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Witnesses: Frank W. Thomas
Thomas O. Bialek

SDG&E SOLAR ENERY PROJECT

CHAPTER II

DETAILED DESCRIPTION

San Diego Gas & Electric Company

Errata to

Prepared Direct Testimony of

Frank W. Thomas

and

Thomas O. Bialek

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF CALIFORNIA

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I. INTRODUCTION (Thomas)

The purpose of this testimony is to provide a detailed description of the SDG&E Solar Energy Project including the need, the objectives, benefits and associated costs thereof. In addition, this testimony will explain how the proposed SDG&E program provides benefits to customers. To implement its proposed SDG&E Solar Energy Project, San Diego Gas & Electric Company ("SDG&E") seeks California Public Utilities Commission ("CPUC" or "Commission") approval for the following:

1. Approval to implement the SDG&E Solar Energy Project that would consist of investment in up to 52 MW_{dc}[1] of utility-owned solar photovoltaic ("PV") generating facilities with a spending cap of $250 million over a five-year period. The proposed SDG&E Solar Energy Project consists of multiple individual installations of solar PV generating facilities of approximately 1 to 2 MW_{ac}[2] each from 2009 through 2013. SDG&E proposes to file Tier 3 Advice Letters for approval of cost recovery for individual PV generating facilities as detailed in the testimony of SDG&E witness Ms. Michelle Somerville.
2. Approval of SDG&E's proposed cost recovery as detailed in SDG&E witness Ms. Michelle Somerville's testimony in Chapter IV.

The description of the SDG&E Solar Energy Project detailed in this chapter is consistent with the policy outlined in the testimony of SDG&E witness Mr. James Avery.

II. OVERVIEW (Thomas)

In support of SDG&E's effort to further diversify its resource portfolio, to promote deployment of distributed solar generation and to contribute to the State of California's

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[1] The direct current capacity reporting basis is frequently utilized in the PV industry to report PV system output. If capacity is expressed on an alternating current (ac) basis the dc to ac conversion will be based on the CEC conversion of 1watt (dc) = 0.67 watt (ac) detailed as follows:
A Guide to Photovoltaic (PV) System Design and Installation, CEC 2001, pg. 8-9

DC to AC inverter conversion:	.90
Production tolerance derate:	.95
Temperature derate:	.89
Dirt & dust derate:	.93
Mismatch & wiring derate:	.95
Total (product):	.67

Using this conversion factor, 52 MW_{dc} equates to approximately 35 MW_{ac}.

[2] While 1-2 MW_{ac} is the primary target range, installations could be larger depending on specific site conditions.

renewable energy goals, SDG&E requests Commission approval of its proposed SDG&E Solar Energy Project. The SDG&E Solar Energy Project will focus on areas of the distributed solar generation market that are not currently being served by the California Solar Initiative ("CSI") programs as explained in Section III. Specifically, SDG&E proposes to pursue installations that are larger in size than the installations to date in the CSI or SDG&E's Sustainable Communities Program ("SCP")[3] but smaller than the large central station PV generating facilities that are connected to the transmission system.

SDG&E's primary objective for the SDG&E Solar Energy Project is to increase capacity benefits during system peak with tracking, by situating facilities in advantageous locations on the distribution grid in order to achieve annual renewable energy deliveries at installed costs less than historical costs of the systems installed under the CSI and Self-Generation Incentive Program ("SGIP")[4]. The proposed SDG&E Solar Energy Project will develop and install up to 52 MW_{dc} of utility-owned solar PV generating facilities connected to SDG&E's distribution grid. The proposed generating facilities will consist of multiple PV installations each sized between 1 and 2 MW_{ac} developed and installed between 2009 and 2013, resulting in up to 52 MW_{dc} of total capacity from all of the installations.

The typical facility size is expected to be 1 to 2 MW_{ac} with each installation influenced by the useable space or real estate for a solar installation. This size range offers greater economies of scale than the typical CSI installation while being small enough for siting flexibility on the distribution system[5]. The primary types of solar PV installations will be land based solar arrays and parking lot shading PV arrays. SDG&E prefers single axis tracking PV installations because the tracking systems allow the PV panels to follow the path of the sun during the day to maximize the output and energy from the generating facility, especially during peak summer periods. The SDG&E Solar Energy Project will fulfill the following objectives:

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[3] SDG&E's Sustainable Communities Program provides incentives for sustainable, efficient building projects and integrates utility-owned distributed generation systems. Refer to Section VI.A. for additional details.

[4] CSI and SGIP are California based programs with significant deliveries to the distribution system with widely known installed costs.

[5] Interconnection to the distribution system effectively limits the size of a facility based upon the constraints of the distribution system. Thus, SDG&E expects individual facilities to be in the 1 to 2 MW_{ac} range, but there could be a potential for up to 5 MW_{ac} depending upon location.

1. Deploy distributed renewable solar power generation in inland areas where SDG&E's load is concentrated.
2. Complete renewable projects in a market segment that has not been substantially reached by existing programs.
3. Further diversify SDG&E's resource portfolio.
4. Increase annual solar resource energy deliveries by employing tracking technologies.
5. Increase the capacity of renewable energy on system peak load.
6. Contribute to SDG&E's Renewable Portfolio Standard ("RPS") goals.
7. Help fulfill SDG&E's future greenhouse gas ("GHG") emissions reductions targets.

A central aspect of the SDG&E Solar Energy Project will be the continuation and development of partnerships. SDG&E will use its established customer and community relationships to identify host solar installations. These hosts will likely consist of municipal governments, entertainment venues, and large retail/shopping complexes. Project hosts wishing to install their own solar facilities in conjunction with the SDG&E Solar Energy Project will be offered the added benefit of lower per unit costs realized through economies of scale such as purchase volume, shared permitting, design, and civil work. An additional aspect of the partnerships will be working with several solar equipment and systems suppliers to facilitate standard solar packages primarily as it relates to solar ~~tree~~ **parking structure** applications. Further, SDG&E has properties that might be well suited for tracking technology installations that it can use to "kick start" the SDG&E Solar Energy Project.

Viable hosts will have undeveloped real estate or parking space with appropriate solar insolation. SDG&E believes the ideal hosts are those that are motivated to participate in the project to enhance their renewable energy presence/image, gain advantages like shaded parking or have a willingness to install their own solar PV system in concert with SDG&E's system to obtain renewable attributes on their side of the electric meter. Lease payments to project hosts, if applicable, will be considered and negotiated on a case by case basis. SDG&E will apply the renewable attributes of its PV ownership toward its RPS goals and future GHG reduction obligations if applicable. The SDG&E systems will be interconnected directly to the distribution grid to support all bundled customers' energy needs, and as such, the host would not be eligible for the generation output or for net metering on the SDG&E owned facility.

SDG&E witnesses Mr. Christopher Yunker and Ms. Michelle Somerville detail the revenue requirements, individual facility approval process, and cost recovery mechanisms for SDG&E's program in their testimony in Chapter III and Chapter IV, respectively.

III. NEED FOR PROGRAM

A. Furthers SDG&E's Portfolio Diversification Goals (Thomas)

SDG&E's resource planning is based on a portfolio approach consistent with the CPUC's loading order that calls for energy efficiency, demand response, renewables, distributed generation, and transmission, followed by the addition of conventional generation to meet long term needs[6]. In the CPUC's 2006 Long Term Procurement Proceeding[7], SDG&E's approved plan identified a mix of various renewable technologies, both in and outside of its service territory. Because of the limited renewable resource potential within its service territory relative to its overall renewable resource needs, SDG&E will be reliant upon renewables delivered via the transmission system in order to meet its resource requirements and RPS goals. Nonetheless, the SDG&E Solar Energy Project is an important, albeit smaller part of SDG&E's resource plan in that it will deliver local renewable attributes at the distribution level without triggering significant system upgrades. Delivered to SDG&E's inland load areas, the SDG&E Solar Energy Project is structured to seek installations that maximize capacity benefits at time of system peak as well as overall energy deliveries. Further, utility ownership provides long term cost of service deliveries of renewable energy and capacity. In sum, the SDG&E Solar Energy Project provides diversification of generation in terms of technology, location of delivery, and ownership all of which are attributes of SDG&E's approved long term resource plan.

