Texas Solar Collaboration
DOE Rooftop Solar Challenge
City of Houston Project Summary

Acknowledgment: "This material is based upon work supported by the Department of Energy under Award Number DE-EE0005702

Disclaimer: "This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."

Table of Contents

Introduction 1

Task 1.0 Stakeholder Coordination 2

Task 2.0 Permit and Interconnection Process Improvement 2

Task 3.0 Net Metering and Interconnection Standards 2

Task 4.0 Financing Options 3

Subtask 4.1 Establish a Solar Communities financing option 3

Subtask 4.2 City of Houston will foster the implementation of Texas Senate Bill 981 3

Task 5.0 Planning and Zoning 4

Task 6.0 Program Performance Analysis 4

Task 7.0 Training 4

Task 8.0 Project Management and Reporting 4

Task 9.0 - Market Assessment 4

Successes and Lessons Learned 5

Appendices

Appendix A Stakeholder Participation
Appendix B Time-Based Process Map
Appendix C Permitting Information Technology Solution Narrative
Appendix D Good Company Report
Appendix E Net Metering In Houston
Appendix F Net Metering and Interconnection Stakeholder Meetings
Appendix G Solar Leasing White Paper
Appendix H Subtask 4.2 Meeting Summaries
Appendix I White Paper – Homeowner's Associations
Appendix J Historic Homes Case Study: Innovation Avenue
Appendix K Verification Letters
Appendix L Onsite Workshop for Code Officials
Appendix M Metrics Verification Letters

Introduction

The City of Houston is committed to achieving a sustainable solar infrastructure. In 2008, Houston was named a United States Department of Energy (DOE) Solar America City. As a Solar America City, Houston teamed with the Houston Advanced Research Center (HARC), Sandia National Laboratory (Sandia), industry, and academia, to implement the Solar Houston Initiative and prepare the Solar Houston Plan. The Solar Houston initiative was focused on identifying and overcoming barriers associated with establishing a solar infrastructure that is incorporated into the City of Houston's overall energy plan. A broad group of Houston area stakeholders, facilitated by HARC, came together to develop a comprehensive solar plan that went beyond technology to address barriers and establish demonstrations, public outreach, education programs and other activities.

The plan included proposed scopes of work in four program areas: policies, solar integration, public outreach, and education. Through the support of the DOE SunShot Rooftop Solar Challenge (RSC) grant to the Texas Collaboration (San Antonio, Austin, and Hosuton), Houston has been able to implement several of the recommendations of the Solar Houston Plan. Specific recommendations that this project was able to support include:

[THE ELECTRIC RELIABILITY COUNCIL OF TEXAS (ERCOT) OPERATES THE ELECTRIC GRID AND MANAGES THE DEREGULATED MARKET FOR 75 PERCENT OF THE STATE, INCLUDING HOUSTON. THE ERCOT MARKET AND THE SOLAR RESOURCES IN HOUSTON OFFER FAVORABLE CONDITIONS FOR SIGNIFICANT PENETRATION OF SOLAR PHOTOVOLTAIC (PV) IN TEXAS, INCLUDING GOOD SOLAR CONDITIONS, CORRELATION OF PEAK POWER PRICES WITH SOLAR PV LOAD CURVE, AN EXPANDING TRANSMISSION SYSTEM AND DEVELOPMENT OF STORAGE AND TRANSMISSION TECHNOLOGIES, AND A RELATIVELY SIMPLE PERMITTING PROCESS]

- Working with the other Texas Solar America Cities (San Antonio and Austin), to harmonize permitting and inspection processes to simplify for installers and lower soft costs of installation.
- Participating in state level solar policy groups such as the Texas Renewable Energy Industries Association (TRIEA).
- Continued coordination with the local transmission and distribution utility (CenterPoint) and retail electric providers (REP).
- Identification of opportunities to improve permitting and interconnection.
- Providing training on PV systems to City inspectors.
- Educating the public by continuing outreach, training, and workshops, particularly using the the Green Building Resources Center.
- Evaluating methods of addressing financial barriers to residential solar
- Maintaining www.solarhoustontx.org.
- Continuing meetings with stakeholders to get ongoing feedback from the solar community on their needs.

The following sections provide a brief summary of the activities completed under each of the nine tasks specifically related to the RSC grant. Reports and other backup information are included in the appendices.

Task 1.0 Stakeholder Coordination

The Texas Solar Collaboration, under the leadership of the City of San Antonio, formed a steering committee. A series of meetings were held to finalize strategies and workflows and assign accountabilities. This task included mandatory attendance of a minimum of twelve teleconferences and two face-to-face workshops. At least one member of the Houston team attended 19 teleconferences and 3 face-to-face meetings/workshops. A summary of these activities is presented in Appendix A.

Task 2.0 Permit and Interconnection Process Improvement

The purpose of Task 2.0 was to develop and establish best practices for a standardized, transparent and expeditious permitting and interconnection process within the City of Houston. Under this task there were three subtasks, described below.

- Subtask 2.1 Create a Time-Based Process Map for the Permitting and Interconnection Process for the City of Houston. A copy of the time-based process map is included in Appendix B.
- Subtask 2.2 Establish Information Technology Solution. This task involved creating a scope of work for the City of Houston technology solution to allow applicants to process solar permitting and interconnection online entirely. A copy of this report is included in Appendix C.
- Subtask 2.3 Outline an Action Plan to remove all non-value elements within the permitting and interconnection process. The collaboration contracted with Good Company and Associates to assist in the review and propose improvements. A copy of the report prepared by Good Company and Associates is included as Appendix D.

Task 3.0 Net Metering and Interconnection Standards

The purpose of this task was to develop and make available standards of equity and quality assurance within net metering and interconnection within the City of Houston. In Houston's deregulated market net metering, as defined by the Texas Public Utilities Commission (PUC), is the responsibility of the REPs and interconnection is the responsibility of the regulated transmission and distribution utility (CenterPoint). Under this task, the Houston team prepared a brief summary of net metering options available to Houston residents (Appendix E). The Houston team also prepared an interconnection factsheet that was distributed at a public meeting held on February 9th, 2013. The net metering and interconnection information is also posted on www.solarhoustontx.org.

In addition, this task included Subtask 3.1 - Make available best practices and technical assistance to relevant stakeholders regarding net metering and interconnection standards. The deliverable under this task was a narrative documenting a minimum of five meetings with relevant stakeholders and solar advocacy groups. Appendix F presents a summary of 19 meetings with relevant stakeholders.

Task 4.0 Financing Options

The purpose of Task 4.0 was to enable multiple financing options by establishing a foundation for community solar programs and/or third party ownership models within the City of Houston. This task included two subtasks, described below.

Subtask 4.1 Establish a Solar Communities financing option

Under this subtask, the City of Houston was to promote existing solar lease programs available to community members. Under the Solar America Cities Solar Houston Initiative project, the Tiger Team contracted with Keyes and Fox to analyze the legal issues surrounding community solar in Texas. These documents were included in the Solar Houston Plan and shared with the other participants in the RSC Texas Collaboration. HARC also presented this information to the trade organization, Houston Custom Homebuilders.

Subtask 4.2 City of Houston will foster the implementation of Texas Senate Bill 981

The 2011 Texas Legislative session passed Senate Bill 981 that permitted third party solar ownership in the unregulated markets. Under this subtask the City of Houston was to encourage the growth of this new solar market, as an alternative to self-own and self-finance. During the course of this project, several companies abandoned their solar lease offerings, however NRG Energy, parent company to Reliant Energy (the largest REP in the Houston area) and Green Mountain Energy (another REP in the Houston Area) has recently reformed and revised their solar leasing offerings, and are rolling out a new program in 2013. In addition, other companies such as SpearPoint Energy have been exploring expanding their commercial solar leasing programs to the Houston market. Under this task, the Houston team:

- prepared a white paper summarizing the pros and cons of solar leasing, leasing options (Appendix G)
- organized meetings with SpearPoint Energy and local commercial and government entities to raise awareness of solar leasing options
- conducted a public meeting on February 9th, 2013 where NRG presented information to the general public on their new residential leasing offering

In addition, this task included a requirement to complete one meeting with Legislative delegates. To this end, HARC representatives participated in the Texas Renewable Energy industries Association Legislative Agenda Meeting for the Distributed Solar Subcommittee on Monday September 24th, 2012 and met with Paul Cuaduro, a member of an energy policy advocacy and lobbying group, to discuss distributed generation and decoupling of rates for utilities on Thursday January 24, 2013 (Appendix H).

Task 5.0 Planning and Zoning

The purpose of task 5.0 was to establish best practices for local codes and land use policies to maximize photovoltaic site options within the City of Houston. Houston is the largest city in the US without zoning. However, residents can still be restricted by Homeowner Association (HOA) rules, or rules related to historic properties. Therefore, under this task, the Houston Team prepared a white paper on working with HOAs in the City of Houston (Appendix I) and a white paper on Reliant Energy's Innovation Avenue Project that included installing solar on a Historic Home (Appendix J). The Houston team also presented information on Texas House Bill 362 to the Houston Custom Homebuilders and at a public meeting held February 9, 2013. The website www.solarhoustontx.org was also updated to include information on working with HOAs and the process for gaining approval on historic homes, including a factsheet/checklist explaining Texas House Bill 362 and providing a sample letter for residents to use to document their neighbors' acceptance of the project. A series of meetings were held with installers to gauge their experience working with HOAs since the implementation of the bill. In general, the installers noted that while there were some HOAs that needed education about House Bill 362, once they were aware of the bill they were generally willing to allow the project to progress. However, challenges remained in both educating the HOAs and in some HOAs interpretation of the law itself. TREIA and others are currently working with members of the legislature to attempt to clarify some of the language during the next legislative session.

Task 6.0 Program Performance Analysis

Under this task, letters were obtained from Akari Energy, Alternative Power Solutions, Ameresco Solar, Ignite Solar, Ontility, NRG Residential Solar, Peterson Dean Roofing and Solar, and Texas Solar Outfitters, to verify from the solar residential and solar commercial sectors that process and protocol improvements are present within the City of Houston. Copies of the letters are included in Appendix K.

Task 7.0 Training

Houston team members completed the DOE "Photovoltaic On-line Training for Code Officials (PVOT). Houston also held a one day on-site workshop for code official and others on January 22, 2013. A copy of the presentation from the onsite training is included in Appendix L

Task 8.0 Project Management and Reporting

The City of Houston provided the City of San Antonio written quarterly progress reports and provided inputs to assist the City of San Antonio in completing administration and reporting in accordance with the Federal Assistance Agreement.

Task 9.0 - Market Assessment

The City of Houston updated the Houston jurisdiction report for 2013 (Appendix M) in DOE/ National Renewable Energy Lab Solar Metrics Rooftop Solar Challenge Database. Appendix M also includes copies of independent industry verification letters provided by Akari Energy,

Alternative Power Solutions, Ameresco Solar, Ignite Solar, Ontility, NRG Residential Solar, Peterson Dean Roofing and Solar, and Texas Solar Outfitters.

Successes and Lessons Learned

Houston has had several successes related to this project. One early success was related to the permitting and interconnection process. Because permitting is managed by the City of Houston, and interconnection is managed by the utility CenterPoint energy, the two entities were not aware that they had slightly differing requirements related to inverter certification. This opened up the possibility that a PV system could be permitted by the city, installed as permitted, but could be denied interconnection because an unacceptable inverter had been used. Based on the conversations that took place under this grant, this potential problem was identified, and the City modified their requirements for permitting to reflect CenterPoint's requirements for inverter certification, thus avoiding any expensive and time consuming replacements at the end of the project.

Under the financing task, NRG is rolling out a new residential solar lease program. That program, bundled with the PV buyback programs offered by the retail electric provider subsidiaries Green Mountain Energy and Reliant Energy (the largest REP in the Houston area) offer customers new cost effective financing mechanisms for residential PV. In addition, new companies, such as SpearPoint Energy have begun marketing commercial lease and PPAs to the commercial market in the Houston area.

Marketing PV can also represent a significant soft cost, and opportunities to lower this portion of the soft cost will benefit installers and customers. Consumer education was one area specifically identified by the stakeholder group areas as an area that needs additional work. Bundling was identified as a promising marketing technique. Customers appear the most willing to purchase PV when done in tandem with other purchases, such as adding PV to a new house or adding PV to an existing house at the same time that the roof is being replaced. Companies like the homebuilder Lennar and the roofing and PV company Peterson Dean are capitalizing on this new market. In addition, NRG has observed that they can lower marketing costs by evaluating their existing customer base and completing targeted marketing to customers that would be most likely to benefit from their programs.

Another success was with training. Inspectors and others in the community have had the opportunity to complete both the DOE on-line PV inspector training and have had the opportunity to be trained in person, best practices for PV installations to increase efficiency and safety. The inspectors present at the code official training were introduced to the Solar ABCs permitting process template for typical installations. Going forward, there should be follow-up with the inspectors to make sure they have read and are using the suggested process and suggesting to contractors that they use the forms.

Collaboratively, the Texas team presented its successes and findings at the Texas Renewable Energy Industries Association Conference. The project has been promoted in the HARC newsletter, a booth at Houston's Energy Day, and Houston's US Green Building Council chapter is preparing a summary paper based in part on the work of this project, and they have scheduled

a press conference for mid-march to promote PV in Houston. The website www.solarhoustontx.org has also been updated to provide additional information to local people interested in PV and present the outputs of the project.

One of the challenges going forward will be to continue the momentum. Stakeholders have responded positively to the process, and have expressed interest in continuing the process going forward, even going so far as to suggest topics for upcoming meetings. Also, educating the general public on PV is an ongoing challenge. To continue the momentum we suggest a community-based social marketing campaign to help build more grassroots enthusiasm and knowledge to empower consumers and frequent, if small, interactions using platforms such as Facebook, to help share success stories, lessons learned, and in general, help build and maintain enthusiasm

Appendix A Stakeholder Participation

Houston's Participation in Texas Collaboration Meetings

1. Teleconference -Thursday, April 26, 2012 2:00 PM-3:00 PM, SunShot Project Management Team
2. Teleconference -Thursday, May 24, 2012 2:00 PM-3:00 PM SunShot Project Management Team
3. Webinar – Thursday June 28, 2012 Addressing Solar Myths and Misconceptions
4. Teleconference - Thursday, June 28, 2012 2:00 PM-3:00 PM,SunShot Project Management Team
5. Teleconference – Tuesday July 3, Solar Permitting training
6. Teleconference- Tuesday, July 10, 2012 10:00 AM-10:30 AM, Scope of Services Budget Development - Houston Community College
7. Teleconference- Friday, July 13, 2012 2:30 PM-4:30 PM, SunShot Regional Facilitator Evaluation
8. Teleconference –Monday July 23, 2012 2:00-2:30, Scoring Solar Regional coordinator call
9. Teleconference –Monday July 30, 2012 2:00-3:00, SunShot Project Management Team
10. Teleconference –Monday August 20, 2012 2:00-3:00, SunShot Project Management Team
11. Teleconference –Wednesday August 22, 2012 10:00-10:30, DOE Bi-Monthly Check-in
12. Teleconference – Thursday September 6, 2012 1:00-2:00, Kick-Off with Chris Winland, Good Company
13. **In-Person Meeting** – September 27, 2012, San Antonio time-based process map meeting
14. Teleconference - Friday, October 05, 2012 1:00 PM-2:30 PM, DOE South Regional Collaboration Call
15. **In-Person Meeting** –October 11, 2012, Austin time-based process map meeting
16. Teleconference – October 12, 2012 2:00-2:30, Value of Solar Progress Report
17. Teleconference – Friday November 2, 2012 2:30-3:00, Agenda Compilation/Prep for Feasibilty-Harmonization Session
18. Teleconference –Thursday November 11, 2012, 1:00-4:00, SunShot Process Map Feasibility and Harmonization Session
19. **In-Person Meeting** –Wednesday December 12, 1:40 – 3:30, Texas Collaboration presentation at Texas Renewables 2012.
20. Teleconference - Friday, January 11, 2013 8:30 AM-10:00, Rooftop Solar Challenge South Regional Collaboration Call
21. Teleconference - Friday, January 11, 2013 1:00 PM-1:30 PM, San Antonio Rooftop Solar Challenge Bimonthly Check-In Call
22. Teleconference - Monday, February 04, 2013 2:00 PM-3:00 PM, Rooftop Solar Challenge PM Team Meeting

Appendix B Time-Based Process Map

Process Map for Solar PV System Permitting and Interconnection

Appendix C Permitting Information Technology Solution Narrative

IT Solution to Improve the Permitting Process

Over the past decade Houston has taken significant strides to implement and promote sustainability. Currently the City of Houston's Green Building Resource Center stands testament to the determination of city officials to make Houston truly green. Houston was named a Solar America City by the Department of Energy (DOE) in 2008 and is part of the Texas Solar Collaboration as part of the DOE Rooftop Challenge Grant. In that time, Houston has made significant progress in addressing the challenges associated with installing solar in the City. One of the challenges related to soft costs of solar are the time and associated costs related to the permitting process. From 2000 to 2010, the Houston area has witnessed unprecedented growth, with the population increasing by nearly 700,000.[1] The City of Houston is working to address the needs of this growing population, including building the new One-Stop Code and Permitting building. The Houston Permitting Center opened in June 2011. It combines the majority of the City of Houston's permitting and licensing into one place with a mission to help customers achieve their goals while complying with the City's regulations. The stated mission "requires a continuous pursuit of improving the customer experience. Providing excellent service, streamlining business processes, implementing innovative technologies, and proactively engaging customers are all cornerstones of this philosophy."

To that end, the City would like to improve the permitting process with a new IT solution. The current system demands that in order to obtain structural and electrical permits for solar PV installations, application packets that include the hard copies of plans must be submitted in-person to the Center. Once submitted the application must be reviewed by up to six different individuals in more than four departments. Challenges with this current process include:

1. **Project plans must be submitted on paper**. Installers must provide a hard copy of all blueprints, manuals, and other documents that pertain to the project. When the Permitting Center receives the plans, they are scanned to a digital file and then recycled.
2. **Customers must be physically present to submit the application**. The Permitting Center has One-Stop Residential where residential plans need to be reviewed by only one plan reviewer and ideally an installer can leave the Permit Building within two hours with permit in hand. However, all designers must be physically present to submit the application. For structural permits, the installer must pick up the permit in person from the Center. If the project plan is incomplete or incorrect, or for some other reason is not approved within the same day, then an installer is forced to make multiple trips. This can prove to be costly for the contractor/customer.

[1] 2012. Harris County Budget Management Population Study. Volume 14 – February 2012. http://www.harriscountytx.gov/CmpDocuments/74/Budget/FY%202012-13%20Population%20Study%20(Frank).pdf

3. **Plans are reviewed sequentially, not in parallel**. For those plans that cannot be reviewed by only one plan reviewer, plans are stepped through the internal departments within the Permitting Center in a sequential manner. Plan review could be expedited if there was a technological solution that allowed for plan reviews to occur in parallel.

According to the Alliance for Building Regulatory Reform in the Digital Age most jurisdictions with a paper plan review process have three major problems. The first problem is that designers submit incomplete application packages. The second is associated with the financial and environmental costs of designers having to submit plans in person. The final major problem is the inability to conduct parallel plan reviews.[2] The major problems stated here are very similar to the ones posed by the Houston Permitting Center. To solve the aforementioned issues, many jurisdictions like Osceola County, FL, Bend, OR, and Atlanta, GA have turned to an IT solution. Atlanta, with a metro-area population of 4.2 million, has successfully streamlined the city's building permit and plan review process. Atlanta's ePlans © System was launched in 2008. Atlanta has estimated that since the installation of ePlans the city's environmental impact has decreased significantly.[3] Alongside the environmental benefits, electronically streamlining permitting and plan review by using an electronic plan review system can reduce the process time by 70%.[4] For Houston, there are numerous advantages to converting the current permitting system to an ePlan system. These benefits include the following:

- Parallel plan review by multiple divisions within the Permitting Center, reducing overall plan review time
- Electronic submittal (eliminates the financial and environmental costs of driving) and storage
- When errors are found, resubmission of corrected plans can be accomplished in hours instead of days to months.
- Ability to purchase and retrieve permits electronically

In 2010 the City of Houston Department of Public Works and Engineering (PWE) held a conference meeting with its internal divisions including Code Enforcement, Public Utilities, Engineering, Traffic and Transportation, Right of Way, and Customer Service. The focus of the conference was to evaluate and recommend an electronic solution for plan submission and management for the permit and engineering review process. The PWE wanted an integrated software package that included viewer software, capture software, electronic image/document

---

[2] "White Paper: On Best Practices in Electronic Plan Submittal, Review, Tracking and Storage." Report prepared by The Alliance for Building Regulatory Reform in the Digital Age at Fiatech. Distributed by Avolve Software Corporation.

[3] 2009. "ProjectDox ® ePlan Review Case Study: The City of Atlanta, Georgia." Prepared by Avolve Software Corporation.

[4] 2009. "Federal Grants to State and Local Governments for streamlining and Information Technology." Report prepared by Robert Wible & Associates/Alliance for Building Regulatory Reform in the Digital Age.

management software, and workflow software. Most importantly, PWE needed a program that could handle the volume of permit applications that are received on a yearly basis. Of the multiple ePlan software systems available, the City of Houston determined that an IT solution similar to Avovle Software's ProjectDox® would address these challenges and improve the experience for residents.

ProjectDox® is a web-based electronic plan solution that provides an interface for citizens/contractors and government personnel to complete the permitting process entirely online. Working alongside permitting software, ProjectDox® helps automate the plan review process. When a contractor applies for a permit via email, ProjectDox® uses the email information and sets up a "project." ProjectDox® then invites the contractor to the "project" where he/she can upload their electronic plan files. Plan reviewers can then gain access to the electronic files from any location as long as there is internet available. Multiple reviewers can then make the necessary changes to the plans simultaneously by using the ProjectDox® tools. The plan changes made by each department are distinguished by a color code. Parallel plan review help make the approval process go more quickly – up to 80% faster than the paper review process. Plan changes are then made available to the applicant who can immediately make the revisions and resubmit the plans for approval. All while both parties never leave their offices, eliminating unnecessary time and expense.

A solution like ProjectDox® would greatly enhance the permit application experience for the contractor/customer as the plans can be submitted online, plan review status can be accessed at any time, and overall approval process time is decreased by as much as 80%.[5] An IT solution similar to ProjectDox ® will also assist in the significant reduction of the paper waste produced by the permitting process. Costs associated with printing blueprints, scanning each individual plan for electronic storage, and then recycling the paper waste would be significantly reduced. Solar installers that work in multiple major cities throughout Texas have expressed that using an on-line system would make their jobs much easier and faster.

Finally an IT solution should log and store files so that they are readily accessible for any government party that may have need of them. That way emergency first responders and disaster preparedness and recovery teams could have access to electronic plans during emergency situations. An appropriate IT solution, with the features described above would solve the three major issues of the current system by eliminating paper wastes, putting the entire permitting approval process online from application submission to permit retrieval, and allowing parallel plan review that cuts approval process time by more than half. All of these benefits would result in lower soft costs related to solar PV installations for the residential consumer.

[5] "ProjectDox® Basics." Prepared by Avolve Software Corporation.

Appendix D Good Company Report

[This area reserved for final Good Company Report]

Appendix E Net Metering In Houston

Net Metering in the Houston Market

Background

In 2007, Texas Governor Rick Perry signed into law House Bill 3693 (HB 3693) that, among its many provisions, declared "net metering… be deployed as rapidly as possible to allow customers to better manage energy use and control costs, and to facilitate demand response initiatives." However, the bill did not define net metering. In the fall of 2007 the Electric Reliability Council of Texas (ERCOT), which manages the flow of electric power to about 20 million Texans (including those in Houston area), convened a Distributed Generation Task Force. After a series of negations, ERCOT interpreted HB 3693 as "requiring that all energy put on the grid by a retail customer be separately metered and that compensation for that energy, if any, be left to negotiation between the retail customer and the retail electric providers supplying the customer's retail load."[1]

In December 2008, the PUC abolished the limited non-ERCOT net metering rules, and replaced them with an order consistent with ERCOT's interpretation of HB 3693. The PUC order requires customers installing renewable distributed generation to separately meter all electricity outflows, and payment is provided at a utility's avoided cost, an amount significantly lower than what is typically thought of as part of "net metering." Efforts in 2009 to implement more traditional net metering rules were unsuccessful. In 2009, the Texas legislature evaluated a net metering bill HB1243, but the vote on the bill failed to make the midnight May 30, 2009 deadline. Similar attempts during the 2011 legislative session failed as well. While there will likely be similar efforts during the 2013 session, the concept of "value of solar" currently does appear to be gaining more traction.

