs Annual Work Plan for future years. This document reports on the results of the 2010 gap analysis process. Solar ABCs also conducted a gap analysis process in 2008.

This report summarizes the method used to conduct the gap analysis, lists the potential topics identified, and establishes the priorities of the topics that will become the future work by Solar ABCs and others. In Years 4 and 5 of its contract with the U.S. Department of Energy, Solar ABCs will work on as many of the high priority topics as resources allow.

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The Solar ABCs changes the practice of developing, implementing, and disseminating solar codes and standards in the following ways:

- By providing formal coordination in the planning and revision of separate, though interrelated, solar codes and standards
- By providing access for stakeholders to participate with members of standards making bodies in setting national priorities on technical issues
- By developing a centralized repository for collection and dissemination of documents, regulations, and technical materials related to solar codes and standards
- And by creating a centralized home for three key technical services: a) generating consensus 'best practices' materials and disseminating such materials to utilities, state and other regulating jurisdictions, b) answering code-related questions (technical or statutory in nature), c) providing feedback on important related issues to DOE and government agencies.

Method

A Gap Analysis was a major project for the Solar ABCs Steering Committee during its first year of operation. This second Gap Analysis was conducted two years after the first one. Stakeholders provided topics for consideration, the Advisory Committee and Steering Committee refined and prioritized the list of topics, and the Steering Committee developed the final list of high priority Gap Analysis topics.

Prior to soliciting stakeholder input for Gap Analysis, the first step was to develop a list of potential topics (or gaps) beginning with topics suggested during the first Gap Analysis process, but which had not been designated high priority. Included in this list were also high priority topics identified during the first process, but for which work has not yet begun. Finally, before soliciting new stakeholder input, a list was compiled that included all gaps suggested to the Solar ABCs Project Administrator since the completion of the first Gap Analysis.

Next, in the September 2009 Newsletter, Solar ABCs requested Gap Analysis input from all stakeholders. This was followed by the annual Solar ABCs Stakeholder meeting on October 29, 2009, during which the Project Administration briefed stakeholders on the Gap Analysis process and encouraged Stakeholders to submit potential topics. Stakeholders submitted proposed topics to the Project Administrator as a result of these requests.

The Project Administrator compiled the list and sent it to both the Steering Committee and the Advisory Committee for review and discussion. These discussions led to combining topics, adding topics, and reorganizing the way the topics were presented in order to facilitate better review and prioritization. The final list of proposed Gap Analysis topics is included in Appendix A.

The Advisory Committee and Steering Committee each reviewed and prioritized the Gap Analysis list. The Project Administrator compiled the results.

Finally, the Steering Committee conducted a day and a half meeting to prioritize the Gap Analysis topics. The Steering Committee reviewed the individual rankings, discussed, and approved a list of high priority Gap Analysis Topics. Then the Steering Committee developed detailed suggestions for the activities needed for each of the high priority topics.

The Gap Analysis Process was led by the Solar ABCs Steering Committee and managed by the Solar ABCs Project Administrator, Larry Sherwood. The Steering Committee includes one representative from the following organizations: Arizona State University, BEW Engineering, Brooks Engineering, Florida Solar Energy Center, Interstate Renewable Energy Council, National Renewable Energy Laboratory, New Mexico State University, North Carolina Solar Center, PowerMark, Sandia National Laboratories, Sunset Technology, Underwriter Laboratories, and U.S. Department of Energy plus a representative from the Solar ABCs Advisory Committee.

At the time of the Gap Analysis process, the Solar ABCs Advisory Committee included: Jim Baak, Vote Solar; Jon Bertolino, Sacramento Municipal Utility District; Suzanne Borek, New Jersey Department of Community Affairs; Alexander Bradley, Dupont; Nick Chaset, formerly with the California Public Utilities Commission; Marv Dargatz, Enphase Energy; Adam Detrick, SunPower Corp.; Mark Dougherty, Long Island Power Authority; Ryan Gaston, Dow Chemical Co.; Smita Gupta, Itron; Tom McCalmont, McCalmont Engineering; Colin Murchie, Solar City; Rhone Resch, Solar Energy Industries Association; Wilson Rickerson, Rickerson Energy Strategies; Mike Taylor, Solar Electric Power Association; Peter Varadi, Consultant; and Donald Warfield, BP Solar.