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[6] Energy Action Plan Adopted May 8, 2003, see http://docs.cpuc.ca.gov/published/AGENDA/docs/3112_results.htm.

[7] R.06-02-013

B. SDG&E Solar Energy Project Addresses a Market Segment between California Solar Initiative and Projects Responding To SDG&E's Renewable Request For Offers (Thomas)

SDG&E is proposing the SDG&E Solar Energy Project to target a segment of the renewable energy generation market that cannot be covered by the CSI and has not been contracted under the renewable Request for Offers ("RFO") process. The characteristics of the SDG&E Solar Energy Project market segment are: 1 – 2 MW_{ac} solar PV distributed generating facilities connected to the distribution system located close to SDG&E's inland load areas with a preference for solar PV technology that increases capacity and energy production, especially during system peak periods.

1. CSI is Focused on Residential and Commercial Less than 1 MW_{ac}

In Decision (D.) 06-01-024, the CPUC, in collaboration with the California Energy Commission ("CEC" or "Energy Commission"), established the California Solar Initiative program, an ambitious incentive program with the goal of ensuring that 3,000 MW_{ac} of new solar facilities are installed in homes and businesses in California by 2017. The CSI supplants the solar portion of two former solar incentive programs, the Emerging Renewables Program ("ERP") and the Self-Generation Incentive Program. In D.06-08-028, the CPUC established implementation details for its portion of the CSI Program, particularly the adoption of the Performance Based Incentive structure. On August 21, 2006, Governor Schwarzenegger signed Senate Bill ("SB") 1, which directs the CPUC and the Energy Commission to implement the CSI Program consistent with specific requirements and budget limits set forth in the legislation. On December 14, 2006, the CPUC adopted D.06-12-033, which reconciled its previous decisions with the requirements contained within SB1.[8]

Under the CSI, the minimum system size eligible for an incentive is 1 $kilowatt_{ac}$ ("kW_{ac}"). The maximum system size eligible for the CSI Program is 5,000 kW_{ac} (5 MW_{ac} CEC-AC); however, incentives are not available for installed capacity greater than 1,000 kW_{ac} (1

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8 California Solar Initiative Program Handbook, California Public Utilities Commission, January 2008.

MW_{ac} CEC-AC). Thus, a host customer site may elect to install up to 5 MW_{ac} of generation and seek incentives for up to1 $MW_{ac.}$[9]

2. Renewable RFO Process

SDG&E has issued renewable RFOs every year since 2002. These RFO solicitations have requested renewable resources offers that meet the California Renewable Portfolio Standard eligibility criteria set forth by the CEC[10] and in accordance with its Commission approved annual renewables procurement plan, as applicable. The primary objective of the RPS RFO process is the solicitation of offers for renewable projects from parties that will develop, install, own and operate renewable energy projects and sell the renewable energy to SDG&E under power purchase agreements or sell the project to SDG&E under a turnkey arrangement.[11] The renewable energy procured as a result of these solicitations can be counted toward SDG&E's RPS obligations.

3. The SDG&E Solar Energy Project Market Segment Has Not Been Addressed by Existing Programs.

SDG&E's approach in designing the SDG&E Solar Energy Project has been to complement and support existing State programs, not duplicate or conflict with them. The SDG&E Solar Energy Project proposal is structured to tap into renewable resource opportunities not addressed by existing State programs, specifically CSI, nor currently by bidders into SDG&E's RPS RFO process. The SDG&E Solar Energy Project will focus on solar PV installations that are connected to the distribution system near its load areas with a significant portion of installations providing the benefits of tracking systems. A specific consideration of the SDG&E Solar Energy Project will be solar project impact to the distribution system.

Any potential host customers would first be informed of their opportunity to participate in the CSI program. Customers that wish to participate in the SDG&E Solar Energy Project will still be eligible to participate in the CSI program.

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9 IBID

10 CEC Renewable Energy Portfolio Eligibility Guidebook, May 2004, 500-04-002FD.

11 To date, no turnkey opportunities have been contracted under the solicitation process.

CSI PV installations are eligible for incentives for a maximum of 1 MW_{ac} and are capped at the customer's historic load if less than 1 MW_{ac}. Thus, the size of PV installations SDG&E is proposing is typically beyond what customers would elect to install.

However, a customer who hosts a solar PV system could gain benefits not otherwise available. Those benefits could include shaded parking, a clear demonstration to their community of their commitment to renewable energy while minimizing a substantial capital investment. Furthermore, a project host who installs its own PV system at the same time as SDG&E could benefit from potential lower installed cost from a larger project.

RPS RFO solicitations have been and will continue to be open to offers for all renewable resource projects that meet the CEC eligibility criteria per SDG&E's CPUC approved annual renewable procurement plans. However, no renewable projects within the market segment addressed by SDG&E in this application (1 – 2 MW_{ac} systems in the San Diego load areas using the technology SDG&E proposes) have been built as a result of SDG&E's RPS RFOs. Consequently, SDG&E is proposing to develop facilities in this renewable market segment to meet the objectives and provide the benefits identified in this testimony.

By targeting an undeveloped part of the renewable generation market segment, SDG&E shares and supports the State's overall goal of enhancing the propagation of solar resources throughout the State.

C. Support for the SDG&E Distribution Grid (Bialek)

Several factors must be considered when integrating larger PV systems into the grid. Adequate distribution system capacity will be needed at the chosen site to carry the generation. This may preclude larger installations near the end of a distribution circuit. The distribution system protection scheme must be examined not only under normal configuration but also other configurations likely during restoration or emergency conditions. Voltage regulation must also be considered. The reverse flow of power may have an impact on voltage at various points on the distribution feeder at different times of the day. Finally, power quality aspects will be reviewed. Generally the 1 – 2 MW_{ac} size of the systems proposed at a few locations will not have a substantial impact on normal operation; however these important elements must be considered and checked to maintain utility service requirements. However, large, wide-scale deployment will impact both the design and operation of the system.

One of the potential benefits to be explored is the strategic location of solar PV in a size large enough to provide a distribution benefit. As part of facility selection process, SDG&E will examine areas where a benefit may be realized such as deferral of a capital upgrade of a distribution circuit. To provide a benefit, the PV systems must be able to meet the following attributes in order to defer the need for a capital improvement project; (1) be located in the right location on the circuit, (2) be of sufficient size not only in nameplate but coincident circuit peak, (3) be built and online when needed, and (4) have physical assurance of reliable operation. Weather conditions, specifically the amount of solar insolation and temperature are more uncertain and directly impact PV output. Further study will be done to better understand and integrate weather data with PV production and local circuit peak conditions.

D. Contributes to California's CSI and RPS Goals (Thomas)

California initially established the Self-Generation Incentive Program to encourage customers to purchase and install various technologies of distributed generation including solar photovoltaics. Subsequently, the incentive funding for PV technology was shifted to the CSI program. The objective of both programs was to promote small solar PV systems.

The State of California has adopted a Renewable Portfolio Standard[12] goal for 20% of SDG&E's energy requirements to be supplied by renewable resources by 2010. Energy provided by solar generating facilities owned by SDG&E can contribute to the RPS requirements. Output from up to 52 MW_{dc} of solar installations proposed in the SDG&E Solar Energy Project is projected to generate up to 69,100[13] megawatt hours on an annual basis contributing approximately up to 0.38% of SDG&E's retail customer electric load by 2013.

