



Abengoa Solar
First Solar
K Road Power
Recurrent Energy
Suntech

Amonix
FRV Renewables
NextEra Energy Resources
Solar Millennium

BrightSource Energy
Infinia
NRG
SunPower

March 1, 2011

Eugenia Laychak
California Energy Commission
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Sacramento, CA 95814-5512
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RE: Comments of the Large-Scale Solar Association on the Draft 2011 Energy Aware Facility Siting and Permitting Guide (CEC-600-2010-007-D)

Dear Ms. Laychak,

Thank you for the opportunity to provide comments on the Draft 2011 Energy Aware Facility Siting and Permitting Guide ("2011 Guide"). The Large-scale Solar Association ("LSA") applauds the Commission's efforts to help local governments in planning for and permitting renewable generation facilities. Local governments, through their permitting responsibilities, play a critical role in meeting the state's clean energy and climate goals.

LSA represents 13 of the nation's largest developers and providers of utility-scale solar generating resources. Collectively, LSA's members have contracted with utilities in California and the West to provide more than 7 gigawatts ("GW") of clean, sustainable solar power. Our members develop, own and operate various types of utility-scale solar technologies, including photovoltaic and solar thermal system designs. LSA and its individual member companies are leaders in the renewable energy industry, advancing solar generation technologies and advocating for policies that ensure environmentally appropriate solar generation facilities to meet the state's renewable and greenhouse gas goals.

LSA provides the comments herein to ensure that the information in the 2011 Guide accurately describes the characteristics of solar generation facilities. Solar technology is relatively new to California. Thus, permitting agencies will benefit from a resource that accurately describes the environmental performance of solar facilities, how this environmental performance compares with other generating technologies, and how environmental impacts could be mitigated. The Draft 2011 Guide includes erroneous information about solar technologies and potential impacts. In these comments, LSA identifies inaccurate and misleading statements in the Draft 2011 Guide and asks that these statements be corrected before the 2011 Guide is finalized. For your reference, we also provide a description of the different utility-scale solar technologies, attached to these comments.

LSA has focused our review to date on the discussion in Chapter 6 of Solar Thermal and Solar Photovoltaic energy facilities (pgs. 171-174). We reserve the right to provide additional comments on the 2011 Guide in the future.

- Throughout the section – PV plants use panels, not mirrors. This correction needs to be made throughout the section.
- Throughout the section – Solar facilities are not necessarily located in remote, undisturbed locations. The 2011 Guide should clearly state that solar technologies do not require remote, undisturbed land.
- Introduction, pg. 171 – Solar facilities are not necessarily located in remote, undisturbed locations. Solar can require large tracts of land, but solar technology does not require that the land be located in undisturbed locations. For solar facilities that are located in remote locations, transmission infrastructure and support services may be needed. The 2011 Guide should clarify that these needs are associated not with the technology generally.
- Air Quality, pg. 171 – The Draft 2011 Guide makes general statements about the “large amount of land that must be disturbed for solar facility installation.” Solar facilities range in sizes and may be sited on disturbed land. The 2011 Guide should define a “large amount of land” and provide estimated land requirements for solar facilities. We recommend that the first sentence of the Air Quality section be amended to read “Due to the large amount of land [define] that could be disturbed for solar facility installation, construction may generate a significant amount of fugitive dust.”
- Air Quality, pg. 171-172 – Operations and maintenance of solar facilities produce very few emissions and cause minimal air quality impacts. The Draft 2011 Guide implies that utility-scale solar is likely to have natural gas firing. Virtually all solar installations going forward will be limited to 2% natural gas in order to qualify as renewable. The current section is misleading, as it implies that natural gas will be commonly used at solar facilities.
- Water Use and Quality, pg. 172 – Dry-cooling also results in a higher capital cost for solar facilities.
- Water Use and Quality, pg. 172 – The 2011 Guide should clarify that the potential impacts associated with construction activities occur if construction is not properly managed.
- Biological Resources, pg. 173 – The 2011 Guide should clarify that biological impacts of solar facilities depend on the location and specifics of the site and facility. These factors, as opposed to the footprint, are the more critical determinant for the impacts of a solar facility.
- Biological Resources, pg. 173 - Similar to the previous bullet, impacts on listed and sensitive species will depend on whether the facility is sited on or near sensitive habitat.
- Biological Resources, pg. 173 – The 2011 Guide should indicate that wildlife displacement, injury, or death could be prevented through proper management or mitigated through construction measures.
- Visual and Noise, pg. 173-174 – LSA recommends that the statement beginning “With the addition of solar projects...” be amended to read “With the addition of solar projects, views of the desert and rural communities would change from a