First and Second Tier

High Priority Gap Analysis Topics

FOLLOW-UP RESEARCH ON FLAMMABILITY ISSUES

RESEARCH OBJECTIVES

1. Provide specific tests and procedures that can be applied to PV installations and components to verify that they will have no impact on the fire rating of roof assemblies (with an emphasis on Class A rated roof assemblies).
2. Develop these tests and procedures into the form needed to serve as input for modifications to existing codes and standards such as UL1703, ICC, Model Codes, etc.

TEST PLAN

Following tests to be conducted at UL Fire Test Laboratory

1. Conduct Class A Spread of Flame tests on Class C PV module mounted over Class A roofs to see if the roof assembly will routinely pass Class A Spread of Flame test. Conduct tests for three different geometries, different module types, and over non-combustible roof products.
2. Verify the Burning Brands Tests previously conducted in order to define when mitigation is required. Conduct tests for different brand locations, different module types, and different roof types including non-combustible roof products. Investigate potential caloric load of debris accumulated under solar array to determine which size burning brand is appropriate for placement between the PV modules and the roof assembly.
3. Conduct Class A Spread of Flame tests for modules at tilts that are not parallel to the roof surface in order to determine how their performance compares with tests conducted on modules parallel to the roof surface.
4. Test several Spread of Flame mitigation techniques in order to develop mitigation recommendations. Document all test methods for preparation of recommendations that these be added to existing standard.
5. Develop and test Burning Brand mitigation techniques in order to provide mitigation recommendations. Tests to be developed after Item 2 tests define when mitigation is required. Develop language for required maintenance and cleaning between module and roof assembly.
6. Conduct Spread of Flame test on a large array to learn if tests conducted on single modules scale accurately to arrays with many modules.

New contractor to be identified for the following task:

7. Perform research to quantify the potential risk identified by the test results. A fire protection research engineer, economist, or actuarial insurance consultant will be hired to conduct this research.

DELIVERABLE: Solar ABCs Report

TIME: Year 4

GROUND FAULT PROTECTION IMPROVEMENTS

GAP: Ground faults have and will continue to be significant cause of failures and fire/fire risk. Arc-fault detection and mitigation measures underdevelopment are not mature for the PV industry and may not address many of the line to ground faults that are common in PV systems. Existing ground fault protection in inverters will not always detect faults in the grounded conductors, and subsequent faults can go uninterrupted (as in the case of the Bakersfield fire) and lead to damaging fires.

SOLUTION: Review and make recommendations on mitigating measures for reducing the risk of damaging ground-faults. These include targeted measures such as improvements to existing ground fault detection circuits in inverters, and/or additional over-current protection in the grounded circuits, to larger systemic solutions such as an emphasis on floating or high-impedance grounded systems as is commonly done in Europe and Asia. The analysis should include cost/benefit of different options as criteria, both for retrofitting existing systems and for new systems.

AUDIENCE: Code and standard makers, inverter manufacturers, industry designers and integrators.

WHO: Solar ABCs should take a lead role in developing recommendations and consensus, and can leverage external activities (such as UL-STP work in the protection area).

LEVEL OF EFFORT: Relatively low to develop problem statement and awareness, and help spearhead solutions with industry.

ENERGY STORAGE AND PV STANDARDS FOR GRID-TIED SYSTEMS

Energy storage required for diversion load, back-feed issues, peak shaving/matching, smoothing for high penetration, or networks with regard to grid-tied PV getting most out of the PV modules.

GAP: A methodology for optimizing power conditioning of PV hybrid systems exists for off-grid applications. An equivalent methodology does not exist for grid-connected PV applications. Currently being applied in an ad-hoc way.