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12 Public Utilities Code Section 399.15(b)(1):
Each retail seller shall, pursuant to subdivision (a), increase its total procurement of eligible renewable resources by at least 1% of retail sales per year so that 20% of its retail sales are procured for eligible renewable energy resources no later than December 31, 2010… See Table II-1.

13 MWh and contribution to RPS are based on ac nameplate values. Tracking PV systems contribute greater MW on peak, more annual MWh and greater contribution to RPS as detailed in Section IVD.

E. Resource Adequacy (Thomas)

In D.05-10-042 the Commission established rules on how solar generation is to be counted toward a load serving entity's resource adequacy requirements. For solar generation facilities resource adequacy capacity is determined on a historical performance basis. The resource adequacy of solar PV facilities is calculated from the month-specific, 3-year rolling average performance history over noon to 6 pm peak hours year round. SDG&E estimates that the performance based resource adequacy contribution from solar PV in the SDG&E Solar Energy Project will be in the range of 60-65% of the installed capacity. Consequently, 35 MWac of solar PV capacity will contribute approximately 23 MW_{ac} toward SDG&E's resource adequacy requirements. From a grid reliability standpoint it is anticipated the SDG&E Solar Energy Project would produce approximately 28 MW_{ac}[14] of capacity when all tracking solar PV systems are installed and operating as expected.

IV. SDG&E SOLAR ENERGY PROJECT DESCRIPTION

A. Size and Length of SDG&E Solar Energy Project (Thomas)

SDG&E proposes to develop, install, own, operate and maintain up to 52 MW_{dc} of solar PV between 2009 and 2013. SDG&E conducted an initial screening of potential parking lot shading solar array opportunities. This evaluation of large contiguous open spaces indicated approximately 450 acres of parking lot real estate located predominately at entertainment and shopping complexes near SDG&E's load areas. The parking lot shading arrays market segment offers the opportunity for approximately 60 MW_{dc} of solar PV generation subject to further solar insolation analysis which could lower this opportunity. SDG&E has also conducted initial discussions with a number of municipalities. Based on the preliminary discussions, the opportunity exists to install solar PV on real estate owned by municipalities in the range of approximately an additional 48 MW_{dc}. Again, this estimate is subject to further solar insolation analysis which could lower this opportunity. SDG&E also owns real estate that could support the installation of approximately 7 MW_{dc} of solar PV generation. Based on this initial analysis SDG&E identified a total of approximately 115 MW_{dc} in project opportunities. However, it is

[14] See Table II-1.

recognized that not all project opportunities create actual installations. The SDG&E Solar Energy Project will commence with regulatory approval in 2009 and the SDG&E Solar Energy Project will finish in 2013, with the exception of ongoing operation and maintenance of the utility-owned solar PV systems. SDG&E Solar Energy Project activities in 2008 will be: refining technical specifications, identifying and researching specific installation opportunities, **and** expanding discussions with potential turnkey vendors.~~, and proceeding with preliminary facility development.~~

B. Selection Considerations (Thomas)

SDG&E has established project selection criteria as a guide to screen potential opportunities with the goal to construct facilities which provide the greatest benefit to all customers. Once potential installations have been identified as meeting basic program characteristics, the following considerations and attributes will be evaluated:

- Engineering estimates for installed and on-going costs.
- Solar PV installations are to be located near SDG&E load areas. They must be able to interconnect with the SDG&E electric grid. Preference will be given to areas where additional generation is desired to potentially provide benefits to the distribution system.
- Preference will be given to developed or undeveloped real estate that allows land based tracking PV panel systems or installation of parking lot shading PV arrays.
- Preference will be given to installation opportunities having 7-10 acres of contiguous real estate that allows greater than 1 MW_{ac} of PV to be installed.
- Preference will be given to installation opportunities located to optimize solar insolation and temperature profiles to enhance energy production.
- Installation areas will be screened for optimum terrain, shading and orientation impacts.
- Individual installation sizes will be targeted at 1 MW_{ac} or larger. Preference will be given to installations that allow larger output opportunities in order to enhance cost effectiveness. Target customer types are municipalities, entertainment

venues, large commercial operations, large retail operations. Installations providing improved cost effectiveness including site costs, and/or through the use of joint PV system procurement with the host, or unique local benefits that provide revenue to off-set installation costs will be given preference.

- Preference will be given to installations that do not require significant interconnection costs.

The remaining sites will be provided to shortlisted vendors to obtain firm pricing. For each installation that SDG&E accepts and that meets the above criteria with installed direct capital cost less than $\$7000/kW_{dc}$[15], SDG&E will file a Tier 3 Advice Letter seeking approval to engineer, procure, install, operate and maintain the solar PV facility. The Tier 3 Advice Letter process is described in the testimony of Ms. Michelle A. Somerville.

C. Description of Solar PV Facilities (Bialek)

The SDG&E Solar Energy Project will be directed toward photovoltaic tracking and parking lot shading PV systems (see Appendix I for descriptions). SDG&E's application is designed to expand and reduce the cost of a different type renewable generation program that is not addressed by large rooftop solar PV installations. The solar PV market for tracking and solar parking shading are distinct and unique segments within the renewable generation sector that can be further developed and deployed. The benefits delivered to SDG&E's customers and to the promotion of deployment of a unique portion of the renewable generation market are not attainable by installation of equivalent amounts of rooftop solar PV.

The solar generating facilities will utilize either crystalline or thin film PV technologies determined on a facility by facility basis. Other solar generating technologies will be considered during the duration of the SDG&E Solar Energy Project if they meet cost and selection criteria.

1. Parking Lot Shading PV Systems

Parking lots, including roof top parking structures, can offer good solar sites. They generally provide large contiguous areas, free from obstructions allowing installations of greater than one megawatt. Solar exposure can be excellent from early morning to early evening. The

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15 See Chapter III testimony of Mr. Christopher Yunker for revenue requirements.

shade below the parking lot PV shading system helps to lower temperatures at ground level and reduce heat absorbed by dark colored asphalt thus reducing the heat island effect. Areas can generally be found nearby to install the balance of plant (inverters, disconnects, metering, etc.). Support structures for parking lot PV shading systems can be found in various design configurations both fixed and tracking.

In anticipation of the advancement and deployment of all electric vehicles the design of the parking lot PV shading systems will include consideration of the addition of plug in service outlets and stations in the future. It is anticipated that in the future, the use of plug-in-hybrids and electric vehicles will become more common place. The ability to charge such vehicles at remote locations will provide an added benefit to our customers.

Examples of parking lot solar shading systems are shown in Appendix I.

2 Single Axis Tracking PV Systems

The power output of a PV array is maximized by keeping the array pointed at the sun. Single axis tracking systems follow the sun in one axis (direction) constantly adjusting for the position of the sun in the sky throughout the day. Single-axis tracking of the array will increase the energy production in some areas of the world by up to 50 percent for some months and by as much as 35 percent over the course of a year. Tracking is most beneficial at sites between 30° latitude North and 30° latitude South.[16] Although the City of San Diego lies just outside this zone at latitude 32 degrees, 42 minutes, it is very close to the optimum zone. Single axis tracking can yield significant gains over fixed array systems in the San Diego area.

Appendix I provides additional details on single-axis tracking systems and the types and configuration of the single axis tracking systems.