Houston Options

Two retail electric providers in the Houston area, Green Mountain Energy and Reliant Energy (both subsidiaries of NRG Energy) offer sellback programs to allow homeowners to receive a reasonable electricity rate for power they sell to the grid. The buyback programs have been available since 2009. Under the Green Mountain Energy Renewable Rewards Program, Green Mountain will buyback excess power produced by the renewable energy system, in the form of a credit per kWh on the customer's monthly invoice. The credit is equal to the excess energy multiplied by the contracted energy rate on the customers Green Mountain Energy electricity contract. Participants must have a system that is less than 50kW, grid tied, with an appropriate Interconnection Agreements in place. Reliant's E-Sense The Reliant e-Sense Sell-Back 12^{SM} plan. The Reliant e-Sense Sell-Back 12^{SM} plan is a time of use plan that has peak pricing from 9:00 a.m. to 4:00 p.m. every day of the year. The sell-back price is equal to the peak-energy charge for the first 500 kWh put back onto the grid each month. Reliant will credit the customer 5 cents/kWh for any surplus electricity placed back onto the grid.

[1] "Freeing the Grid Best and Worst Practices in State Net Metering Policies and Interconnection Procedures" November 2009 edition. Network for New Energy Choices.

Appendix F Net Metering and Interconnection Stakeholder Meetings

Net Metering and Interconnection Meetings with Stakeholders

May 21, 2012

Phone conversation with Texas Solar Collaboration team

June 1, 2012

J. Ronk met with the Houston Renewable Energy Group (HREG), a local renewable energy advocacy organization to discuss issues related to solar in Houston, including net metering and interconnection.

June 20, 2012

J. Ronk attended Webinar "Interconnection Best Practices Guide Update and Comments", presented by Clean Coalition

July 24, 2012

J. Ronk met with S. Stelzer, Director of Houston's Green Building Resources Center, to discuss issues related to PV, including net metering and interconnection, and how that can be communicated to public visitors at his facility.

September 6, 2012

Teleconference with Texas Collaboration and Good Company to discuss permitting and interconnection.

September 10, 2012

C. Morgan teleconference with CenterPoint Energy's Distributed Generation (DG) Services (G. B. Raborn). Bruce Raborn heads the DG division and oversees all solar interconnection applications within the City of Houston. Discussed the basics of CenterPoint's interconnection policy and regulations. Mr, Raborn confirmed that CenterPoint does not offer incentives within the Houston region; there is neither a buyback offer nor a credit offer for those customers that install a residential solar energy system. Raborn stated that he strongly adheres to the Public Utility Commission of Texas (PUCT) regulations regarding interconnection standards and requirements regarding interconnection design and equipment used. For instance, CenterPoint will only accept IEEE or UL standard meters in order to pass their inspection process. The City of Houston's Electrical Inspection Division did not have this knowledge previously and it was discovered that there was a high potential for customers to pass the City's electrical inspection and not CenterPoint's. Raborn confirmed that there have been instances where a customer was denied connection because they had the wrong meter installed. Due to this the City of Houston is in the process of amending the meter equipment standard requirements to match that of CenterPoint. At the end of the first meeting Raborn made it very clear that he supported the

collaboration of the utilities, installers, and city administration to encourage solar power in the Houston region.

September 12, 2012

J. Ronk meeting with Toner Kirsting, builder consultant regarding residential energy. Discussed challenges and best practices, including interconnection and net metering.

September 19, 2012

J. Ronk, G. Dillingham, and C. Morgan meeting with Ontility, local solar training and installation company, to discuss challenges and opportunities in lowering soft costs to solar, including net metering and interconnection.

September 26, 2012

J. Ronk presentation at the Houston Custom Homebuilders association monthly luncheon describing best practices and answering questions related to residential solar in Houston.

September 27, 2012

C. Morgan attended the permitting and interconnection process mapping meeting held in San Antonio.

October 9, 2012

C. Morgan and J. Ronk teleconference with G. B. Raborn of CenterPoint Energy.. Focused on the specifics of the interconnection process, in detail, from the time of applying for distributed generation to the signing of the Interconnection Agreement (ICA) and finally synchronization. Raborn pointed out multiple means to improve the interconnection process. The first amendment that could be made is to begin the interconnection process at the same time as the permitting process by immediately filling out a distributed generation application form when the contractor has begun to design the system. Raborn states that it is best to contact CenterPoint DG when the preliminary design has been sketched up. "Because if they just build…we can come back and say that the generator just will not work with us. It will cause voltage issues…they [customers] should wait until we look over the applications before they buy [the equipment]" (Raborn, October 2012). Therefore it is good to have the ICA in hand before the system is built. Following installation of the design, DG inspects the interconnection components to make sure that they are in compliance with PUCT standards. According to Raborn, failure to pass inspection is the main barrier for a customer successfully being connected to the grid. The main cause for not passing inspection is that the disconnect switch is not on the outside of the meter and there is not a placard indicating where the disconnect switch is located. Raborn also stated that it is becoming increasingly common for the DG inspector to be given the wrong address of the inspection site. In the case of failing the inspection the DG inspector will return to CenterPoint and immediately contact the customer to notify them of their failed status.

Typically another inspection is requested by the customer after corrections are made to interconnection design and the system passes the second inspection. Raborn commented that a major issue rested with the development builders who are installing solar on homes and then selling the property with solar included in the mortgage package. When the ownership of the property is handed over from the builder to the home owner, CenterPoint needs a new ICA from the home owner. Typically receiving a newly signed ICA is difficult and time consuming. Most homeowner's do not understand what they are signing and why it has to be signed. In some cases the homeowner refuses to sign the ICA. When this occurs, Raborn must reluctantly threaten to have the customer's power turned off. "This is an ERCOT (Electric Reliability Council of Texas) rule that we need a valid ICA. We are sent a list of new property owners and then we have to turn around and send them an announcement in the mail that they need to sign an agreement. And they don't know what's going on so we end up having to drive out there and trying to get these signatures in person. A lot of footwork and paperwork goes into this" (Raborn, October 2012).

October 11, 2012

J. Ronk attended the permitting and interconnection process mapping meeting held in Austin.

October 16, 2012

C. Morgan and Good Company lead a meeting on permitting and interconnection. Attendees included City of Houston and CenterPoint employees.

October 20, 2012

C. Morgan and J. Ronk shared a booth with HREG at Houston Energy Day 2012. Conducted education an outreach on best practices for PV at this event attended by over 15,000 people.

November 8, 2012

Teleconference – Permitting and interconnection harmonization meeting

November 13, 2012

Meeting with the Houston Chapter of the US Green Building Council to talk about best practices for PV, including net metering and interconnection.

November 26, 2012

C. Morgan meeting with Reliant Energy to discuss Innovation Avenue project and net metering.

January 9, 2013.

Teleconference, C. Morgan and B. Raborn. Discussed the current issues facing DG. At the beginning of 2013 CenterPoint's legal department had directed that only an updated ICA was necessary for new homeowner's who bought houses with solar already installed on the

property. This eliminated much of the earlier complaints that Raborn had made concerning the reality of interconnecting in Houston. However, Raborn expressed that there is still a problem with sites that are generating electrics but have not sent an interconnection application to CenterPoint nor have they signed an ICA. Raborn (2013) tossed this up to "do-it-yourselfers that purchase an inexpensive, non-certified inverter and install it themselves." When this occurs, Raborn has to instruct the property owner that they must purchase a certified inverter (which is much more expensive) or they have to disconnection their installation. Raborn admitted that this tends to be a tedious process with the customers typically resisting to comply. The do-it-yourselfers only comprise a small percentage of the non-approved installations in the Houston region. A majority of the non-approved installations are related to builders who subcontract out their electrical work (who then turn around and subcontract the solar work) to a third party. The subcontractors are not filling out the necessary DG paperwork at the time of the solar installation. By the time that Raborn and his team is notified of a builder-based non-approved installation, the builder, electricians, and solar contractors are no longer involved in the property. As a result, DG is forced to retrieve the paperwork from the property owner who normally does not know the specifics of their solar installation (equipment, voltage parameters, etc.). CenterPoint is gives the owner several options – complete the DG application (which is a long and arduous process), have the solar disconnected (met by much resistance), or have the property's electric disconnected (CenterPoint's last resort). Currently Raborn is in the process of starting communications with some of the larger retail electric providers to attempt to come up with a solution to the aforementioned.

February 9, 2013

Public meeting for Houston Residents to discuss best practices for residential PV in Houston.

Appendix G Solar Leasing White Paper

Solar Leasing

Introduction

A relatively new option for homeowners looking to add solar to their home is the solar lease. At present, the solar lease option can be found in California, Arizona, Texas, Colorado, Hawaii, New York and Oregon. The most active companies currently offering solar leases are NRG Energy, Sungevity, Solar City and Sun Run. With the uncertainty and/or lack of subsidies the states participating in these programs have ebbed and flowed over the last few years. However, there is an expectation that in the current market solar leasing will make solar viable without the utility and federal subsidies. NRG Energy is currently testing this expectation in Houston, TX where currently no subsidies or incentives beyond the federal tax incentives, exist. Following is an explanation on the state of solar leasing in Houston, TX and explanation of the current financing options.

Background of Solar Leasing in Texas

Solar leasing was introduced to Texas by Solar City in 2010. The program was administered through TXU Energy and covered its Dallas Forth-Worth territory. In 2011, Green Mountain Energy, a part of NRG Energy, began offering a solar leasing program to the Houston area, followed by Reliant Energy, also an NRG company, in 2012. Several other installers in the Houston area also began solar leasing in 2012. These leasing programs were backed by NRG's Sun Capital Financing group. Solar was relatively viable in the Houston area due to the 1603 Treasury Program. . This program provided a direct grant to solar project developers which increased the liquidity in the market by allowing developers to more easily monetize existing tax credits. The expiration of the 1603 Treasury Program in 2012, has made it very difficult to cost effectively install solar in the Houston market. At the end of 2012, NRG ended this leasing program. However, it is expected that in early 2013, NRG will reintroduce solar leasing back into the Houston market. There will no longer be separate retail electricity providers, Green Mountain Energy and Reliant offering separate programs. For this new program, the minimum system size is 2.5 kW and the maximum size is approximately 33 kW. The maximum system price is $150K. To further develop the market, Green Mountain Energy and Reliant Energy will continue to offer sellback programs (a type of net metering) to allow homeowners to receive a reasonable electricity rate for power they sell to the grid. The buyback programs have been available since 2009. One sellback plan is through the Green Mountain Energy Renewable Rewards Program. Under the Renewable Rewards® Green Mountain

will buy-back excess power produced by the renewable energy system, in the form of a credit per kWh on the customer's monthly invoice. The credit is equal to the excess energy multiplied by the contracted energy rate on the customers Green Mountain Energy® electricity contract. Particiapnts must have a <50kW grid tied system with an appropriate TDSP Interconnection Agreements in place. The second option in Houston is Reliant's E-Sense program. E-Sense will provide a sell-back price that will be equal to the peak-energy charge for the first 500 kWh put back onto the grid each month and will credit 5 cents/kWh for any surplus electricity placed back onto the grid.

What is a solar lease and how does it work?

A solar lease is a financing mechanism that allows a homeowner to have a solar system placed on their house with zero to minimal upfront cost. The homeowner does not own the system, rather the homeowner provides the rooftop space to the solar leasing company and in return receives the power generated from the system with the potential, and many times the expectation, of paying less on their energy bills over time. The system is leased from a solar provider, such as SunRun, Sungevity or NRG Residential Solar Solutions. The solar lease is typically set up as a turnkey operation where the solar leasing company has an installer provide the design, procurement, installation, permitting, and commissioning. The leasing company provides the funding for the lease program.

To qualify for a lease, a homeowner must have excellent credit, a FICO score of 700 or greater. Upon credit approval, the leasing company puts the capital up front to pay the solar installer to provide the turnkey service. Upon completion, the homeowner pays the solar leasing company over a specific, agreed upon term. A solar lease typically lasts between 15 to 25 years. In most cases, the homeowner can enter a lease with no upfront costs and pay the same monthly payment over the life of the lease. There is also an option to place a down payment on the system to reduce the monthly solar system payments. A final option includes the homeowner paying for the entire lease at one time at the beginning of the project. This is called a prepaid option. In this case, the homeowner will not have any additional monthly payments for the system, but will have the benefits of having a lease. Benefits for any lease option include: free maintenance, performance monitoring, warranty work over the life the system, and insurance. At the end of the lease, the homeowner can purchase the system at current market rates, renew the lease or have the panels removed.

Outlook on Solar Leasing

At present, the success of solar leasing is largely tied to the availability of subsidies for the solar systems, as well as the expectation that electricity grid prices will increase over time making the system cash flow positive as the grid prices go up and the fixed lease/cost of solar stays the same over the life of the lease. According to the US Energy Information Administration (EIA) although power prices have been rising historically, more recently they have been leveling off and there is an expectation that they will fall slightly in the upcoming decade. US EIA is predicting a 6% decrease nationwide through 2019. This could pose a problem for leasing companies that are including a significant energy price escalation in their customer proposals. The new program rolling out in Houston by NRG Energy Residential Solar Solutions is including zero escalation in energy prices over the time of the lease.

Homeowners choose to place solar on their home for a variety of reasons including environmental benefits and economic savings. Specific to economic benefits, many homeowners anticipate saving on their monthly electricity bill over the long term. This assumption is bolstered by how solar installers develop the solar installation proposal. As mentioned above, some solar installers will place an energy price escalator in the proposal. This escalator helps improve the return on investment and payback of the project. With this escalator, some solar installation companies predict homeowners will save 10% to 15% (Sungevity) per year on their energy bill over the term of the lease. However, homeowners should keep in mind that much of the savings will depend upon price of grid electricity. If the price of grid electricity increases over time, then savings from the solar system will likely increase or be positive over time. If the price of grid power declines over time, then there may be a decrease in savings and potentially no savings on the system.

Solar Financing Options in Houston Metropolitan Area

In Houston, there are few options homeowners can use to purchase a solar system. Each has their own pros and cons. The installation options include paying with cash, taking out a home equity loan, or solar leasing. At present, there are no solar rebates or incentives beyond the federal tax credits, in the Houston area. Below is a table that lists the purchasing options and the pros and cons associated with each.

Options	Pros	Cons
Cash	• No loan payments or interest to pay • Own the system from the start • Likely to add value to your home and does not impede ability to sell home	• Responsible for operation and maintenance, as well as repairs • Unaffordable option for most, particularly without significant subsidies

Options	Pros	Cons
Home Equity Loan	• Likely to add value to your home and does not impede ability to sell home • Can deduct interest from loan on federal taxes minimizing interest costs of loan	• Responsible for operation and maintenance, as well as repairs • Home is collateral for loan • Do not own system until system is paid off
Solar Lease	• Lowest hurdle for entry - zero to minimal upfront costs • Maintenance and Operations, Repair, Insurance and performance monitoring are covered for lifetime of lease	• Solar system may not add value to home since it is not a purchase • Difficult to transfer lease if selling home; • May not realize renewable energy credit benefits or income tax credits over life of system

The benefit of the lease is that it lessens or removes the ownership uncertainty that comes with such a long-term investment by a household. The lease allows for free operation and maintenance, warranty service and system insurance over the life of the lease. However, the extent to which this uncertainty is reduced depends largely on the solar provider. Homeowners need to do their homework as to the reputation of the solar provider to see how well the solar provider provides these added benefits of free maintenance, warranty repair and monitoring.

Most solar installations could be eligible for the 30% federal tax credit. The entire tax credit being available depends largely on the tax burden of the individual. When purchasing a solar system, the homeowner has the option of applying for the solar tax credit. However, when leasing the system, the homeowner does not receive the tax credit, rather the company providing the lease receives the credit. Leasing companies, such as NRG Energy, state they will apply the tax credit to the purchase price of the system, resulting in a lower monthly payment for the homeowner. The homeowner should speak with their solar company to see if the credit is being applied to the price. Further, homeowners need to realize that some solar companies may not have a high enough tax burden to receive the full credit of the system. If this is the case, the homeowner may want to way purchasing options if having that full tax credit would make a straight purchase optimal.

The homeowner must also understand the long-term implications of loaning their roof space to a third party to make sure they are clear on the repercussions of having the system removing prior to the lease term or how the lease will affect their ability to sell the home. The ability to sell the home is a very important component when entering into a lease. The homeowner does have options when selling the

home. One option is after year six, the homeowner may purchase the entire system, thereby removing the monthly lease payment obligation, but still receiving the lease benefits. At his time, if the homeowner decides to sell the home, they may transfer the lease to the new homeowner at no charge. Another option is for the existing homeowner to transfer the lease to the individual purchasing the home. The new homeowner must have a FICO credit score of 700 or better to take on the lease. If the new homeowner does not want to take on the lease or does not qualify for the lease, the existing homeowner can prepay the remainder of the lease payments, after year six of the lease. The new homeowner will receive the rights and obligation of the lease without the monthly payments.

Speaking with NRG Energy, their expectation for Houston is that most homeowners will participate in the pre-pay option. The user will purchase the lease upfront. Without rebates or incentives, those participating in the market will likely be those who can purchase the system outright. We have found this to be the case when speaking with solar installers. Texas Community Solar stated that their primary customers are those who purchase the system outright. The benefit of a lease for those purchasing is that they receive the benefits of the lease without monthly payments. These benefits include, free life-time maintenance and repairs and life-time system monitoring to make sure system is working as expected. Further, the leasee will have the system insured through the lease and not have to increase their homeowner's insurance. Further, the homeowner will not be subject to many of the leasing limitations when they attempt to sell their home. The lease will be transferred to the new homeowner at no charge.

Example of Solar Leasing Saving Outcomes

Below is an example of a leasing project based on different solar leasing scenarios. In this example, it is assumed the system is a 4 kW system that produces approximately 5,846 kWh per year. The total installed cost is $3.00 per watt. The yearly lease payment is $600 or $50 per month. The electricity rate of $0.1108 is the average electricity rate paid by Texans in 2011 per the US Energy Information Administration.

	Solar Lease – No Escalation	Solar Lease - 2% Escalation
Average Savings per year	$47.74	$186.92
Cumulative Savings (20 years)	$954.74	$3,738

The above sample is an example of the cost per watt needed to make the project cash flow positive. The cash flow was positive from year one without an accelerator. However, the price of $3.00 per watt may not be truly reflective of actual pricing for residential installations in Houston. To get a better idea of what the cash flow would look like specific to Houston, a local contractor was asked to provide a bid for a 4 kW system. The contractor provided a bid of $4.07 per watt. Based on this actual quote, using the same leasing method explained above the first years savings is a negative $167.48. Without using an escalator for grid electricity the cumulative savings were a negative $3,349. With a 2% accelerator the first year of savings was at year 13 of the 20 year lease. The cumulative savings was a negative $566.05. A 3% accelerator is required for a net positive cash flow. The likelihood of such an accelerator being applicable in the Texas market is particularly unlikely with current energy pricing forecasts from EIA.

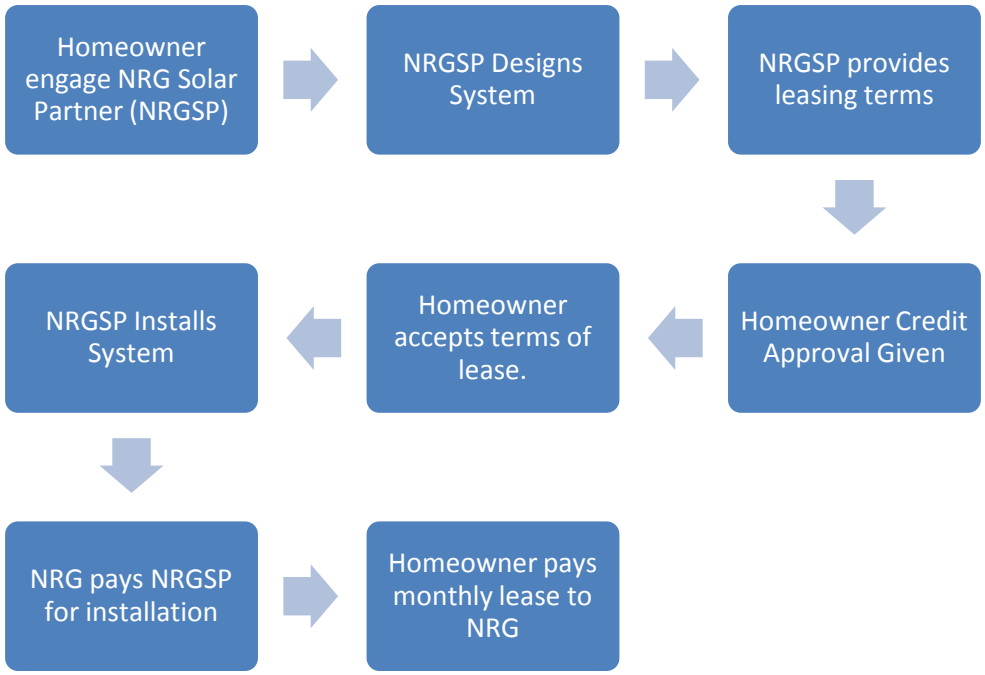
NRG Energy – Residential Solar Solutions – Leasing Process

When setting up the lease NRG works to make the monthly lease amount equivalent to the current electricity price that homeowner would be paying if the homeowner was not participating in the lease. In NRG's latest solar lease rollout the goal will be to have the monthly lease payment and the customer's new monthly utility bill to be less than what the customer was paying to the utility. Whether or not this occurs is due largely to the price of grid electricity, the partner's costs and the availability of incentives and rebates. In markets where rebates and incentives are available NRG expects to achieve a positive cash flow from the beginning. Positive cash flow may be realized later in the duration of the lease period for owners that have leased in a market without incentives or rebates.

To help make the lease more appealing, NRG offers sellback programs to go with lease through their retail electricity provider (REP). However, these are two distinct transactions for those who are participating in the monthly payment plan for their solar system. For these individuals they will receive a monthly bill for the solar lease payment and their electricity bill. The electricity bill will have a credit for whatever excess energy is sent to the grid from the rooptop system, depending on who the customer chooses as their REP. NRG is in the process of engaging multiple solar installer partners in Houston. These solar partners will provide turn-key services and will work with the homeowner throughout the entire process, from design, leasing , installation and maintenance. Currently, NRG has partnered with Native Renewable Energy. The solar partner will develop leasing terms based on system specs and available utility rebates and tax credits. These cost savings will be applied to the final system price resulting in a lower system cost. Once a lease is drafted, NRG checks credit of homeowner. Upon

homeowner credit approval, homeowner signs lease if they want to move ahead with the project. When the lease is signed, the system is installed. The system installation is expected to take 2 to 3 days**.** The entire process is expected to take no longer than 90 days. Upon completion of the project, NRG will pay the solar partner for the installation work and the homeowner will begin to pay monthly payments to NRG. The homeowner will pay a fixed monthly fee over the term of the lease. In return the homeowner will be provided solar power, installation insurance, a system warranty and a power production guarantee.

Steps to Solar Leasing in Houston – NRG's model



Appendix H Subtask 4.2 Meeting Summaries

Meeting Summary – Subtask 4.2

Under Subtask 4.2 Houston was to encourage growth in the solar market by fostering the implementation of Texas Senate Bill 981. This was to include one meeting with legislative delegates and one public meeting to provide resources on solar lease financing options.

- Jennifer Ronk participated in the Texas Renewable Energy industries Association Legislative Agenda Meeting for the Distributed Solar Subcommittee on Monday September 24th, 2012, from 9am to 12pm.
- Gavin Dillingham met with Paul Cuardo, a member of an energy policy advocacy and lobbying group, to discuss distributed generation and decoupling of rates for utilities on Thursday January 24, 2013
- Public meeting to be held February 9 from 12-2 at the Houston Green Building Resources Center. Among other topics, NRG is presenting on their new solar leasing option that is available as of 2013 in the Houston market.

The City of Houston and HARC

Present

How to Go Solar in Houston

Saturday, February 9, 2013

12:00 – 2:00 PM

Houston Green Building Resource Center

FREE TO THE PUBLIC

Come Learn About:

Solar Installation– From Conception to Connection

Residential Solar Financing Options

Working with Home Owners Associations

Historic Homes and Energy Efficiency

Renewable Technologies and You

Houston Permitting Center

1002 Washington

Houston, Texas 77002

Please call or email Cheyenne Morgan with any questions:
Email: CMORGAN@HARC.EDU
PH: 281.364.6010

The City of Houston and HARC present

How to Go Solar in Houston

Saturday, February 9, 2013
12:00 to 2:00pm
Houston Green Building Resource Center

FREE TO PUBLIC

Please come join us for a public seminar on residential solar options for the people of Houston. Public speakers will present on topics about the solar installation process, residential solar financing options, how to avoid Home Owner Association battles, making historic homes energy efficient, and further opportunities in green technology.