SOLUTION:

- Gather existing data
  (Cost-benefit analysis, literature search and review, gather field data on existing demonstration projects - e.g. Lanai, Portland General Electric, San Ramon Facility)
- Write a White Paper on information gathered
  (Potential value to utilities, potential interactions with Smart Grid functions, recommendations for additional investment if needed)

AUDIENCE

Utilities, System Integrators, System designers, Public utility commissions
Eventually, funding bodies, EPRI

WHO

Solar ABCs
- Overseeing the project
- Progress reviews
- White paper

Labs
- NREL
- Sandia National Laboratories (SEGIS, Storage)
- PNNL
- Other test labs – ASU, DUIT

NIST Smart Grid group
Utilities (SMUD, Xcel, APS, AEP, OUC, PNM, etc.)
EPRI members
NYSERDA, CEC, other state energy offices, which may have funding available

LEVEL OF EFFORT

Solar ABCs:
- Overseeing, performing lit searches
- Writing white paper

Labs, utilities and manufacturers:
- Data sharing
- Writing/reviewing white paper
- Additional effort would likely be required based on results of white paper

STANDARDS FOR CONNECTION OF INTELLIGENT PV OR DG SYSTEMS TO UTILITY SMART GRIDS OR MICROGRIDS

GAP: Most inverter manufacturers may not aware of requirements to interface with smart grid and do not seem to be participating in development of interface, though ~5 contractors are required to be involved through SEGIS (solar energy grid integration systems)

SOLUTION: Identify current activities and inverter communication issues; get manufacturers involved

AUDIENCE: Inverter manufacturers, project developers, utilities

WHO: NC Solar Center

LEVEL OF EFFORT: limited

DELIVERABLE: Two-page description, webinar

WHEN: Year 4

DEVELOP OPERATIONS AND MAINTENANCE BEST PRACTICES GUIDELINE

GAP: There needs to be an larger overall system inspection procedure, for periodic evaluation of component damage that can result in later failures - including diodes, cabling, connections, etc. An example issue is undetected bypass-diode failures may be an endemic industry-wide sleeper problem and may lead to long term and failure/fire concerns. Need to determine the extent of problem and develop solutions.

SOLUTION: Outline and draft high-level and targeted inspection procedures. Leverage existing expertise in the area to create publicly available guidelines, which can be individually tailored for specific applications and market segments, e.g. residential systems with shading, vs. large scale commercial, event targeted inspections such as post lightning strike, e.g. apply inspection protocols and take note on each inspection item's value and resulting importance. Consider research on non-invasive, low labor methods of detecting bypass diode failures, e.g. high frequency or AC impedance measurements at the string or combiner box level. Also consider quality-based problems — better test standards for the diodes themselves. Consider an initial survey — targeted inspections to try and get some statistical understanding of the extent of the problem.

AUDIENCE: Installers, owners.

WHO: Solar ABCs led effort, possible leveraging of research and testing tasks.

DELIVERABLE: Report with Guideline recommendations.

EXTEND EXPEDITED PERMITTING GUIDELINES TO MORE SMALL SYSTEMS

GAP: Further expedite the process. There may be a gap for ac modules and other new technologies such as string inverter concepts.

SOLUTION: Update Expedited Permit Process report and then keep it up to date. Include minor expansions for new technologies.

AUDIENCE: Code officials, installers, designers

WHO: Brooks Engineering

LEVEL OF EFFORT: Small

DELIVERABLE: Revised Expedited Permit Report

WHEN: Year 4

INTERNATIONAL CODE COUNCIL (ICC) CODE DEVELOPMENT

Prioritized topic was Model Building Codes Regarding PV

(recommendation developed by Larry Sherwood)

GAP: Stakeholders are not participating in International Code Council (ICC) Code Development activities. Recently, ICC has considered code changes for the International Fire Code and the International Plumbing Code, which affect PV installations.

SOLUTION: Solar ABCs should facilitate a group of stakeholders to develop code change proposals and provide comments on proposed changes. The group could operate similar to the PV Industry Forum, which provides recommendations for changes to the National Electrical Code. Codes include the International Building Code, the International Fire Code, the International Plumbing Code and the new International Green Construction Code. Perhaps this group could also comment on the Uniform Solar Energy Code developed by IAPMO.

AUDIENCE: ICC, solar industry, code officials

LEVEL OF EFFORT: Moderate – need someone to coordinate the activity.