- desert landscape to a more industrial one, characterized by solar panel or mirror arrays.” Solar facilities are not necessarily located on undisturbed lands.
- Visual and Noise, pg. 174 – Glare is not likely to be significant issue for either solar panels or mirrors. For panels, glare is mitigated through a dark glass pane that is highly absorptive. The FAA has approved numerous solar PV facilities located near airports, indicating that glare is not a significant issue. For mirrors, the existing Solar Energy Generating Systems plants have been operating for over 20 years without a reported disturbance.
 - Safety/Health and Public Services, pg. 174 – The 2011 Guide should indicate that health concerns associated with valley fever are unlikely.
 - Safety/Health and Public Services, pg. 174 – Fire protection and public services will not necessarily be strained by solar facilities. For instance, the SEGS III-VII facilities have an on-site fire brigade that services the need of the project. This brigade also provided support to the San Bernardino county fire department, supplementing, rather than straining, the local fire protection services.

We appreciate the opportunity to provide these comments and are happy to provide additional information on solar technologies moving forward.

Thank you,

/s/Kristin Burford

Kristin Burford

Policy Director, Large-scale Solar Association

Attachments:

Attachment A: Lori Schell, *Value Proposition of Large-Scale Solar Power Technologies in California – Description of Methodology* White Paper prepared for the Center for Energy Efficiency and Renewable Technology, Appendix A (April 27, 2009)

**Attachment A: Excerpt of Lori Schell, Value
Proposition of Large-Scale Solar Power
Technologies in California – Description of
Methodology White Paper (April 27, 2009)**

APPENDIX A: LARGE-SCALE SOLAR TECHNOLOGY OVERVIEW

This technology overview of large-scale solar power (“LSSP”) technologies is designed to provide the reader with basic information about a number of utility-scale solar electric generating technologies. A number of these technologies concentrate the sun’s energy on a thermal conductor (*i.e.*, water, molten salt or oil for most thermal electric systems; helium or hydrogen for dish-engine systems) and then use the resultant heat to move an engine or turbine. These technologies concentrate the sun’s energy using concave or flat mirrors that are arranged in a line or around a point. Photovoltaic technologies create electricity directly, and may or may not concentrate the sun’s energy using mirrors or reflectors. Concentrating thermal systems tend to have higher day-to-day operating and maintenance costs than PV systems because of more moving parts and the heat generated, though PV systems incur periodic inverter replacement costs (every 10-15 years). Concentrating thermal systems also have the potential to store the heat generated or to use the heat in systems hybridized with natural gas to make dispatchable power. The directly generated electricity from PV systems makes storage more difficult, and limits the dispatchability of PV-generated electricity.¹

Concentrating thermal electric and photovoltaic systems rely on direct normal irradiation (“DNI”), which is that portion of sunlight that comes directly from the sun and falls perpendicular to the solar collector. This is in contrast to diffusion insolation, which is that portion of sunlight that has been scattered by the atmosphere or is reflected off the ground or other surfaces.² Total insolation is the amount of solar energy striking a flat surface over time. Non-concentrating PV can use total insolation, *i.e.*, both the DNI and diffuse sunlight, to directly generate electricity. For this reason, concentrating solar collectors are much more sensitive to solar resource characteristics than are flat-plate PV collectors.³ Depending on latitude, DNI can range from 60-80% of total insolation. Some of the loss of available sunlight to concentrating thermal technologies is offset by the higher efficiency of the solar-to-electricity conversion efficiency of concentrating thermal technologies compared to non-concentrating PV technology. Concentrating thermal technologies are best suited for middle-latitude climates with high sun and minimal cloud cover.⁴

The quality of the solar resource is location-specific. A common measure of total insolation is average energy per unit area per day, expressed in terms of kilowatt-hour per square meter per day (“kWh/m²/day”). The range of average insolation in the United States on a flat, horizontal surface is roughly 3.0-5.8 kWh/m²/day.⁵ Concentrating thermal systems are generally deemed to require a minimum average annual DNI of 6.0 kWh/m²/day. The Southwest

¹ Prometheus Institute and Greentech Media, 2008, p. 3.