Come Learn About:

- Solar Installation Processes
- Residential Solar Financing Options
- Working with Home Owners Associations
- Historic Homes and Energy Efficiency
- Renewable Technologies and You

Event Location:

Houston Permitting Center

1002 Washington

Houston, Texas 77002

Please call or email Cheyenne Morgan with any questions:
Email: CMORGAN@HARC.EDU
PH: 281.364.6010

Appendix I White Paper – Homeowner's Associations

The Opening of a New Frontier: HOAs and Residential Solar in Houston, TX

Introduction

The City of Houston, Texas was chosen by the U.S. Department of Energy as a Solar America City for a project called the Solar Houston Initiative. Part of the Solar Houston Initiative included identifying barriers to solar. Under the DOE SunShot Initative Rooftop Challenge Grant, the City of Houston, along with the other Cities in the Texas Solar Collaboration, has received assistance to begin addressing some of these barriers. Deed restrictions instituted by individual Homeowners Associations (HOAs) have been identified as a barrier for residential solar in most of the nation. This report views the current status of deed restrictions within the City of Houston that are focused on the installation of rooftop solar energy systems.

Past Research

In 2010, Sandia National Laboratories conducted a report on deed restrictions for solar as a deliverable for the Solar Houston Initiative, Task 3: "Examples of residential deed restrictions allowing solar" of the Technical Assistance Statement of Work for the City of Houston. In the report, Sandia presented examples of positive deed restrictions as well as deed restrictions that could encumber solar.

Houston is fairly unique among the large metropolitan areas of the United States in its lack of zoning. The dearth of zoning laws has allowed a large number of different residential communities to create their own restrictive covenants or deed restrictions that the City then enforces. The City requested that Sandia research these restrictive codes to determine the types of barriers present for property owners that would want to invest in a solar energy device. Gathering information dominantly by means of searching the internet, Sandia was able to compile a list of deed restrictions that were present in the Houston area. Sandia distributed their finds into three main categories: positive deed restrictions for solar, deed restrictions that allow but could encumber solar, and deed restrictions that do not address but could encumber solar (Klise, 2010). The following is a short description of Sandia's findings.

Positive deed restrictions refer to those restrictions that directly allowed or encouraged the development of solar. Two examples of these were Discover at Spring Trails and The Woodlands. Both communities are mast planned communities that are located approximately 28 miles north of Houston. Both communities openly approve of the installation of any solar panels on any roof. There was more restrictive language for the Woodlands when concerning street-side installations. Discover at Spring Trails is a unique community in that every home was envisioned as having solar installed on the property. Each home was built with 1kW of solar already installed with the capacity of 5kW after the implementation of solar upgrades (Klise, 2010).

Deed restrictions that allow but could encumber solar refer to those restrictions that "are restrictive to a point of potentially making it too expensive to generate solar electricity, or working that speaks to roof composition and penetrations might be stretched to disallow any solar collectors" (Klise, 2010). Aliana

and Cinco Ranch are both located approximately 30 miles west of Houston. Aliana's deed restrictions simply indicated that no paneling would be allowed to be seen from the street. This restriction would have made it difficult for homes that had south-facing roof space (ideal for solar panel placement) in view of an adjacent street way. Cinco Ranch's Protective Covenants and By-Laws stated that all solar collectors must be similar in scope to the architecture of the house. The restriction at Cinco Ranch would have made it possible for the HOA to demand that the solar panels be building integrated photovoltaics (BiPV) which are far more expensive (Klise, 2010).

Deed restrictions that do not address but could encumber solar refers to those communities that have restrictive language in such a way as to potentially bar solar installation on a property. The First Colony community located 30 miles southwest of Houston fell into this category. Though the community did not have references to solar within their deed restrictions, there was mention of how only certain roofing materials and penetrations would be allowed. The language here strongly indicated that solar installations on roofs would be prohibited (Klise, 2010).

The Sandia report mentions that there had been previous legislative attempts to prevent any HOA from barring the installation of a solar energy device. The Texas Renewable Energy Industries (TREIA) is a state-wide nonprofit organization that aggressively promotes the use of renewable energies in the state. Having more than 500 member companies, organizations, and individuals, TREIA actively lobbies a renewable energy agenda on a yearly basis. In 2009, TREIA's legislative agenda included a focus that would "disallow property owner association's rules which either explicitly or in effect prevent Renewable Energy systems from being installed by homeowners. Rules would be permitted to ensure any installation meets reasonable safety and aesthetic guidelines" (TREIA, 2009). Prior to the completion of the Sandia report no immediate headway had been made within the legislative arena to curtail the HOA barriers to residential solar.

Texas House Bill No. 362

In 2011 the Texas State Legislature enacted Texas House Bill No. 362 into law. This act amended Section 1, Chapter 202 of the Property Code by adding sections 202.010 and 202.011. These amendments target HOA regulation of solar energy devices. The law states that "a property owners' association may not include or enforce a provision in a dedicatory instrument that prohibits or restricts a property owner from installing a solar energy device" (Texas HB 362, 202.010.b).

The following is a comprehensive listing of the regulations stated within Texas House Bill 362, Section 202.010.

1. The solar energy device must not:
    a. Threaten public health or safety.
    b. Violate the law.
2. The solar energy device cannot be located:
    a. On property owned or maintained by the property owner's HOA.
    b. On property owned in common by the members of the property owner's HOA.
    c. In an area on the property owner's property that is not:

        i. On the roof of a structure that has been validated by the structural engineer that designed the installation plan.
        ii. Located in a fenced in yard or patio owned and maintained by the property owner.
3. If the device is located on a roof, it cannot:
    a. Have paneling extend above the roofline.
    b. Have paneling extend out over the edges of the roof.
    c. Be located in an area other than what the property owner's HOA has designated
        i. If located in another area then the proposed location must increase the estimated annual energy production of the device by more than 10%.
4. If the device is located on a roof, it must:
    a. Follow the slope of the roof.
    b. Be parallel to the roofline.
    c. Have its frame, support bracket, and wiring be silver, black, or bronze in color.
5. If the device is located in a fenced in yard or patio, it cannot:
    a. Be taller than the fence line.
6. For those devices that have already been installed:
    a. The overall set-up and layout of the device cannot void any material warranties.
    b. The device must be installed with prior approval from the property owner's HOA.
7. The property owner must supply the property owner's HOA with a written statement that has been signed by all of the property's adjoining neighbors acknowledging that the device does not cause either discomfort or annoyance.

The institution of the bill has had a great impact in the solar community. Donovan Dawson of Alternative Power Solutions, a Houston-based solar installation company, says that he can only remember a handful of instances within the past few years where there was an HOA that actively wanted to bar the installation of a solar energy device within their community. Every time this occurred Dawson stated that it would be common for there to be an HOA meeting that would take place. The contractor would attend the monthly meeting and give a presentation to the committee concerning Texas HB 362. Once the HOA committee realized that there is a law in place that protects the installation of residential solar devices, most HOAs allow the installation to progress. Bill Graves of PetersenDean Roofing and Solar reported similar experiences. Graves remarked that most HOAs simply are not informed about the law however once the committee realizes that they cannot bar an installation for aesthetic reasons, they allow the construction to commence. Multiple installers and solar installation companies agree that Texas HB 362.202.010 was a great step in the right direction, although additional outreach and education to HOAs about the new law could be helpful.

Conclusion

There is still a lot of work that needs to be done in the Houston area in order for solar to reach its full potential in the energy market. Luckily, there are people in place that have a vision for Houston. The hopes for a solar tomorrow that is just on the horizon are still burning brightly. HOAs in Houston were once seen as a barrier to solar energy development at the residential level. In 2011, the Texas state legislature made a monumental step showing their support in promoting the use of renewable technologies by implementing Texas House Bill 362.202.010. Throughout Houston, the value of solar is

becoming more and more known. The word on solar is getting out there. As costs continue to fall and awareness continues to rise, this market will continue to grow in Houston and beyond.

Bibliography

Klise, G., 2010, "Deed Restrictions for Solar," Sandia National Laboratories report for Solar America City – Houston.

TREIA, 2009, "TREIA 2009 Legislative Agenda," taken from http://data.memberclicks.com/site/treia/LegisAgen09.Amend.2.6.09.doc on February 4, 2013.

Solar Installation in Homeowner Association

The following checklist is to assist in determining if a Solar Installation can be prohibited or forced to relocate in accordance with Texas House Bill Number 362.

A "Yes" answer simply means that an HOA or POA can bar the installation or require relocation.

Does/Is the Installation:

Conditions	Yes	No
Threatens Public health and Safety. Sec 202.010 (2)(d)(1)(A)		
Violates a Law. Sec 202.010 (2)(d)(1)(B)		
On property owned or maintained by associations. Sec. 202.010 (2)(d)(2)		
On property owned by common Property Owners of POA. Sec. 202.010 (2)(d)(3)		
Installed anywhere other than home roof or other approved structure or inside fenced yard or patio maintained by owner. Sec. 202.010 (2)(d)(4)(A)(B)		
Extends higher than the roof line. Sec 202.010 (2)(d)(5)(A)		
Not conforming to the slope of the roof line. Sec. 202.101 (2)(d)(5)(C)		
Frame, Piping or Wiring that are any color other than silver, bronze or black. Sec. 202.010 (2)(d)(5)(D)		
A ground mount system that is higher than the fence line. Sec. 202.010 (2)(d)(6)		
Install voids warranties. Sec. 202.010 (2)(d)(7)		
Installed without permission from POA where prior permission currently required. Sec 202.010 (2)(d)(8)		
Causes unreasonable discomfort or annoyance Sec. 202.010 (2)(e) Neighbors have signed letter		
POA's suggested location will not decrease the system's annual production by 10% or more from owner's preferred install location. Sec. 202.010 (2)(d)(4)(A)		

If all answers are checked "No" then the installation cannot be prohibited in accordance with Texas House Bill 362. If "discomfort or annoyance" is a question, letters from neighbors resolves that question. (See sample)

***Note that this is only applicable to homes/subdivisions that are not under control of the developer.**

Sample letter

To answer any “discomfort or annoyance” issue.

To Whom It May Concern,

I understand that my neighbor, _____ (Name) at _____(Address) is planning to install a Solar energy system on their property. I understand that, in accordance with Texas law, one of the determining factors in whether this installation is approved is that it does not cause any unreasonable discomfort or annoyance. [Sec. 202.010(2)(e)]

I have no problems with this solar installation and it does not cause my household any unreasonable discomfort or annoyance.

Signed,

_____(Signature)

_____(Print Name)

_____(Address)

_____

_____(Date)

Appendix J Historic Homes Case Study: Innovation Avenue

Historic Homes Case Study – Innovation Avenue

Project Conception

Reliant wanted to develop a project they called "Innovation Avenue." The goal was to use a real street as a testing ground for developing new energy technology. Initially, Reliant contacted the City of Houston for ideas of where Innovation Avenue should be located. Houston suggested the Old Sixth Ward as a possible location because it had a good mix of old and new homes.

The Neighborhood

Old Sixth Ward represents the greatest concentration of historic homes in the City of Houston. Its proximity to downtown, along with the increasing interest in redeveloping inner city areas, has resulted in a surge of development activity around and within the District. These design guidelines have been developed and adopted by the City of Houston in order to promote the following goals and objectives:

• To preserve the existing building stock and general neighborhood character of Old Sixth Ward.

• To allow for the orderly and compatible alteration of existing historic properties in the District in a manner that protects and enhances the building or structure.

• To provide for new infill development and additions that are compatible with the surrounding historic structures and preserve the existing neighborhood character.

Project Initiation

Reliant then began the process of finding the right street in the Old Sixth ward. The only requirements were that the customers had to have a smart meter and be (or be willing to become) Reliant Energy customers. Eventually, the 12 houses nestled on State St became Innovation Avenue. State Street has a mix of historic and new houses with families and couples.

Wayne Morrison, Principal Director of Smart Energy for Reliant Energy in Houston walked up to each door personally and introduced himself to the confused and rather skeptical neighbors. He tucked an application package underneath one arm as he told the residents of the benefits of being involved with the program. Initially, there was a bit of hesitancy on the side of the residents; not only did Reliant want to start using them as guinea pigs for their energy research but he wanted to install all of this fancy energy equipment – FOR FREE! The only obligation was that the homeowners allow Reliant to have access to all of the homes energy data and that the customers would give feedback on the system.

The first step in the process was a home energy audit. If the audit went well and the homeowners decided to opt into the program then there was a two year obligation. All 12 homeowners eventually agreed to the home energy audit. "One step at a time." A little step here and a little step there and before he knew it all 12 homeowners had agreed to do the project. Each home is equipped with e-Sense tools. These include e-Sense weekly summary emails, home energy monitor, smart appliances, smart thermostats, and a home automation system.

Why solar as an option? Solar was brought forth as an option because Reliant had begun their leasing and buy back solar options in the previous year (2010). However, due to the shading of the street, only one house would really benefit from a solar installation. He approached the Beck family, and their historic home, with the idea. They agreed.

Image of the historic home chosen for solar option. (Image courtesy of Reliant Energy.)

Installation of Solar on a Historic Home

Overall the project went well. Reliant made sure to hire a qualified solar installer with experience working with Home Owners Associations. Because Wayne had never worked with historical homes before he didn't know where to start, but the contractors and the local HOA aided Wayne in knowing who he needed to talk to in order to get things moving. The local HOA sent him a list of their guidelines. The primary issue was that the solar panels on the house could not be seen from the street level. However, because this was a historic home, an application for a Certificate of Appropriateness (COA) also needed to be completed and approved by the Houston Archaeological and Historical Commission.

Solar panels were placed on the upper portion of the rear roof so that they could not be seen from the street level. (Image courtesy of Reliant Energy.)

COA Application Process

There is no fee for filing a COA application and the Planning and Development Department's Historic Preservation staff can guide you through the process. Houston highly recommends that applicants contact a staff member in the beginning stages of a project before any designs are finalized, and well in advance of an application deadline. Staff is able to offer technical assistance in order to ensure proposed projects are sensitive to the historic character of the designated site or district. COA Application and Checklists may be downloaded from the Historic Preservation Forms web section. A complete application includes a COA application form signed by the legal property owner along with the following documentation:

- Written Description detailing existing conditions and the proposed activity
- Current Photographs of the subject of the proposal
- Application Checklist for the proposed action type and applicable documentation requested within the checklist
- Renderings or drawings detailing existing conditions and the proposed activity, when applicable
- Deed Restriction compliance, when applicable

Because the addition of PV panels falls under the "Addition, Alteration, Rehabilitation and/or Restoration" clause, additional information is needed including:

- site and subject information
- detailed description of proposed work
- material description, specifications, and/or samples
- criteria adherence
- current photographs of subject of work
- historic architectural evidence of authenticity, when applicable
- site plan, architectural plans and elevations

A checklist is available here.

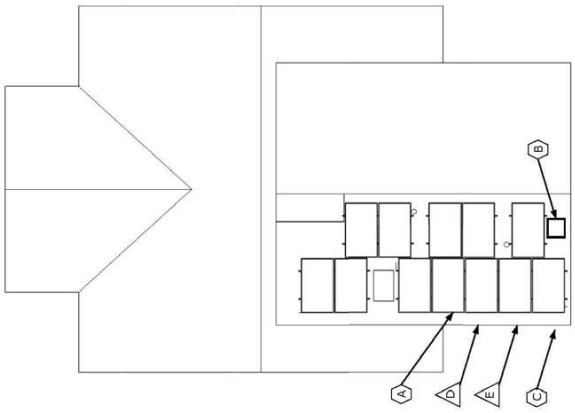
A complete application should be submitted to staff 15 days prior to the next Houston Archaeological and Historical Commission meeting, which meets once a month. Because the commission only meets once a month, it is important to have the application complete and submitted on time or the project will be delayed.

When the application is approved, any plans required to obtain a building permit will need to be reviewed and stamped by a Historic Preservation staff member at 611 Walker, 6th floor. Houston recommends contacting a staff to make a COA plan review appointment.

The Innovation Avenue application was reviewed at the July 14, 2011, meeting. Wayne had signed up to speak to the Committee, to briefly describe the project and answer any questions or concerns from the Committee. After a short speech, Wayne waited for questions. There were none. The COA was approved and Wayne received his confirmation in the mail a little over a week later and sent a copy to the homeowner and the contractor.

Construction

Twelve solar panels were installed on the back end of the rooftop, facing south. CenterPoint Energy was contacted to assure that appropriate interconnection process was followed. The homeowners smart meter was reprogrammed to allow a second channel of data to record the energy that has been generated but not used to be put back on the grid.



Placement of solar panels on rooftop. (Image courtesy of Reliant Energy.)

Conclusion and Lessons Learned

. A video of the project can be seen here.

Planning may take a bit longer, but solar CAN be installed on historic properties in Houston. It's important to have a property that isn't shaded and is oriented correctly. HOAs and the Houston Archaeological and Historical Commission should be involved early in the process.

Appendix K Verification Letters

HARC
MOVING KNOWLEDGE TO ACTION

HOUSTON ADVANCED RESEARCH CENTER

4800 Research Forest Drive | The Woodlands, TX 77381
T 281-364-4059 | F 281-363-7935 | www.harc.edu

Liza Meyer
Office of Sustainability, City of San Antonio
1400 South Flores
San Antonio, Texas 78205

Re: DOE SunShot Initiative Rooftop Solar Challenge

Dear Ms. Meyer:

The Houston Advanced Research Center (HARC) has been pleased to participate in the work performed under the DOE contract referenced above. The leadership shown by the City of San Antonio in seeking this funding and by DOE in recognizing the potential of the Texas Solar Collaboration established a platform for making very valuable improvements in the entire solar process and in examining alternatives for expanding the deployment of solar. The project also established relationships within the Texas Solar Collaboration that will continue the work begun under this program. We also acknowledge the significant participation by the utilities serving the different jurisdictions represented within the Collaboration.

The solar installation companies signing this letter join me in expressing our appreciation for the contributions this project has made to improving the future for the solar industry.

As one of the twenty-two teams funded by this grant, the Texas Solar Collaboration, comprised of grant partners within the cities of Austin, Houston and San Antonio, focused on reducing the non-hardware costs of rooftop PV systems and associated processes such as customer acquisition, permitting, interconnection, installation and financing.

Specifically, the Texas Solar Collaboration is addressing the following solutions to aid the solar industry in saving time and money:

1. **Common Processes** – when permit offices and utilities refer to their permitting and interconnection processes, it is beneficial to utilize common terms and forms for solar installers whether they are doing business in San Antonio, Austin, or Houston. The Collaboration has completed business process workshops to improve individual processes and is taking actions to harmonize terminology, forms, and processes in the region.
2. **Technology Improvements, including On-Line Application Systems** – members of the Collaboration are providing solar installers with new tools to expedite processes, such as on-line access to submit permit applications and electronic signature capabilities.
3. **Continuing Education** – Each jurisdiction is cognizant of the continuing education needs of the solar installer, as permit and interconnection processes are not intuitive and requirements continue to evolve. Cities and utilities will be providing various training opportunities to solar installers to ensure their employees are updated on the latest

municipal and utility requirements to obtain permits and interconnection approvals.

4. **Regional Clearinghouse and Best Practices Guide** - the Texas Solar Collaboration includes numerous suburban cities within its service areas. Solar installers doing business in suburban cities will have access to comprehensive information on administrative protocols and processes on how to obtain permits within each participating suburban city. The suburban cities, along with Homeowners Associations within those cities, will have access to a best practices guide developed by the Texas Solar Collaboration that can help streamline processes and encourage beneficial standardization throughout the region.
5. **New Financing Options and Frameworks** – members of the Texas Solar Collaboration are developing new financing options for solar customers in the region and are completing a "value of solar" study to help with valuation of regional incentives.

The Texas Solar Collaboration will complete its work under this grant initiative on February 14, 2013.

Company

By: Garrett Gandy

Title: Owner

Date: 2-9-13

HARC
MOVING KNOWLEDGE TO ACTION

HOUSTON ADVANCED RESEARCH CENTER

4800 Research Forest Drive | The Woodlands, TX 77381
T 281-364-4059 | F 281-363-7935 | www.harc.edu

Liza Meyer
Office of Sustainability, City of San Antonio
1400 South Flores
San Antonio, Texas 78205

Re: DOE SunShot Initiative Rooftop Solar Challenge

Dear Ms. Meyer:

The Houston Advanced Research Center (HARC) has been pleased to participate in the work performed under the DOE contract referenced above. The leadership shown by the City of San Antonio in seeking this funding and by DOE in recognizing the potential of the Texas Solar Collaboration established a platform for making very valuable improvements in the entire solar process and in examining alternatives for expanding the deployment of solar. The project also established relationships within the Texas Solar Collaboration that will continue the work begun under this program. We also acknowledge the significant participation by the utilities serving the different jurisdictions represented within the Collaboration.

The solar installation companies signing this letter join me in expressing our appreciation for the contributions this project has made to improving the future for the solar industry.

As one of the twenty-two teams funded by this grant, the Texas Solar Collaboration, comprised of grant partners within the cities of Austin, Houston and San Antonio, focused on reducing the non-hardware costs of rooftop PV systems and associated processes such as customer acquisition, permitting, interconnection, installation and financing.

Specifically, the Texas Solar Collaboration is addressing the following solutions to aid the solar industry in saving time and money:

1. **Common Processes** – when permit offices and utilities refer to their permitting and interconnection processes, it is beneficial to utilize common terms and forms for solar installers whether they are doing business in San Antonio, Austin, or Houston. The Collaboration has completed business process workshops to improve individual processes and is taking actions to harmonize terminology, forms, and processes in the region.
2. **Technology Improvements, including On-Line Application Systems** – members of the Collaboration are providing solar installers with new tools to expedite processes, such as on-line access to submit permit applications and electronic signature capabilities.
3. **Continuing Education** – Each jurisdiction is cognizant of the continuing education needs of the solar installer, as permit and interconnection processes are not intuitive and requirements continue to evolve. Cities and utilities will be providing various training opportunities to solar installers to ensure their employees are updated on the latest

municipal and utility requirements to obtain permits and interconnection approvals.

4. **Regional Clearinghouse and Best Practices Guide** - the Texas Solar Collaboration includes numerous suburban cities within its service areas. Solar installers doing business in suburban cities will have access to comprehensive information on administrative protocols and processes on how to obtain permits within each participating suburban city. The suburban cities, along with Homeowners Associations within those cities, will have access to a best practices guide developed by the Texas Solar Collaboration that can help streamline processes and encourage beneficial standardization throughout the region.
5. **New Financing Options and Frameworks** – members of the Texas Solar Collaboration are developing new financing options for solar customers in the region and are completing a "value of solar" study to help with valuation of regional incentives.

The Texas Solar Collaboration will complete its work under this grant initiative on February 14, 2013.

Company ALTERNATIVE POWER SOLUTIONS

By: DONOVAN DAWSON

Title: BUSINESS DEVELOPMENT

Date: 2/9/2013.

HARC
MOVING KNOWLEDGE TO ACTION

HOUSTON ADVANCED RESEARCH CENTER

4800 Research Forest Drive | The Woodlands, TX 77381
T 281-364-4059 | F 281-363-7935 | www.harc.edu

Liza Meyer
Office of Sustainability, City of San Antonio
1400 South Flores
San Antonio, Texas 78205

Re: DOE SunShot Initiative Rooftop Solar Challenge

Dear Ms. Meyer:

The Houston Advanced Research Center (HARC) has been pleased to participate in the work performed under the DOE contract referenced above. The leadership shown by the City of San Antonio in seeking this funding and by DOE in recognizing the potential of the Texas Solar Collaboration established a platform for making very valuable improvements in the entire solar process and in examining alternatives for expanding the deployment of solar. The project also established relationships within the Texas Solar Collaboration that will continue the work begun under this program. We also acknowledge the significant participation by the utilities serving the different jurisdictions represented within the Collaboration.

The solar installation companies signing this letter join me in expressing our appreciation for the contributions this project has made to improving the future for the solar industry.

As one of the twenty-two teams funded by this grant, the Texas Solar Collaboration, comprised of grant partners within the cities of Austin, Houston and San Antonio, focused on reducing the non-hardware costs of rooftop PV systems and associated processes such as customer acquisition, permitting, interconnection, installation and financing.

Specifically, the Texas Solar Collaboration is addressing the following solutions to aid the solar industry in saving time and money:

1. **Common Processes** – when permit offices and utilities refer to their permitting and interconnection processes, it is beneficial to utilize common terms and forms for solar installers whether they are doing business in San Antonio, Austin, or Houston. The Collaboration has completed business process workshops to improve individual processes and is taking actions to harmonize terminology, forms, and processes in the region.
2. **Technology Improvements, including On-Line Application Systems** – members of the Collaboration are providing solar installers with new tools to expedite processes, such as on-line access to submit permit applications and electronic signature capabilities.
3. **Continuing Education** – Each jurisdiction is cognizant of the continuing education needs of the solar installer, as permit and interconnection processes are not intuitive and requirements continue to evolve. Cities and utilities will be providing various training opportunities to solar installers to ensure their employees are updated on the latest

municipal and utility requirements to obtain permits and interconnection approvals.