The key advantage of this type of array is the increase in early morning and late afternoon power output. In late August, a typical time of the year for high utility system peaks in Southern California, the PV system output at 4 PM PST from a single axis tracking system can be approximately 80% of maximum while a fixed system oriented south to maximize annual

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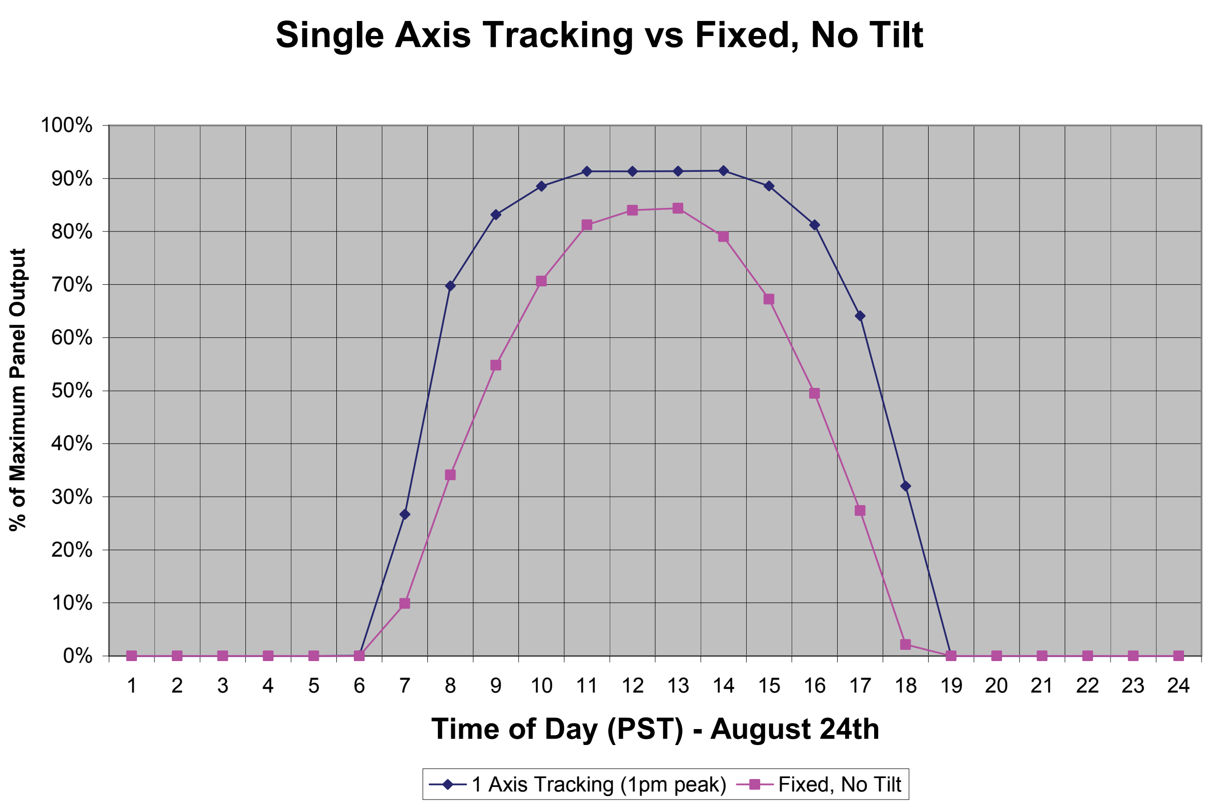
[16] http://www.eere.energy.gov/solar/cfm/faqs/third_level.cfm/name=Photovoltaics/cat=The%20Basics

production would be producing approximately 50% of its maximum output at the same time.[17] The ability of the tracking system peak to more closely match SDG&E annual system peak which generally occurs during late summer in the late afternoon provides a significant benefit not attainable by fixed axis systems. This is the reason single axis tracking systems are preferred by SDG&E for the SDG&E Solar Energy Project.[18]

The chart below shows the output curve of a fixed axis, no tilt, no tracking array compared to a single axis tracking system array sited in San Diego.[19] The day displayed is August 24th, a typical time of the year for SDG&E system peak. SDG&E's system peak is generally in the late afternoon corresponding to the maximum air conditioning load. The fixed system's output has dropped to approximately 50% of maximum output by 4 PM PST. The single axis tracking system is at approximately 80% of peak output at the same time.



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[17] http://rredc.nrel.gov/solar/calculators/PVWATTS/version1/ PV WATTS simulation estimates performance based upon historical data.

[18] Dual axis tracking systems are not precluded, however, such systems will be required to prove that installed costs and ongoing O&M cost are outweighed by the incremental energy and capacity benefits afforded by dual axis tracking over single axis tracking.

[19] Data is from PV Watts for San Diego. Fixed array at 180 degrees Azimuth, no tilt. Tracking array at 180 degrees Azimuth, 32.7 degree tilt.

D. Performance of PV Systems (Bialek)

The output of photovoltaic systems is affected by many factors. When the losses, conversion factors, and other derating factors are considered, the direct current (dc) MW capacity rating of a PV system is significantly higher than the alternating current (ac) MW output during a utility's system peak. Table II-1 demonstrates the estimated MW output during system peak, and the estimated energy (MWh) generated per year that will result from 52 MW_{dc} installations of various types. The first data column in the table shows the estimated MW output and energy (MWh) generated using a fixed, no tilt, no tracking panel configuration typical of large commercial rooftop installations. The third column shows the estimated output for a fixed tilt, single axis tracking facility. It is significant that the capacity delivered at the time of system peak is 65% higher for fixed tilt, single axis tracking (28.0 MW_{ac}) compared to the no tilt, no tracking configuration (17 MW_{ac}). Further, annual energy deliveries are 40% greater. It is for this reason that the SDG&E Solar Energy Project will focus on tracking PV, while not precluding other applications that meet the overall objective of maximizing annual energy and on-system peak capacity deliveries. Additional details on various photovoltaic applications and technologies are provided in Appendix I.

Table II-1

Comparison of Solar PV System Performance	No tilt, no tracking	Fixed tilt, no tracking	Fixed tilt, single axis tracking
MW (DC) installed[20]:	52	52	52
Combined adjustment factor for DC to AC conversion and equipment & environmental losses[21]:	0.67	0.67	0.67
Factor for orientation (tilt)[22]:	0.89	1	1

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[20] 52 MW_{dc} is the capital cost of the program divided by the loaded low end PV system cost range which SDG&E believes is an ambitious target.

[21] A Guide to Photovoltaic (PV) System Design and Installation, CEC 2001, pg. 8-9:

DC to AC inverter conversion:	0.9
Production tolerance derate:	.95
Temperature derate:	.89
Dirt & dust derate:	.93
Mismatch & wiring derate:	.95
Total (product):	.67

[22] Ibid, page 9.

MW (AC) at meter:	31	35	35
Peak coincidence factor:	0.49[23]	0.5[24]	0.81[25]
MW output during system peak:	17	17	28.0
Energy adjustment factor:	1.00	1.00	1.25[26]
Energy (MWh) generated per year[27]:	49,200	55,300	69,100
% of SDG&E 2012 retail sales[28]:	0.27%	0.30%	0.38%

1. Rooftop PV systems cannot provide the capacity benefits that SDG&E is seeking from the tracking system technology.

PV systems produce electricity in DC current, which must be converted to AC current through an inverter. The CEC recommends an overall conversion from AC to DC of 0.67 for a fixed tilt array.[29] With a due south orientation and a tilt equal to the site latitude, the PV system produces the maximum energy output for the year in this configuration. Typical large commercial system installations are laid flat to reduce the cost of the PV system installation. The impact of a flat panel orientation is an additional derate of system output by 89 percent.[30]

Tracking systems improve the overall energy output of a PV system by improving the orientation of the array to the incoming solar radiation. A single axis tracking system produces approximately 40 percent more energy annually than the comparable flat panel, no tilt rooftop PV system. Additionally, tracking systems improve the peak coincidence factor for the August 4 pm PST system peak load that is the norm for SDG&E. The peak coincidence factor improves from 0.49 to 0.81 for the comparable no tilt, flat panel PV system based upon the National Renewables Energy Laboratory PV Watts calculator.

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23 Calculated factor by SDG&E using NREL PV Watts program for an array using fixed, no tilt.

24 http://www.sdenergy.org/uploads/SGIP_M&E_Sixth_Year_Impact_Evaluation_Final_Report August_30_2007.pdf, pg. 5-7.