² http://www.energymanagertraining.com/power_plants/sources_of%20energy.htm

³ U.S. Department of Energy and U.S. Department of the Interior, February 2003, p. B2.

⁴ Prometheus Institute and Greentech Media, 2008, p. 4.

⁵ American Solar Energy Society, January 2007, p. 94.

has the best solar resource in the United States, with average annual DNI for land having no greater than a 3% slope, as shown below in Figure A-1.

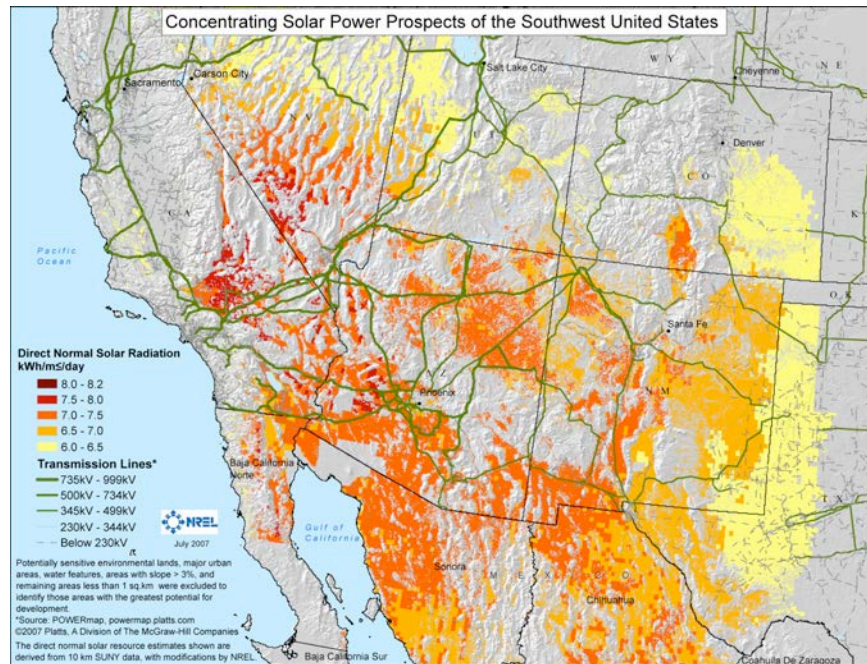


Figure A-1. Annual Average Direct Normal Insolation, Land with $\leq 3\%$ Slope (Source: National Renewable Energy Laboratory)

The federal Solar America Initiative, launched in 2006, aims to boost research and development (“R&D”) to reduce costs and expand production of solar technologies while also achieving market transformation through non-R&D activities that will reduce market and institutional barriers and promote deployment of solar energy technologies.⁶

Table A-1, located at the end of this technology overview, summarizes some of the operating and cost characteristics of the six types of solar electric generating technologies described herein. Although the cost per kWe for LSSP systems appears high relative to conventional central station generating plants, it must be remembered that this cost per kWe includes “virtually” the lifetime fuel costs of the LSSP system.⁷

⁶ U.S. Department of Energy, February 7, 2008, p. 6 and p. 36.

⁷ ECOSTAR, p. 39.

Parabolic Troughs^{8 9 10 11}

The key components of a parabolic trough power plant are mirrors, receiver tubes, and a steam turbine system. The solar field of a parabolic trough plant consists of long parallel rows of trough-like solar collectors, typically aligned in a north-south orientation to track the sun in one axis. A parabolic trough solar collector is designed to concentrate the sun's rays via parabolic curved solar reflectors onto a heat absorber element – a “receiver tube” – located in the optical focal line of the collector. The receiver consists of a specially coated absorber tube that is embedded in an evacuated glass envelope and designed to achieve the high temperatures necessary to ensure high steam power-cycle efficiency. The troughs track the sun from east to west so that the sun's radiation is continuously focused on the receiver tube.

The heat transfer fluid (typically synthetic oil)¹² flowing through the receiver tube is heated to 752°F, and is then pumped to a central power block where it passes through a series of heat exchangers. The collected heat is used to raise steam, which is then used to generate electricity in a conventional steam Rankine cycle. Beyond the heat exchanger, parabolic trough plants are just conventional steam plants that can use thermal energy storage or be hybridized with fossil fuel to generate electricity when the sun does not shine. A molten salt thermal energy storage system can be integrated into a parabolic trough plant to enable power dispatch.



