NABCEP

PV Technical Sales Resource Guide

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Raising Standards. Promoting Confidence

Overview

The NABCEP PV Technical Sales Certification is targeted to solar sales professionals responsible for the sales process and the non-installation aspects of commissioning residential and light commercial solar electric systems.

The credential is aimed at technical sales representatives responsible for site analysis, financial analysis, initial system design, and an ethical, accurate presentation of the PV systems' electrical, financial, and environmental performance projections.

No matter how well a PV system may be installed, the consumer will not be satisfied if the sales person or designer over-promises performance or provides inadequate site and structural analysis.

NABCEP offers the PV Technical Sales Certification so that consumers of PV systems can have full confidence that the sales, installation, and commissioning processes are being conducted/managed by a competent professional.

Introduction

This resource guide is intended to help those that meet the eligibility requirements to prepare for the NABCEP PV Technical Sales Exam. (Refer to the "Certification Handbook" at www.nabcep.org for details of the eligibility requirements for this Certification).

This guide is **not** intended to be definitive. While the resources listed in this guide are intended to help prepare test takers, they are not indented to serve as the only resources that a candidate should use in preparation for the exam. NABCEP recommends using a combination of the references in this guide plus the candidate's favorite informational resources to prepare for the exam.

The format of this guide follows the Job Task Analysis (JTA) for the PV Technical Sales Certification and offers the Resource Guide Committee's best recommendations for materials that may be useful to candidates in preparing for the examination.

NABCEP strongly recommends that ALL candidates review the JTA carefully and thoroughly, then ask themselves if they feel well-trained, experienced, and fully conversant with all the elements of the JTA. If the answer is "yes", the candidate is likely ready for the examination. If the answer is "no", the candidate should do additional research, take additional training, or gain additional experience in the areas they have identified as weaknesses.

Section	*Section Title*	*# of questions*	*% of test*
A	Qualify the Customer	15	25%
B	Site Analysis	10	17%
C	Conceptual Design	14	23%
D	Financial Costs, Incentives, and Savings	5	8%
E	Financial Benefit Analysis and Financing	4	7%
F	Non-financial Benefit Analysis	3	5%
G	Performance Analysis	5	8%
H	Prepare Proposals	4	7%
	Totals	**60**	**100%**

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Skills & Tools

The PV Technical Sales Representative uses a broad set of tools and skills to perform the tasks outlined in the Job Task Analysis. The specific tools, software, and processes may vary from job to job, depending on size and type of PV system, site conditions, engineering requirements, permitting requirements, and other factors.

Listed below are the basic skills and tools you should have prior to sitting for the NABCEP PV Technical Sales Certification exam.

Basic Skills

- Computer: MS Word, Excel, Internet, E-mail, etc...
- Written and verbal communication
- Reading, comprehension, and listening
- Basic math and trigonometry
- Read and interpret drawings: electrical & structural
- Map interpretation: Google Earth, MapQuest, topographic maps, solar insolation maps, aerial photographs, and others as appropriate
- Utility interconnection and net metering: bill interpretation, net metering, and interconnection, familiarity with different types of utilities (public/private/co-op)
- Familiarity with the National Electric Code (NEC)
- Basic construction: terminology, methodology, safety, and best practices
- Use of solar site assessment and measurement tools
- Mechanical and electrical: Basic understanding of concepts, safety, and best practices
- Power production estimating based on manual calculation
- Power production estimating using software or online tools

Basic Tools

- Checklist
- Digital camera
- Computer with internet access
- Appropriate clothing
- Roof-friendly footwear
- Gloves
- Safety glasses
- First aid kit, emergency numbers, hospital location
- Ladder(s)
- Fall protection — where appropriate
- Shade assessment tool
- Tape measure
- Inclinometer
- Multi-meter
- Flashlight

General Resources

Solar Energy International "PV Design and Installation Manual"
www.solarenergy.org/bookstore/photovoltaics-design-installation-manual

Photovoltaic Systems, Second Edition, Dunlop, Jim:
www.solarenergy.org/bookstore/photovoltaic-systems-2nd-edition-w-cd-rom

NEC: Codebook/Handbook
www.nfpa.org

- Published by the National Fire Protection Association
- **2011 NEC Codebook**—Hundreds of revisions in the 2011 NEC include groundbreaking changes that broaden the Code's scope to cover alternate energy sources, green technologies, IT systems, and high voltage installations. (Softbound, 870 pages)
- **2011 NEC Handbook** — Source for practical solutions and Code rationale. The NEC Handbook has the full 2011 NEC text, expert commentary on NEC use including new applications, and real-world examples from the field. 500+ full-color visuals include schematics, floor plans, flow charts, and photos that depict application of requirements. (Hardbound, 1,512 pages)

Home Power: Magazine articles
(shown as: HP<issue number>-<page number>)

SolarPro: Magazine articles
(shown as: SP<issue number>-<page number>)

Photon USA Magazine articles

Solar Today Magazine articles

Task Analysis

A. Qualify the Customer (25%)

The purpose of qualifying the customer is to determine the appropriateness of a prospective solar electric system following an evaluation of the client's site and needs.

A remote site evaluation using satellite imagery is advisable prior to a site visit. This process helps the PV Technical Sales Representative identify available space and possible location(s) for a PV array. For many sites, satellite images can help in identifying significant shading problems or structural challenges. This process can be invaluable in helping avoid wasted trips to poor prospective solar sites. Customers with a poor site (due to shade obstacles, roofing structural problems, zoning issues, etc...) should be informed about the limitations of installing a PV system in unsatisfactory locations.

Next, the customer's historical electricity usage is analyzed (desired minimum of 12 months history) with focus on annual kilowatt hour (kWh) consumption and daily/monthly usage patterns. The PV Technical Sales Representative should address any specific concerns over owning, operating, and maintaining a PV system. Finally, the PV Technical Sales Representative must assess the prospects' anticipated budgetary expectations and financial capacity to purchase or lease a PV system. Now is the time to prepare and deliver the ball park estimate for the project cost.

If the ball park estimate is acceptable to the prospective customer, it is advisable to evaluate any jurisdictional issues and communicate clearly any important information required to effectively and ethically manage customer expectations relative to system ownership and financial/electrical performance. If the customer is interested in proceeding after the qualification process, it is then time to schedule the site visit.

From the Task Analysis:

The PV Technical Sales Representative should have knowledge of:

- How site conditions impact feasibility of solar system
- Internet tools
- The limitations of remote tools
- Magnetic declination
- Basic sales skills
- Financial tools
- The use of electric rates function
- Batteries
- Electrical terminology
- Correlating usage to specific appliances
- Price adders
- Roof type
- Licensing requirements
- How the height of building impacts installation costs
- Impact of long runs of conduit, wiring on costs
- Steepness
- Distance from load center
- Zoning issues for your area
- Codes for your area
- Utilities process, interconnection procedures, and rules
- Laws relating to homeowners associations
- Insurance limitations
- Basic solar system knowledge
- General financial understanding
- Product knowledge
- Knowledge of return on investment
- Product limitations

To properly determine the customer's ability to go solar, the PV Technical Sales Representative should be able to provide a thorough assessment based on the customer's electric usage, site location, needs, expectations, financial situation and jurisdictional issues In order to successfully complete this step, the representative should be able to:

1.1 Gather bills. Collect a minimum of the last 12 months of electric bills most representative of the client's usage.

1.2 Look for seasonal patterns. Use kWh usage from bills to locate high and low usage time periods.

1.3 Look at different fuel sources being used. Determine the client's heating and cooling source of energy, i.e. propane, natural gas, electric, etc.

1.4 Review utility rates. Examine electric bills and reference utility rate tariffs to determine Time of Use, Seasonal, Demand, or Tiered rate structures as appropriate.

1.5 Explain why solar may not be appropriate. Low avoided cost of power, poor solar access, and difficult construction make solar a difficult proposition.

1.6 Determine house orientation. Use readily available online satellite imagery software with a compass tool to determine main roof planes azimuth.

1.7 Determine roof tilt/angle, available area. Use readily available online satellite imagery software with measurement tools to determine roof pitch with surface area available.

1.8 Determine shading. Using readily available online satellite imagery software, look for relatively long shadows caused by objects directly to the south of considered roof surfaces.