WHEN: On-going

ACCURACY OF ELECTRO-MECHANICAL METERS OPERATING IN THE REVERSE DIRECTION IS MUCH LOWER THAN AS DESIGNED FOR FORWARD OPERATION

GAP: A report from Measurement Canada indicates electro-mechanical meters operating in the reverse direction run slightly slow

SOLUTION: Review Canadian study and meter standards to identify if inaccuracy in reverse direction is possible and recommend next steps (not testing meters)

AUDIENCE: Utilities, utility commissions, standards bodies (NIST and ANSI)

WHO: NCSC, BEW, or FSEC, etc. (or NIST or ANSI)

DELIVERABLE: Report

EFFORT: Small effort

RATE STRUCTURES

GAP: No existing factual analysis of rate impact by utility

SOLUTION: Need analysis of impact on utilities of various rate structures, including flat, TOU and demand-metered. Need to address variations by utility of location, generation mix, etc.

AUDIENCE: Utility commissions, legislators

EFFORT: Huge if utility by utility, but helpful to start with a few

DELIVERABLE: Report

WHEN: Year 5

Appendix A

Suggested Gap Analysis Topics

(in pdf file)

STANDARDS	
Needed Standards	
	Standards for Installation and Operation
	Standards for CPV Tests (done?)
	Standards for connection of intelligent PV or DG systems to utility smart grids or microgrids. May require more than one standard.
	Limitations in the *NEC* for determining the ampacity of conductors operating over 80 degress C.
	Standards on Manufacturing Safety Practices
	Test standards for non-PV solar technologies (apart from solar thermal). Safety, reliability and performance testing standards. Examples are dish sterling technology and solar thermal for absorption chillers.
	User education standards, e.g. specify, use, test, measure, install, operate, maintain, integrate, connect, analyze, trouble-shoot, repair
	EVA Gel Content Test Method Validation (Need to make standard acceptable for PV manufacturer)
	Standards for connections between equipment including hardware, firmware, software
	Standards for packing, labeling, shipping and recycling
	Manufacturing Waste Practices: Defined standards on manufacturing waste stream and subcontractor waste management (follow up from Washington Post article on Poly waste disposal)
	Standards for shipping & recycling –consider voluntary industry product take-back standards as well.
	Clairfy the boundary between UL listing and local permitting requirements.
Standards/Certification Process	
	Need cell qualification process (Why do component testing if you still have to do module testing?)
	Concern about new UL test facility and near monopoly of UL with testing
	Significant Interpretations from UL are onerous and in some cases require UL lab testing. Not fair for other NRTLs who may interpretate differently. Changes of this magnitude should be run through STP and written into standard.
	Overall certification process takes too long
	Restructure the UL Standards writing process to allow it to better meet the needs of an industry where the technology is changing rapidly.
	Exact list of polymeric materials tests (as per UL 1703) for encapsulant, junction box, cable, connector and backsheet.
Certification/Qualification	
	Develop QA Guidelines for deterining lifetime testing
	Encourage adoption of Solar ABCs qualification policy
CODES	
Fire Safety Issues	
	Fire Codes vs Electrical Codes when dealing with batteries
	National Model Fire Safety Guidelines (so California Guidelines do not become the national model)
	Follow-up work to Fire Safety Research Project (recommendations, more research?)
	Fire Rating of PV Laminates
	BIPV and Fire Safety issues
	Testing for fire safety. Generic testing to answer questions firefighters have about interaction of PV and structural fires.
	Flammability Testing of Roofs and Rack-mounted PVs (follow-up to previous research)
	Test a large array rather than one module (what is the sensitivity of results to the size of the array?). One manufacturer for all modules in the array. Are the completed results with one module the same or different as a test with a large array.
	Vary the impingement location of the flame so the flame is at the top of the PV module.
	Test varying stand-off heights to determine at what threshold the roofs passed
	Characterize the exposure of the roof from a room of content fire over the roof eave.
	Test the performance of Class C PV on concrete tile roof (plus maybe metal roofing) on combustible decks (non-combustible roofing) (790 test) How does this construction differ with current test results?
	Test other typical commercial applications. Vary tilt of module relative to roof. Low slope
	What is correlation between Class A brand and debris accumulated under solar array in the field. Caloric load. (do literature search first)
	What is the extra potential fire risk from PV installations? Address field data.
	Research possible solutions (testing mitigation measures).
NEC	
	Gap between NEC 690 for PV and non-PV Concentrating Solar Power Systems
	Semi-conductor based disconnects: right now, a solid-state wwitch is not allowed as a system disconnect
	Smart grid connections realted to fire safety and the NEC
	Initiate discussions with NFPA concerning the lack of current technical expertise on Code Making Panels, which is significantly hampering the development of codes that address the requirements for the application of sophisticated electrical and electronic power conversion devices as well as circuits containing these devises.
	Investigate whether or not the dc overcurrent devices currently used in outdoor PV combiner boxes are or are not suitable for use in the PV combiner box environment.
Model Codes	
	Wind Load Testing, Analysis and Design Code Development
	Wind loading codes for ballasted rooftop systems
	Expedited permitting and/or best practices for systems which do not fall within the criteria of the current expedited permitting process