**Figure A-2. Parabolic Trough Solar Thermal Power Plant, Kramer Junction, California
(Source: National Renewable Energy Laboratory)**

⁸ U.S. Department of Energy, April 15, 2008, p. 114 and p. 117.

⁹ European Commission, 2007, p. 9.

¹⁰ http://www1.eere.energy.gov/solar/linear_concentrators.html

¹¹ http://www1.eere.energy.gov/solar/linear_concentrator_rnd.html

¹² Water is the heat transfer fluid in a Direct Steam Generation (“DSG”) system. Newer parabolic trough systems are being designed to use molten salt as the heat transfer fluid.

The key technical challenges for parabolic trough technology relate to improving the efficiency and reducing the installed capital cost of the solar field, including the concentrator and solar receiver.¹³

Dish/Engine Systems¹⁴

Solar dish/engine systems comprise a solar concentrator, or dish, and the power conversion unit (“PCU”). The PCU, which includes the thermal receiver and the engine-generator, is air-cooled, so cooling water is not required. The concentrator consists of mirrors that form a parabolic dish; the mirrors focus the sun’s energy onto the thermal receiver, which is located at the focal point of the parabolic dish. The dish/engine system is mounted on a structure with 2-axis tracking so that the concentrator points continuously at the sun.¹⁵

The receiver absorbs the energy of the solar radiation and is the interface between the dish and the engine-generator. The receiver contains an intermediate heat transfer medium (hydrogen or helium gas) that transfers heat to the engine and may also be the working gas for the engine. The heat is transferred to (typically) a Stirling engine, which is an engine that uses external heat sources to expand and contract a gas. The engine sits at the focal point of the parabolic dish, with temperatures of the heat transfer gas reaching 1452°F. The Stirling engine uses the heated fluid to move pistons, which provides the energy either to rotate the engine’s crankshaft or to cause a pressure pulse, depending on the technology. This, in turn, drives a generator to produce electricity.¹⁶

Other types of engines may also prove useful in a dish/engine system and it is also possible for concentrating photovoltaics to act as the receiver.¹⁷ Stirling engines offer high efficiency, high power density (i.e., power output per unit of volume), tolerance of non-uniform flux distributions, and the potential for long-term, low-maintenance operation; Stirling engines have far fewer parts than an automotive and are cleaner because the heat source is external to the engine.¹⁸

Dish/engine systems are modular in design, with standard systems currently sized up to 25kW. This modularity allows for flexibility in sizing and placement, making dish/engine (and CPV) systems well-suited to central station generation. Dish/engine systems have not generally been used with solar energy storage in the form of heat, though development efforts are underway to demonstrate the feasibility of doing so.¹⁹ Similarly, efforts are underway to

¹³ U.S. Department of Energy, April 15, 2008, p. 117.

¹⁴ http://www1.eere.energy.gov/solar/dish_engines.html

¹⁵ U.S. Department of Energy, February 5, 2007, p. 20.

¹⁶ U.S. Department of Energy, April 15, 2008, p. 114 and pp. 117-118.

¹⁷ Renewable Energy Focus, January/February 2008, p. 44.

¹⁸ U.S. Department of Energy, April 15, 2008, p. 118.

¹⁹ U.S. Department of Energy, September 19, 2008, p. 2.

hybridize large dish/engine systems with natural gas firing to increase the ability of such systems to provide dispatchable power.



**Figure A-3. Dish-Stirling Solar Thermal Power Plant
(Source: Sandia National Laboratories)**

The key technical challenges for dish/engine systems are improving the solar collector (e.g., optics and controls) and increasing the reliability of the engine (e.g., valves, seals, and controls).²⁰

Power Towers²¹

Power tower systems lack the modularity of dish/engine systems in that they have a single receiver placed on top of a tall, centrally located tower. Therefore, power towers favor larger-scale systems with maximum DNI. The power tower is surrounded by hundreds of tracking mirrors (heliostats) that follow the apparent motion of the sun in the sky and that re-direct and focus sunlight onto the receiver. The solar energy is absorbed by the heat transfer fluid flowing through the receiver, reaching temperatures of 1050°F. Some power towers use water/steam as the heat-transfer fluid, though advanced designs use molten salt because of its superior heat-transfer and energy-storage capabilities. Energy is transferred from the heat transfer fluid is used to generate steam to drive a conventional Rankine steam-turbine power block.