1.9 Evaluate obstructions. Using readily available online satellite imagery software look for rock obstructions for ground mounts, chimneys, air conditioners, roof pipes, etc. for roof mounted systems.

1.10 Inquire about type and condition of roof. Ask customer about roof age, roof material composition, and any significant roofing related events in the last 5 years.

1.11 Determine ownership status. Inquire as whose name is on the building's title and the name on the electric bill.

1.12 Determine type of property (residential, commercial, non-profit). Ask what the property is primarily used for.

1.13 Ask about reasons for going solar: Identify whether motivation is driven by energy independence, financial return, environmental stewardship, or increased value of building.

1.14 Evaluate future energy usage. Inquire as to customer's plans to increase or decrease usage in the future.

1.15 Determine desired time frame. Ask when the customer would like to have their solar installation generating usable power.

1.16 Determine whether customer needs financial assistance. Ask if customer is looking to pay cash or if financing will be needed.

1.17 Determine electric usage pattern, time of day. Ask when the building is most occupied, if large motors run at any specific times, and if there are any other high load devices used during a typical day.

1.18 Discuss pros/cons of battery backup vs. generator. Discuss costs, environmental impacts, maintenance, and audible effects of both options.

1.19 Estimate array size based on kWh consumption and available array area. Having knowledge of average solar hours for the geographic location and module efficiency; be able to determine number of modules needed, square footage required, and energy thus produced.

1.20 Price array size based on average $/watt. Multiply system size in kW by the average $/Watt to determine system price.

1.21 Evaluate potential price adders. Determine if additional construction needs require added charges to typical projects costs.

1.22 Factor in incentives. Identify local and federal incentives available, discussing the effect of incentives on the retail pricing to the customer.

1.23 Develop price range. A technique used to provide general pricing guidance. Many sales reps will ball park quote a single price, or set the floor of the range at the price likely to be accepted by the customer. Customer tends to gravitate to the lowest number spoken if offered a range and can hold you accountable.

1.24 Develop savings estimate. Multiply the estimated production by the avoided cost of power to determine the savings for the first year.

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1.25 Develop preliminary economic analysis. Use generated yearly savings estimate to determine cash flow, pay back, ROI, IRR, and NPV of investment in solar.

1.26 Present (verbally/briefly) initial ball park proposal and benefits. Walk the customer through the pricing, incentives, and metrics derived from the economic analysis.

1.27 Discuss customer budget limits. Identify if the customer has a set budget or financial constraint.

1.28 Determine zoning. Inquire about the client's jurisdiction and any known problems, benefits, or logistics associated with the jurisdiction including property setbacks.

1.29 Determine fire marshal awareness. Contact the local fire and building departments to understand roof setbacks and fire safety equipment.

1.30 Determine reservation issues.

1.31 Check city, county, and utility requirements. Contact city, county, and utility for specific permitting and interconnection requirements.

1.32 Identify utility. Review the customer's electric bill to identify utility.

1.33 Identify homeowner association. Determine if there is an HOA and what restrictions may apply.

1.34 Advise customer that system doesn't provide backup power; when grid is down, it won't work. Ensure client understands the anti-islanding stipulation for all UL listed inverters.

1.35 Explain differences between battery and non-battery systems. Ensure client understands the benefits, features, and trade-offs between a stored energy system and an on-demand system.

1.36 Explain that PV does not heat water, space, or pools. Ensure client understands the difference between electrical photovoltaic production and thermal hot water generation.

1.37 Explain that PV generates electricity, does not offset gas loads. Ensure client understands that only the electrical portion of a combined gas and electric bill will be offset.

1.38 Explain seasonal variations in output. Ensure client understands that longer daylight hours mean more production and vice versa.

1.39 Explain required level of routine maintenance. Ensure client understands the need to periodically clean panels of excessive soiling and review the inverter output for expected production.

1.40 Explain system equipment manufacturer warranties. Ensure client has and has reviewed copies of the manufacturers' warranties.

1.41 Review life expectancy of equipment. Point client to third party resources describing theoretical end of useful life of equipment.

1.42 Discuss aesthetics. Use photos, videos, and/or drive-by references to ensure client understands and is comfortable with the look and feel of the system.

1.43 Discuss ROI. Use third party resources to provide case specific ROI calculations.

1.44 Explain emerging vs. existing technologies. Understand and be able to explain existing PV production technologies and availability in contrast to products in R&D and typical time for bringing PV technologies to market.

1.45 Explain expected output vs. system capacity. Ensure client understands the difference between the system's kW capacity and the kWh output of the system over time.

1.46 Explain instantaneous power vs. annual energy production. Describe the difference between a kW of power and kWh of energy.

1.47 Explain installation warranties. Review contractor warranty requirements provided and other potential warranties offered, including roofing penetrations.

1.48 Explain manufacturer warranties. Describe and provide copies of the manufacturer's warranties.

1.49 Explain insurance issues, workers' comp, liability. Describe effect on building insurance, and review the contractor's worker's compensation insurance and other potential liabilities.

1.50 Explain effects on homeowner's insurance. Advise client to contact their homeowner's insurance carrier and inquire about the coverage for the PV system. Provide the client with a detailed questions that can be sent to insurance agent to insure that the important aspects of the insurance coverage are addressed.

1.51 Explain potential impact on roof warranty. Provide an explanation of how the roofing warranty will be impacted by the installation of the PV system on the structure. Review the warranty documents with the customer and provide a statement that they can use with the roofing company to determine what impact the PV system installation might have on the roofing warranty.

1.52 Explain performance validation methods. Describe third party tools used to estimate production, system monitoring tools available to client for validation, and any production guarantees offered.

Resources:

Local Authority Having Jurisdiction (AHJ)

Local Utility

Utility Interconnection Agreement

Local Solar Rights Access Law (if available)

SP2.4-16 Aerial Site Survey Saves Time and Resources

Solar Energy International "PV Design and Installation Manual"
www.solarenergy.org/bookstore/photovoltaics-design-installation-manual

- *Chapter 1*, An Overview of Photovoltaics
- *Chapter 3*, The Solar Resource
- *Chapter 4*, Electric Load Analysis

Dunlop, Jim: Photovoltaic Systems, Second Edition
www.solarenergy.org/bookstore/photovoltaic-systems-2nd-edition-w-cd-rom

- *Chapter 3*, Site Surveys and Preplanning

San Francisco Examiner: "How to read your electric bill before you go solar"
www.examiner.com/solar-in-san-francisco/how-to-read-your-electric-bill-before-you-go-solar

Solar Living Source Book
www.realgoods.com/product/id/1012624.do

PVWatts: NREL online tool for production estimates
www.nrel.gov/rredc/pvwatts/

Photon Magazine
www.photon-magazine.com/

Solar Electric Power Association (SEPA) Webinars
www.solarelectricpower.org/events/webinars.aspx

Sandia National Laboratories
www.sandia.gov/

OnGrid Solar Sales Slides: OnGrid Publications, Papers & Presentations
www.ongrid.net/papers/index.html

Insurance Requirements of PV installations: Allocating Risks: An Analysis of Insurance Requirements for Small-Scale PV Systems
www.puc.state.pa.us/electric/pdf/NMIC_SunEdison_Comments_Att3.pdf

Google Maps (street view): Satellite imagery
maps.google.com

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Bing: Satellite imagery
www.bing.com/maps

Google SketchUp: Online 3D modeling service
sketchup.google.com

Zillow: Find home values and listings
www.zillow.com

Precigeo: Solar layout reports and roof dimensions
www.precigeo.com

Pictometry: View, measure, and plan your jobs with this online satellite imagery service
www.pictometry.com/home/home.shtml

AutoCad: 3D design and engineering software
usa.autodesk.com

Vizio: Diagramming tools
office.microsoft.com/en-us/visio

NEC Codebook and NEC Handbook:
National Fire Protection Association 70
www.nfpa.org

NRCA: National Roofing Contractors Association
www.nrca.net

IREC: Interstate Renewable Energy Council
irecusa.org

DSIRE: Database of State Incentives for Renewables & Efficiency
www.dsireusa.org

Clean Power Finance: Review assumptions through initiation of CPF license, free trial available
www.cleanpowerfinance.com/solar/installer-tools

Understanding the solar business:
An insider's guide to success
www.solarspies.net/downloads.htm

B. Site Analysis (17%)

Prior to developing a design concept, it is necessary for the PV Technical Sales Representative to carefully evaluate a client's site. Gathering and interpreting relevant site-specific information is critical for an appropriate conceptual design and a successful sales opportunity.