25 Calculated factor by SDG&E using NREL PV Watts program for an array using single axis tracking.

26 Ibid.

27 Calculated using the energy output formula and factors stated in the CEC PV Design Guide, page 9: 1582 kWh per DC kW installed in San Diego (1582 is the average of the range given: 1406 to 1758 kWh).

28 The RPS goal is 20% of the annual retail sales for SDG&E, percentage contributing to 2013 RPS is based upon 18,424 GWh of total sales in 2012.

29 A Guide to Photovoltaic (PV) System Design and Installation, CEC 2001, pg. 8-9

30 Ibid, pg. 9

The net result as shown in Table II-1 and discussed earlier is that large commercial rooftop PV systems cannot provide the capacity benefits that SDG&E is seeking from the tracking system technology.

2. Batteries cannot provide the capacity benefits that SDG&E is seeking from the tracking system PV technology.

It has been hypothesized that by adding a battery to each PV system, the capacity produced by the PV system at noon time can somehow be stored and delivered back to SDG&E when it is needed to meet SDG&E system peak. SDG&E believes that tracking PV offers a superior solution, particularly in the near term. By adding a battery to a PV system, a customer can rely on that battery to back-up that customer's utility service in the event of an outage from the utility, today these PV systems with battery backup are not capable of injecting power back into the utility system when they are connected to the grid. These batteries are simply a means to back-up service when service is interrupted.

The type of technology that has been hypothesized to actually store energy from a residential type of development and deliver energy on demand is nascent. The estimated additional cost is $850/kWh or $1250/kW for lead-acid batteries for energy storage backup applications.[31] To date, it is unusual to find a grid connected PV system with battery backup in SDG&E's service territory.

To the extent that batteries may be utilized in the future to provide system capacity benefits, they would add significant cost to a PV system, require additional energy necessary to charge the batteries and reduce the achievable MWs from the SDG&E Solar Energy Project.

V. BENEFITS OF THE SDG&E SOLAR ENERGY PROJECT (Thomas)

A. Customer Benefits

Customers will benefit from the SDG&E Solar Energy Project by the following:

1. Additional renewable resources and contribution to SDG&E's RPS goals. Output from up to 52 MW_{dc} of solar installations are projected to generate up to

31 "HELCO Operational Issues Bulk Energy Storage", Hawaii Electric Co. and Sentech Inc., October 2004.

approximately 69,100 megawatt hours on an annual basis contributing to approximately ~~0.37%~~ **0.38%** of SDG&E's retail electric sales in ~~2013~~ **2012**.

2. Contribution toward SDG&E's annual resource adequacy and grid reliability requirements as detailed in Section IIIE.
3. The distributed generation solar PV generation facilities will be connected to the SDG&E distribution system located in areas that do not require notable interconnection costs.
4. Reduction in GHG emissions that SDG&E can use in the future to meet its Assembly Bill ("AB") 32 obligations, if applicable[32]. Output from up to 52 MW_{dc} will reduce annual GHG emissions by approximately 34,480 metric tons.
5. SDG&E Solar Energy Project will create opportunities for SDG&E's customers hosting a solar PV facility to participate with a facility of their own at the same time SDG&E develops and installs its solar PV facility, thereby realizing lower installed costs through economies of scale and the receipt of CSI incentives up to the first megawatt (ac) of installed capacity.
6. SDG&E will gain knowledge and experience about projecting the generation and scheduling the output and energy from distributed solar generation resources. This knowledge and experience will be of increasing benefit as SDG&E increases the amount of solar generation in its resource portfolio.
7. SDG&E will gain knowledge and experience about the potential for localized impacts due to intermittent energy deliveries to its distribution system, specifically, the potential for and impacts of voltage deviations, and mitigation measures.
8. Through SDG&E's development and ownership of solar renewable facilities, SDG&E will further the State's objectives under the CSI as well as the development and the promotion of the solar market.

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32 AB 32 obligations are presently being developed by the California Air Resource Board ("CARB"). While, the CPUC has yet to specify the requirements of its regulated utilities pursuant to CARB, GHG emissions are tracked by SDG&E.

9. SDG&E's generation and energy resource portfolio in the future will contain increasing and significant amounts of renewable energy resources. Through utility-owned development and ownership, the SDG&E Solar Energy Project will provide valuable experience and knowledge concerning the development, ownership, operations and maintenance, performance, cost, integration and utilization of solar renewable energy.

B. Environmental Benefits

The environmental benefits associated with solar PV installations result from the utilization of the sun to generate electricity instead of fossil fuel based generating resources. Unlike fossil fueled generation, solar PV does not produce emissions, noise or consume water during the production of electrical energy. Displacement or reduction of fossil fueled generation by solar PV results in the lower production of emissions and greenhouse gases.

The generating units that would be displaced by PV generation are those units that follow variations in regional load during off-peak shoulder seasons and peaking units during peak seasons. For projection of the emissions benefits of the SDG&E Solar Energy Project it is assumed that the fossil fuel generation that is displaced by solar PV results in a reduction of 1,100 lbs CO_2/MWh. Table II-2 provides a projection of the quantity of NO_x, particulate and greenhouse gas emissions that would be offset by 52 MW_{dc} of solar PV generation.

Table II-2

		52 MW_{dc}
Estimated Annual PV Energy Production (MWh)		69,100
Equivalent NO_x Reduction (Metric Tons/year)		2.7
Equivalent Particulate Reduction (Metric Tons/year)		2.2
Equivalent Greenhouse Gas Reduction (Metric Tons/year)		34,480

VI. SDG&E IS UNIQUELY SITUATED TO ACCELERATE IMPLEMENTATION (Thomas)

Because SDG&E has long established relationships with its customers, owns and operates the electric grid and ensures safe interconnection, and has the necessary financial strength for ownership, it is in a unique position to implement the SDG&E Solar Energy Project. This will be accomplished in part, by matching the SDG&E Solar Energy Project's desired attributes with the appropriate potential host customers. Additionally, as described below, SDG&E has experience with renewable PV development and execution through its Sustainable Communities Program ("SCP").

A. SDG&E's Experience With Renewable PV Development and Execution

SDG&E has five years of experience in the planning, installing, owning and maintaining clean energy systems on customer sites as a part of its Sustainable Communities Program. Initially conceived in 2003, SCP's foundation program, "Sustainable Community Energy System Project" was proposed and approved in the TY2004 Cost of Service filing[33] whereby SDG&E would "design and operate an efficient, effective and environmentally sound energy system"[34]

The Sustainable Community Energy System Project quickly evolved into the Sustainable Communities Program, a broader, multi-faceted program -- combining the promotion of "green" building design, sustainability and high energy efficiency design practices and integrated clean energy generation, which may be owned and operated by SDG&E.[35] The program has provided SDG&E with the broad experience to implement the SDG&E Solar Energy Project and accelerate its implementation schedule.

1. Lessons Learned from SCP

As the first utility program of its kind in the nation, it was necessary for SDG&E to design and implement all aspects of the photovoltaic component of SCP, striving for best practices to maximize program effectiveness and minimize risks to SDG&E and its customers. The program's design of locating clean energy systems on customer sites using third party

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33 Authorized an annual budget of $4.3 million in capital equipment and $699,000 O&M expenses through 2009.
34 TY2004 COS, page DLG 143.
35 Energy efficiency component of SCP funded through energy efficiency.

contractors required identifying and resolving legal and risk management issues, qualifying project opportunities with consideration of customer concerns and requirements, networking with the solar and building design industries, determining energy system technical specifications and requirements, engaging a competitive yet responsive bidding processing, considering interconnection/delivery system impacts and designing system monitoring requirements.

2. Adaptation – SCP provides experience directly transferable and scalable to the SDG&E Solar Energy Project

While SCP fosters a broader program focus than SDG&E Solar Energy Project due to SCP's integration of green building design and sustainability, the photovoltaic component of the program has provided SDG&E with direct experience in building and operating solar system projects. Methodologies used to implement projects are the result of extensive planning and feedback from multiple groups within the utility, the solar and design industry, and customers. This on-going development has resulted in approaches, procedures, and materials that support effective and efficient program implementation which is directly transferable and scalable to the SDG&E Solar Energy Project.