4. **Regional Clearinghouse and Best Practices Guide** - the Texas Solar Collaboration includes numerous suburban cities within its service areas. Solar installers doing business in suburban cities will have access to comprehensive information on administrative protocols and processes on how to obtain permits within each participating suburban city. The suburban cities, along with Homeowners Associations within those cities, will have access to a best practices guide developed by the Texas Solar Collaboration that can help streamline processes and encourage beneficial standardization throughout the region.
5. **New Financing Options and Frameworks** – members of the Texas Solar Collaboration are developing new financing options for solar customers in the region and are completing a "value of solar" study to help with valuation of regional incentives.

The Texas Solar Collaboration will complete its work under this grant initiative on February 14, 2013.

Company

By: NRG Residential Solar Solutions Jason Crossett

Title: Partner Consultant

Date: 2/9/13

HARC
MOVING KNOWLEDGE TO ACTION

HOUSTON ADVANCED RESEARCH CENTER

4800 Research Forest Drive | The Woodlands, TX 77381
T 281-364-4059 | F 281-363-7935 | www.harc.edu

Liza Meyer
Office of Sustainability, City of San Antonio
1400 South Flores
San Antonio, Texas 78205

Re: DOE SunShot Initiative Rooftop Solar Challenge

Dear Ms. Meyer:

The Houston Advanced Research Center (HARC) has been pleased to participate in the work performed under the DOE contract referenced above. The leadership shown by the City of San Antonio in seeking this funding and by DOE in recognizing the potential of the Texas Solar Collaboration established a platform for making very valuable improvements in the entire solar process and in examining alternatives for expanding the deployment of solar. The project also established relationships within the Texas Solar Collaboration that will continue the work begun under this program. We also acknowledge the significant participation by the utilities serving the different jurisdictions represented within the Collaboration.

The solar installation companies signing this letter join me in expressing our appreciation for the contributions this project has made to improving the future for the solar industry.

As one of the twenty-two teams funded by this grant, the Texas Solar Collaboration, comprised of grant partners within the cities of Austin, Houston and San Antonio, focused on reducing the non-hardware costs of rooftop PV systems and associated processes such as customer acquisition, permitting, interconnection, installation and financing.

Specifically, the Texas Solar Collaboration is addressing the following solutions to aid the solar industry in saving time and money:

1. **Common Processes** – when permit offices and utilities refer to their permitting and interconnection processes, it is beneficial to utilize common terms and forms for solar installers whether they are doing business in San Antonio, Austin, or Houston. The Collaboration has completed business process workshops to improve individual processes and is taking actions to harmonize terminology, forms, and processes in the region.
2. **Technology Improvements, including On-Line Application Systems** – members of the Collaboration are providing solar installers with new tools to expedite processes, such as on-line access to submit permit applications and electronic signature capabilities.
3. **Continuing Education** – Each jurisdiction is cognizant of the continuing education needs of the solar installer, as permit and interconnection processes are not intuitive and requirements continue to evolve. Cities and utilities will be providing various training opportunities to solar installers to ensure their employees are updated on the latest

municipal and utility requirements to obtain permits and interconnection approvals.

4. **Regional Clearinghouse and Best Practices Guide** - the Texas Solar Collaboration includes numerous suburban cities within its service areas. Solar installers doing business in suburban cities will have access to comprehensive information on administrative protocols and processes on how to obtain permits within each participating suburban city. The suburban cities, along with Homeowners Associations within those cities, will have access to a best practices guide developed by the Texas Solar Collaboration that can help streamline processes and encourage beneficial standardization throughout the region.
5. **New Financing Options and Frameworks** – members of the Texas Solar Collaboration are developing new financing options for solar customers in the region and are completing a "value of solar" study to help with valuation of regional incentives.

The Texas Solar Collaboration will complete its work under this grant initiative on February 14, 2013.

Company

By: Bio Grams

Title: Solar Estimator

Date: 2/9/13

HARC
MOVING KNOWLEDGE TO ACTION

HOUSTON ADVANCED RESEARCH CENTER

4800 Research Forest Drive | The Woodlands, TX 77381
T 281-364-4059 | F 281-363-7935 | www.harc.edu

Liza Meyer
Office of Sustainability, City of San Antonio
1400 South Flores
San Antonio, Texas 78205

Re: DOE SunShot Initiative Rooftop Solar Challenge

Dear Ms. Meyer:

The Houston Advanced Research Center (HARC) has been pleased to participate in the work performed under the DOE contract referenced above. The leadership shown by the City of San Antonio in seeking this funding and by DOE in recognizing the potential of the Texas Solar Collaboration established a platform for making very valuable improvements in the entire solar process and in examining alternatives for expanding the deployment of solar. The project also established relationships within the Texas Solar Collaboration that will continue the work begun under this program. We also acknowledge the significant participation by the utilities serving the different jurisdictions represented within the Collaboration.

The solar installation companies signing this letter join me in expressing our appreciation for the contributions this project has made to improving the future for the solar industry.

As one of the twenty-two teams funded by this grant, the Texas Solar Collaboration, comprised of grant partners within the cities of Austin, Houston and San Antonio, focused on reducing the non-hardware costs of rooftop PV systems and associated processes such as customer acquisition, permitting, interconnection, installation and financing.

Specifically, the Texas Solar Collaboration is addressing the following solutions to aid the solar industry in saving time and money:

1. **Common Processes** – when permit offices and utilities refer to their permitting and interconnection processes, it is beneficial to utilize common terms and forms for solar installers whether they are doing business in San Antonio, Austin, or Houston. The Collaboration has completed business process workshops to improve individual processes and is taking actions to harmonize terminology, forms, and processes in the region.
2. **Technology Improvements, including On-Line Application Systems** – members of the Collaboration are providing solar installers with new tools to expedite processes, such as on-line access to submit permit applications and electronic signature capabilities.
3. **Continuing Education** – Each jurisdiction is cognizant of the continuing education needs of the solar installer, as permit and interconnection processes are not intuitive and requirements continue to evolve. Cities and utilities will be providing various training opportunities to solar installers to ensure their employees are updated on the latest

municipal and utility requirements to obtain permits and interconnection approvals.

4. **Regional Clearinghouse and Best Practices Guide** - the Texas Solar Collaboration includes numerous suburban cities within its service areas. Solar installers doing business in suburban cities will have access to comprehensive information on administrative protocols and processes on how to obtain permits within each participating suburban city. The suburban cities, along with Homeowners Associations within those cities, will have access to a best practices guide developed by the Texas Solar Collaboration that can help streamline processes and encourage beneficial standardization throughout the region.
5. **New Financing Options and Frameworks** – members of the Texas Solar Collaboration are developing new financing options for solar customers in the region and are completing a "value of solar" study to help with valuation of regional incentives.

The Texas Solar Collaboration will complete its work under this grant initiative on February 14, 2013.

Company

By: Frank Molina Frank Molina

Title: COO

Date: 2/12/13

HARC
MOVING KNOWLEDGE TO ACTION

HOUSTON ADVANCED RESEARCH CENTER

4800 Research Forest Drive | The Woodlands, TX 77381
T 281-364-4059 | F 281-363-7935 | www.harc.edu

Liza Meyer
Office of Sustainability, City of San Antonio
1400 South Flores
San Antonio, Texas 78205

Re: DOE SunShot Initiative Rooftop Solar Challenge

Dear Ms. Meyer:

The Houston Advanced Research Center (HARC) has been pleased to participate in the work performed under the DOE contract referenced above. The leadership shown by the City of San Antonio in seeking this funding and by DOE in recognizing the potential of the Texas Solar Collaboration established a platform for making very valuable improvements in the entire solar process and in examining alternatives for expanding the deployment of solar. The project also established relationships within the Texas Solar Collaboration that will continue the work begun under this program. We also acknowledge the significant participation by the utilities serving the different jurisdictions represented within the Collaboration.

The solar installation companies signing this letter join me in expressing our appreciation for the contributions this project has made to improving the future for the solar industry.

As one of the twenty-two teams funded by this grant, the Texas Solar Collaboration, comprised of grant partners within the cities of Austin, Houston and San Antonio, focused on reducing the non-hardware costs of rooftop PV systems and associated processes such as customer acquisition, permitting, interconnection, installation and financing.

Specifically, the Texas Solar Collaboration is addressing the following solutions to aid the solar industry in saving time and money:

1. **Common Processes** – when permit offices and utilities refer to their permitting and interconnection processes, it is beneficial to utilize common terms and forms for solar installers whether they are doing business in San Antonio, Austin, or Houston. The Collaboration has completed business process workshops to improve individual processes and is taking actions to harmonize terminology, forms, and processes in the region.
2. **Technology Improvements, including On-Line Application Systems** – members of the Collaboration are providing solar installers with new tools to expedite processes, such as on-line access to submit permit applications and electronic signature capabilities.
3. **Continuing Education** – Each jurisdiction is cognizant of the continuing education needs of the solar installer, as permit and interconnection processes are not intuitive and requirements continue to evolve. Cities and utilities will be providing various training opportunities to solar installers to ensure their employees are updated on the latest

municipal and utility requirements to obtain permits and interconnection approvals.

4. **Regional Clearinghouse and Best Practices Guide** - the Texas Solar Collaboration includes numerous suburban cities within its service areas. Solar installers doing business in suburban cities will have access to comprehensive information on administrative protocols and processes on how to obtain permits within each participating suburban city. The suburban cities, along with Homeowners Associations within those cities, will have access to a best practices guide developed by the Texas Solar Collaboration that can help streamline processes and encourage beneficial standardization throughout the region.
5. **New Financing Options and Frameworks** – members of the Texas Solar Collaboration are developing new financing options for solar customers in the region and are completing a "value of solar" study to help with valuation of regional incentives.

The Texas Solar Collaboration will complete its work under this grant initiative on February 14, 2013.

Company

By: Colin Gates – Colin Gates

Title: VP Sales and Marketing, Ameresco Solar

Date: 2/7/13

HARC
MOVING KNOWLEDGE TO ACTION

HOUSTON ADVANCED RESEARCH CENTER

4800 Research Forest Drive | The Woodlands, TX 77381
T 281-364-4059 | F 281-363-7935 | www.harc.edu

Liza Meyer
Office of Sustainability, City of San Antonio
1400 South Flores
San Antonio, Texas 78205

Re: DOE SunShot Initiative Rooftop Solar Challenge

Dear Ms. Meyer:

The Houston Advanced Research Center (HARC) has been pleased to participate in the work performed under the DOE contract referenced above. The leadership shown by the City of San Antonio in seeking this funding and by DOE in recognizing the potential of the Texas Solar Collaboration established a platform for making very valuable improvements in the entire solar process and in examining alternatives for expanding the deployment of solar. The project also established relationships within the Texas Solar Collaboration that will continue the work begun under this program. We also acknowledge the significant participation by the utilities serving the different jurisdictions represented within the Collaboration.

The solar installation companies signing this letter join me in expressing our appreciation for the contributions this project has made to improving the future for the solar industry.

As one of the twenty-two teams funded by this grant, the Texas Solar Collaboration, comprised of grant partners within the cities of Austin, Houston and San Antonio, focused on reducing the non-hardware costs of rooftop PV systems and associated processes such as customer acquisition, permitting, interconnection, installation and financing.

Specifically, the Texas Solar Collaboration is addressing the following solutions to aid the solar industry in saving time and money:

1. **Common Processes** – when permit offices and utilities refer to their permitting and interconnection processes, it is beneficial to utilize common terms and forms for solar installers whether they are doing business in San Antonio, Austin, or Houston. The Collaboration has completed business process workshops to improve individual processes and is taking actions to harmonize terminology, forms, and processes in the region.
2. **Technology Improvements, including On-Line Application Systems** – members of the Collaboration are providing solar installers with new tools to expedite processes, such as on-line access to submit permit applications and electronic signature capabilities.
3. **Continuing Education** – Each jurisdiction is cognizant of the continuing education needs of the solar installer, as permit and interconnection processes are not intuitive and requirements continue to evolve. Cities and utilities will be providing various training opportunities to solar installers to ensure their employees are updated on the latest

municipal and utility requirements to obtain permits and interconnection approvals.

4. **Regional Clearinghouse and Best Practices Guide** - the Texas Solar Collaboration includes numerous suburban cities within its service areas. Solar installers doing business in suburban cities will have access to comprehensive information on administrative protocols and processes on how to obtain permits within each participating suburban city. The suburban cities, along with Homeowners Associations within those cities, will have access to a best practices guide developed by the Texas Solar Collaboration that can help streamline processes and encourage beneficial standardization throughout the region.
5. **New Financing Options and Frameworks** – members of the Texas Solar Collaboration are developing new financing options for solar customers in the region and are completing a "value of solar" study to help with valuation of regional incentives.

The Texas Solar Collaboration will complete its work under this grant initiative on February 14, 2013.

Company

By: Peter J Neff

Title: CEO of Ignite Solar

Date: 2/11/13

HARC
MOVING KNOWLEDGE TO ACTION

HOUSTON ADVANCED RESEARCH CENTER

4800 Research Forest Drive | The Woodlands, TX 77381
T 281-364-4059 | F 281-363-7935 | www.harc.edu

Liza Meyer
Office of Sustainability, City of San Antonio
1400 South Flores
San Antonio, Texas 78205

Re: DOE SunShot Initiative Rooftop Solar Challenge

Dear Ms. Meyer:

The Houston Advanced Research Center (HARC) has been pleased to participate in the work performed under the DOE contract referenced above. The leadership shown by the City of San Antonio in seeking this funding and by DOE in recognizing the potential of the Texas Solar Collaboration established a platform for making very valuable improvements in the entire solar process and in examining alternatives for expanding the deployment of solar. The project also established relationships within the Texas Solar Collaboration that will continue the work begun under this program. We also acknowledge the significant participation by the utilities serving the different jurisdictions represented within the Collaboration.

The solar installation companies signing this letter join me in expressing our appreciation for the contributions this project has made to improving the future for the solar industry.

As one of the twenty-two teams funded by this grant, the Texas Solar Collaboration, comprised of grant partners within the cities of Austin, Houston and San Antonio, focused on reducing the non-hardware costs of rooftop PV systems and associated processes such as customer acquisition, permitting, interconnection, installation and financing.

Specifically, the Texas Solar Collaboration is addressing the following solutions to aid the solar industry in saving time and money:

1. **Common Processes** – when permit offices and utilities refer to their permitting and interconnection processes, it is beneficial to utilize common terms and forms for solar installers whether they are doing business in San Antonio, Austin, or Houston. The Collaboration has completed business process workshops to improve individual processes and is taking actions to harmonize terminology, forms, and processes in the region.
2. **Technology Improvements, including On-Line Application Systems** – members of the Collaboration are providing solar installers with new tools to expedite processes, such as on-line access to submit permit applications and electronic signature capabilities.
3. **Continuing Education** – Each jurisdiction is cognizant of the continuing education needs of the solar installer, as permit and interconnection processes are not intuitive and requirements continue to evolve. Cities and utilities will be providing various training opportunities to solar installers to ensure their employees are updated on the latest

municipal and utility requirements to obtain permits and interconnection approvals.

4. **Regional Clearinghouse and Best Practices Guide** - the Texas Solar Collaboration includes numerous suburban cities within its service areas. Solar installers doing business in suburban cities will have access to comprehensive information on administrative protocols and processes on how to obtain permits within each participating suburban city. The suburban cities, along with Homeowners Associations within those cities, will have access to a best practices guide developed by the Texas Solar Collaboration that can help streamline processes and encourage beneficial standardization throughout the region.
5. **New Financing Options and Frameworks** – members of the Texas Solar Collaboration are developing new financing options for solar customers in the region and are completing a "value of solar" study to help with valuation of regional incentives.

The Texas Solar Collaboration will complete its work under this grant initiative on February 14, 2013.

Company

By: Janet Hughes - Janet Hughes

Title: Master Solar Trainer/Senior Solar Consultant

Date: February 11. 2013

Appendix L Onsite Workshop for Code Officials

Onsite Workshop

For

Code Officials

Solar Photovoltaic Systems

Presented in Partnership by:

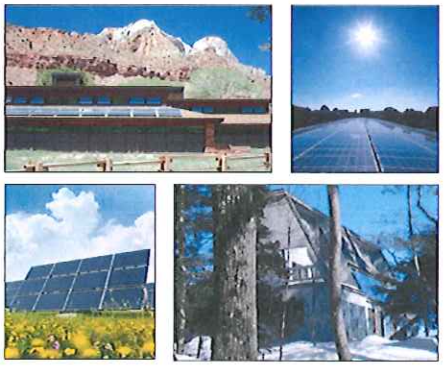
1

Solar Photovoltaic Systems

Developed in Partnership with:

2

Solar Photovoltaic Systems



3

Solar Photovoltaic Systems

- What is PV?
- Where is it installed?
- Installation requirements

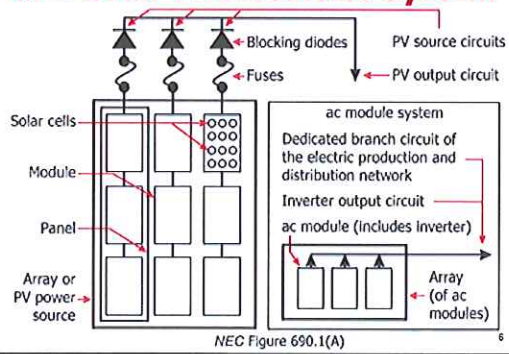
4

What is PV?

- **Definition: Solar Photovoltaic System**
- The total components and subsystems that, in combination, convert solar energy into electrical energy suitable for connection to a utilization load

5

Basic Components of a Solar Photovoltaic System

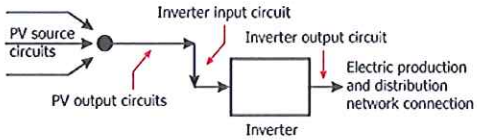


NEC Figure 690.1(A)

6

Different Configurations of PV Installations

Interactive System

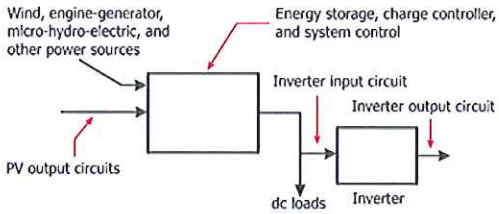


Copyright - UL LLC 2012

7

Different Configurations of PV Installations

Hybrid System

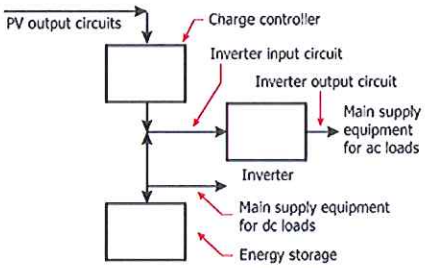


Copyright - UL LLC 2012

8

Different Configurations of PV Installations

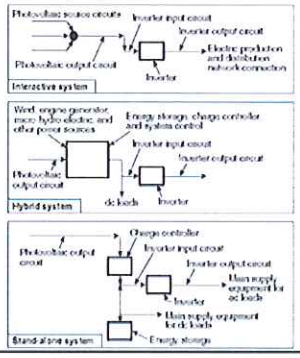
Stand-Alone System



Copyright - UL LLC 2012

9

Different Configurations of PV Installations



10

Where is PV Installed?

- ***NEC* 690.4(A) Photovoltaic systems**
- Photovoltaic systems shall be permitted to supply a building or other structure in addition to any other electricity supply system(s)

11

Residential Rooftops

Photos courtesy of DOE/NREL

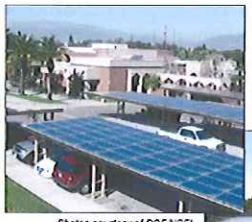
12

Commercial Rooftops

Photos courtesy of DOE/NREL

13

Shade Structures



Photos courtesy of DOE/NREL

14

Ground Mounted

Photos courtesy of DOE/NREL

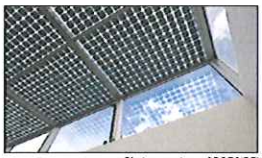
15

Windows

Photos courtesy of DOE/NREL

16

Skylights



Photos courtesy of DOE/NREL

17

Awnings

Photo courtesy of DOE/NREL

18

Pole Top Mount

Photos courtesy of DOE/NREL

19

Solar Generating Plant

Photo courtesy of DOE/NREL

20

PV Installation Concerns

- Utility compatibility and interaction
- Environment
  (e.g. indoor, rainproof, corrosion resistant)
- Maximum number of modules
- Fire exposure ratings
- Location on roof
- Effect on roof covering
- Wind and snow loading

21

Items needed to Inspect PV?

- Permits
- Plans
- Wiring
- Attachment
- Equipment

22

Plans - Electrical

- **Electrical plan should be submitted that includes the following:**
  - Locations of main service or utility disconnect
  - Total number of modules, number of modules per string and the total number of strings
  - One-line diagram of system
  - Specify grounding/bonding, conductor type and size, conduit type and size and number of conductors in each section of conduit

23

Plans - Electrical *(cont.)*

- **Electrical plan should be submitted that includes the following:**
  - Make and model of modules, inverter(s) and/or combiner box if used
  - If batteries are to be installed include them in the diagram and show there locations and venting
  - Equipment cut sheets including inverters, modules, AC and DC disconnects and combiners

24

Plans - Electrical *(cont.)*

- **Electrical plan should be submitted that includes the following:**
  - Labeling of equipment as required by Article 690 and Article 705
  - Site diagram showing the arrangement of modules on the roof or ground, north arrow, lot dimensions, and the distance from property lines to adjacent buildings/structures *(existing and proposed)*

25

Plans - Structural

- **Structural plan identifying support information for roof mounted systems including the following:**
  - The type of roof covering and the number of roofing layers installed
  - Type of roof framing, size of members and spacing
  - Weight of modules, support locations and method of attachment

26

Plans - Structural *(cont.)*

- **Structural plan identifying support information for roof mounted systems including the following:**
  - Framing plan and details for any work necessary to strengthen the existing roof structure
  - Any relevant calculations *(when required)*
  - Location of PV equipment on the building

27

Plans - Structural *(cont.)*

- **Structural plan identifying support information for roof mounted systems including the following:**
  - Where an approved racking system is used...
    - provide documentation showing the manufacturer of the rack system
    - maximum allowable weight the system can support
    - attachment method to the roof or ground
    - product evaluation information or structural design for the rack system

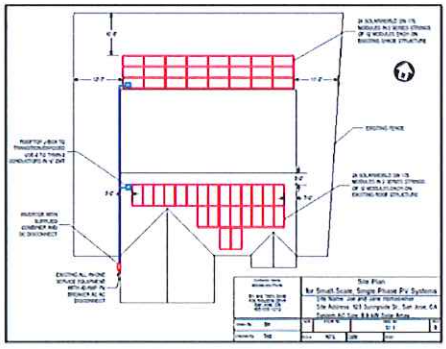
28

Plans - Code Requirements

- **Site Plan –**
  NEC 80.21 (Annex H), IBC 107.2.5, IRC R106.2
- **One-Line Diagram –**
  NEC 215.5
- **Attachment Details –**
  NEC 110.3(B), IBC 107.2.1, IRC R106.1.2
- **Equipment Specifications –**
  NEC 690.4(D), IRC R905.16.1, IRC R905.16.3, IRC M2302.3, IRC M2302.4, IBC 1505.8, IBC 1507.17.1, IBC 1507.17.3, IBC 1509.7.2, IBC 1509.7.4

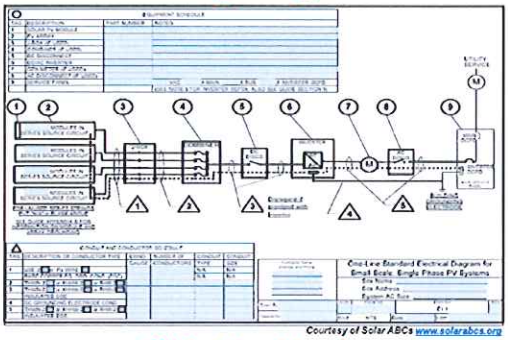
29

Site Plan



30

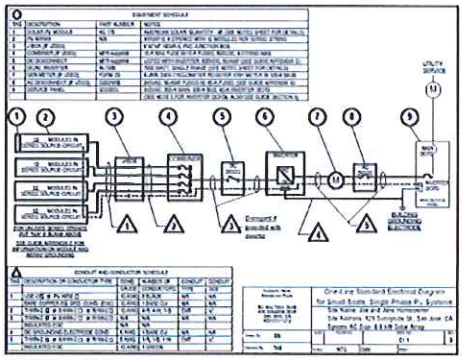
Wiring Diagram



Courtesy of Solar ABCs www.solarabcs.org

Fill in the blanks

31



Courtesy of Bill Brooks

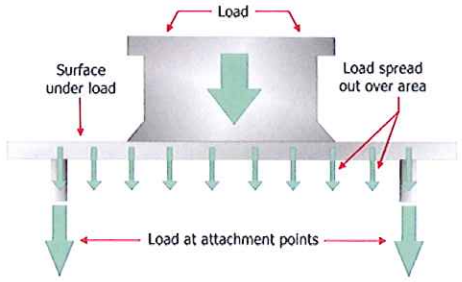
32

Attachment

- The International Building Code (IBC) Section 106.3 Load Supports
- Dead loading and wind loading of roof are covered in IBC 1603.1.4, 1603.1.8, 1604.2, 1606,2