The major tasks in site analysis include:

- Electrical service inspection
- Identification of system component locations
- Evaluation of structural integrity of potential mounting locations
- Quantification of the solar resource at the location

The primary objective of the site assessment (relating to the electrical service) is to determine whether the existing or planned electrical distribution system is suitable for interconnecting a PV system, and if so, of what capacity. This requires a working knowledge of the National Electrical Code and the allowances in Article 690 for making supply or load side interconnections in residential or non-residential settings. Knowledge of major PV system and electrical service components is required, as well as an understanding of how the two systems interconnect, both schematically and mechanically. The PV Technical Sales Representative must be able to identify and avoid electrical hazards when documenting as-built electrical service conditions.

The site analysis will also identify and document potential locations for major equipment and BOS components. This includes determining the possible location(s) for the PV array, and identifying potential locations for inverter(s), service disconnects, combiner boxes, and conduit runs. Different component location configurations will have different code and cost implications. A strong knowledge of PV system components, their relative size, required working clearances, and installation practices is required. The PV Technical Sales Representative should be able to communicate the various location options to the customer, as well as to differentiate between the pros and cons of different approaches. It is especially important to be able to exclude locations that are not code compliant.

Following the identification of potential areas for a PV array, the mounting location will need to be assessed. This requires a working knowledge of PV system installation practices as it pertains to roof or ground mounted systems. Knowledge of construction practices, nomenclature, and materials is required. It is necessary to understand roofing systems in general, as well as to be able to differentiate between specific roofing materials. The ability to measure accurately is required, as is the ability to read blueprints.

Quantifying the solar resource at potential array locations is another critical part of any site analysis. This step is essential to providing a realistic annual energy output estimate, which will be used for any financial models. It is also a requirement for many incentive programs, which may randomly audit sites. Knowledge of how shading impacts PV system performance is required, as is a familiarity with standard shade analysis tools and their operation. The PV Technical Sales Representative shall also be able to determine the sun's location at various times of the day or year. It is imperative that the salesperson be able to gather this information in a manner consistent with OSHA best safety practices.

A professional PV Technical Sales Representative will be able to use and interpret online, topographic, and satellite imagery (Google Maps), understand interconnection and zoning requirements, and be well versed in all of the equipment that is reliable and available. A good site assessor will be able to realistically (and objectively) evaluate the client, the site, and the local solar resource. Further, the client should be promptly informed when a PV system is not a good fit due to site limitations, unrealistic expectations, or poor solar resource.

From the Task Analysis:

The PV Technical Sales Representative should have knowledge of:

- Electrical safety
- OSHA
- Electrical principles
- Electrical codes
- NEC and manufacturer clearance requirements
- Solar exposure
- Hazards (i.e., power lines, gas lines, meters)
- The difference between AC & DC disconnects
- Voltage ratings on fuses, AC & DC switches
- Utility differences on requirements for disconnects
- Tape measure
- Laser level
- Roofing materials
- Basic framing
- Standard building practices (spacing)
- Roofing terminology
- Risks of falling
- Walking on roofs without causing damage
- Reading blueprints
- Angle gauge
- Safety harness
- The impact of shade on solar systems
- The proper use of the available tools

In conducting a site assessment for a PV system, in the field or from a plan set, the PV Technical Sales Representative should be able to:

2.1 Determine service rating current and voltage.

2.2 Identify major electrical service components, ratings and manufacturers, as well as relevant subcomponents, including buss bars and main breakers.

2.3 Identify opportunities for a Code-compliant PV system interconnection on either the supply or load side of the service.

2.4 Determine available breaker space. Calculate the maximum allowable PV interconnection breaker for a load side connection.

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2.5 Determine grounding. Identify grounding electrode system components.

2.6 Identify manufacturer of panel.

2.7 Determine method of interconnection.

2.8 Determine limits (max back fed breaker) based on local electrical code.

2.9 Inform customer of potential additional costs related to utility hardware, transformers.

2.10 Discuss findings with customer.

2.11 Identify inverter location. Identify potential, preferred and optimal locations for inverter.

2.12 Identify array location options. Identify potential, preferred, and optimal locations for PV array and determine the need for any appropriate setbacks from overhead utility lines, road right-of-ways, or property lines, if applicable.

2.13 Identify AC & DC disconnects location(s). Identify potential, preferred, and optimal locations for major system disconnects.

2.14 Identify junction box location(s). Identify potential, preferred, and optimal locations for combiner box(es).

2.15 Locate conduit run location(s). Identify potential, preferred and optimal locations for conduit runs.

2.16 Identify utility disconnect location(s) if applicable. Differentiate between DC and AC electricity and identify suitable electrical equipment and components for each. Understand the difference between National Electrical Code requirements and those of the local utility or PV rebate program administrator.

2.17 Determine lengths of conduit runs.

2.18 Identify roofing material used and identify any site-specific safety hazards or other issues associated with the installation of a PV system.

2.19 Identify framing and construction configuration of roof.

2.20 Gather relevant structural information, including spacing and spans.

2.21 Determine if there is an attic space vs. flat roof.

2.22 Assess structural integrity of roof (look at underside). Walk on a roof without damaging it.

2.23 Document condition of roof (photos, notes, etc.) and describe existing site conditions relevant to the installation of a PV system.

2.24 Determine soil composition for ground/pole mounts.

2.25 Identify underground obstructions (septic, gas lines).

2.26 Determine solar exposure.

2.27 Measure roof area or ground area.

2.28 Identify existing shading obstructions and other variable sources of shade.

2.29 Consider future shading obstructions.

2.30 Perform inter-row shading analysis.

2.31 Use shade analysis tools to complete shade study.

2.32 Analyze annual loss from shading.

2.33 Analyze seasonal/daily variations in shade.

2.34 Determine whether rooftop analysis is necessary.

2.35 If safe, proceed with rooftop analysis.

2.36 If necessary, bring in crew for rooftop analysis.

2.37 If rooftop analysis is not feasible, incorporate buffer.

2.38 Calculate within acceptable limits of third-party audit, 3-5%.

2.39 Prepare site analysis report for customer or colleague.

Resources:

NEC codebook

- Article 690.13
- Article 690.14
- Article 690.64 (refer to Article 705.12 in NEC 2011)

Solar Energy International "PV Design and Installation Manual"
www.solarenergy.org/bookstore/photovoltaics-design-installation-manual

- *Chapter 3*, The Solar Resource

Dunlop, Jim: Photovoltaic Systems, Second Edition
http://www.solarenergy.org/bookstore/photovoltaic-systems-2nd-edition-w-cd-rom

- *Chapter 3*, Site Surveys and Preplanning

HP136-70 iPhone Apps for Solar Geeks

SP2.1-54 Solar Site Evaluation: Tools & Techniques to Quantify & Optimize Production
SP1.1-72 Pitched Roof Racking
SP2.1-16 Calculating Inter-Row Spacing
SP2.2-46 Flat Roof Mounting Systems
SP2.3-28 Pulling It All Together: Strategies for Making Common Connections in PV Power Circuits
SP2.4-24 Can We Land? Means and Methods of PV System Utility Interconnection
SP3.1-26 2010 Grid-Direct String Inverter Guide
SP3.2-30 Pitched Roof PV Mounting: Design and Engineering Considerations
SP3.4-26 Ground-Mounted PV

Building code manuals – IBC, UBC, State Code, etc.

Local tree guide: for your area

Local AHJ (Authority Having Jurisdiction)

- Local planning commission documents as relevant

General construction books

Manufacturers' and solar training programs
Manufacturers' manuals

Expedited Permit Process
www.solarabcs.org
www.brooksolar.com

On-Site Shade Analysis Made Easy
www.californiasolarcenter.org/pdfs/forum/2007.1.29-SolarForum_Heckeroth_SunEye_presentation-v2.pdf

Solar Pathfinder
www.solarpathfinder.com

Solmetric
www.solmetric.com

Wiley Electronics
www.we-llc.com

C. Conceptual Design (23%)

It is necessary to establish a conceptual design to accurately estimate the cost of a PV system during the sales process. PV system performance and long-term viability vary due to factors such as irradiance, temperatures, array layout, and system components. The conceptual design process provides the opportunity to review project goals against various design considerations.