This is described in more detail below:

Project Development

Identifying, evaluating, and selecting appropriate project opportunities is vital to successful project implementation. Potential sites often present differing criteria that require careful consideration. As such, a site evaluation and screening tool was developed for weighting important criteria such as site physical attributes, solar insolation, and impact on the local distribution grid. While the larger SDG&E Solar Energy Project systems may require use of additional criteria, SCP's evaluation and screening tool can be directly utilized by the program. In addition, the SCP has established processes for multiple outreach strategies to identify, at the earliest stages of development, projects and project sites appropriate for consideration for the program. These outreach strategies can be utilized in the SDG&E Solar Energy Project. In addition, where appropriate, the SCP's current outreach efforts may also be used to identify potential sites for SDG&E Solar Energy Project installations where a customer host may be qualified for both programs but be better suited to SDG&E Solar Energy Project.

SCP Customer Contract Development

SDG&E has developed the template contracts necessary for the utility to build, own and maintain solar system on customer sites. It also has gained experience dealing with the many business related nuances that require specialized contracts such as when the site owner and site improvement owner are not the same. As a consequence, SDG&E has developed many types of lease and license arrangements to meet the needs of the many complex owner arrangements. SDG&E utilizes: 1) energy systems agreements to define party responsibilities and rights regarding the energy system design, installation, and operation; 2) facilities lease (or license) agreements to set out terms for the space where the energy system is located and operates; 3) Memorandum of Lease agreements to document the lease arrangement; 4) and additional documents such as Sublease Consent forms, Affiliate Self-Insurance forms, Certificates of Estoppel, etc. which are used as needed to accommodate the needs of other involved parties. SDG&E's experience in this area and contract templates will provide valuable tools in the implementation of the SDG&E Solar Energy Project.

System Contractor Selection, Installation and Maintenance

SDG&E utilizes third parties in the solar industry to construct and maintain its utility owned solar systems and has developed a process and qualification standards to pre-qualify contractors – allowing for efficient, high quality bidding processes, construction and maintenance of systems. An important part of the process includes the involvement of the owner to participate in the design evaluation process and schedule planning to assure the selected proposal provides a best fit for the joint needs of the owner and SDG&E. Site monitoring to track system operational performance and characteristics is performed by SDG&E. These processes and experience are scalable and transferable to SDG&E Solar Energy Project.

Knowledge and Experience Transfer

Knowledge, procedures, and materials developed through implementation of the SCP establish a platform from which to launch implementation of the SDG&E Solar Energy Project.

SDG&E has established relationships with its largest customers who will host the SDG&E Solar Energy Project installations. Established relationships with solar energy system vendors through its current SCP program to install, maintain and operate systems exist. Moreover, documents and procurement expertise developed through the SCP are in place for use in establishing contracts with owners and vendors. The principles of these relationships and materials scale up easily and are transferable to the requirements of the SDG&E Solar Energy Project. This will contribute to a rapid ramp-up and an accelerated implementation process and result in the ultimate success of the SDG&E Solar Energy Project through the delivery of quality long-lived beneficial solar generation facilities.

VII. SDG&E Solar Energy Project Costs (Thomas)

SDG&E expects the total SDG&E Solar Energy Project costs to be up to $250 million. Included in the costs of SDG&E Solar Energy Project are all costs required to develop and install the solar PV facilities, consisting of direct capital costs and indirect capital costs[36] and the annual SDG&E Solar Energy Project administrative costs. Costs associated with on-going lease payments (if applicable), operations and maintenance ("O&M") staffing and operations and maintenance activities are not included in the $250 million SDG&E Solar Energy Project cost. In addition, post installation capital costs such as inverter replacement are not included in the $250 million SDG&E Solar Energy Project costs. Lease payments and O&M costs approval will be requested in the Tier 3 Advice Letter submitted to the Commission for each PV installation.

A. Direct Capital Costs

SDG&E expects the installed direct capital cost will be in the range of $4,000kWdc - $7,000/kWdc[37]. This estimated cost includes materials, engineering, and installation costs including construction labor, for the photovoltaic panels and all balance of plant (which includes inverters, cables, wires, conduit, mounting structures, and all required hardware). Historical

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36 Indirect capital costs are provided in the Chapter III testimony of Mr. Christopher Yunker.

37 The lower range value $4,000/kW$_{dc}$ is based upon Southern California Edison Company's (SCE's) Solar PV Program application (A.08-03-015) $1.024 billion for 250 MW$_{dc}$, with consideration given to the differences between SCE's program and SDG&E's Solar Energy Project. In any event, SDG&E's actual costs will be based on competitive bids.

installed costs of the CSI program have been approximately \$6,500 to \$7,000 kW_{dc}.[38] Given the scale considered for the SDG&E Solar Energy Project, SDG&E expects to achieve cost savings such that installed costs will be consistent with or lower than those of the CSI program which delivers predominantly fixed, no tracking, systems.

Individual installations will be executed on a turnkey basis utilizing competitive solicitations for each installation to obtain the lowest evaluated installed capital cost. SDG&E will acquire the engineering, procurement and construction services for each solar facility through competitive solicitations.

B. Operations & Maintenance Costs

Operations and maintenance of the solar PV systems will include a combination of performance based monitoring, manufacturer recommendations and visual inspections. Annual maintenance will consist of a visual and infrared scanning of connections, and checking of inverter(s) including maintaining inverter filters. Systems will be monitored with alarms for operational problems. Predicted performance will be compared with actual performance to detect problems. If system performance has dropped notably below expectations, a check of output at key points would be undertaken to isolate and resolve the problem. Tracking systems may require additional maintenance consisting of alignment checks, lubrication and adjustment of the tracking mechanisms. A panel washing schedule will be implemented if it appears heavy soiling is reducing output more than 5%. Additional O&M costs may include replacement of broken panels or replacement of control equipment. Annual operations and maintenance costs are projected to be \$25/kW-yr in 2008 dollars[39]. The annual operations and maintenance costs include the cost of two incremental SDG&E employees who will monitor the PV installation performance and conduct system maintenance activities along with other outsourced maintenance costs.

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[38] This estimate is based on the average cost per kW for photovoltaic projects listed as part of the California Solar Initiative April 30, 2008, and the average cost per kW for photovoltaic projects listed in the Self Generation Incentive Program (SGIP) in 1st quarter 2008. These two lists were accessed through the California Center for Sustainable Energy website.

[39] Solar – Photovoltaic (Single Axis) 1 MW Gross Capacity data from Table 6: Common Assumptions, "Comparative Costs of California Central Station Electricity. The O&M cost of \$24/kW-yr in the table is in 2007 dollars that was escalated at 3% to establish the O&M cost in 2008 dollars.

Lease credits or payments, if applicable, for specific installations are not included in the $25/kW-yr annual O&M budget.

C. Annual SDG&E Solar Energy Project Administrative Costs (Staffing, Program Administration and Development Costs)

The purpose of this section is to identify the annual staffing, program administration and development incremental activities and related costs necessary for SDG&E to implement the SDG&E Solar Energy Project.

1. Staffing

The SDG&E Solar Energy Project will require a staff of seven incremental full time equivalent ("FTE") employees and support from other existing SDG&E functional groups. The program and functional requirements of the program staff are provided in Table II-3. In addition to the incremental employees required for the SDG&E Solar Energy Project there will be on-going, periodic support provided by individuals in the SDG&E's Supply Management, Commercial Legal, Accounting and Business Planning and Environmental groups.