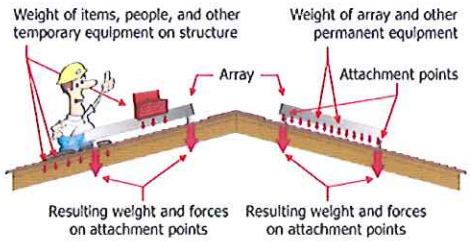
33

Rooftop Loading



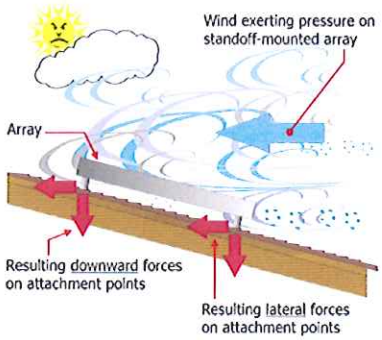
34

Live Versus Dead Loads



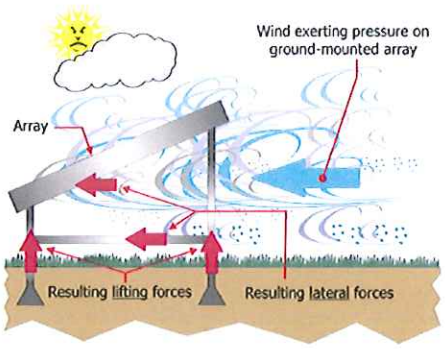
35

Wind Loading



36

Wind Loading



37

Wind & Dead Loading

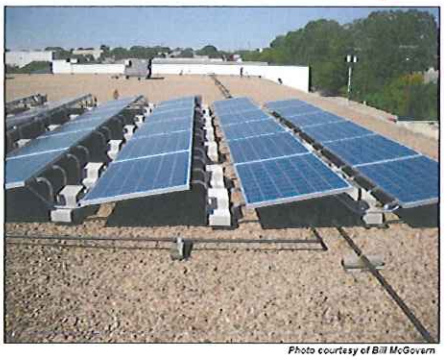


Photo courtesy of Bill McGovern

38

Rooftop Anchorage

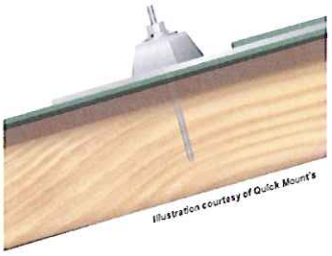
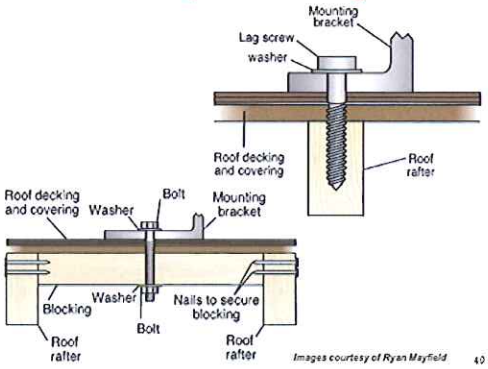


Illustration courtesy of Quick Mount's

39

Rooftop Anchorage



Images courtesy of Ryan Mayfield

40

Module Details

41

PV Module Label

Photo courtesy of Jeff Fecteau

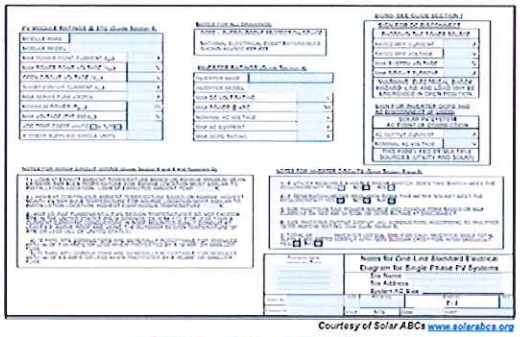
42

Inverter Details

Courtesy of SMA

43

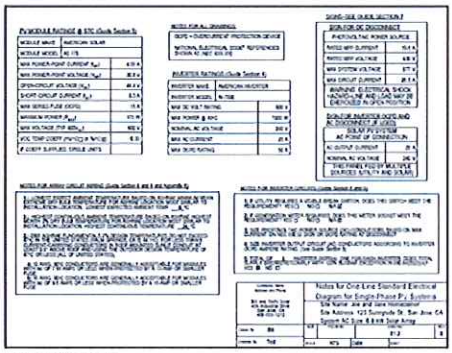
Equipment Details



Courtesy of Solar ABCs www.solarabcs.org

Fill in the blanks

44



Courtesy of Bill Brooks

45

Key Inspection Points

- Number of PV modules and PV model numbers match plans
- Array conductors and components are installed in a neat and workman like manner
- PV array is properly grounded
- Electrical boxes are accessible and connections are suitable for environment
- Array is fastened and sealed according to attachment detail
- Conductors ratings and sizes match plans

46

Key Inspection Points *(cont.)*

- Appropriate signs are properly constructed, installed and displayed, including:
  - Sign identifying PV power source system attributes at dc disconnect
  - Sign identifying ac point of connection
  - Sign identifying switch for alternative power system

47

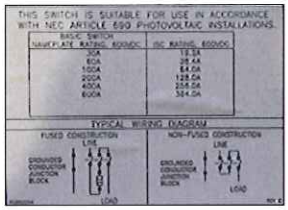
Key Inspection Points *(cont.)*

- Equipment ratings are consistent with application and installed signs on the installation, including:
  - Inverter has a rating as high as max voltage on PV Power Source sign
  - DC-side OCPD's are DC rated at least as high as max voltage on sign
  - Switches and OCPDs are installed according to manufacturers specifications

48

Key Inspection Points *(cont.)*

- Many 600 volt dc switches require passing through the switch poles twice in a specific way



Photos courtesy of Jeff Fecteau

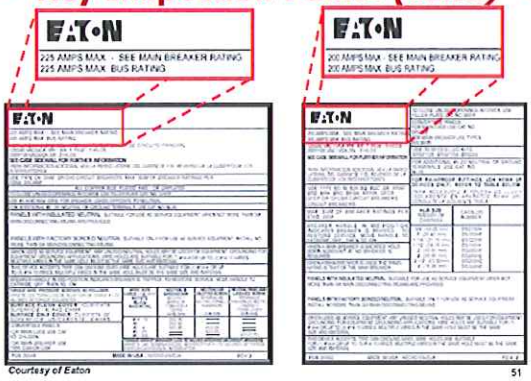
49

Key Inspection Points *(cont.)*

- Equipment ratings are consistent with application and installed signs on the installation, including:
  - Inverter is rated for the site ac voltage supplied and shown on the ac point of connection sign
  - OCPD connected to the ac output of the inverter is rated at least 125% of maximum current on sign, and is no larger than the maximum OCPD on the inverter listing label
  - Sum of the main OCPD and the inverter OCPD is rated for not more than 120% of the busbar rating

50

Key Inspection Points *(cont.)*



Courtesy of Eaton

51

NEC Article 690 Solar Photovoltaic (PV) Systems

- Part I — General
- Part II — Circuit Requirements
- Part III — Disconnecting Means
- Part IV — Wiring Methods
- Part V — Grounding
- Part VI — Marking
- Part VII — Connection to Other Sources
- Part VIII — Storage Batteries
- Part IX — Systems Over 600 Volts

52

NEC Article 705 Interconnected Electric Power Production Sources

- Part I — General
- Part II — Utility-Interactive Inverters
- Part III — Generators

(see Article 705 slides later in presentation)

53

Article 690 - Part I General

Photos courtesy of DOE/NREL

54

NEC Article 690 - Definitions

- **Definitions:**
  - Array
  - Building Integrated Photovoltaics
  - Interactive System
  - Inverter
  - Inverter Output Circuit
  - Module
  - Panel
  - Photovoltaic Output Circuit
  - Photovoltaic Source Circuit
  - Stand-Alone System

55

NEC Article 690 - Definitions

Array. A mechanically integrated assembly of modules or panels with a support structure and foundation, tracker, and other components, as required, to form a direct-current power-producing unit.

Photos courtesy of DOE/NREL

56

NEC Article 690 - Definitions

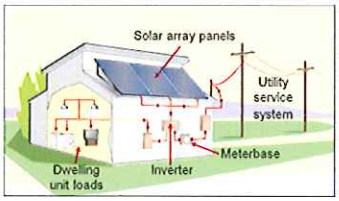
Building Integrated Photovoltaics. Photovoltaic cells, devices, modules, or modular materials that are integrated into the outer surface or structure of a building and serve as the outer protective surface of that building.

Photos courtesy of DOE/NREL

57

NEC Article 690 - Definitions

Interactive System. A solar photovoltaic system that operates in parallel with and may deliver power to an electrical production and distribution network. For the purpose of this definition, an energy storage subsystem of a solar photovoltaic system, such as a battery, is not another electrical production source.



58

NEC Article 690 - Definitions

Inverter. Equipment that is used to change voltage level or waveform, or both, of electrical energy.

Commonly, an inverter [also known as a power conditioning unit (PCU) or power conversion system (PCS)] is a device that changes dc input to an ac output.

Inverters may also function as battery chargers that use alternating current from another source and convert it into direct current for charging batteries.

59

NEC Article 690 - Definitions

Inverter. Equipment that is used to change voltage level or waveform, or both, of electrical energy.

60

NEC Article 690 - Definitions

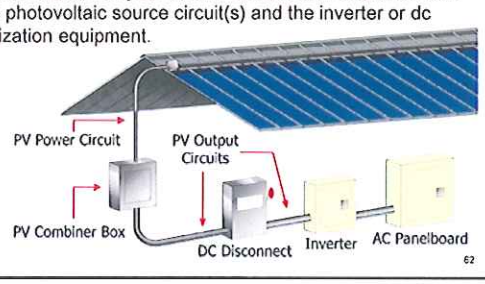
Module. A complete, environmentally protected unit consisting of solar cells, optics, and other components, exclusive of tracker, designed to generate dc power when exposed to sunlight.

61

NEC Article 690 - Definitions

Photovoltaic Source Circuit. Circuits between modules and from modules to the common connection point(s) of the dc system.

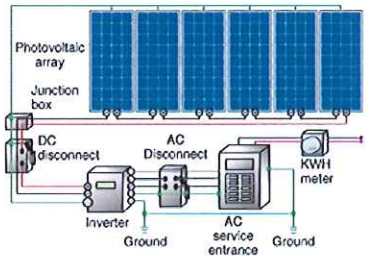
Photovoltaic Output Circuit. Circuit conductors between the photovoltaic source circuit(s) and the inverter or dc utilization equipment.



62

690.3 Other Articles

- Where the PV system is operated in parallel with a primary source(s) of electricity, the applicable requirements in Article 705 shall apply



**Article 705 Interconnected Electric Power Production Sources*

Image courtesy of Ryan Mayfield

63

690.4(A) Photovoltaic Systems

- PV system(s) shall be permitted to supply a building or other structure in addition to any other electricity supply system(s)

Photo courtesy of DOE/NREL

64

690.4(B) Identification & Grouping

- PV circuits (dc/ac) shall not be contained in the same raceway, cable tray, cable, outlet box, junction box, or similar fitting as conductors, feeders, or branch circuits of other non-PV systems, unless the conductors of the different systems are separated by a partition

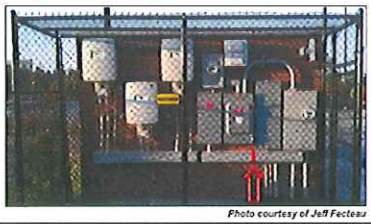


Photo courtesy of Jeff Fecteau

65

690.4(B) Identification & Grouping

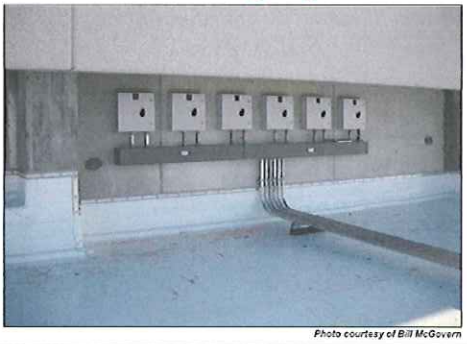


Photo courtesy of Bill McGovern

66

690.4(B) Identification & Grouping

(1) **PV Source Circuits.** ...shall be identified at all points of termination, connection, and splices

(2) **PV Output and Inverter Circuits.** ...shall be identified at all points of termination, connection, and splices

(3) **Conductors of Multiple Systems.** ...of more than one PV system occupy the same ... the conductors of each system shall be identified at all termination, connection, and splice points

(4) **Grouping.** ...of more than one PV system occupy the same junction box or raceway with a removable cover(s), the ac and dc conductors of each system shall be grouped separately by wire ties or similar means at least once, and then shall be grouped at intervals not to exceed 1.8 m (6 ft)

67

690.4(D) Equipment

- Inverters, PV modules, combiners, charge controllers and ... shall be identified and listed for the application

68

690.4(E) Wiring & Connections

- "Qualified persons" are required to perform the described work on photovoltaic (PV) systems

- **Qualified Person.** One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved

69

70

NABCEP Recognized PV Training Programs

- UL Knowledge Services
  http://lms.ulknowledgeservices.com/certification

North American Board of Certified Energy Practitioners* *(NABCEP)***

71

Basic PV Standards

- **UL 1699B** – Photovoltaic DC Arc-Fault Circuit Protection
- **UL 1703** - Flat Plate Photovoltaic Modules and Panels
- **UL 1741** - Inverters, Converters, Controllers, and Interconnection System Equipment For Use With Distributed Energy Resources
- **UL 2703** - Rack Mounting Systems and Clamping Devices for Flat-Plate Photovoltaic Modules and Panels
- **ICC ES AC 365** - Building Integrated Photovoltaic Systems

72

UL Product Categories

DIUR - Circuit Breakers, Molded Case and Circuit-breaker Enclosures for Use in Photovoltaic Systems

IZMR - Fuseholders, Photovoltaic

JFGA - Fuses for Photovoltaic System

JDDZ - Cartridge Fuses, Nonrenewable
(Intended for AC circuits only, unless also marked with DC voltage rating)

QIGU - Photovoltaic Modules & Panels

QIKA - Photovoltaic Solar Trackers

QIKH - Photovoltaic Inverters

QIBP - Photovoltaic Charge Controllers

73

UL Product Categories

QIIO - Distributed Generation Power Systems Accessory Equipment

QIJL - Distributed Resource Power Systems

QIMS - Photovoltaic Mounting Systems, Mounting Devices, Clamping Devices and Ground Lugs
(Both mounting systems and clamping devices may be for bonding and/or mechanical loading)

QHYZ - AC Modules

QHZK - Building-integrated Photovoltaic Modules & Panels

QHZS - Distributed Generation Wiring Systems and Harnesses

74

UL Product Categories

QHZQ - Building-integrated Photovoltaic Mounting Systems

QIIA - Photovoltaic Modules and Panels with System Voltage Ratings above 600 V

WJBE - Switches, Molded Case, for Use in Photovoltaic Systems

WHXX - Switches, Dead-front for Use in Photovoltaic Systems

WIBC - Switches, Enclosed for Use in Photovoltaic Systems

ZKLA - Photovoltaic Wire

75

690.4(F) Circuit Routing

- New requirements were added for visibility and roof marking of certain PV circuits
- Firefighting community has expressed concern about the safety of ventilating roofs where PV circuits are present
- Routing PV circuits along the building structural members will lower probability that the structural members will be compromised by the firefighting process during a fire
- When PV module system circuits are integrated into the roof, PV associated circuits are to be clearly marked on the surface of the roof as a visual aid for firefighters and other maintenance personnel

76

690.4(H) Multiple Inverters

- PV systems permitted to have multiple utility-interactive inverters installed in or on a single building or structure

Photo courtesy of DOE/NREL

77

690.4(H) Multiple Inverters

- Where the inverters are remotely located from each other, a directory in accordance with 705.10 shall be installed at each dc PV system disconnecting means, at each ac disconnecting means, and at the main service disconnecting means showing the location of all ac and dc PV system disconnecting means in the building

Photo courtesy of DOE/NREL

78

690.5 Ground-Fault Protection

- Grounded DC PV arrays shall be provided with dc ground-fault protection per 690.5(A) through (C) to reduce fire hazard

Not for personnel protection!
(That would be GFCI protection)

Photo courtesy of Jeff Facteau

79

Ground-Fault Protection

80

690.5(A) Ground-Fault Detection and Interruption

- Permits automatic opening of the grounded conductor of the faulted circuit
- If the grounded conductor is opened, all conductors of the faulted circuit shall be automatically and simultaneously opened
- Manual operation of the PV dc disconnect shall not activate the GFP or result in the grounded conductors becoming ungrounded

81

UL 1741 Overcurrent Protection

- 31.1 Inverters or charge controllers with direct photovoltaic inputs from a grounded photovoltaic array or arrays shall be provided with a ground-fault detector/interrupter (GFDI)
  - *Exception No. 1: ac modules are not required to be provided with a GFDI*
  - *Exception No. 2: Inverters or charge controllers without GFDI devices may be used when the unit includes the following markings*

82

690.5(C) Labels and Markings

- A warning label shall appear on the utility-interactive inverter or be applied by the installer near the ground-fault indicator at a visible location, stating the following:

WARNING
ELECTRIC SHOCK HAZARD
IF A GROUND FAULT IS INDICATED, NORMALLY GROUNDED CONDUCTORS MAY BE UNGROUNDED AND ENERGIZED

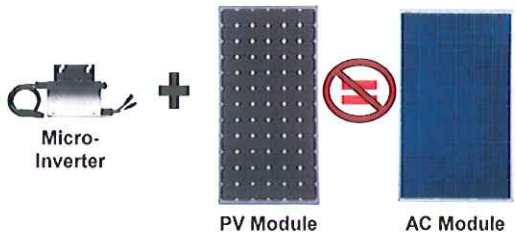
83

690.6 Alternating-Current (ac) Modules

- **690.2 Definitions**
  - **Alternating-Current (ac) Module (Alternating-Current Photovoltaic Module).** A complete, environmentally protected unit consisting of solar cells, optics, inverter, and other components, exclusive of tracker, designed to generate ac power when exposed to sunlight.
- An ac PV module consists of a single integrated mechanical unit
- Because there is no accessible, field-installed dc wiring in this single unit, the dc PV source-circuit requirements in the *NEC* are not applicable to the dc wiring in an ac PV module

84

690.6 Alternating-Current (ac) Modules



65

690.6 Alternating-Current (ac) Modules

Photo courtesy of Bill McGovern

66

Article 690 Part II Circuit Requirements

Photo courtesy of Jeff Facteau

87

690.7 Maximum Voltage

- One- and Two-Family dwellings maximum is 600 volts
- Other occupancies is unlimited

Photos courtesy of DOE/NREL

88

690.7 Maximum Voltage

- When open-circuit voltage temperature coefficients are supplied in the instructions for listed PV modules, they shall be used to calculate the maximum photovoltaic system voltage as required by 110.3(B) instead of using Table 690.7
- These temperature coefficients provide a more accurate maximum system voltage and are required to be used instead of applying Table 690.7
- The *NEC* does not require temperature coefficient information to be included in the installation instructions

89

Table 690.7 Voltage Correction Factors for Crystalline and Multicrystalline Silicon Modules *(in part)*

Correction Factors for Ambient Temperatures Below 25° C (77F) (Multiply the rated open circuit voltage by the appropriate correction factor shown below)		
Ambient Temperature (°C)	Factor	Ambient Temperature (°F)
24 to 20	1.02	76 to 68
19 to 15	1.04	67 to 59
14 to 10	1.06	58 to 50
9 to 5	1.08	49 to 41
4 to 0	1.10	40 to 32
-1 to -5	1.12	31 to 23
-6 to -10	1.14	22 to 14
-11 to -15	1.16	13 to 5

90

690.8(A) Circuit Sizing

- DC: The maximum current shall be the sum of parallel module rated short-circuit currents multiplied by 125%

5.5 X 1.25 = **6.875 A** maximum current

Maximum Power (P_{max})	185 Wp -0/+5 Wp
Voltage at P_{max}	36,27 V
Current at P_{max}	5,10 A
Short Circuit Current	5,50 A
Open Circuit Voltage	45,00 V
Max. System Voltage	600 V (VDE certificated 1000V)
Fuse Rating	10 A
NOCT	+47 +/- 2 °C
Fire Rating	C
Field Wiring	copper only 12 AWG min. insulated for 90° C min.

Photo courtesy of Jeff Fecteau

Reason: *PV output circuits can deliver output currents higher than the rated short-circuit currents for more than 3 hours near solar noon*

91

690.8(A)(3) Circuit Sizing

- AC: The maximum current shall be the inverter continuous output current rating

Max. continuous output Power* **xxxxx Wac**		
Operating voltage range (Vac)*		
MIN	NOMINAL	MAX
XXX	**XXX**	**XXX**
Operating frequency range (Hz)*		
MIN	NOMINAL	MAX
XX.X	**XX.X**	**XX.X**
Max. continuous output current* **xx Aac**		

Nameplate courtesy of SMA

92

690.8(B)(1) Ampacity

- The circuit conductors and overcurrent devices shall be sized to carry not less than 125 percent of the maximum currents as calculated in 690.8(A)

690.8(A) Maximum Circuit Current

SSC 5.50 x 125 % = 6.875 Amps

Maximum Power (P_{max})	185 Wp -0/+5 Wp
Voltage at P_{max}	36,27 V
Current at P_{max}	5,10 A
Short Circuit Current	5,50 A
Open Circuit Voltage	45,00 V
Max. System Voltage	600 V (VDE certificated 1000V)
Fuse Rating	10 A
NOCT	+47 +/- 2 °C
Fire Rating	C
Field Wiring	copper only 12 AWG min. insulated for 90° C min.