The design process begins with a review of the available components and technologies that can support the project goals. Aesthetic, budgetary, and performance expectations must be addressed to achieve an acceptable balance for the customer. The PV Technical Sales Representative must be able to guide the customer, architects, and/or engineers through the

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multiple design variables and decisions. This may include presenting several component options, array locations/orientations, monitoring solutions, and racking and mounting methods. In order to effectively communicate these options, the representative must possess a working knowledge of the National Electric Code (NEC), manufacturer installation requirements and limitations, and how site-specific variables will impact the system. In addition, it is important to work with the Authority Having Jurisdiction (AHJ), local fire departments, and the interconnecting utility (for grid-direct systems) to understand any additional requirements that may apply to the project, such as the location and labeling of disconnects, roof setbacks, or acceptable equipment.

Various module technologies offer different aesthetics, efficiencies, and mounting options, but they may not be rated for adverse environmental conditions such as abnormally high wind speeds or close proximity to salt water. Inverter selection should be based on the available maximum power point voltage window as well as maximum allowable system voltage to ensure optimal performance. Certain module/inverter combinations may perform well in some climates yet operate outside the inverter voltage windows much of the year in other climates. Understanding the impacts of temperature on module voltage is critical when determining the number of modules in each PV source circuit. This design detail can determine system availability and efficiency for the majority of its lifespan. Another inverter specification that must be considered is the output voltage relative to the interconnection voltage. This necessitates that on-site electrical equipment be assessed for interconnection voltages, as well as compliance with Article 690.64 from the NEC.

Another important step in the design process is determining the location of the various system components. Several racking options exist for installing both roof and ground mounted arrays. Site conditions, aesthetic considerations, and performance goals can influence factors such as array location, stand-off height, pitch, and orientation. Roof types or ground array locations often dictate the attachment and support details (i.e. flat roofs may accommodate a penetration-less ballasted system). The array layout will be determined not only by the selected racking technology, but roof obstacles and setbacks. Array layout may also vary based on the inverter technology or other optimization tools. In order for the representative to effectively locate the system components, detailed site drawings should be created. Computer-aided drafting tools can be quite useful for this step. These tools can also be used to specify the location of the inverter and balance of system components (combiner boxes, disconnects, etc.).

After the various design options have been established, it is necessary to use site specific irradiation data or resources like PV Watts to accurately compare the variation in production between the different designs. Example: You can compare the difference in kWh production as a result of moving an array from an eastern to a western orientation to meet aesthetic requirements enabling the customer to select the option that is most consistent with their goals.

When done properly, a conceptual design benefits the sales process by enabling more accurate estimating and costing.

From the Task Analysis:

The PV Technical Sales Representative should have knowledge of:

- Product
- Voltage windows
- Websites that provide insolation data
- Noise level generated by equipment
- Risks of damage to equipment
- NEC requirements and local codes (AHJ)
- Cooling requirements
- Manufacturer's clearances
- Fire department requirements
- String layout
- Roof set backs
- Geometry
- Computer skills
- Spacing between modules
- Applying temperature coefficients
- Correlation between temperature and voltage

- Spacing between modules
- Electrical service sizes
- Current ratings
- Line side tap
- Roofing
- Product
- Mounting systems

Based on the project goals, budget, and limitations, the PV Technical Sales Representative should be able to provide a conceptual design. In order to successfully complete this step, the representative should be able to:

3.1 Explain module aesthetic options to customer.

3.2 Recommend and/or specify the appropriate system components based on cost, efficiency, aesthetics, project location, and performance.

3.3 Consider geographic location and climate. Access and utilize site specific insolation and irradiation data.

3.4 Select the module(s) that provide the best cost, performance, and aesthetics for the clients needs.

3.5 Match the inverter to the array.

3.6 Match the inverter to service voltage.

3.7 Assess potential impacts from environmental and ambient conditions such as salt water or dust. Avoid locations that will expose modules to salt water.

3.8 Comply with manufacturer specifications for inverter location.

3.9 Discuss potential sites for inverter with customer. Provide the customer the necessary guidance to determine the appropriate location for components such that they are installed per the manufacturer guidelines and comply with NEC required clearances.

3.10 Ask customer about long-term plans for renovations, etc. Work with the customer, architect, and/or engineer to determine the best location for the system and the associated components given the site's existing and future conditions.

3.11 Consider type of monitoring system, broadband vs. wired.

3.12 Discuss conduit runs. Identify site specific details that may require special provisions such as long conduit runs or underground conduit runs.

3.13 Determine module layout. Identify site specific details that may require special provisions, walkways and/or setbacks for firefighters, etc.

3.14 Determine electrical layout. Advise customers of potential drawbacks associated with particular components, such as noise from inverters, or off-gassing from batteries.

3.15 Determine which faces of roof to use. Determine and sketch the locations of multiple arrays based on factors such as aesthetics, energy production, and load management (i.e. Time-of-Use).

3.16 Determine and sketch the proposed module layout based on setbacks, shading, roof obstructions, and spacing between modules as determined by the racking technology. Sketch a site plan detailing the electrical layout and point(s) of interconnection with the utility and/or other power sources.

3.17 Select the string sizing method and calculate string sizing given the selected module and inverter platforms and local maximum and minimum temperatures.

3.18 Understand the impacts of high and low temperatures on module voltage and select module and inverter technologies accordingly.

3.19 Determine stand-off height above the roof to insure proper convective airflow for cooling modules.

3.20 Match array voltage to inverter voltage with applicable temperature conditions.

3.21 Consider module voltage degradation over time.

3.22 Determine max inverter output given buss bar limitations.

3.23 Evaluate whether there is room for a breaker.

3.24 Evaluate the service amperage. Determine the voltage and current ratings of the existing electrical service and assess interconnection options compliant with NEC Article 690.64.

3.25 Determine whether new electrical service is needed.

3.26 Determine whether line side tap can be used.

3.27 Assess roof type, age, condition, and sub-structure.

3.28 Evaluate roof pitch.

3.29 Evaluate structural members (wood, steel, trusses, rafters) with careful attention to remaining life of the roof.

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3.30 Determine space required under modules needed for convective cooling airflow, and debris (leaves) or snow.

3.31 Consider impact on roofing warranties. Review the warranty with the client and provide them with the questions necessary to discuss warranty impact with the roofing contractor.

3.32 Specify an appropriate racking technology and racking details.

3.33 Determine number and type of roof penetrations, and select code compliant flashings suitable for the clients roofing structure.

3.34 Evaluate performance and aesthetic impact of various tilt angles.

3.35 Identify trenching considerations needed for underground conduit runs.

3.36 Determine local height restrictions for ground mounted arrays.

Resources:

Inverter manufacturers: websites and installation manuals

Module manufacturers: websites and installation manuals

Local Utility
Local Fire Department
Local Authority Having Jurisdiction

National Electrical Manufacturers Association
www.nema.org

National Roofing Contractors Association
www.nrca.net

PVWatts: NREL online tool for production estimates
www.nrel.gov/rredc/pvwatts

HP121-102: The Whole Picture, Computer-Based Solutions for PV System Monitoring
HP122-36: Solarscapes — a new face for PV
HP130-38: Residential building-integrated photovoltaic systems
HP133-50: Seeking peak performance
HP134-50: 2010 PV module guide

SP1.1-32: From kW to MW: system design considerations
SP2.1-78: Array to inverter matching: mastering manual design calculations
SP2.4-24: Can we land?
SP2.4-48: c-Si photovoltaics: trends, design, purchasing, and 2009 specs
SP2.5-46: Making the case for residential photovoltaics
SP3.1-26: 2010 grid-direct string inverter guide
SP3.1-50: The building side of building integrated photovoltaics
SP3.2-30: Pitched-roof PV mounting: design and engineering considerations
SP3.2-50: Racking equipment guide
SP3.4-26: Ground mounted PV
SP3.5-62: c-Si photovoltaics: performance, design, installation & 2010 technical specs

Solar Energy International: Photovoltaics: Design and Installation Manual, 2007

- *Chapter 3*, The Solar Resource
- *Chapter 5*, Photovoltaic Modules
- *Chapter 8*, Inverters