Table II-3

Solar Energy Project Requirement	**Functional Requirement**	**Staffing Requirement**
Project Management • Project Definition • Project Focal Point • Staffing • Budgeting • CPUC Reporting • Project Promotion	Project Management	1 FTE
Administrative Support	Administrative Support	1 FTE
Identifying Facility Opportunities • City Governments • Shopping Malls • Entertainment Venues	Customer Installation Management/ Facility Identification	Utilize support from existing Account Executives
Scope and Detail Facilities/Product Standardization • Technical Knowledge • Technical Specification • Systems Knowledge • Technical Performance	PV Technical Specialist	1 FTE
Facility Development • Specific Facility Definition • Scoping and Contracting Development	Facility Development	2 FTE

• Customer Agreements • Permitting • Interconnection • Customer Relations/Customer Focus		
PV System Contracting • Equipment • Services	Procurement	Utilize Support from existing Supply Management Organization
PV System Installation • Project Management • Contactor Management • Customer Interface	Project Management	2 FTE
Legal • Commercial Agreements • Real Estate Agreements		Utilize support from existing Commercial Law Dept.
Environmental/Permitting	Environmental	Utilizing support from existing Environmental Organization
• Project and Facility Accounting	Accounting/Business Planning	Utilize support from existing Accounting Organization
		Total New FTE – 7

Position descriptions for each of the incremental employees who will be dedicated to the program are provided in Appendix II.

The annual staffing budget for the 7 FTEs dedicated to the program is $1,326,000 fully-loaded in 2008 dollars for years 2009-2013.

2. Annual Non-labor Administration and Development Cost

In addition to labor costs the SDG&E Solar Energy Project will require facility development costs consisting of non-labor administrative costs, development consultants and project development costs. 2008 non-labor program administration and development cost is budgeted to be $214,000 and in years 2009-2013 the annual budget for these items is budgeted to be $336,000 fully-loaded in 2008 dollars.

VIII. WITNESS QUALIFICATIONS (Mr. Frank Thomas)

My name is Frank Thomas. My business address is 8315 Century Park Court, CP21G, San Diego, California.

I am employed by SDG&E as Manager of Electric Project Development and Business Planning. In this role I have a group that is responsible for generation investigations and assists the Electric and Gas Procurement Department with its solicitations relative to generation development and generation technology. I am also responsible for the oversight and management of SDG&E's participation in SONGS. I was formerly Manager of Procurement Planning & Analysis within the Electric and Gas Procurement Department. My responsibilities in this former role included overseeing a staff of gas and electric analyst/planners that support the Procurement Department's traders and schedulers, assisting Resource Planning by taking the lead with short-term planning, valuing energy resources for acquisition, and supporting regulatory filings. I also took lead in developing and carrying out SDG&E's 2003 Grid Reliability RFO. I was lead or key contributor to the contract development and oversight of the Palomar, Otay Mesa, and Miramar generation projects resulting from this RFO.

I received my Bachelor's Degree in Hydrology and a Master's Degree in Civil Engineering from the University of New Hampshire. I have received an MBA from the University of Southern New Hampshire (formerly New Hampshire College) with a focus on finance. Much of my career has been as a consultant where I managed projects including the divestiture of utility assets and relicensing of FERC regulated hydroelectric projects. I spent four years with Citizen's Utilities Company where I valued hydroelectric assets and life extending capital additions, represented the company in deregulation activities, and analyzed its generation portfolio relative to stranded benefits and costs. My work at Citizen's culminated with strategic planning for the acquisition and divestiture of utility franchises.

I joined SDG&E in October, 2002. I have provided testimony before the CPUC previously.

This concludes my prepared direct testimony.

IX. WITNESS QUALIFICATIONS (Mr. Thomas Bialek)

My name is Thomas O. Bialek, Ph.D., P.E. My business address is 8316 Century Park Court, San Diego, California 92123. I am employed by San Diego Gas & Electric Company ("SDG&E") as a Chief Engineer in Electric Transmission and Distribution Asset Management. My present responsibilities involve a technical oversight role on distribution issues including equipment, operations, planning and distributed generation. These activities generally include technical review, policy development and strategic planning of distribution systems. I am also responsible for the preparation of exhibits and proposals for regulatory proceedings in these areas.

I have been employed by SDG&E since 2000 and have held various positions with other North American utilities and equipment manufacturers subsequent to that time. My experience includes electric utility design, planning and operation and equipment design, development and manufacturing.

I received a Bachelor and Master of Science and Degrees in Electrical Engineering from the University of Manitoba in 1982 and 1986. I received my Ph.D. in Electrical Engineering from Mississippi State University in 2005 respectively. I am a registered Professional Engineer, Electrical Engineering, in the State of California. In addition, I have actively participated in all the distributed generation rulemakings and workshops since 1998. I was also one of the primary authors of the Technical Potential for Renewables in the San Diego Region, August 2005.

I have previously testified before the California Public Utilities Commission.

APPENDIX I

Technical Details Of Photovoltaic Systems

A. Types Of Tracking Systems And Tracker Mount Types

Solar tracking systems may be active or passive and may be single axis or dual axis. Single axis trackers use either polar or horizontal mount systems.

Polar

Single axis SunPower T20 trackers, with roughly polar orientation, at Nellis Air Force Base, in Nevada, USA. The arrays form part of the Nellis Solar Power Plant and was designed and built by SunPower corporation. Credit: Joe Frani, SDG&E

Polar tracking systems have one axis aligned to be quasi-parallel to the axis of rotation of the earth, hence the name *polar*. In simple terms the tracking describes an elliptical arc in the sky following the sun as it makes it daily journey. Since the earth is round this path most closely follows the sun's path. Partial or continuous adjustments can also be made in the second axis (the elevation angle) to account for the height of the sun above the horizon as it makes its seasonal journey. Manual adjustments are generally made twice a year. Adjusting this axis continually with dual axis trackers, can improve performance slightly but add another layer of complexity and cost.

Horizontal axle

Wattsun HZ-Series Linear Axis Tracker in South Korea. These trackers use a horizontal axis.

Another option is a single axis horizontal axis tracking. With this type of tracking a long horizontal tube is supported on bearings mounted upon pylons or frames. The axis of the tube is on a North-South line. Panels are mounted upon the tube framework. The tube rotates east to west during the day to track the apparent motion of the sun. These systems are not quite as effective, especially during the winter due to the low angle of the sun but are effective when the sun is high in the sky. The main advantage of this type of tracking is its simplicity and robustness. Since the panels are horizontal, they can be compactly placed on the axle tube without danger of self-shading and are also readily accessible for cleaning. Drive types are either active or passive. Active trackers generally use light sensing mechanisms or Global Positioning Systems to keep the array oriented toward the sun. Passive systems use a low boiling point compressed gas fluid. For active mechanisms, a single control and motor may be used to actuate multiple rows of panels.

B. Parking Lot Shading Structures

Parking lot shading structures come in various designs from a single support column to cantilever to multiple columns and support systems. Structures can be stand alone like the example below or physically linked in long contiguous rows. The shape and size of the parking lot and flow of traffic often suggests the most appropriate design. A grid system is built on top of the columns to support the PV panels. The balance of the system, combiner boxes, dc disconnects, inverter, ac disconnects, meter/communication equipment, conduit and wiring follows normal PV design. Combiner boxes are often located under the carport structures. The other components can be located at a convenient location adjacent to the carport structure.