	Companion report to Expedited Permitting Report dealing with utility permitting/inspection best practices or recommendations.
	Web-based Code Official Training
	Model code should be developed for seismic areas (Some stakeholders thought this is not necessary)
Building Codes (non-electrical)	
	Model building codes regarding PV
	Coordinate with ICCon model building codes
	OSHA rules on PV set-backs on roofs
	Coordinate with ICC-ES, on code compliant testing standards
INTERCONNECTION AND NET METERING	
Utility Rate Design/Net Metering	
	Residential Rate Structures and Solar (AB1x/flat or volumetric rates vs. TOU rates)
Interconnection	
	Potential of AMI Data to Reduce Technical Issues Related to Interconnection
	Examination of NREL RSI Studies and guidance to states adopting interconnection procedures and net metering laws
	Ownership data from AMI Systems
	Standard for access to AMI data for Smart Grid interconnection priorities related to energy availability and energy useage
	Issue of large installations and high penetration on grid stability. Can beneficial voltage support requirements and anti-islanding provisions co-exist?
	Accuracy of electro-mechanical meters operating in the reverse direction is much lower than as designed for forward operation
	Review of costs associated with different interconnections standards (Ca's Rule 21, FERC Small Generator Interconnection Protocol). In CA, solar participating in CSI is subject to fast-track interconnection (no interconnection study), whereas through AB 1969 feed-in tariff, generators are subject to FERC SGIP, and therefore may have to bear the costs of interconnection studies and system upgrades.
	Common SW & HW connection protocal from all inverter manufactures: Mechanical connection, refresh rates, minimum data transferred.
GENERAL OR CROSS-CUTTING	
Installation Guidance/Best Practices	
	Provide guidance for sizing line-side interconnection conductors
	Best practices for solar thermal permits and inspections - wide variation in Minn. Some require 3 inspections (plumbing, mechanical, structural)
	Work with OSHA to get roof safety issues before PV stakeholders
	What tools, methods, knowledge, training is required to design, assemble, install functional systems – handbooks for designers, installers, users
BIPV Issues	
	Develop research agenda to create data on which to base BIPV Standards related to NOCT test. Could be based on CEC specifications.
	Add BIPV to list of issues for Product Safety Panel
	Parametric certification of BIPV
	Include in NEC: BIPV Issues
Performance Study	
	Study the effects of airborne debris on PV modules or solar heating panels. Is this in regards to soiling or impact resistance/reliability?
	Study the effects of shading on PV performance. In particular in the context of PV Incentive Programs where incentive calculators that include shading calculations.
	Thermal interaction of BIPV with the building envelope and the effective heat transfer through the building element into the conditioned space
Utility-Scale Solar Policies	
	Large Generator Interconnection Policies and Procedures
	Streamlined Environmental Permitting
	Renewable Energy Transmission Access Policies & Procedures
Solar ABCs PROCESS/PRODUCTS	
	Start Industrial Affiliates Program to fund some additive codes and standards work from industry.
	Conduct more discussions/presentations/webinars on reports
	Redesign web site – current website is confusing. Want to be able to find reports easily.
	Some "quick survey" work with the stakeholders involved in these reports might be a useful addition – no more than 5 questions – firefighters, utilities, city planning departments, code inspectors, etc.