Dunlop, Jim: Photovoltaic Systems, Second Edition, 2010

- *Chapter 2*, Solar Radiation
- *Chapter 5*, Cells, Modules, and Arrays
- *Chapter 8*, Inverters

National Electric Code (NEC), 2008

- NEC Article 690.4 (D)
- NEC Article 110.26 (A)
- NEC Article 690.14 (D)
- NEC Article 342, 344, 348, 350, 358

Resources Continued

NABCEP Study Guide, Version 4.2, 2009

- Section 3.2.5 – BOS locations
- Section 3.3.1 – Differentiating among available modules and inverters
- Section 3.4 – Adapting the mechanical design

Solar Radiation Data Manual: for flat-plate and concentrating collectors
rredc.nrel.gov/solar/pubs/redbook

Understanding the Solar Business:
An Insider's Guide to Success
www.solarspies.net

Surface Meteorology and Solar Energy: RETScreen data
eosweb.larc.nasa.gov/sse/RETScreen

PV Select: Design tool
www.pvselect.com

Solar Design Tool: Design tool
www.solardesigntool.com

Update on California Fire Marshall Proceedings:
February 2008
www.solarabcs.org

International Fire Code: Proposal F-30 — May 2010
www.solarabcs.org

Expedited Permit Process
www.solarabcs.org
www.brooksolar.com

A Guide to PV System Design and Installation
www.brooksolar.com

Solar Sales & Marketing
www.ongrid.net/papers/index.html

D. Financial Costs, Incentives, and Savings (8%)

Determining the net cost of a project and the net savings are fundamental to analyzing the economics of a project.

One important step is determining the gross top-line cost of the project. This cost will include parts, labor, warrantee, utility and municipality fees, and profit. Additional costs can come from complications due to the location, type of surface upon which the PV array(s) are to be mounted, the slope of the mounting location, the need for trenching (or opening a surface) to install conduit, extra material/labor costs resulting from longer, thicker wires, etc. Unknown factors, such as subsoil conditions, roofing materials that are no longer manufactured, roofing materials with unfamiliar properties, and/or structural reinforcement can often necessitate "allowances" to be included in the contract. When this occurs, the customer and the contractor agree to an estimate with final cost to be determined at predetermined times agreeable to both parties.

Incentives may reduce the customer's costs of ownership either up-front or over the longer term. "Up Front" rebates and cash grants immediately reduce the customer's initial cost and are sometimes accepted by the contractor directly as partial payment. Feed-In Tariffs (FITs), Renewable Energy Credits (RECs), and Performance Based Incentives (PBIs) are often paid over several years, based upon actual system performance. Since they aren't received up front, they don't immediately reduce customer cost, therefore the customer must cover their cash value until they are received.

Tax credits often act like cash received from the government, but usually not until tax time. Often, state tax credits get taxed federally. In that event, they are rarely worth face value. Tax deductions reduce taxable income so they are worth their face value times the taxpayers tax rate, adjusted for federal taxation, if any. Similarly, depreciation also reduces taxable income, but the benefit is spread out over time.

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Other types of incentives can include sales or property tax abatements, transfer credits, and net metering. "Net Metering" or "Net Energy Metering" is a way the customer may exchange electricity with the utility. In locales with true "Net Metering," the customer will be given credit for the retail value of any electricity produced in excess of their consumption at all times of the day. This often blends nicely with Time-of-Use (TOU) electric rates, which are often have higher rates during the day and during summer months.

Some utilities provide the option to switch to a TOU rate. This may allow the customer to effectively sell their excess daytime production to the utility at higher "peak" rates, and purchase at lower cost "off-peak" (night, winter, and weekend) rates, however, not all utilities have favorable Time-of-Use rates. Some utilities also have tiered electric rates, which provide either a discount or a penalty for consuming electricity above specified quantity over a fixed time period. Solar systems offset the last kWh consumed in a give time period, so the value of those last kWhs determines the savings. Demand charges generally cannot be reduced or eliminated directly by solar production. However, some utilities provide the option to switch to other rate schedules. Sometimes these other rate schedules (in combination with a solar system) can yield lower future electric bills, enhancing savings.

Electric bill savings and/or incentive payments (PBIs, RECs, FITs) generated from solar systems may be effectively taxable depending on the customer's taxpayer status. This will reduce the net benefit.

Electric rate increases across the United States from 1990-2010 averaged 2.2% per year compounded (with some variation from state to state). Predicting the rate of electrical price escalation is challenging. Carbon legislation may cause electricity prices to increase faster than historical rates; however, the increase in shale-bed methane production is expected to put downward pressure on natural gas prices, which could reduce electricity production costs.

From the Task Analysis:

Based on the project cost, location, incentive availability, and local utility, the PV Technical Sales Representative should be able to provide a total system cost, net system cost after incentives are applied, and estimated electric bill savings. In order to successfully complete this step, the representative should be able to:

4.1 Explain local net metering policies.

4.2 Explain feed-in tariffs. Explain the benefits and consequences of switching to an alternative tariff.

4.3 Identify utility financial models.

4.4 Identify and be able to explain all applicable incentives including up-front incentives (rebates, grants, U.S. Treasury grants), incentives received over time (FITs, RECs, PBIs), tax incentives (federal, state, and city tax credits, tax deductions, and depreciation; sales or property tax exemptions), transfer credits, and net metering. Be able to explain the tax consequences of receiving any savings on the customer's electric bill for commercial customers. Identify and explain the possible tax or financial consequences of receiving any incentives.

4.5 Calculate net cost after incentives. Identify and sum all system cost components and identify any unknown costs, including adders and allowances for mounting location, wiring, and difficulty in access or installation.

4.6 Explain to the customer Time-of-Use and how it interacts with solar and the Net Metering or Net Energy Metering policies of the utility.

4.7 Explain tiered rate structures and how they interact with solar and the Net Metering or Net Energy Metering policies of the utility.

4.8 Explain energy and demand charges and how they interact with solar and the Net Metering or Net Energy Metering policies of the utility.

4.9 Explain how solar impacts demand charges.

4.10 Explain how solar impacts energy charges.

4.11 Identify the customer's current electric rate schedule or utility tariff, usage, usage profile, and demand quantities, and identify alternative tariffs for which the customer may be eligible.

4.12 Explain historical rate escalation patterns and estimate future rate escalation or possible rate decreases.

4.13 Calculate the net expected electric bill savings based on current and new electric tariffs, and system size and performance. Appropriately apply all incentives to develop an analysis of the true customer net cost a various stages of the project and its ownership.

Resources:

Incentives, Tax Benefits & Consequences

DSIRE: Database of State Incentives for Renewables and Efficiency
www.dsireusa.org
www.dsireusa.org/summarymaps
www.dsireusa.org/library
www.dsireusa.org/solar/solarpolicyguide

SEIA Guide To Federal Tax Incentives for Solar: SEIA members can download a copy of the full manual by logging into the members-only section of SEIA's web-site
www.seia.org

Economics of Solar Electric Systems for Consumers: Payback and other financial tests
www.ongrid.net/papers/PaybackOnSolarSERG.pdf

Treasury Grant: treas1603.nrel.gov

State Taxation of U.S. Treasury Grant: State level taxability of American Recovery and Reinvestment Act of 2009 Section 1603: Grants for Specified Energy Property
www.reznickgroup.com/sites/reznickgroup.com/files/papers/rg1078_section1603_state_matrix.pdf

Tax advice from the IRS: www.irs.gov

Tax advice from the Canada Revenue Agency
www.cra-arc.gc.ca

Tax advice from a qualified tax advisor

Lawrence Berkeley Lab: Electricity Markets and Policy
eetd.lbl.gov/ea/emp/re-pubs.html

Preliminary Evaluation of the Impact of the Section 1603 Treasury Grant Program on Renewable Energy Deployment in 2009
eetd.lbl.gov/ea/emp/reports/lbnl-3188e.pdf

Shaking Up the Residential PV Market — Implications of recent changes to the ITC
eetd.lbl.gov/ea/emp/cases/res-itc-report.pdf

Photon, November 2009-p28, Matz: The 13 solar colonies

FIT coalition: www.fitcoalition.com

Ontario Power Authority: fit.powerauthority.on.ca

Electricity Feed Laws: Feed-in laws, feed-in tariffs, advanced renewable tariffs, and renewable energy payments
www.wind-works.org/articles/feed_laws.html