Power towers can be coupled with a molten-salt thermal energy storage system to increase the ability to dispatch power.²²

²⁰ U.S Department of Energy, February 2007, p. 8.

²¹ http://www1.eere.energy.gov/solar/power_towers.html

²² U.S. Department of Energy, April 15, 2008, p. 115.



**Figure A-4. 10 MW Solar Two Power Tower Plant, Daggett, California
(Source: Sandia National Laboratories)**

The key elements of a power tower system are the heliostats – provided with a two-axis tracking system – the receiver, the steam generation system, and the storage system. The number of heliostats will vary according to the particular receiver’s thermal cycle and the heliostat design.²³ Power towers offer good longer-term prospects because of their relatively high solar-to-electrical efficiency.

Compact Linear Fresnel Systems

The linear Fresnel system may be considered as innovation for the direct steam generating (“DSG”) parabolic trough system, since it is also designed for DSG rather than for the utilization of a heat transfer fluid. However, instead of using trough-shaped mirrors that track the sun, the Fresnel reflector is made up of long flat mirrors at varying angles that focus the sunlight on one or more receiver tubes that are mounted above the mirrors. The flat mirrors track the sun throughout the day to that the sunlight is always concentrated on the heat-collecting receiver tube.²⁴ A small parabolic mirror called a second-stage receiver is sometimes added atop the receiver to further focus the sunlight that did not directly hit the receiver.²⁵ The receiver tubes do not operate under a vacuum and steam is generated directly in the solar field, eliminating the need for costly heat exchangers. Superheated steam is used to spin a turbine that drives a generator to produce electricity.²⁶

²³ European Commission, 2007, p. 9.

²⁴ Renewable Energy Focus, January/February 2008, p. 44.

²⁵ http://www.spg-gmbh.com/index.asp?document_id=161

²⁶ http://www1.eere.energy.gov/solar/linear_concentrators.html

The simple structure of the flat mirrors in linear Fresnel systems lends itself to mass production, and these structures are considerably lighter than the concentrating structures of parabolic troughs, dish/engines, and power towers.²⁷ Linear Fresnel systems have higher intrinsic optical losses compared to parabolic trough systems,²⁸ but manufacturers believe that the lower optical performance will be offset by lower investment costs in the collectors due to the more-standardized components.²⁹



**Figure A-5. Compact Linear Fresnel Reflector Power Plant, Kimberlina, California
(Source: Ausra, Inc.)**

Non-Concentrating Photovoltaics³⁰

Photovoltaics (“PV”) convert sunlight directly into electricity. Photovoltaics are highly modular, with the smallest element being the PV cell. PV solar cells are made of semiconducting materials similar to those used in computer chips. The most commonly used PV material is crystalline silicone, though new thin film technologies are now available that essentially “print” a few micrometers thickness of the semiconducting material onto a flexible film or onto a glass substrate. When direct or diffuse sunlight is absorbed by the semiconducting materials, the solar energy knocks electrons loose from their atoms, allowing the electrons to flow through the material to produce direct-current (“DC”) electricity. This process of converting sunlight directly into electricity is called the “photovoltaic effect.”

Multiple solar cells of crystalline silicone are combined into a module, modules are wired in series into strings, and strings are wired in parallel to form a solar array. Ongoing efforts are

²⁷ Renewable Energy Focus, September/October 2008, p. 49.

²⁸ ECOSTAR, 2005, p. 47.

²⁹ ECOSTAR, 2005, p. 132.

³⁰ U.S. Department of Energy, April 15, 2008. p. 111-113.

being made to reduce material costs by developing processes with higher silicon utilization (e.g., thinner cells). For thin film systems, the thin film solar cells are connected together in a similar fashion to form a solar array. Thin film solar cells have a much higher rate of light absorption than do crystalline cells, which allows for material thicknesses approximately 100 times thinner than that of crystalline cells. Thin film manufacturers are working to increase module efficiency, create a robust encapsulation material, and achieving large area uniformity and high throughput rates.