Solar Grove Kyocera, Envision Solar

C. Types Of Photovoltaic Cells

The majority of photovoltaic cells are made from silicon. In general, the silicon photovoltaic cells are either crystalline or thin film. Other materials are also used as semiconducting materials in the manufacturing of photovoltaic cells. For the SDG&E Solar Energy Project, SDG&E could use crystalline or thin film silicon, or other materials. The building or structure size, buildable area, terrestrial orientation, and other factors will dictate what type of photovoltaic system is ultimately selected to meet the guiding objectives of the SDG&E Solar Energy Project

Crystalline Photovoltaic Cells

Crystalline photovoltaic cells can be made from single crystal or multi-crystal silicon. The majority of installations in the SDG&E service territory are crystalline silicon. The crystallinity refers to the ordering of the atoms in the material. In single crystalline silicon, the silicon atoms are very ordered. The performance of PV solar cells is measured in terms of its efficiency at turning sunlight into electricity. Single crystal PV cells are manufactured using a single crystal growth method and have commercial efficiencies between 16 and 18%. Multi-crystal cells are usually manufactured from a melting and solidification process. They are less expensive to produce than single crystal cells, but they are also less efficient, with production efficiencies between 14 and 15%.[40]

Thin Film Photovoltaic Cells

Thin-film PV cells are constructed by depositing extremely thin layers of semiconducting materials on low cost backing such as glass, stainless steel, or plastic. Thin film materials include amorphous-silicon, cadmium-telluride, and copper-indium-gallium-diselenide. Thin film cells are less expensive than crystalline cells because they require less semiconductor material, and because they can be produced as large, complete modules. Commercially available thin film modules have efficiencies in the range of 6 to 11%. Because of its lower efficiency, thin film requires a larger area of PV arrays than crystalline cells to produce the same amount of electrical output.[41]

D. Inverter And Controls

The electricity generated by a PV module is in the form of direct current (dc). Transformation of direct current to alternating current (ac) required by many common appliances and for grid-connection is achieved with an inverter. Based upon laboratory tests, the efficiency of the inverter is generally greater than 90%, when the inverter is operating above 10% of its rated output, and can peak as high as 96%. Installation of a solar PV system also requires wires or cables, conduit, and disconnect switches. The amount and size of this additional equipment will depend on the size and configuration of the solar PV system.

[40] http://www.iea-pvps.org/pv/materials.htm
[41] Ibid

E. Interconnection Facilities

The solar system can be interconnected to the utility grid in a variety of ways. If the site has a customer transformer of sufficient size with spare terminations available, the PV system may be directly connected to the existing transformer (see Figure 1). The drawing shows the output of the inverter sharing the common transformer on the secondary side (normally 480/277 Volts). In this case the interconnection facilities will consist of a new line (conduit and cable) from the existing transformer to a new utility panel containing a disconnect switch and meter. The output from the solar inverter(s) would tie to this panel. The disconnect switch would serve as a visible open for utility workers to readily identify where to manually isolate the PV system from the rest of the grid. Remote control of the switch via SCADA control may also be utilized if warranted.

In many cases, especially at larger customer facilities, there may not be spare terminations at the transformer for new secondary cable. In this case a secondary terminator may be able to be installed to provide a tie-in point. A new line would be installed from the transformer to the secondary terminator. The existing feed from the customer would be intercepted and rerouted to the terminator. A new line would be added from the terminator to the new utility panel serving the PV system. (See Figure 2). The rest of the PV system would be identical to the first case.

If the appropriate type and size of transformer does not exist at the site, a transformer will need to be installed. In the most complex instance a new pad mounted switch will also need to be installed to allow the transformer to be connected to the primary circuit. (See Figure 3). In this case a cable would be connected from a primary tap point (hand hole) to the pad mounted switch. From there a cable would be connected to the new transformer. The connection to the PV system would then be the same as described above.

Figure 1 transformer common connection

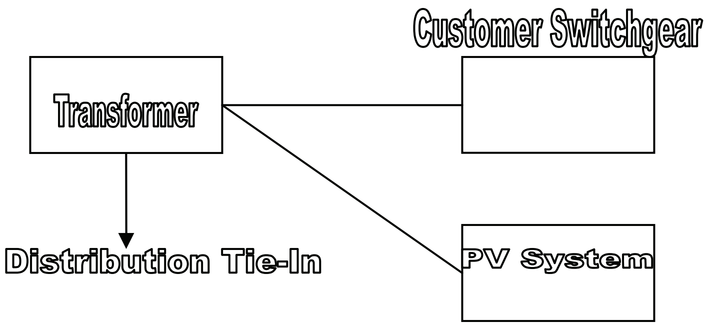


Figure 2 showing terminator connection

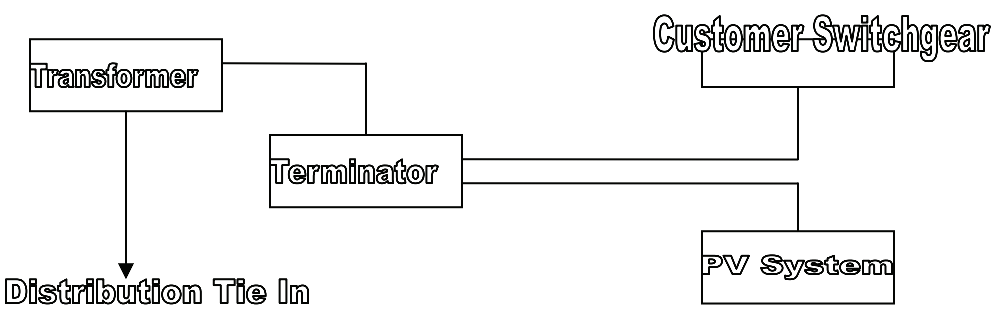
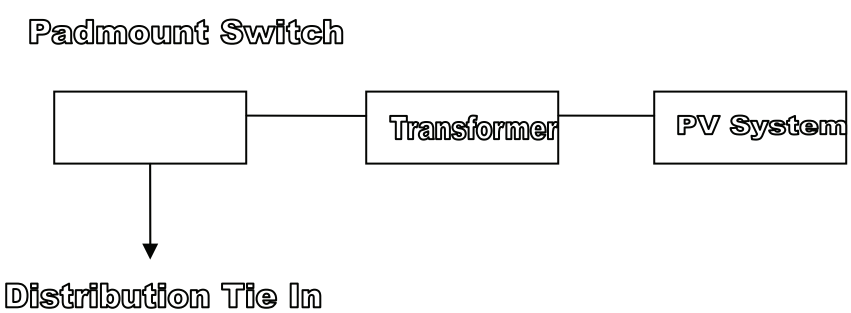


Figure 3 separate transformer and switch



A data acquisition system (DAS) will provide operating data at each site including power output, energy production, and power quality. Together with weather data the system will allow the optimal management of the system by tracking performance and triggering any maintenance, alarming any operational issues, verifying power quality at the site, and assisting with a predictive tool for hour and day ahead output based on weather forecasts. This last feature will allow interaction with CAISO to provide the operational data as requirements for scheduling solar are formulated, including potential future requirements to schedule solar generation in CAISO's Participating Intermittent Resource Program (PIRP).

The interconnection equipment to be installed will include a meter, communications, data collection interface, weather station and auxiliaries such as a power supply. SDG&E's generation control center will include server and IT interface(s) with all of the solar system installations.

APPENDIX II

SDG&E Solar Energy Project Staffing Position Descriptions

Program and Business Manager

Responsible for planning, strategy, reporting and management of department and facility budgets, staffing, regulatory reporting and other activities as necessary to achieve the SDG&E Solar Energy Project goals.

PV Technical Specialist

Responsible as technical specialist with specific knowledge of PV technologies, PV systems, PV system performance parameters, distribution system integration, managing technical consultants and preparation technical specifications.

Project Developer

Responsible for development of specific facility opportunities. This individual develops specific facility details, negotiates agreements, develops and negotiates installation agreements and manages receipt of project permits and approvals.

Construction and Project Management

Responsible for vendor, site and installation management. Serves as SDG&E's primary point of control to installation vendors and manages technical site criteria, executes site design/management plan, bid process, vendor selection and installation process. Responsible for necessary coordination to ensure all installations meet internal requirements, such as interconnection processes and interactions with distribution and procurement requirements. Ensures necessary metering and monitoring equipment are installed to meet the needs of SDG&E's requirements for ongoing operations.