Electric Rates & Tariffs

HP133-50: Seeking peak performance (TOU explained sidebar), Brian Mehalic
homepower.com/view/?file=HP133_pg50_Mehalic

Resources Continued

SRP Time-of-Use Price Plan:
Time-of-Use pricing explained
www.srpnet.com/prices/home/Tou.aspx

Tiered Rates Explained: San Diego Gas and Electric
www.sdge.com/customer/rates

Economics of Solar: Andy Black 2010 — Making the financial case — class slides
www.ongrid.net/papers/PVEconomicsSlides.pdf

U.S. DOE Energy Information Administration (EIA)
www.eia.doe.gov/fuelelectric.html

IREC Net Metering Rules
www.irecusa.org/fileadmin/user_upload/ConnectDocs/IREC_NM_Model_October_2009-1.pdf

Utility websites

State utility regulatory agencies such as:

- California Public Utility Commissions
- Arizona Corporations Commissions
- Public Service Commissions

Cost and Savings Modeling Tools

Solar Advisor Model (SAM): from the National Renewable Energy Laboratory: www.nrel.gov/analysis/sam

Clean Power Estimator
www.consumerenergycenter.org/renewables/estimator

QuickQuotes: www.solarquickquotes.com

CPF Tools: Clean Power Finance Tools
tools.cleanpowerfinance.com

OnGrid Tool:
The OnGrid Tool for solar financial analysis
www.ongrid.net

RETscreen: www.retscreen.net

E. Financial Benefit Analysis and Financing (7%)

Generally the most critical element in a customer's decision-making process is the financial benefit of purchasing a PV system. The financial benefit analysis and clear understanding of financing methods/options will provide the client the economic rationale necessary to evaluate an investment in PV system.

Based on the estimated production and avoided cost of power, the monthly savings can be calculated providing the basis for traditional economic analysis metrics: cash flows, ROI, IRR, Payback, etc.

Whether it is a cash purchase, or is financed through various financial vehicles such as an equity loan, a lease, a PPA, or a PACE funding model, the monthly savings and other economic metrics will be used to compare one financing or purchase option to another.

From the Task Analysis:

The PV Technical Sales Representative should have knowledge of:

- Financials
- Compound interest calculations
- Financing options

Based on the customer's estimated production and avoided cost of electricity, the PV Technical Sales Representative should be able to evaluate the solar investment through financial analysis calculation. Viable financial vehicles should be provided and accurately modeled for the customer. In order to successfully complete this step, the representative should be able to:

5.1 Calculate cash flow analysis. Use third party tools and resources to analyze cash flow of the site specific solar system.

5.2 Calculate bill savings. Using customer-avoided cost of power relative to proposed system's production, derive electric bill savings.

5.3 Calculate maintenance expenses. Using third party research, combined with site specific issues, develop a projected maintenance cost schedule for proposed system.

5.4 Calculate replacement/repair costs for inverter. Use appropriate third party research estimates to project inverter replacement cost after the inverter's warranty expires.

5.5 Develop multi-year timeline detailing costs/benefits while also calculating internal rate of return (exclude financing costs), simple return on investment, years to payback, and net savings. Using derived monthly electric bill savings, calculate ROI, payback and total savings.

5.6 Calculate internal rate of return (exclude financing costs).

5.7 Calculate simple return on investment.

5.8 Calculate years to payback.

5.9 Explain pre-tax and after-tax benefits, calculate theoretical resale value increase on property as well as customer potential property equity impact. Inform client of pre-tax versus post-tax benefits of electricity savings, theoretical building value increase and potential impacts on property taxes by installing a solar system.

5.10 Calculate theoretical resale value increase on property.

5.11 Explain to customer potential property equity impact.

5.12 Explain degradation rate of solar system's production to the customer. Using third party information, ensure client understands that production minimally degrades over time.

5.13 Calculate net savings.

5.14 Inform customer that projections are not legally binding, provide disclaimer. Ensure client understands system production is affected by myriad factors and estimated production represents best estimates.

5.15 Cash up front purchase. Evaluate purchasing system with cash. Using available third party resources describe and present the financial analysis.

5.16 Home Equity financing. Evaluate financing purchase with a home equity loan. Using available third party resources describe and present the financial analysis.

5.17 Leasing programs. Evaluate the cost of leasing the system. Using available third party resources describe and present the financial analysis.

5.18 Power Purchase Agreements (PPAs). Evaluate the option of financing the system using a PPA. Using available third party resources describe and present the financial analysis.

5.19 Consumer loans. Evaluate the option of financing the system with a consumer loan. Using available third party resources, describe and present the financial analysis.

5.20 Community based financing program (i.e. PACE). Evaluate the option of financing the system with a community-based financing program. Using available third party resources, describe and present the financial analysis

5.21 Utility loans. Evaluate the option of financing the system with a utility loan financing program. Using available third party resources, describe and present the financial analysis.

Resources:

DSIRE: Database of State Incentives for Renewables & Efficiency
www.dsireusa.org

Clean Power Finance: www.cleanpowerfinance.com

Solar Electric Power Association: Webinars
www.solarelectricpower.org/events/webinars.aspx

SANDIA Labs: http://www.sandia.gov/

OnGrid Sales Slides:
OnGrid Publications, Papers & Presentations
www.ongrid.net/papers/index.html

HP129-58: PV Financing Mo Rousso

SEIA Guide To Federal Tax Incentives for Solar: SEIA members can download a copy of the full manual by logging into the members-only section of SEIA's web-site
www.seia.org

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Lawrence Berkeley Labs: Case studies of state support for renewable energy
eetd.lbl.gov/EA/EMP/cases/property-tax-finance.pdf

Investopedia: General information on investing
www.investopedia.com

Wikipedia: Cash flow statement
en.wikipedia.org/wiki/Cash_flow_statement

Tom Hoff: Clean Power Research
www.cleanpower.com/Content/Documents/research/customerPV/CleanPowerEstimatorUses.pdf

Solar Photovoltaic Financing: Deployment by federal government agencies (2009) Cory, K.; Coggeshall, C.; Coughlin, J.; Kreycik, C. NREL Report No. TP-6A2-46397: www.nrel.gov/analysis/pdfs/46397.pdf

Appraisal Journal: More evidence of rational market values for home energy efficiency
www.icfi.com/markets/community_development/doc_files/apj1099.pdf

Solar Advisor Model (SAM): from the National Renewable Energy Laboratory (NREL)
www.nrel.gov/analysis/sam/

PVWatts: NREL online tool for production estimates
www.nrel.gov/rredc/pvwatts/

Green Tech Media: www.greentechmedia.com/

U.S Department of Energy:
Solar energy technologies program
www.energy.gov/energysources/solar.htm

F. Non-Financial Benefit Analysis (5%)

When evaluating a solar photovoltaic system purchase, the focus tends to be on financial benefits (ROI, payback, energy price inflation protection), however, there are several important non-financial benefits of installing a PV system that are equally or more important to many system buyers.

The most common non-financial benefits of owning a PV system are:

- Environmental
- Energy Independence
- Distributed Energy System
- Economic — Jobs

Environmental benefits — Most PV modules produce enough electricity within 1-3 years to offset the power needed to manufacture them. For the remainder of their life (an estimated 30-50 years) most PV modules produce electricity without any adverse environmental effects. Since PV systems do not produce carbon emissions, they are considered one of the best ways to combat air pollution and climate change.

Energy independence benefits — Using solar PV reduces our reliance on non-renewable forms of electrical power generation. Currently, most electricity comes from domestic coal sources. However, as electric vehicle usage grows, solar PV power can be used to fuel our transportation infrastructure, reducing the need for oil to fuel our vehicles.

Distributed energy systems benefits — Generating electricity on thousands of rooftops instead of making the power in a centralized power plant offers grid security (a serious national security concern). Reducing the need to build more centralized power generation systems helps keep our electric utility system working smoothly and minimizes peak loads common in summer AC hours.

Economic benefits (jobs) — Solar installation services are almost always provided by local installation companies. These jobs cannot be exported and solar PV installation creates more jobs per megawatt hour than any other energy type.