**Figure A-6. 15 MW Large-Scale Photovoltaic Power Plant,
Nellis Air Force Base, Nevada
(Photo: Courtesy of Sunpower Corp.)**

Although a number of applications use the DC electricity from PV modules, the fastest-growing markets for PV integrate the panels into systems with power-conditioning inverters that convert the DC electricity into alternating current (“AC”). These systems are then interconnected to the electric grid and are referred to as grid-tied systems.³¹ Losses in the inverter, wiring, and other balance-of-system components reduce the DC electricity output by 10-20%. As a result, the overall AC rating of a PV system is typically around 80% of its DC rating.³²

³¹ U.S. Department of Energy, February 7, 2008, p. 18.

³² American Solar Energy Society, January 2007, p. 94.



Figure A-7. 10 MW Large-Scale Thin Film Photovoltaic Power Plant, El Dorado, Nevada (Photo: Courtesy of First Solar)

Concentrating Photovoltaics^{33 34}

PV solar cells are the most expensive components of a PV system on a per-area basis, accounting for up to 75% of a flat-plate module. The primary reason for using concentrators is to be able to use less solar cell material in a PV system;³⁵ concentrating PV systems increase power output while reducing the size or number of solar cells needed. Concentrating PV incorporates high-efficiency (III-V) semiconductors (or traditional silicon) solar cells with trackers and reflective or refractive optics. The required concentrating optics are significantly more expensive than the simple covers needed for flat-plate PV systems and can at best transmit only 90-95% of the incident light.

CPV modules take advantage of the high performance offered by expensive multi-junction cells while maintaining low costs by focusing sunlight by 100-1000 times onto small solar cells. The optics and the cells must be well integrated. The increased efficiencies of the multi-junction cells increases power density, though the significant concentration of sunlight requires dissipating heat away from the cells for two reasons: (i) Solar cell efficiencies decrease as temperatures increase, and (ii) higher temperatures threaten the long-term stability of the solar cells. Modules must be sealed to protect the solar cells from moisture, and the process of concentrating the sunlight requires 2-axis tracking that must be precisely calibrated.

Because they generate electricity directly from sunlight, CPV systems do not lend themselves well to the storage of solar energy in the form of heat and are not well-suited to hybridization with natural gas firing.³⁶

³³ U.S. Department of Energy, April 15, 2008. p. 114 and p. 121.

³⁴ http://www1.eere.energy.gov/solar/concentrator_systems.html

³⁵ The SolFocus 1100S CPV system is reported to use 1/1000th of the expensive solar cell material compared to traditional PV modules. <http://social.cpvtoday.com/content/solfocus-announces-its-new-cpv-solution> To put this in more familiar terms, if a football field was completely covered in 17% efficient silicon PV cells, it would produce about 500 kW of electricity. The same area of multi-junction II-V solar cells with a concentration ratio of 500 would increase that figure by a factor of 1000, to 500 MW. <http://compoundsemiconductor.net/cws/article/magazine/27051>

³⁶ Renewable Energy Focus, January/February 2008, p. 45.

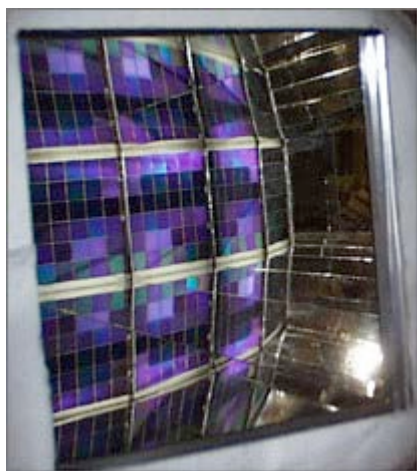


Figure A-8. Concentrating Photovoltaics: Dense Array of High-Efficiency Silicon Cells (Source: National Renewable Energy Laboratory)

The fundamental challenge of CPV is to lower cost, increase efficiency, and demonstrate reliability to overcome barriers to entry into the market on a large scale. Reliability factors specific to CPV include the high-flux, high-current, high-temperature operating environment encountered by the solar cells; weathering and other degradation of the optical elements; the bonding of the concentrating optics to the solar cell; and, the operation of the mechanical parts of the trackers.

The 2 MW combined PV/CPV Casaquemada power plant was connected to the Spanish electrical grid in 2008, mixing flat-plate PV with CPV. The advantage of such a combination system is a more even and constant power output curve. Flat-plate PV systems produce electricity during brief cloudy periods; CPV systems provide their peak power when it is very sunny, at which time flat-plate PV systems may experience some degradation due to high temperature. Combining the two types of PV systems draws on the strengths of both technologies.³⁷

³⁷ CPV Today, November 24, 2008.