Photo courtesy of Jeff Fecteau

690.8(B)(1) Conductor & OCPD Size

6.875 Amps x 125% = **8.59 Amps**

93

690.8 Circuit Sizing and Current

(D) Where a single overcurrent device is used to protect a set of two or more parallel-connected module circuits, the ampacity of each of the module interconnection conductors shall not be less than the sum of the rating of the single fuse plus 125 percent of the short-circuit current from the other parallel-connected modules

Photo courtesy of Jeff Fecteau

94

690.9 OCPD for PV Array

- When modules are shaded, back feeding is possible from other parallel strings
  - Result - overheating of modules and wiring
  - Key - proper rated fuse, not exceeding modules' max. fuse rating

Photos courtesy of DOE/NREL and Jeff Fecteau

95

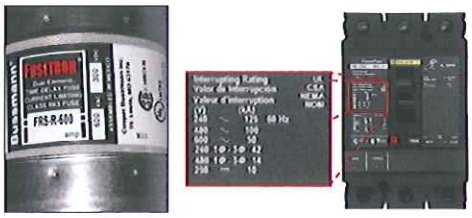
Combiner Box

Photos courtesy of DOE/NREL and Jeff Fecteau

96

690.9(D) Direct-Current Rating

- Overcurrent devices, either fuses or circuit breakers, used in any DC portion of a PV power system shall be listed for use in DC circuits



97

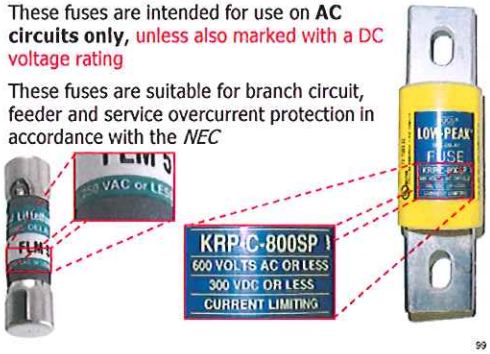
690.9(D) Direct-Current Rating

- DC fault currents are considerably harder to interrupt than AC fault currents
- Overcurrent devices marked or listed only for AC use should not be used in DC circuits
- Automotive and marine-type fuses, although used in DC systems, are not suitable for use in premise wiring of residential or commercial electrical power systems

98

UL Category JDDZ

- These fuses are intended for use on **AC circuits only**, unless also marked with a DC voltage rating
- These fuses are suitable for branch circuit, feeder and service overcurrent protection in accordance with the *NEC*



99

690.10 Stand-Alone Systems

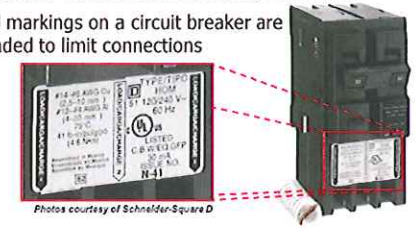
- **690.10(E) Back-fed Circuit Breakers.** Plug-in type back-fed circuit breakers connected to a stand-alone inverter output in either stand-alone or utility-interactive systems shall be secured in accordance with 408.36(D)

Photos courtesy of Jeff Simpson

100

Back-fed Circuit Breakers

- **690.10(E) Back-fed Circuit Breakers.** Circuit breakers that are marked "line" and "load" shall not be backfed
- **UL 489.** Line and load markings on a circuit breaker are intended to limit connections thereto as marked
- Load markings on a circuit breaker are intended to limit connections



Photos courtesy of Schneider-Square D

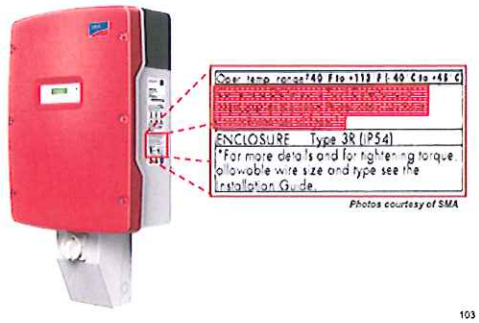
101

690.11 Arc-Fault Circuit Protection (Direct Current)

- AFCI protection (dc) shall be provided for PV systems with dc source circuits, dc output circuits, or both, on or penetrating a building operating at a PV system maximum system voltage of 80 volts or greater
- System shall detect and interrupt arcing faults in the dc PV source and output circuits
- System shall disable or disconnect inverters or charge controllers connected to the fault circuit or system components within the arcing circuit
- Disabled or disconnected equipment shall be manually restarted
- System to have an annunciator that provides a visual indication that the AFCI has operated
- Indication shall not reset automatically

102

690.11 Arc-Fault Circuit Protection (Direct Current)



Photos courtesy of SMA

103

Article 690 Part III Disconnection Means

104

690.13 All Conductors

- Means shall be provided to disconnect all current-carrying dc conductors of a PV system from all other conductors in a building or other structure
- A switch, circuit breaker, or other device shall not be installed in a grounded conductor if operation of that switch, circuit breaker, or other device leaves the marked, grounded conductor in an ungrounded and energized state

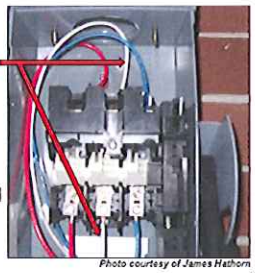


Photo courtesy of James Hathorn

105

690.13 All Conductors

- Means shall be provided to disconnect all current-carrying dc conductors of a PV system from all other conductors in a building or other structure
- ***Ex. No. 1:*** *A switch or circuit breaker that is part of a ground-fault detection system required by 690.5, or that is part of an arc-fault detection/interruption system required by 690.11, shall be permitted to open the grounded conductor when that switch or circuit breaker is automatically opened as a normal function of the device in responding to ground faults*

106

690.13 All Conductors

- Means shall be provided to disconnect all current-carrying dc conductors of a PV system from all other conductors in a building or other structure
- ***Ex. No. 2:*** *A disconnecting switch shall be permitted in a grounded conductor if all of the following conditions are met:*
  - *(1) The switch is used only for PV array maintenance*
  - *(2) The switch is accessible only by qualified persons*
  - *(3) The switch is rated for the maximum dc voltage and current that could be present during any operation, including ground-fault conditions*

107

690.14(C) Disconnecting Means

- Means shall be provided to disconnect all conductors in a building or other structure from the PV system conductors

1. ...shall be installed in a readily accessible location ... outside of a building or structure or inside nearest the point of entrance...not to be installed in bathrooms

Photo courtesy of Mark Ode

108

690.14(C) Disconnecting Means

- Means shall be provided to disconnect all conductors in a building or other structure from the PV system conductors

2. Each PV system disconnecting means shall be permanently marked to identify it as a PV system disconnecting means

Photo courtesy of Bill McGovern

109

690.14(C) Disconnecting Means

- Means shall be provided to disconnect all conductors in a building or other structure from the PV system conductors

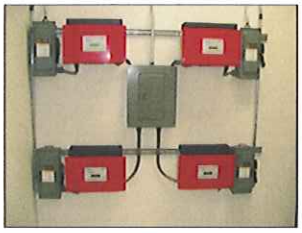
3. Each PV system disconnecting means shall be suitable for the prevailing conditions

110

690.14(C) Disconnecting Means

- Means shall be provided to disconnect all conductors in a building or other structure from the PV system conductors

4. PV disconnecting means shall consist of not more than six switches or six circuit breakers mounted in a single enclosure, in a group of separate enclosures, or in or on a switchboard



111

690.14(C) Disconnecting Means

- Means shall be provided to disconnect all conductors in a building or other structure from the PV system conductors

5. PV disconnecting means shall be grouped with other disconnecting means for the system… shall not be required at the PV module or array location

112

690.14(D) Utility-Interactive Inverters Mounted in Not-Readily-Accessible Locations

- Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible
- These installation through (4):

113

690.14(D) U-I Inverters

- Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible
- These installations shall comply with (1) through (4):

(1) A direct-current PV disconnecting means shall be mounted within sight of or in the inverter

(2) An alternating-current disconnecting means shall be mounted within sight of or in the inverter

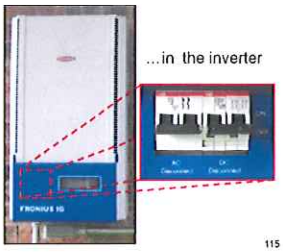
114

690.14(D) U-I Inverters

- Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible
- These installations shall comply with (1) through (4):

(1) A direct-current PV disconnecting means shall be mounted within sight of or in the inverter

(2) An alternating-current disconnecting means shall be mounted within sight of or in the inverter



115

690.14(D) U-I Inverters

- Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible
- These installations shall comply with (1) through (4):

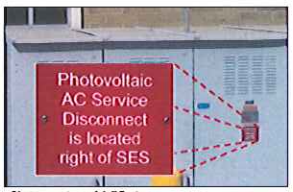
(3) The ac output conductors from the inverter and an additional ac disconnect for the inverter shall comply with 690.14(C)(1)... *(readily accessible location)*

116

690.14(D) U-I Inverters

- Utility-interactive inverters shall be permitted to be mounted on roofs or other exterior areas that are not readily accessible
- These installations shall comply with (1) through (4):

(4) A plaque shall be installed in accordance with 705.10... *(permanent plaque or directory denoting all electric power sources...)*



Photos courtesy of Jeff Fecteau

117

690.15 Disconnection of PV Equipment

- Means shall be provided to disconnect equipment, such as inverters, batteries, charge controllers, and the like, from all ungrounded conductors of all sources
- If the equipment is energized from more than one source, the disconnecting means shall be grouped and identified

Photo courtesy of Bill McGovern

118

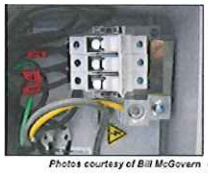
690.16(B) Fuse Servicing

- A disconnecting means shall be installed on PV output circuits where fuses must be serviced that cannot be isolated from energized circuits
- Shall be within sight of, and accessible to, the location of the fuse or integral with fuse holder and shall comply with 690.17
- Where located more than 1.8 m (6 ft) from the overcurrent device, a directory showing the location of each disconnect shall be installed at the OCPD location
- Non-load-break-rated disconnecting means shall be marked "Do not open under load"

Photo courtesy of Bill McGovern

119

690.16(B) Fuse Servicing



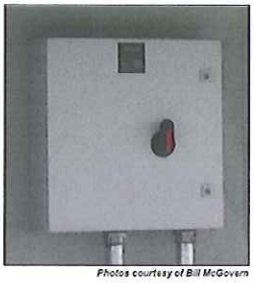
Photos courtesy of Bill McGovern

120

Photo courtesy of Bill McGovern

121

Integrated Disconnect



Photos courtesy of Bill McGovern

122

Integrated Disconnect

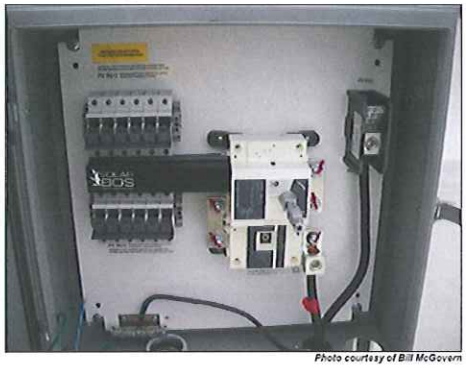


Photo courtesy of Bill McGovern 123

Integrated Disconnect

Photo courtesy of Bill McGovern

(Close-up of previous switch)

124

690.17
Switch or Circuit Breaker

- The disconnecting means for ungrounded conductors shall consist of a manually operable switch(es) or circuit breaker(s) complying with all of the following requirements:
  - (1) Located where readily accessible
  - (2) Externally operable without exposing the operator to contact with live parts
  - (3) Plainly indicating whether in the open or closed position
  - (4) Having an interrupting rating sufficient for the nominal circuit voltage and the current that is available at the line terminals of the equipment

125

690.17
Switch or Circuit Breaker

- Where all terminals of the disconnecting means may be energized in the open position, a warning sign shall be mounted on or adjacent to the disconnecting means
- The sign shall be clearly legible and have the following words or equivalent:

WARNING

ELECTRIC SHOCK HAZARD

DO NOT TOUCH TERMINALS

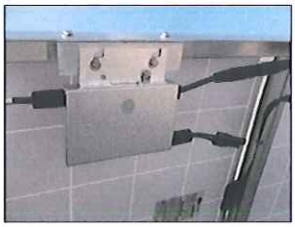
TERMINALS ON BOTH THE LINE AND LOAD SIDES MAY BE ENERGIZED IN THE OPEN POSITION

Photo courtesy of Bill McGovern

126

690.17
Switch or Circuit Breaker

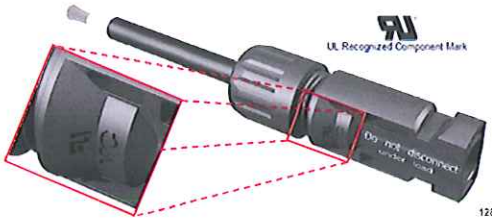
- ***Exception:*** *A connector shall be permitted to be used as an ac or a dc disconnecting means, provided that it complies with the requirements of 690.33 (connectors) and is listed and identified for the use*



127

690.17
Switch or Circuit Breaker

- Listed and identified for the use
- The UL Recognized Component Mark does not provide evidence of listing or labeling, which may be required by installation codes or standards



128

Article 690
Part IV Wiring Methods

129

690.31(A) Wiring Systems

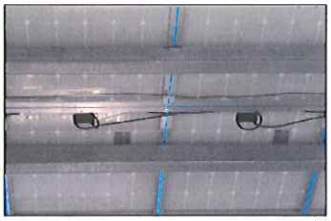
- All raceway and cable wiring methods included in the *NEC* and other wiring systems and fittings specifically intended and identified for use on PV arrays shall be permitted
- **Informational Note:** PV modules operate at elevated temperatures when exposed to high ambient temperatures and to bright sunlight

Photo courtesy of Bill McGovern

130

690.31(B)
Single-Conductor Cable

- Single-conductor cable type USE-2, and single-conductor cable listed and labeled as PV wire shall be permitted in exposed outdoor locations in PV source circuits for PV module interconnections within the PV array



131

690.31(E) Direct-Current PV Source and Output Circuits Inside a Building

- Where dc PV source or output circuits from a building-integrated or other PV system are run inside a building or structure, they shall be contained in the following wiring methods:
  - Metal raceways
  - Type MC metal-clad cable that complies with 250.118(10) *(for EGC)*
  - Metal enclosures
- Shall comply from the point of penetration of the surface of the building or structure to the first readily accessible disconnecting means

132

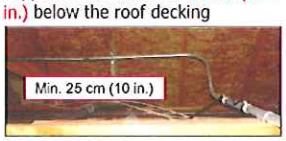
690.31(E) Direct-Current PV Source and Output Circuits Inside a Building

Photo courtesy of Jeff Simpson

133

690.31(E)(1) Beneath Roofs

- Wiring methods shall not be installed within 25 cm (10 in.) of the roof decking or sheathing except where directly below the roof surface covered by PV modules and associated equipment
- Circuits shall be run perpendicular to the roof penetration point to supports a minimum of 25 cm (10 in.) below the roof decking



Photos courtesy of Bill McGovern

134

690.31(E)(2) Flexible Wiring Methods

- Where FMC smaller than MD 21 (trade size ¾) or Type MC cable smaller than 25 mm (1 in.) in diameter containing PV power circuit conductors is installed across ceilings or floor joists, the raceway or cable shall be protected by substantial guard strips that are at least as high as the raceway or cable
- Where run exposed, other than within 1.8 m (6 ft) of their connection to equipment, these wiring methods shall closely follow the building surface or be protected from physical damage by an approved means

Photo courtesy of Jeff Simpson

135

690.31(E)(3) Marking or Labeling Required

- The following wiring methods and enclosures that contain PV power source conductors shall be marked with the wording "Photovoltaic Power Source" by means of permanently affixed labels or other approved permanent marking:
  - (1) Exposed raceways, cable trays, and other wiring methods
  - (2) Covers or enclosures of pull boxes and junction boxes
  - (3) Conduit bodies in which any of the available conduit openings are unused

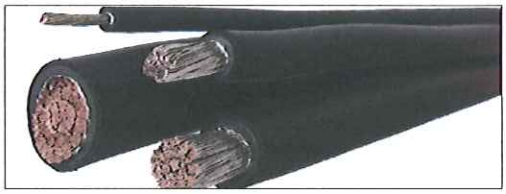
136

690.31(E)(4) Marking and Labeling

- Labels or markings shall be visible after installation
- PV power circuit labels shall appear on every section of the wiring system that is separated by enclosures, walls, partitions, ceilings, or floors
- Spacing between labels and markings shall not be more than 3 m (10 ft)
- Labels shall be suitable for the environment where they are installed

137

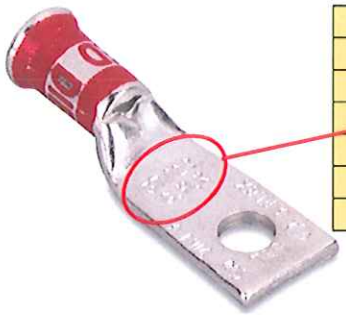
690.31(F) Flexible, Fine-Stranded Cables



- Flexible, fine-stranded cables shall be terminated only with terminals, lugs, devices, or connectors in accordance with 110.14(A)

138

690.31(F) Flexible, Fine-Stranded Cables



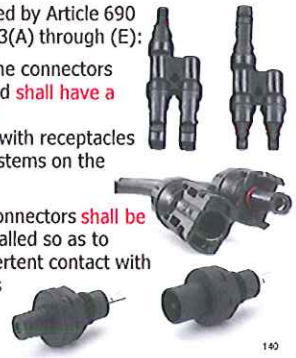
14	19/0.0147
12	19/0.0185
10	27/24
8	37/24
6	61/24
4	105/24
2	154/24

Photo courtesy of T&B

139

690.33 Connectors

- The connectors permitted by Article 690 shall comply with 690.33(A) through (E):
  - (A) Configuration. The connectors shall be polarized and shall have a configuration that is noninterchangeable with receptacles in other electrical systems on the premises
  - (B) Guarding. The connectors shall be constructed and installed so as to guard against inadvertent contact with live parts by persons



140

690.33 Connectors *(cont.)*

- The connectors permitted by Article 690 shall comply with 690.33(A) through (E):
  - (C) Type. The connectors shall be of the latching or locking type
  - Connectors that are readily accessible and that are used in circuits operating at over 30 volts, nominal, maximum system voltage for dc circuits, or 30 volts for ac circuits, shall require a tool for opening
  - (D) Grounding Member. The grounding member shall be the first to make and the last to break contact with the mating connector

141

690.33 Connectors

- The connectors permitted by Article 690 shall comply with 690.33(A) through (E):
  - (E) Interruption of Circuit. Connectors shall be either (1) or (2):

    (1) Be rated for interrupting current without hazard to the operator

    (2) Be a type that requires the use of a tool to open and marked "Do Not Disconnect Under Load" or "Not for Current Interrupting"

142

UL Category QIJQ2 Recognized Component

- ... may consist of in-line connectors, panel-mounted connectors, distribution blocks and splitter connectors for the purpose of facilitating connections up to and including inverters, combiner boxes, and like devices in a PV system
- They are not intended to be used on the output side of inverters and combiner boxes or to downstream system components from such devices

143

690.35 Ungrounded PV Power Systems

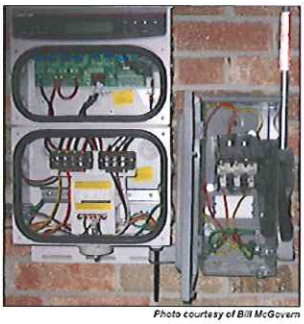


Photo courtesy of Bill McGovern

- PV Power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with 690.35(A) through (G):

144

690.35 Ungrounded PV Power Systems

- PV Power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with 690.35(A) through (G):
  - **(A) Disconnects.** All photovoltaic source and output circuit conductors shall have disconnects complying with 690, Part III
  - **(B) Overcurrent Protection.** All photovoltaic source and output circuit conductors shall have overcurrent protection complying with 690.9

145

690.35 Ungrounded PV Power Systems *(cont.)*

- PV Power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with 690.35(A) through (G):
  - **(C) Ground-Fault Protection.** All PV source and output circuits shall be provided with a ground-fault protection device or system that complies with (1) through (3):
    (1) Detects a ground fault
    (2) Indicates that a ground fault has occurred
    (3) Automatically disconnects all conductors or causes the inverter or charge controller connected to the faulted circuit to automatically cease supplying power to output circuits

146

690.35 Ungrounded PV Power Systems *(cont.)*

- PV Power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with 690.35(A) through (G):
  - **(D)** The photovoltaic source conductors shall consist of the following:
    (1) Nonmetallic jacketed multiconductor cables
    (2) Conductors installed in raceways, or
    (3) Conductors listed and identified as Photovoltaic (PV) Wire installed as exposed, single conductors

147

690.35 Ungrounded PV Power Systems *(cont.)*

- PV Power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with 690.35(A) through (G):
  - **(F)** The PV power source shall be labeled with the following warning at each junction box, combiner box, disconnect, and device where energized, ungrounded circuits may be exposed during service:

WARNING

ELECTRIC SHOCK HAZARD

THE DC CONDUCTORS OF THIS PHOTOVOLTAIC SYSTEM ARE UNGROUNDED AND MAY BE ENERGIZED

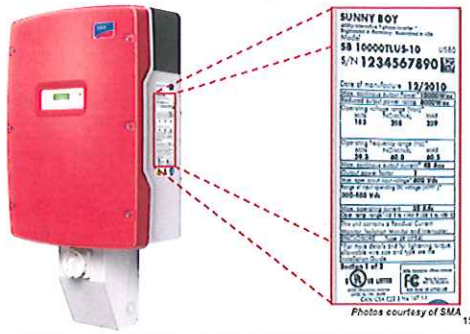
148

690.35 Ungrounded PV Power Systems *(cont.)*

- PV Power systems shall be permitted to operate with ungrounded PV source and output circuits where the system complies with 690.35(A) through (G):
  - **(G)** The inverters or charge controllers used in systems with ungrounded PV source and output circuits shall be listed for the purpose

149

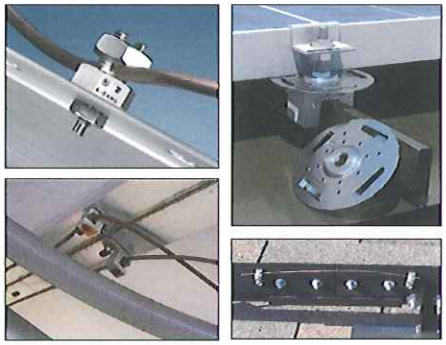
690.35 Ungrounded PV Power Systems



Photos courtesy of SMA

150

Article 690 - Part V Grounding



151

690.42 Point of System Grounding Connection

- The DC circuit grounding connection shall be made at any single point on the photovoltaic output circuit
  - ***Exception:*** *Systems with a 690.5 GFP device shall be permitted to have the required grounded conductor-to-ground bond made at the GFP device*
  - *This bond, where internal to the GFP equipment, shall not be duplicated with an external connection*
- **Note:** Locating the grounding connection point as close as practicable to the PV source better protects the system from voltage surges due to lightning

152

690.43 Equipment Grounding

- Equipment grounding conductors and devices shall comply with 690.43(A) through (F):
  - **(A) Equipment Grounding Required.** Exposed non–current-carrying metal parts of module frames, equipment, and conductor enclosures shall be grounded in accordance with 250.134 or 250.136(A) regardless of voltage

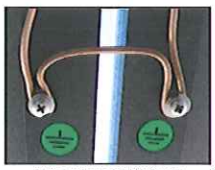


Photo courtesy of Bill McGovern

153

690.43 Equipment Grounding

- Equipment grounding conductors and devices shall comply with 690.43(A) through (F):
  - **(B) Equipment Grounding Conductor Required.** An equipment grounding conductor between the PV array and other equipment shall be required in accordance with 250.110

Photos courtesy of Bill McGovern

154

690.43 Equipment Grounding

- Equipment grounding conductors and devices shall comply with 690.43(A) through (F):
  - **(C) Structure as Equipment Grounding Conductor.** Devices listed and identified for grounding the metallic frames of PV modules or other equipment shall be permitted to bond the exposed metal surfaces or other equipment to mounting structures
  - Metallic mounting structures, other than building steel, used for grounding purposes shall be identified as equipment-grounding conductors or shall have identified bonding jumpers or devices connected between the separate metallic sections and shall be bonded to the grounding system

155

690.43 Equipment Grounding

- Equipment grounding conductors and devices shall comply with 690.43(A) through (F):
  - **(C) Structure as Equipment Grounding Conductor.** ...listed and identified for grounding...

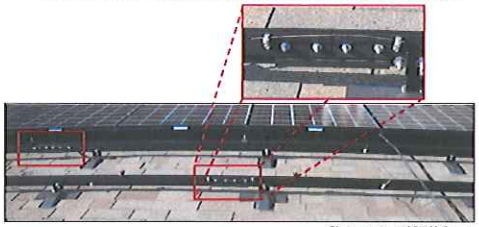
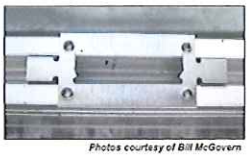


Photo courtesy of Bill McGovern

156

690.43 Equipment Grounding



Photos courtesy of Bill McGovern

157

690.43 Equipment Grounding

Photo courtesy of Bill McGovern

158

UL 2703 Use and Installation

- PV mounting systems, mounting devices, clamping devices and ground lugs are intended for use with specific PV modules and panels, specified module frames, mounting structures as identified in the individual certifications
- Mounting systems and clamping devices may be investigated for mechanical mounting alone, or mechanical mounting and ground bonding as identified in the individual certifications
- Ground lugs may be investigated for use with specific PV modules, specific PV module frames, or specific mounting-system rails

Photo courtesy of S-5

159

690.43 Equipment Grounding

- Equipment grounding conductors and devices shall comply with 690.43(A) through (F):
  - **(E) Adjacent Modules.** Devices identified and listed for bonding the metallic frames of PV modules shall be permitted to bond the exposed metallic frames of PV modules to adjacent PV modules
- Concerns:

Exposed terminations

Photo courtesy Bill Brooks

Dissimilar metals

Photo courtesy Rhonda Parkhurst

160

690.45(A) Size of EGCs

- Where protected by GFP per 690.5, the min. size for equipment grounding conductors shall be in per 250.122

Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	1	1/0
600	1/0	2/0

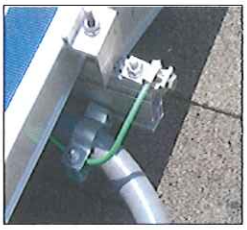
Note: Where necessary to comply with 250.4(A)(5) or 250.4(B)(4), the equipment grounding conductor shall be sized larger than given in this table.