From the Task Analysis:

The PV Technical Sales Representative should understand the non-financial motivations for a client's interest in a PV system and be able to effectively communicate the benefits of solar electricity to the customer. In order to successfully complete this step, the representative should be able to:

6.1 Calculate the amount of Carbon Dioxide that will not be emitted into the atmosphere (in one year) when comparing electricity production from a PV system to electricity from a coal fired power plant.

6.2 Calculate the amount of coal in tons that would be saved by using a PV system compared to getting the electricity from a coal fired power plant.

6.3 Calculate the amount of water saved by using a PV system compared with getting power from hydro-electric, coal fired, and nuclear plants.

6.4 Calculate and compare the carbon produced driving a car (per mile) to the amount of carbon offset achieved by using a PV system.

6.5 Calculate acres of trees necessary to offset the carbon used to generate the electricity used by a PV system owner.

6.6 Calculate the barrels of oil that are saved if using PV to power your vehicles.

6.7 Articulate/calculate energy independence considerations including less reliance on foreign energy sources, grid stability benefits, and grid efficiency benefits.

6.8 Articulate the social benefits including local job creation and the positive impact on community energy awareness.

6.9 Articulate the range of other non-environmental benefits that important to your local community.

Resources:

NPR: Animated climate video
Understanding carbons' effect on climate change
www.npr.org/news/specials/climate/video/

EPA: Household emissions calculator
www.epa.gov/climatechange/emissions/ind_calculator.html

Findsolar.com: Calculator
www.findsolar.com/index.php?page=rightforme

Carbonfootprint.com: Calculator
www.carbonfootprint.com/calculator.aspx

Ongrid.net: Sales and marketing presentation
www.ongrid.net/papers/SalesMktg_SEI_NJ_2009.04.pdf

REW: Coal vs. solar article
www.renewableenergyworld.com/rea/blog/post/2010/05/time-to-step-up-the-comparisons-solar-and-wind-vs-coal-and-oil

EPA: Carbon sequestration in agriculture and forestry
www.epa.gov/sequestration/faq.html

EPA: CO2 vehicle emissions
www.epa.gov/oms/climate/regulations/420f10014.pdf
www.epa.gov/oms/climate/regulations/420f10014.htm

USGS: Report on power plant water use
ga.water.usgs.gov/edu/wupt.html

American Energy Independence
www.americanenergyindependence.com/

House Select Committee on Energy Independence
globalwarming.house.gov/issues/energyindependence

US Energy Information Administration:
Energy dependence analysis
tonto.eia.doe.gov/energy_in_brief/foreign_oil_dependence.cfm

NREL: Distributed energy basics
www.nrel.gov/learning/eds_distributed_energy.html

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Resources Continued

World Alliance for Decentralized Energy: Benefits of distributed energy
www.localpower.org/ben_economic.html

Wikipedia: Article on distributed energy – see "references" and "external links"
en.wikipedia.org/wiki/Distributed_generation

Solarbuzz: Distributed power generation comparison of solar energy to other alternatives
www.solarbuzz.com/DistributedGeneration.htm

NREL: Job and economic development impact model (JEDI): www.nrel.gov/analysis/jedi/

SEIA: 2009 solar industry report and charts
www.seia.org/cs/about_solar_energy/industry_data

Apollo Alliance: Green jobs report
apolloalliance.org/downloads/gjfgreenjobsrpt.pdf

The Solar Foundation: National Solar Jobs Census 2010: www.thesolarfoundation.org/sites/thesolarfoundation.org/files/Final%20TSF%20National%20Solar%20Jobs%20Census%202010%20Web%20Version.pdf

G. Performance Analysis (8%)

System production estimates need to consider both the system's initial performance as well as changes in performance over time.

Initial system performance factors can be organized into several groups.

- Component Losses
- Local Solar Resource
- Unavoidable "location specific" performance factors
- System designer and customer influenced performance factors
- Shading

Component losses factor the performance of the modules and inverters, taking account of real-world operating temperatures. Most PV modules typically produce 8-15% less electricity in continuous operation in full sunlight than when flash tested in controlled conditions in a factory. Inverters in adequately ventilated locations generally convert 90-97% of the DC electricity to AC power. Equipment listed on the Go Solar California website Equipment web page provides typical rating factors for both modules and inverters for the reference location of Davis, California.

The local solar resource varies from location to location. System performance is directly proportional to the sunlight level of the location; however, the sunlight level across most of the United States is within 20% of that of San Francisco, Miami, or Austin. The variation between locations is one of the more minor factors affecting system financial results compared to electric rates and incentives. Sunlight levels are often thought of in terms of "equivalent noontime sunlight hours" and are also know as the "Sun Hours" of a location. Average "Sun Hour" tables can be found in the NREL resource databases including the NREL Redbook (out of print, but available online).

Unavoidable location-specific performance factors include:

- Dust & dirt for location: 5-20%
- Manufacturer production tolerance: 0-5%
- Module mismatch: ~2%
- AC & DC wiring: 1-5%
- Temperature in location. Temperature performance loss is 0.5% per °C rise

System designer and customer influenced performance factors include array orientation (tilt angle and azimuth), shading, and spacing for ventilation. Example: mounting an array with less than a 6-inch clear air-flow gap can cause up to a 10% additional temperature related performance loss due to thermal stagnation. Preference for mounting the array on a particular roof surface location may reduce performance over a more optimal location or orientation. Choosing to mount the array parallel to the surface of the roof, rather than rack it up to face the optimal orientation has the tradeoffs of aesthetics, mounting cost,

and system performance. Sub-optimal orientations can often cost 5-20% or more of system performance and/or Time-of-Use value of electricity to be lost.

Shading is often the most under-diagnosed system performance loss factor, and can easily cost 25 - 50% of system performance. Sadly, there are some systems that have been installed with up to 90% shading where the customer was told "The trees will cause 'some' loss of output." Shading cannot be accurately estimated by eye — only a 3D analysis model or on-site measurement tool can determine shading with any reasonable degree.

System performance over time is affected by changes in site conditions, system component performance degradation, component failure, system monitoring, and timeliness of system repair. Changes in site conditions can include vegetation growth or construction of shading obstructions. Most solar modules power output is thought to degrade 0.5% to 1.0% per year, but this factor varies among products and may be affected in the future by new module production methods and materials. Based on current manufacturing processes, modules have not expected to rarely fail before their warranted life (typically 25 years); however, inverters do sometimes experience failure before their 15th year, and sometimes much sooner.

Most systems will periodically have an electrical/electronic glitch requiring they be reset or restarted. One study estimated that 100% of larger systems will experience some type of electrical or mechanical problem within 3 years (see resources); therefore, some form of monitoring is essential to keep system uptime to 98% (2% loss) or better. The more active and frequent the monitoring, and the more immediate the response time to any issue.

Use industry standard tools to perform the power production calculations based on data provided by the site analysis. Standard tools provide a baseline for checking calculations, and improve speed and accuracy by incorporating inputs for all performance related factors.

From the Task Analysis:

The PV Technical Sales Representative should have knowledge of:

- Sites that can provide data
- PVWatts or SAM
- RETScreen
- How various factors impact production

Based on the project location, site characteristics, and publicly available performance data tables, the PV Technical Sales Representative should be able to estimate current and future hourly performance for each array mounting location option, factoring in all applicable system performance loss factors. In order to successfully complete this step, the representative should be able to:

7.1 Consider insolation data for the proposed site when performing the production estimates.

7.2 Review temperature data for the area with particular focus on record low temperatures and average high temperatures.

7.3 Consider microclimate data if available. In some geographies (mountainous or coastal areas) local temperature data may not be sufficiently accurate to know the actual record low and average high temperatures for the site. In these situations, conservative estimates are often the best strategy.

7.4 Consider impact of dust and dirt when calculating kWh output. In dry dusty climates, PV output can decline 20% or more if modules are not cleaned by rain or routine washing.

7.5 Understand the relationship between module name plate rating and actual DC power output.

7.6 Consider Time-of-Use pricing when making financial projections. Often it is desirable to have a more westerly facing array in areas with Time-of-Use net metering since power in the later afternoon is more expensive in most TOU plans.

7.7 Adjust the system performance estimate based on shading data providing by a shading analysis tool.

7.8 Consider wire losses when calculating AC power output from a PV system. Keeping

wire lengths shorter, designing to the higher voltage ranges, and using larger wire are all strategies to minimizing losses in wiring.

7.9 Consider module operating temperature, regional ambient temperatures, and air flow when estimating power output.

7.10 Consider component efficiencies (i.e., inverter, DC modules).

7.11 Consider tilt angle in the production estimates. Evaluate the losses when mounting at same pitch angle of the roof versus the optimal angle for solar electric production.

7.12 Consider azimuth (orientation) for the various proposed roofing surfaces and communicate the power production and aesthetic impact of siting the array in these different locations.

7.13 Consider diodes and connections in the power production estimate.

7.14 Consider module mismatch, both initial and over time, and factor for this in the power production estimate.

7.15 Consider system availability. Even though properly designed and installed PV systems are very reliable, small problems (which are easily remedied) can shut down production for days at a time if not caught quickly. This is one of the key reasons that monitoring is so valuable, but consideration for down days must be anticipated.

7.16 Consider tracking, dual or single axis. While tracking is rarely cost effective with the dramatic reduction in module prices, it does have financial viability in select applications or with some incentive programs.

7.17 Consider system age or degradation.

7.18 Factor for module degradation over time. Most module manufacturers warranty for less than ½-1% per year decline in power production.

7.19 Evaluate plants and trees that will grow to shade the array. Make landscaping decisions that will keep the array as shade-free as possible during the solar productive hours.

7.20 Evaluate the possibility that new construction could impact the shading of a prospective array.

Resources:

California Energy Commission: Eligible equipment section: equipment performance and monitoring listings
www.gosolarcalifornia.org/equipment

Solar resource data

NREL Redbook: Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors — for sun hours by location
rredc.nrel.gov/solar/pubs/redbook

Natural Resources Canada: www.nrcan.gc.ca

NREL: Solar resources data
www.nrel.gov/rredc/solar_resource.html

3Tier: Solar resources data: www.3tier.com

California Energy Commission: Consultant report, June 2001, A guide to photovoltaic (PV) system design and installation
www.energy.ca.gov/reports/2001-09-04_500-01-020.PDF
www.abcsolar.com/pdf/endocon.pdf

Temperature averages

WeatherBase: www.weatherbase.com

ASHRAE: The American Society of Heating, Refrigerating and Air-Conditioning Engineers — photovoltaic research & development: www.ashrae.org/technology/page/336#design in "2. Weather Data" under "4. Design"

Resources Continued

Sandia National Labs: Photovoltaic research & development
photovoltaics.sandia.gov

- Library of publications on these subjects, which receives periodic additions. Click the "Publications" link under the "Technical Reports and Publications" section.

NREL: Comparison of PV system performance-model predictions with measured PV system performance
www.nrel.gov/analysis/sam/pdfs/2008_sandia_ieee_pvsc.pdf

Tree growth: www.arborday.org/treeguide/growth.cfm

Weed growth: Google "weed control"
en.wikipedia.org/wiki/Weed_control
landscaping.about.com/od/weedsdiseases/Chemical_Organic_Weed_Control_.htm
plants.usda.gov/index.html

Solar Access Laws
http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CA45R&re=1&ee=1

California's Solar Access Laws:
By Kurt Newick & Andy Black
www.solardepot.com/pdf/CASolarAccessLaws.pdf
solartownhouse.com/docs/CASolarAccessLaws.pdf

California Solar Rights Act: The 1978 California solar rights act and historic resources
ohp.parks.ca.gov/?page_id=25664
California Solar Rights Act and Solar Shade Control Act
www.ucan.org/energy/energy_efficiency_alternatives/california_solar_rights_act_and_solar_shade_control_act

Solar Pathfinder: www.solarpathfinder.com

Solmetric Suneye: www.solmetric.com

Precigeo: www.precigeo.com

Performance Modeling Tools

Solar Advisor Model (SAM): www.nrel.gov/analysis/sam

PVWatts: NREL online tool for production estimates
www.nrel.gov/rredc/pvwatts/

California Solar Initiative EPBB calculator
www.csi-epbb.com

QuickQuotes: www.solarquickquotes.com

CPF Tools: tools.cleanpowerfinance.com

OnGrid Tool for Solar Financial Analysis: www.ongrid.net

RETscreen: www.retscreen.net

SP2.6-34 Commissioning: Blake Gleason article on dust & dirt's effect on system performance and performance verification

Reliability and Availability Analysis of a Fielded Photovoltaic System: Sandia National Labs (Collins, et al) using TEP data
http://photovoltaics.sandia.gov/Pubs_2010/PV%20Website%20Publications%20Folder_09/Collins_PVSC09[1][1].pdf

- *Figures 9 & 10*, Table 4, and associated text

H. Prepare Proposals (7%)

It is important that a potential client of a renewable energy system receive a proficient proposal from a Technical PV Sales Professional. The goal of a competent proposal is to provide a document that clearly states realistic power production, contract cost, equipment specifications, financial calculations, incentives, and any other important site specific or local jurisdictional information pertaining to buying a solar energy system.

The proposal process begins by gathering the required data from the solar site assessment. Once the site assessment data is recorded, it is the responsibility of the PV Technical Sales Representative to create a proposal that addresses all relevant factors that help the purchaser make an informed buying decision.

The ideal proposal will help the prospective client understand the true benefits of purchasing solar energy for their application and guide them to making a wise purchasing decision. A quality proposal helps the consumer feel confident in their investment of solar energy.

From the Task Analysis:

The PV Technical Sales Representative should have knowledge of:

- Reading manufacturer data sheets
- Rating specs
- Documents required for completing the sale

Based on the customer goals and information from the site evaluation, the Technical PV Sales professional should be able to provide a proficient solar proposal. In order to successfully complete this step, the representative should be able to:

8.1 Include a production estimate based on the clients proposed system size. Provide an annual projection of savings each year for the first 25 years of system operation based on changes in site conditions, system component performance degradation, component failure, system monitoring, and timeliness of system repair.

8.2 Include DC and AC system power rating to identify realistic output power (STC DC system power rating and CEC AC or other rating as applicable).

8.3 Provide estimated monthly electric bill savings in order for the client to understand the financial incentives of solar.

8.4 Include total cost, rebates, tax incentives, and net on the solar proposal.

8.5 Indentify estimated permit fees, interconnection fees, taxes, and other foreseeable cost to client.

8.6 Identify variable or unknown costs and provide estimated range of cost that could be added to the contract if circumstances require it.

8.7 Include clearly defined payment schedule and make sure client fully understands the specific dates, amounts, and conditions.

8.8 Identify incentives paid over time (PBI, FIT, SRECs). Educate the client about local and federal solar incentives that help reduce cost of the renewable energy system.

8.9 Include construction timeline and milestone dates, understand and clarify documents required for completing the sale to the client.

8.10 Include major equipment list, power ratings, and part count. Include an information packet that educates the client of the major equipment and power ratings proposed. Read and understand manufacturer data sheets and explain to the customer.

8.11 Indentify construction assumptions, special factors, and location of equipment installation to the client.

8.12 Include a detailed and comprehensible financial document that shows benefits of the investment over time and the financing options available.

8.13 Include information regarding the non-financial benefits to the client as applicable.

8.14 Include energy efficiency and conservation discussion as applicable.

Resources:

Solar Design Tool: For configuring grid-tied solar electric systems: www.solardesigntool.com

Expedited Permit Process: Solar America Board for Codes and Standards: www.solarabcs.org

Brooks Engineering: A guide to PV system design and installation: www.brooksolar.com

OnGrid Publications: Papers & presentations — solar sales & marketing
www.ongrid.net/papers/index.html

The OnGrid Tool for Solar Financial Analysis
www.ongrid.net

Database of Sate Incentives for Renewables & Efficiency: DSIRE: www.dsireusa.org

Clean Power Finance: Sales tools for solar professionals
www.cleanpowerfinance.com/solar/installer-tools/

Developing a Proposal to Close the Sale
consulting.about.com/od/gettingstarted/tp/CF_WritingProposals0907.htm

How to Write a Business Proposal
www.ehow.com/how_12848_write-business-proposal.html

Sample Business Proposal
www.sample-business-proposal.info/index.html

Sales Element: Web-based proposal creation tool
saleselement.com

Proposal Kit: Proposal generation software
www.proposalkit.com

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