* See installation restrictions in 250.120 *(in part)*

161

690.46 Array EGCs

- Equipment grounding conductors for PV modules smaller the 6 AWG shall comply with 250.120(C)

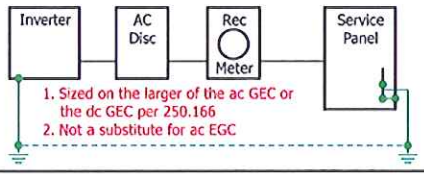


Photos courtesy of Bill McGovern

162

690.47(C) Grounding Electrode System

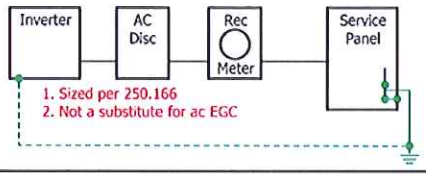
- **(C) Systems with Alternating-Current and Direct-Current Grounding Requirements.** PV systems having dc and ac circuits shall have the dc grounding system bonded to the ac grounding system by one of the following (3) methods:
  - (1) Separate Direct-Current Grounding Electrode System Bonded to the Alternating-Current Grounding Electrode System



163

690.47(C) Grounding Electrode System

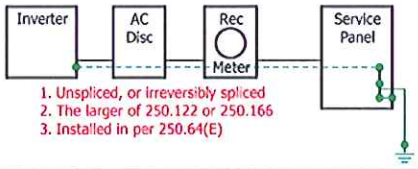
- **(C) Systems with Alternating-Current and Direct-Current Grounding Requirements.** PV systems having dc and ac circuits shall have the dc grounding system bonded to the ac grounding system by one of the following (3) methods:
  - (2) Common Direct-Current and Alternating-Current Grounding Electrode



164

690.47(C) Grounding Electrode System

- **(C) Systems with Alternating-Current and Direct-Current Grounding Requirements.** PV systems having dc and ac circuits shall have the dc grounding system bonded to the ac grounding system by one of the following (3) methods:
  - (3) Combined Direct-Current Grounding Electrode Conductor and Alternating-Current Equipment Grounding Conductor



165

Article 690 - Part VI Marking

Photo courtesy of Rhonda Parkhurst

166

690.53 Direct-Current Photovoltaic Power Source

- A permanent label for the direct-current PV power source indicating items (1) through (5) shall be provided by the installer at the PV disconnecting means:
  - (1) Rated maximum power-point current
  - (2) Rated maximum power-point voltage
  - (3) Maximum system voltage
  - (4) Short-circuit current
  - (5) Maximum rated output current of the charge controller *(if installed)*

167

690.54 Interactive System Point of Interconnection

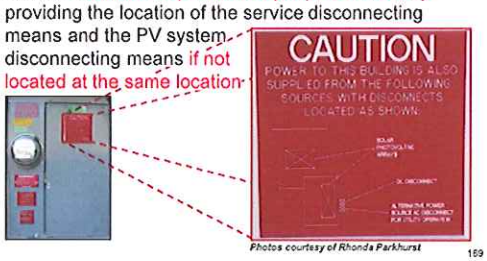
- All interactive system(s) points of interconnection with other sources shall be marked at an accessible location at the disconnecting means as a power source and with the rated ac output current and the nominal operating ac voltage

Photos courtesy of Bill McGovern

168

690.56 Identification of Power Sources

- **(B) Facilities with Utility Services and PV Systems.** Buildings or structures with both utility service and a PV system shall have a permanent plaque or directory providing the location of the service disconnecting means and the PV system disconnecting means if not located at the same location



Photos courtesy of Rhonda Parkhurst

169

Article 690 - Part VII Connection to Other Sources

170

690.64 Point of Connection

- Point of connection shall be in accordance with 705.12
- **705.12 Point of Connection.** The output of an interconnected electric power source shall be connected as specified in (A), (B), (C), or (D):
  - (A) Supply Side
  - (B) Integrated Electrical Systems
  - (C) Greater Than 100 kW
  - (D) Utility-Interactive Inverters

171

NEC Article 705 Interconnected Electric Power Production Sources

- Part I General
- Part II Utility-Interactive Inverters
- Part III Generators

172

705.12(A) Point of Connection

- **705.12 Point of Connection.** The output of an interconnected electric power source shall be connected as specified in (A), (B), (C), or (D):
  - **(A) Supply Side.** An electric power production source shall be permitted to be connected to the supply side of the service disconnecting means as permitted in 230.82(6)
  - The sum of the ratings of all OCPD's connected to power production sources shall not exceed the rating of the service

173

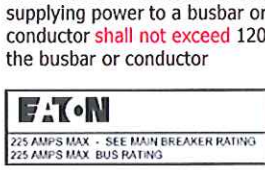
705.12(D) Utility-Interactive Inverters

- **705.12 Point of Connection.** The output of an interconnected electric power source shall be connected as specified in (A), (B), (C), or (D):
  - **(D) Utility-Interactive Inverters.** Output of a utility-interactive inverter shall be permitted to be connected to the load side of the service disconnecting means
  - Where distribution equipment is fed simultaneously by a primary source(s) and one or more utility-interactive inverters, the interconnecting provisions for the utility-interactive inverter(s) shall comply with (D)(1) through (D)(7):

174

705.12(D) Utility-Interactive Inverters

- (1) Each source interconnection shall be made at a dedicated circuit breaker or fusible disconnecting means
- (2) The sum of the ampere ratings of overcurrent devices in circuits supplying power to a busbar or conductor shall not exceed 120% of the busbar or conductor



Photos courtesy of Jeff Fecteau

175

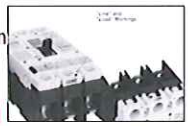
705.12(D) Utility-Interactive Inverters

- (3) The interconnection point shall be on the line side GFP
- (4) Equipment containing overcurrent devices in circuits supplying power to a busbar or conductor supplied from multiple sources shall be marked to indicate the presence of all sources

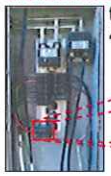
176

705.12(D) Utility-Interactive Inverters

- (5) Circuit breakers, if backfed, shall be suitable for such operation



- (6) Listed plug-in-type circuit breakers backfed from utility-interactive inverters that are listed and identified as interactive shall be permitted to omit the additional fastener normally required by 408.36(D) for such applications



Photos courtesy of Jeff Fecteau and Eaton

177

705.12(D) Utility-Interactive Inverters

- (7) ... a connection in a panelboard shall be positioned at the opposite (load) end from the input feeder location or main circuit location
- A permanent warning label shall be applied to the distribution equipment with the following wording or equivalent:

Photos courtesy of Bill McGovern

178

UL 1741 Utility Interaction

- **UL 1741 - Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources**
- Prevention of exporting power after utility outage ("anti-islanding")
- Addresses:
  - Shock hazards to utility line crews
  - Current contribution to the utility fault
  - Potential problems in re-energizing the line
  - Damage to equipment if line re-energized out of sync with the inverter

179

NEC Applications to PV Installations

- Article 690 is not the only section of the *NEC* applicable to PV Installations
- Knowledge of the structure of the *NEC* is a must for PV installers and enforcers
- See *NEC* 90.3 and Figure 90.3

180

NEC 90.3 Code Arrangement

Chapter 1 - General
Chapter 2 - Wiring and Protection
Chapter 3 - Wiring Methods and Materials
Chapter 4 - Equipment for General Use

} Applies generally to all electrical installations

Supplements or modifies Chapters 1 through 4 { Chapter 5 - Special Occupancies; Chapter 6 - Special Equipment; Chapter 7 - Special Conditions

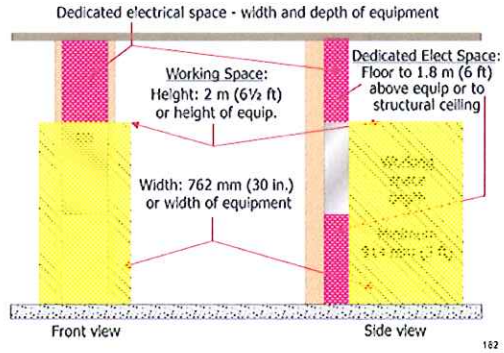
Chapter 8 - Communication Systems } Chapter 8 is NOT subject to the requirements of Chapters 1 through 7 except where the requirements are specifically referenced in Chapter 8

Chapter 9 - Tables } Applicable as referenced

Informational Notes & Annexes } Information only - not mandatory

151

110.26(A) Working Space



182

Table 110.26(A)(1) Working Space

Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
0-150	914 mm (3 ft)	914 mm (3 ft)	914 mm (3 ft)
151-600	914 mm (3 ft)	1.07 m (3½ ft)	1.22 m (4 ft)

Condition 1 Live parts one side, insulated or ungrounded parts other side

Condition 2 Live parts ones side, grounded parts on the other side

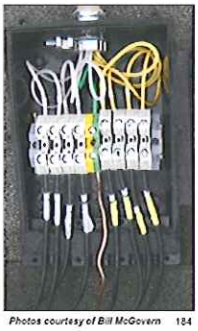
Condition 3 Live parts on both sides of the work space

The requirements in Conditions 1, 2, and 3 to Table 110.26(A)(1) must be applied to establish the minimum depth of working space required in front of electrical equipment

183

200.6(A)(6) Means of Identifying Grounded Conductors

- A single-conductor, sunlight-resistant, outdoor-rated cable used as a grounded conductor in photovoltaic power systems, as permitted by 690.31, in sizes 6 AWG and smaller shall be identified at the time of installation by distinctive white marking at all terminations



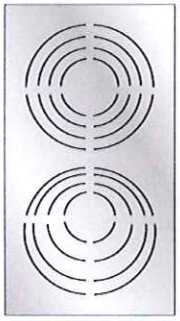
Photos courtesy of Bill McGovern 184

250.97 Bonding for Over 250 Volts

- For circuits of over 250 volts to ground, where oversized concentric, or eccentric knockouts are encountered "Listed Fittings" are required to provide a reliable bonding connection
- Bonding jumpers shall be used around impaired connections, such as reducing washers or oversized, concentric, or eccentric knockouts at service equipment regardless of the voltage *[see 250.92(B)]*

185

Concentric and Eccentric Knockouts



Concentric knockouts

May be necessary to bond around concentric knockouts to ensure current-carrying capacity

Bonding jumpers required around impaired connections such as reducing washers, concentric or eccentric knockouts

Eccentric knockouts

Eccentric rings present the same obstacle to carrying fault current as concentric knockouts

186

250.97 Bonding for Over 250 Volts

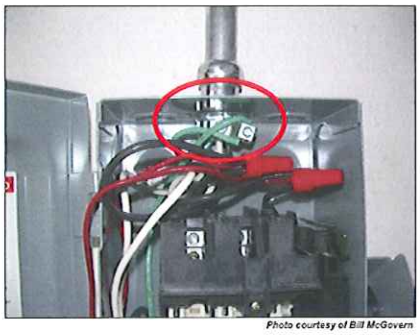


Photo courtesy of Bill McGovern

187

250.97 Bonding for Over 250 Volts

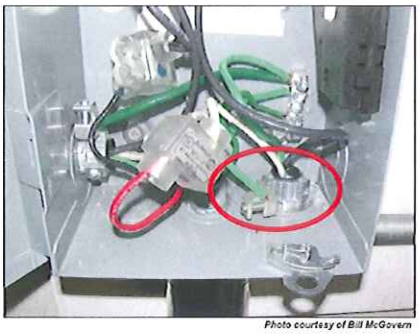


Photo courtesy of Bill McGovern

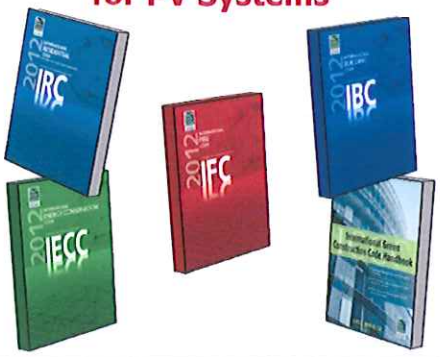
188

Conduit Exposed to Sunlight Above Rooftops Table 310.15(B)(2)(c)

Photos courtesy of Bill Brooks

189

Other Code Requirements for PV Systems



190

2012 IFC - PV Systems

- **601.2 Permits**
  Permits shall be obtained for refrigeration systems, battery systems and PV power systems as set forth in Sections 105.6 and 105.7
- **605.11 Solar Photovoltaic Power Systems**
  PV power systems shall be installed in accordance with Sections 605.11.1 through 605.11.4, the International Building Code and the *NEC*
  - ***Exception:*** *Detached, nonhabitable Group U structures including, but not limited to, parking shade structures, carports, solar trellises and similar structures shall not be subject to the requirements of this section*

191

2012 IFC - PV Systems

- **605.11.1 Marking**
  - Marking is required on interior and exterior DC conduit, enclosures, raceways, cable assemblies, junction boxes, combiner boxes and disconnects
- **605.11.1.1 Materials**
  - The materials used for marking shall be reflective, weather resistant and suitable for the environment
  - Marking as required in Sections 605.11.1.2 through 605.11.1.4 shall have all letters capitalized with a minimum height of 10 mm (⅜ in.) white on red background

Photos Courtesy of RLP & Associates

192

2012 IFC - PV Systems

- **605.11.1.2 Marking Content**
  The marking shall contain the words "WARNING: PHOTOVOLTAIC POWER SOURCE"
- **605.11.1.3 Main Service Disconnect**
  The marking shall be placed adjacent to the main service disconnect in a location clearly visible from the location where the disconnect is operated

193

2012 IFC - PV Systems

- **605.11.1.4 Location of Marking**
  Marking shall be placed on interior and exterior DC conduit, raceways, enclosures and cable assemblies every 3.0 m (10 ft), within 300 mm (1 ft) of turns or bends and within 30 mm (1 ft) above and below penetrations of roof/ceiling assemblies, walls or barriers

194

2012 IFC - PV Systems

- **605.11.2 Locations of DC Conductors**
  - Conduit, wiring systems, and raceways for PV circuits shall be located as close as possible to the ridge or hip or valley and from the hip or valley as directly as possible to an outside wall to reduce trip hazards and maximize ventilation opportunities
  - Conduit runs between sub arrays and to DC combiner boxes shall be installed in a manner that minimizes the total amount of conduit on the roof by taking the shortest path from the array to the DC combiner box

195

2012 IFC - PV Systems

- **605.11.2 Locations of DC Conductors *(cont.)***
  - The DC combiner boxes shall be located such that conduit runs are minimized in the pathways between arrays
  - DC wiring shall be installed in metallic conduit or raceways when located within enclosed spaces in a building
  - Conduit shall run along the bottom of load bearing members

196

2012 IFC - PV Systems

- **605.11.3 Access and Pathways**

  Roof access, pathways, and spacing requirements shall be provided in accordance with Sections 605.11.3.1 through 605.11.3.3.3
  - ***Exception No. 1.*** *Residential structures shall be designed so that each photovoltaic array is no greater than 45 m (150 ft) by 45 m (150 ft) in either axis*
  - ***Exception No. 2.*** *Panels/modules shall be permitted to be located up to the roof ridge where an alternative ventilation method approved by the fire chief has been provided or where the fire chief has determined vertical ventilation techniques will not be employed*

Photo courtesy of DOE/NREL

197

2012 IFC - PV Systems

- **605.11.3.1 Roof Access Points**
  Roof access points shall be located in areas that do not require the placement of ground ladders over openings such as windows or doors, and located at strong points of building construction in locations where the access point does not conflict with overhead obstructions such as tree limbs, wires, or signs

Photo courtesy of DOE/NREL

198

2012 IFC - PV Systems

- **605.11.3.2 Residential Systems for One- and Two-Family Dwellings**
  Access to residential systems for one- and two-family dwellings shall be provided in accordance with Sections 605.11.3.2.1 through 605.11.3.2.4

Photo courtesy of DOE/NREL

199

2012 IFC - PV Systems

- **605.11.3.2.1 Residential Buildings with Hip Roof Layouts**
  - PV panels/modules installed on residential buildings with hip roof layouts shall be located in a manner that provides a 900 mm (3 ft) wide clear access pathway from the eave to the ridge on each roof slope where PV panels/modules are located
  - The access pathway shall be located at a structurally strong location on the building capable of supporting the live load of fire fighters accessing the roof
  - *Exception: These requirements shall not apply to roofs with slopes of two units vertical in 12 units horizontal (2:12) or less*

200

2012 IFC - PV Systems

- Hip roofs need one a 900 mm (3 ft) wide clear access pathway from the eave to the ridge on each roof slope where PV panels/modules are located

Photo courtesy of DOE/NREL

201

2012 IFC - PV Systems

- **605.11.3.2.2 Residential Buildings with a Single Ridge**
  - PV panels/modules installed on residential buildings with a single ridge shall be located in a manner that provides two, 900 mm (3 ft) wide access pathways from the eave to the ridge on each roof slope where PV panels/modules are located
  - *Exception: This requirement shall not apply to roofs with slopes of two units vertical in 12 units horizontal (2:12) or less*

202

2012 IFC - PV Systems

- Ridge roofs need two, 900 mm (3 ft) wide access pathways from the eave to the ridge

Photo courtesy of DOE/NREL

203

2012 IFC - PV Systems

- **605.11.3.2.3 Residential Buildings with Roof Hips and Valleys**
  - PV panels/modules installed on residential buildings with roof hips and valleys shall be located no closer than 450 mm (18 in.) to a hip or a valley where panels/modules are to be placed on both sides of a hip or valley
  - Where panels are to be located on only one side of a hip or valley that is of equal length, the panels shall be permitted to be placed directly adjacent to the hip or valley
  - ***Exception:*** *These requirements shall not apply to roofs with slopes of two units vertical in 12 units horizontal (2:12) or less*

204

2012 IFC - PV Systems

- Residential buildings with PV panels placed on both sides of a hip or valley, they shall not be located closer than 450 mm (18 in.) to a hip or a valley

Photo courtesy of DOE/NREL

205

2012 IFC - PV Systems

- Roofs with hips and valleys, with PV panels only one side of a hip or valley that is of equal length, the panels shall be permitted to be placed directly adjacent to the hip or valley

Photo courtesy of DOE/NREL

206

2012 IFC - PV Systems

- **605.11.3.2.4 Residential Building Smoke Ventilation**
  PV panels installed on residential buildings shall be located no higher than 900 mm (3 ft) below the ridge in order to allow for fire department smoke ventilation operations

Photo courtesy of DOE/NREL

207

2012 IFC - PV Systems

- **605.11.3.3 Other Than Residential Buildings**
  Access to systems for occupancies other than one- and two-family dwellings shall be provided in accordance with Sections 605.11.3.3.1 through 605.11.3.3.3
  - ***Exception:*** *Where it is determined by the fire code official that the roof configuration is similar to that of a one- or two-family dwelling, the residential access and ventilation requirements in Sections 605.11.3.2.1 through 605.11.3.2.4 shall be permitted to be used*

208

2012 IFC - PV Systems

- **605.11.3.3.1 Access**
  There shall be a minimum 1.8 m (6 ft) wide clear perimeter around the edges of the roof
  - ***Exception:*** *Where either axis of the building is 75 m (250 ft) or less, there shall be a minimum 1.2 m (4 ft) wide clear perimeter around the edges of the roof*

Photo courtesy of DOE/NREL

209

2012 IFC - PV Systems

- **605.11.3.3.2 Pathways**
  - The PV installation shall be designed to provide designated pathways
  - The pathways shall meet the following requirements:
    1. The pathway shall be over areas capable of supporting the live load of fire fighters accessing the roof
    2. The centerline axis pathways shall be provided in both axes of the roof

    Centerline axis pathways shall run where the roof structure is capable of supporting the live load of fire fighters accessing the roof

210

2012 IFC - PV Systems

- **605.11.3.3.2 Pathways *(cont.)***
  - The PV installation shall be designed to provide designated pathways
  - The pathways shall meet the following requirements:
    3. Shall be a straight line not less than 1.2 m (4 ft) clear to skylights or ventilation hatches
    4. Shall be a straight line not less than 1.2 m (4 ft) clear to roof standpipes
    5. Shall provide not less than 1.2 m (4 ft) clear around roof access hatch with at least one not less than 1.2 m (4 ft) clear pathway to parapet or roof edge

211

2012 IFC - PV Systems

Photo courtesy of DOE/NREL

212

2012 IFC - PV Systems

- **605.11.3.3.3 Smoke Ventilation**
  The PV installation shall be designed to meet the following requirements:
  - 1. Arrays shall be no greater than *45 m (150 ft) by 45 m (150 ft)* in distance in either axis in order to create opportunities for fire department smoke ventilation operations

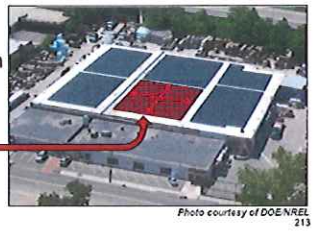


Photo courtesy of DOE/NREL

213

2012 IFC - PV Systems

- **605.11.3.3.3 Smoke Ventilation**
  The PV installation shall be designed to meet the following requirements:
  - 2. Smoke ventilation options between array sections shall be one of the following:
  - 2.1. A pathway 2.5 m (8 ft) or greater in width
  - 2.2. A 1.2 m (4 ft) or greater in width pathway and bordering roof skylights or smoke and heat vents
  - 2.3. A 1.2 m (4 ft) or greater in width pathway and bordering 1.2 m (4 ft) by 2.5 m (8 ft) "venting cutouts" every 6.0 m (20 ft) on alternating sides of the pathway

Photo courtesy of DOE/NREL 214

2012 IFC - PV Systems

- **605.11.4 Ground-Mounted PV Arrays**
  - Ground-mounted PV arrays shall comply with Sections 605.11 through 605.11.2 and this section
  - Setback requirements shall not apply to ground-mounted, free-standing PV arrays
  - A clear, brush-free area of 3.0 m (10 ft) shall be required for ground-mounted PV arrays

Photos courtesy of DOE/NREL

215

2012 IRC & IBC- PV Systems

- **R905.16 & 1507.17 Photovoltaic Modules/Shingles**
  The installation of PV modules/shingles shall comply with the provisions of this section
- **R905.16.1 & 1507.17.1 Material Standards**
  Photovoltaic modules/shingles shall be listed and labeled in accordance with UL 1703

216

2012 IRC & IBC PV Systems

R905.16.2 & 1507.17.2 Attachment.
PV modules/shingles **shall be attached** in accordance with the manufacturer's installation instructions.

217

2012 IRC & IBC - PV Systems

- **R905.16.3 & 1507.17.3 Wind Resistance**
  - PV modules/shingles shall be tested in accordance with procedures and acceptance criteria in ASTM D 3161.
  - PV modules/shingles shall comply with the classification requirements of Table R905.2.4.1(2) & Table 1507.2.7.1(2) for the appropriate maximum basic wind speed.
  - PV modules/shingle packaging shall bear a label to indicate compliance with the procedures in ASTM D 3161 and the required classification from Table R905.2.4.1(2) & Table 1507.2.7.1(2).

218

2012 IRC & IBC - PV Systems

c UL us LISTED 3YY6

FOR FIELD CONNECTIONS;
USE MINIMUM NO. 14 AWG (USE-2 or UL PV WIRE)
COPPER WIRES INSULATED FOR MINUMUM OF 90° C.
PREPARED ROOF COVERING MATERIALS DEGREE OF RESISTANCE TO EXTERNAL FORE-CLASS A
DEGREE OF WIND RESISTANCE INCESTIGATED IN ACCORDANCE WITH PROCEDURES ADOAPTED FROM ASTM D3161 AT A WIND SPEED OF 110 MPH
PREPARED ROOF COVERING MATERIALS FOR ROOFING SYSTEMS AS TO UPLIFT RESISTANCE
ALSO CLASSIFICE BY UNDERWRITERS LABORATORIES INC. IN ACCORDANCE WITH IEC 61646

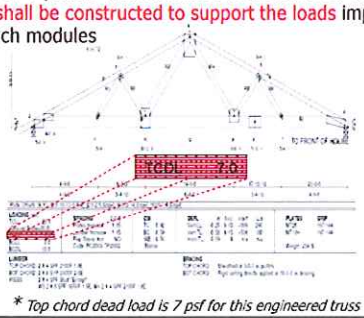
2012 IRC - PV Systems

- **M2302.2.1 Roof-Mounted Panels and Modules**
  - Where PV panels and modules are installed on roofs, the roof shall be constructed to support the loads imposed by such modules
  - Roof-mounted PV panels and modules that serve as roof covering shall conform to the requirements for roof coverings in Chapter 9
  - Where mounted on or above the roof coverings, the PV panels and modules and supporting structure shall be constructed of noncombustible materials or fire-retardant-treated wood equivalent to that required for the roof construction

220

2012 IRC - PV Systems

- **M2302.2.1 Roof-Mounted Panels and Modules**
  Where PV panels and modules are installed on roofs, the roof shall be constructed to support the loads imposed by such modules

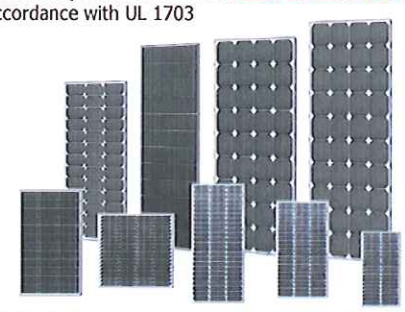


** Top chord dead load is 7 psf for this engineered truss*

221

2012 IRC & IBC - PV Systems

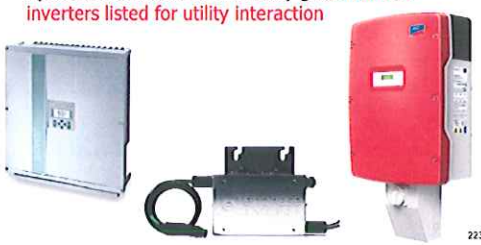
- **M2302.3 Photovoltaic Panels and Modules**
  Photovoltaic panels and modules shall be listed and labeled in accordance with UL 1703



222

2012 IRC - PV Systems

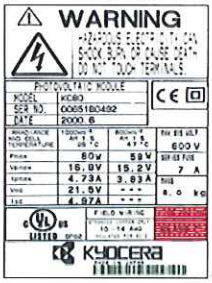
- **M2302.4 Inverters**
  - Inverters shall be listed and labeled in accordance with UL 1741
  - Systems connected to the utility grid shall use inverters listed for utility interaction



223

2012 IBC - PV Systems

- **1505.8 Photovoltaic Systems**
  Rooftop installed photovoltaic systems that are adhered or attached to the roof covering or PV modules/shingles installed as roof coverings shall be labeled to identify their fire classification in accordance with the testing required in Section 1505.1



224

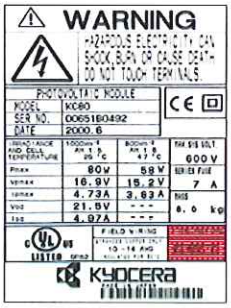
2012 IBC - PV Systems

- **1509.7 Photovoltaic Systems**
  Rooftop mounted PV systems shall be designed in accordance with this section
- **1509.7.1 Wind Resistance**
  Rooftop mounted PV systems shall be designed for wind loads for component and cladding in accordance with Chapter 16 using an effective wind area based on the dimensions of a single unit frame

225

2012 IBC - PV Systems

- **1509.7.2 Fire Classification**
  Rooftop mounted PV systems shall have the same fire classification as the roof assembly required by Section 1505



226

2012 IBC - PV Systems

- **1509.7.3 Installation**
  Rooftop mounted PV systems shall be installed in accordance with the manufacturer's installation instructions
- **1509.7.4 Photovoltaic Panels and Modules**
  PV panels and modules mounted on top of a roof shall be listed and labeled in accordance with UL 1703 and shall be installed in accordance with the manufacturer's installation instructions

227

2012 IBC - PV Systems

- **1511.1 Solar photovoltaic Panels/Modules**
  Solar PV panels/modules installed upon a roof or as an integral part of a roof assembly shall comply with the requirements of this code and the International Fire Code
- **1511.1.1 Structural Fire Resistance**
  The structural frame and roof construction supporting the load imposed upon the roof by the PV panels/modules shall comply with the requirements of Table 601

228

2012 IBC - PV Systems

TABLE 601 FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A[a]	B	A[a]	B	HT	A[a]	B
Primary structural frame[f] (see Section 202)	3[a]	2[a]	1	0	1	0	HT	1	0
Bearing walls									
Exterior[d, e]	3	2	1	0	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[g]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1½[b, c]	1[b, c]	1[b, c]	0[c]	1[b, c]	0	HT	1[b, c]	0

229

2012 IGCC - PV Systems

- **610.1 Renewable Energy Systems Requirements**
  - Buildings that consume energy shall comply with this section
  - Each building ... shall be equipped with one or more renewable energy systems in accordance with this section
  - Renewable energy systems shall comply with the requirements of Section 610.2 for solar photovoltaic systems, Section 610.3 for wind systems, or Section 610.4 for solar water heating systems, and Section 610.5 for performance monitoring and metering of these systems as approved by the Code Official
  - These systems shall be commissioned in accordance with the requirements of Section 611

230

2012 IGCC - PV Systems

- **610.1.1 Building Performance-Based Compliance**
  Buildings and surrounding property or building sites where there are multiple buildings on the building site...
  - that are designed and constructed in accordance with Section 601.3.1, Performance-Based Compliance...
  - shall be equipped with one or more renewable energy systems that have the capacity to provide not less than 2 percent of the total calculated annual energy use of the building, or collective buildings on the site

231

2012 IGCC - PV Systems

- **610.1.2 Building Prescriptive Compliance**
  Buildings that are designed and constructed in accordance with Section 601.3.2, Prescriptive Compliance...
  - shall be equipped with one or more renewable energy systems having the capacity to provide not less than 2 percent of the total estimated annual energy use of the building or collective buildings on the building site...
  - with onsite renewable energy demonstrating that onsite renewable energy production has a rating of not less than 1.75 Btu/h (0.5 W) or not less than 0.50 watts per sq. ft. of conditioned floor area...
  - and using any single or combination of renewable energy generation systems meeting the requirements of Sections 610.2, 610.3, or 610.4

232

2012 IGCC - PV Systems

- **610.2 Solar Photovoltaic systems**
  PV systems shall be sized to provide not less than 2 percent of the total estimated annual electric energy consumption of the building, or collective buildings on the building site in accordance with Section 610.1.1 or 610.1.2
- **610.2.1 Limitation**
  PV systems shall not be used to comply with Section 610.1 where building sites have total global insolation levels lower than 2.00 kWh/m2/day as determined in accordance with NREL SERI TR-642-761

233

2012 IGCC - PV Systems

- **610.2.2 Requirements**
  The installation, inspection, maintenance, repair and replacement of PV systems and system components shall comply with the manufacturer's instructions, Section 610.2.2.1, the International Fire Code, the International Building Code and NFPA 70 *(NEC)*
- **610.2.2.1 Performance Verification**
  - PV systems shall be tested on installation to verify that the installed performance meets the design specifications
  - A report of the tested performance shall be provided to the building owner

234

2012 IECC - PV Systems

- **C402.2.1.1 Roof Solar Reflectance and Thermal Emittance**
  Low-sloped roofs, with a slope less than 2 units vertical in 12 horizontal, directly above cooled conditioned spaces in Climate Zones 1, 2, and 3 shall comply with one or more of the options in Table C402.2.1.1
  - ***Exceptions:*** *The following roofs and portions of roofs are exempt from the requirements in Table C402.2.1.1:*
    1. Portions of roofs that include or are covered by:
    1.1. Photovoltaic systems or components
    1.2. Solar air or water heating systems or components
    1.3. Roof gardens or landscaped roofs
    1.4. Above-roof decks or walkways
    1.5. Skylights
    1.6. HVAC systems, components, and other opaque objects mounted above the roof

235

Solar Photovoltaic Systems

Thanks for Participating

Any Questions?

236

Appendix M Metrics Verification Letters

San Antonio Houston Jurisdiction Report for 2013

Printed Date: 02/12/2013 **Submitted Date:** In progress
Team: Texas Collaboration to Streamline and Enable An Increase in Photovoltaic Capacity

Reporting Year: 2013

Jurisdiction(s): San Antonio Houston

Permit

Application	Residential	Commercial
1. To how many departments does an installer have to submit separate applications? (a municipal utility does not count as a city department here)	• 2	• 2
2. What types of departmental approvals are required? (check all that apply)	• Electrical • Structural	• Electrical • Structural
3. What approvals from Professional Engineers are required as part of the permit package? (Check all that apply)	• Structural	• Structural
4. What is the average time required for an installer/customer to complete a permit application?	• <= half day	• <= 1 day
5. What are the options for obtaining an application? (Check all that apply)	• Online • In person	• Online • In person
6. What are the options for submitting an application? (Check all that apply) **Comments:** *Structural must be submitted in person with the plans, then the electrical application may be submitted online*	• Online • In person	• Online • In person

Information Access	Residential	Commercial
7. How is information describing the permitting process accessible? (Check all that apply)	• Online • Email • In person/mail	• In person/mail
8. Is there an accessible designated point of contact, with contact information available online, for questions about the PV permitting process? **Comments:** *Steve Stelzer at the Green Building Resources Center is the one-stop contact for questions related to green building topics. He is available to answer simple questions on the process, he can provide contact information for other persons in the permitting department if more detailed information is necessary.*	• Yes	• Yes

Permit Process Time	Residential	Commercial
9. Is there a policy to issue/deny PV permits within a specified number of business days from submission of application?	• Yes, <= 3 days	• 6-15 days
10. Does the jurisdiction track the number of days each permit takes to process?	• Yes	• Yes
11. What is the average number of business days between application submission and decision (issuance or denial) regarding permit?	• <= 3 days	• 6-10 days
Provide exact answer in terms of hours (e.g., 5 days should be entered as 40 hours)	2 hours	64 hours
12. Are there mechanisms in place for accelerating PV permitting processes under certain conditions?	• No —	• Yes, *Specify "small install"

Fee	Residential	Commercial
13. How is information on permit fees made available? (Check all that apply)	• Online • In person	• Online • In person
14. What is the average total for the applicable permit fee(s) for typical installations?	• <=$250	electrical permit flat fee $95, Structural based on value
Provide exact answer in dollars	151	3800
15. Is/are the permit fee(s) structured as flat, cost recovery, valuation open ended, or valuation capped?	• Other (*Specify) electrical permit flat $95, structural based on value	• Other (*Specify) electrical permit flat $95, structural based on value

Model Process	Residential	Commercial
16. To what degree do you use the Solar ABCs expedited permitting process template for typical installations? **Comments:** *Inspectors in the code official training were introduced to the Solar ABCs permitting template for typical installations. Followup will be needed to make sure they have read and are using the suggested process and suggesting to contractors that they use the forms.*	• Have reviewed and considered	

Inspection	Residential	Commercial
17. What is the average number of business days from inspection request to actual inspection?	• <= 2 days	• <= 2 days
Provide exact answer in terms of hours (e.g., 5 days	24	24

should be entered as 40 hours)		
18. What is the typical window of time given to the installer for final onsite inspection?	• 5-8 hrs	• 5-8 hrs
Provide exact answer in terms of hours (e.g., 5 days should be entered as 40 hours)	8	8
19. How is information on inspection requirements made available? (Check all that apply)	• Online • In Person	• Online • In Person
20. How many separate inspection trips are required? (Check all that apply) **Comments:** *New construction might require a rough inspection if wires are run within wall or ceiling assemblies.*	• Single Comprehensive Inspection	• Single Comprehensive Inspection

Communication Protocol with Utility

	Residential	Commercial
21. Do the utility and local jurisdiction coordinate regarding inspection requirements and on-site inspection times for the permit inspection and interconnection inspection?	• No	• No

Interconnection Process

Application

	Residential	Commercial
1. What is the average time required for an installer/customer to complete an interconnection application?	• <= half day	• <= 1 day
2. What are the options for obtaining an application? (Check all that apply)	• Online • Email • In person • Mail	• Online • Email • In person • Mail
3. What are the options for submitting an application? (Check all that apply)	• Email • In person • Mail	• Email • In person • Mail
4. Is there an application fee? Base fee averages on typical installations.	• No	• No

Information Access

	Residential	Commercial
5. How is information describing the utility interconnection process accessible? (Check all that apply)	• Online and easily accessible • Online • Email • In person/mail	• Online and easily accessible • Online • Email • In person/mail

6.	**Is there an accessible designated point of contact, with contact information available online, for questions about the PV interconnection process?**	• Yes	• Yes
7.	**What mechanism, if any, is available for a contractor/homeowner to check the status of an application? (Check all that apply)**	• Email • In person/mail	• Email • In person/mail

Interconnection Process Time		Residential	Commercial
8.	**Does the utility track the number of days each application takes to process?**	• Yes	• Yes
9.	**What is the average number of business days between application submission and utility decision (approval/denial) for installation to proceed?**	• <= 3 days	• 11 - 30 days
	Provide exact answer in terms of hours (e.g., 5 days should be entered as 40 hours)	8 hours	160 hours

Inspection		Residential	Commercial
10.	**What is the average number of business days from the inspection request to actual inspection?**	• 6 - 10 days	• 6 - 10 days
	Provide exact answer in terms of hours (e.g., 5 days should be entered as 40 hours)	168	168
11.	**What is the typical window of time given to the installer for final onsite inspection?**	• Specific Time	• 3 - 8 hours
	Provide exact answer in terms of hours (e.g., 5 days should be entered as 40 hours)	1	4
12.	**How is information on inspection requirements made available? (Check all that apply)**	• Online • Email • In person • Mail	• Online • Email • In person • Mail

Enabling Financing Options

Third-party ownership or equivalent market activity		Residential	Commercial
1.	**Is there legislation/regulation that allows for the following ownership structures whereby the PV system is owned by a third-party (not owned by the utility or site host)?**	• Allows both PPA and leases	• Allows both PPA and leases
2.	**Does the utility offer a roof lease program whereby a homeowner or business owner could host and receive benefits from a rooftop PV system that is owned by the utility?** **Comments:** *NRG offers to residential, in the competitive market other entities offer commercial lease programs (such as SpearPoint energy).*	• Roof lease program is established	• None of the above

Direct Finance Options

	Residential	Commercial
3. Is there state-level enabling legislation in place for creating a residential or commercial PACE program?	• No	• No
4. Is there a competitive loan/financing program offered for rooftop PV consumers in the jurisdiction or utility territory? (Check all that apply)	• No —	• Private sector program (specify) SpearPoint Energy is one company that offers several commercial financing options for PV.

Community solar

5. Is there legislation/regulation that accepts one or more of the following community solar enabling mechanisms? Not sector specific. (Check all that apply)	• Virtual net metering • Group billing • Joint ownership
6. Does the primary utility offer a community solar program that provides benefits to participating consumers? Not sector specific.	• No —

Other

	Residential	Commercial
7. Does the jurisdiction and/or utility have other programs not listed in the above criteria which provide consumers with a means of financing solar? (Do not include direct rebate/subsidy programs)	• No —	• No —

Siting, Planning and Zoning

Solar Rights and Access

	Residential	Commercial
1. Is there a state or local law that protects property owner rights to install solar systems on their property?	• Yes	• No
2. If there is a state or local law that protects property owner rights to install solar systems on their property, does it protect from both local ordinances and restrictive covenants?	• Yes	• No
3. What type of enforcement mechanism is used to support solar rights?	• Court of law	• None of the above
4. Is there a state or local law that provides for solar easements to protect access to sunlight (solar access)?	• No	• No
5. Is there a state or local process for a PV system to be registered in order to protect solar access?	• No	• No

Zoning

Residential Commercial

6. Approximately what percent of structures in your jurisdiction are zoned to allow rooftop solar facilities automatically "as a matter of right" or "by right"? (Calculate residential and commercial(non-residential) separately) **Comments:** *Houston does not have zoning*	• None of the above	• None of the above
7. Approximately what percent of structures in your jurisdiction are zoned to allow rooftop solar facilities only after a public hearing and the issuance of a special or conditional use permit? (Calculate residential and commercial (non-residential) separately) **Comments:** *Houston does not have zoning*	• None of the above	• None of the above
8. Has your jurisdiction conducted a review of local ordinances to identify barriers to solar installations and make recommendations for updating ordinances to address those barriers? **Comments:** *Houston does not have zoning*	• None of the above	• None of the above

New Construction	Residential	Commercial
9. Are there state or local standards for new construction that reduce barriers to solar deployment? (Check all that apply)	• None of the above	• None of the above

NNEC Net Metering

NNEC Net Metering

1. Individual System Capacity **Comments:** *Green Mountain Energy - Residential systems only, capped at 25kW or less*		• Only residential systems allowed and capped at less than 20 kW
2. Total Program Capacity Limits (as % of Peak Demand)		• None of the above • No bonuses applied
3. Restrictions on "Rollover" **Comments:** *Green Mountain Energy product*		• Indefinite rollover
4. Metering Provisions **Comments:** *Reliant and Green Mountain Energy*		• Dual meters or dual registers - customer pays for the additional meter
5. Metering Provisions Under Time-of-Use **Comments:** *Reliant product offers time of use pricing, with higher prices (and solar credits) from 9:00 am - 4:00 pm, and lower electricity rates the remaining times*		• TOU meters with segregated time periods

lower electricity rates the remaining times.

6.	**Renewable Energy Credit Ownership** **Comments:** *Green Mountain Energy*	• Owned by customer
7.	**Eligible Technologies** **Comments:** *Green Mountain Energy*	• Solar, wind and other renewable and zero-emission technologies
8.	**Eligible Customers**	• Residential only
9.	**Bonus for Aggregate Net Metering: A customer may aggregate all meters on his or her contiguous property for purposes of net metering.**	• No
10.	**Bonus for Community Renewables: A customer may receive net metering credits for investing in or subscribing to a renewable energy system that may not be physically located on their property.**	• No
11.	**Safe Harbor Provisions, Standby Charges, or Other Fees**	• Not addressed
12.	**Policy Coverage** **Comments:** *Net metering is at the discretion of the retail electric providers*	• None of the above
13.	**Third-Party Model** **Comments:** *Net metering is at the discretion of the retail electric providers*	• Not specified
14.	**Aside from Question # 3, are the scores reported above consistent with the respective state responses/scoring provided in Appendix A of the Freeing the Grid (2010) report?**	• Yes

NNEC Interconnection

NNEC Interconnection

1.	**Eligible Technologies**	• All customer-sited generators qualify
2.	**Individual System Capacity**	• Up to 10 MW permitted
3.	**"Breakpoints" for Interconnection Process**	• Three levels • No bonuses applied
4.	**Timelines**	• Timelines longer than the FERC standards
5.	**Interconnection Charges**	• Fees lower than the FERC standards

6.	**Engineering Charges**	• Engineering fees fixed
7.	**External Disconnect Switch**	• Redundant external disconnect switch required
8.	**Certification**	• UL 1741 / IEEE 1547 used
9.	**Technical Screens**	• No screens used or utility discretion • No bonuses or penalties applied
10.	**Network Interconnection**	• Spot networks limited to 50 kW • (Bonus) Network interconnections allowed provided the generating facility is inverter-based and uses additional non-exporting protective schemes
11.	**Standard Form Agreement**	• Standard agreement with standard clauses • No bonuses applied
12.	**Insurance Requirements**	• Not addressed, or left to the development of the standard form agreement
13.	**Dispute Resolution**	• Utility discretion
14.	**Rule Coverage**	• Rules apply to investor-owned utilities only
15.	**Miscellaneous (Bonus and Penalties)** **Comments:** *Adverse system check not required for installation under 10kW*	• Adverse system impact check required for systems under 2 MW
16.	**Aside from Question #10, are the scores reported above consistent with the respective state responses/scoring provided in Appendix A of the Freeing the Grid (2010) report?**	• No

Installed PV Capacity and PV Costs

PV Capacity

1.	**Installed PV capacity (direct current (DC))**	3319.2 kW

PV Cost		Residential	Commercial
2.	**The average installed cost (not end consumer price) for a typical (~4 kilowatts [kW]) residential PV system and a typical (~300 kW) commercial PV system completed in 2012, excluding all state and federal incentives (in $/W)**	$4.07	$3.80

Comments:
Vendor quote

3.	**Date on which this measurement is based**	02/04/2013

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Co. 80401-3393

Department of Energy:

This letter serves as verification that we have reviewed the Market Evaluation prepared by the City of San Antonio and agree with the information reported for the City of Houston. Our company represents a significant portion of the residential and commercial PV sales in the above jurisdiction. Based on our experience doing business in these jurisdictions, the information reported is an accurate reflection of the status of the permitting and interconnection processes in these jurisdictions.

Sincerely,

Frank Molina
Signature

2/12/13
Date

Frank Molina, COO
Printed name, Title

Akari Energy
Company

PO Box 920824
Houston, TX 77292
Address

713-849-3022

Phone Number

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Co. 80401-3393

Department of Energy:

This letter serves as verification that we have reviewed the Market Evaluation prepared by the City of San Antonio and agree with the information reported for the City of Houston. Our company represents a significant portion of the residential and commercial PV sales in the above jurisdiction. Based on our experience doing business in these jurisdictions, the information reported is an accurate reflection of the status of the permitting and interconnection processes in these jurisdictions.

Sincerely,

Signature

2/7/13
Date

Colin Gates
Printed name, Title

Ameresco Solar
Company

202 South Live Oak, Ste B
Tomball, TX. 77375
Address

281-378-2313

Phone Number

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Co. 80401-3393

Department of Energy:

This letter serves as verification that we have reviewed the Market Evaluation prepared by the City of San Antonio and agree with the information reported for the City of Houston. Our company represents a significant portion of the residential and commercial PV sales in the above jurisdiction. Based on our experience doing business in these jurisdictions, the information reported is an accurate reflection of the status of the permitting and interconnection processes in these jurisdictions.

Sincerely,

Signature

2/9/13
Date

Jasen Crossett, Partner Consultant
Printed name, Title

NRG Residential Solar Solutions
Company

1331 Lamar Street, Suite 550
Houston, Texas 77010
Address

713.655.1180
Phone Number

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Co. 80401-3393

Department of Energy:

This letter serves as verification that we have reviewed the Market Evaluation prepared by the City of San Antonio and agree with the information reported for the City of Houston. Our company represents a significant portion of the residential and commercial PV sales in the above jurisdiction. Based on our experience doing business in these jurisdictions, the information reported is an accurate reflection of the status of the permitting and interconnection processes in these jurisdictions.

Sincerely,

Donovan Dawson — 2/9/2013

Signature — Date

DONOVAN DAWSON, — ALTERNATIVE POWER SOLUTIONS

Printed name, Title — Company

15150 SOMMERMEYER ST. SUITE 100
HOUSTON, TX. 77041

Address

877.861.3061

Phone Number

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Co. 80401-3393

Department of Energy:

This letter serves as verification that we have reviewed the Market Evaluation prepared by the City of San Antonio and agree with the information reported for the City of Houston. Our company represents a significant portion of the residential and commercial PV sales in the above jurisdiction. Based on our experience doing business in these jurisdictions, the information reported is an accurate reflection of the status of the permitting and interconnection processes in these jurisdictions.

Sincerely,

Garrett Gordy
Signature

2-9-13
Date

Garrett Gordy, Owner
Printed name, Title

Texas Solar Outfitters
Company

705 Shepherd Dr
Houston, TX 77007
Address

713 802 0223

Phone Number

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Co. 80401-3393

Department of Energy:

This letter serves as verification that we have reviewed the Market Evaluation prepared by the City of San Antonio and agree with the information reported for the City of Houston. Our company represents a significant portion of the residential and commercial PV sales in the above jurisdiction. Based on our experience doing business in these jurisdictions, the information reported is an accurate reflection of the status of the permitting and interconnection processes in these jurisdictions.

Sincerely,

Signature

2/9/13
Date

Bill Graves
Printed name, Title

Petersen Dean Roofing & Solar Systems
Company

5050 Timber Creek
Houston, TX 77017
Address

281-486-1660 x 215
Phone Number

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Co. 80401-3393

Department of Energy:

This letter serves as verification that we have reviewed the Market Evaluation prepared by the City of San Antonio and agree with the information reported for the City of Houston. Our company represents a significant portion of the residential and commercial PV sales in the above jurisdiction. Based on our experience doing business in these jurisdictions, the information reported is an accurate reflection of the status of the permitting and interconnection processes in these jurisdictions.

Sincerely,

Signature

2/11/13
Date

Peter Mathey, CEO
Printed name, Title

Ignite Solar
Company

2000 Edwards St
Houston TX 77007
Address

281-203-4271
Phone Number

U.S. Department of Energy
Golden Field Office
1617 Cole Blvd.
Golden, Co. 80401-3393

Department of Energy:

This letter serves as verification that we have reviewed the Market Evaluation prepared by the City of San Antonio and agree with the information reported for the City of Houston. Our company represents a significant portion of the residential and commercial PV sales in the above jurisdiction. Based on our experience doing business in these jurisdictions, the information reported is an accurate reflection of the status of the permitting and interconnection processes in these jurisdictions.

Sincerely,

Janet Hughes

Signature

February 11, 2013

Date

Janet Hughes, Master Solar Trainer/Senior Solar Consultant, Ontility

Printed name, Title

Company

3403 N Sam Houston Pkwy, W, Suite 300

Houston, Texas 77086

Address

512-845-3568

Phone Number