SOLAR PHOTOVOLTAIC (PV) AND CONCENTRATING SOLAR POWER (CSP)
UTILITY SCALE ELECTRICAL INSTALLED COSTS AND VARIABLES

Testimony by
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The use of solar energy to produce electricity is not new. Photovoltaic modules to generate electricity for residential, military, space and commercial applications go back to the 1960's. A large solar thermal electric plant was installed in the Mojave Desert in the early 1980's and is still in use.

The fastest growing use of solar energy to generate utility scale electricity is with fixed or 1-axis photovoltaic modules hooked directly to the transmission grid. The price of the PV modules has dropped dramatically in the last few years. So, in California alone, 570 PV projects of over 1MW of capacity each have been financed.

According to data collected by the solar industry from operating projects in the United States, the **installed fixed and variable cost of industrial scale arrays of at least 500 kilowatt capacity are now down to 15.15 cents/kilowatt hour as of March 2012.** The larger the array of PV modules producing electricity, the lower the fixed costs. **This means that the Levelized Cost of Energy (LCOE) in cents per kilowatt hour for these larger systems ranges from 7.5 cents to 15 cents per kilowatt hour.** This is based on an average of 5.5 hours per day of annual solar radiation.

For solar utilities of 50MW to 700MW, another excellent way to produce electricity is with either parabolic trough concentrating collector arrays or installing thousands of heliostats focused on a direct steam boiler on top of a tower. For example, there are 4,242.5MW of solar thermal projects already approved by the California Energy Commission. These projects are in various stages of receiving financing, doing site preparation and finalizing end use agreements.

The largest CSP project in the world started construction in October 2010 in California's Mojave Desert. It is being built for BrightSource Energy by Bechtel. Equity investment partners include BrightSource, NRG Solar, and Google.

This Ivanpah project will produce 392MW of gross solar power. Three sites combine to generate enough electricity to serve more than 140,000 homes during peak daylight hours.

Since this is a proprietary project and is still under construction, the total installed costs are not known. However, the SunShot Vision Study published by the U.S. Department of Energy in February 2012 reports on page 105 that **"For locations in the southwestern United States, the LCOE is currently in the 12-18 cents/kWh range with a 30% investment tax credit (ITC)."**

Like any large project, there are many variables and assumptions which go into these unit cost figures. Since the renewable energy industry has been growing rapidly in the USA, Germany, Spain, India, and China, the cost of PV modules is steadily coming down. New designs for inverters, charge controllers and mirror surfaces are also lowering costs. So, large PV and CSP projects are becoming more cost competitive without the negative environmental impact of fossil fuel generated electricity.

The cost of financing, land acquisition, site preparation, availability of tax credits, debt-to-equity ratio and electricity purchase agreement terms with end users all impact the final installed cost. However, operating and maintenance costs for both photovoltaic and solar thermal sites are relatively low which also improves the ROI and cash flow.

Large scale PV and CSP projects are ideal for Western Kansas. Hybrid systems using solar for peak daytime demand with 24/7 wind plus coal or gas turbine backup is a winning combination. PV and CSP will also create thousands of manufacturing, installation and maintenance jobs for Kansas workers.

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Solar Energy Industry Electricity Prices – SolarBuzz March 2012 Update

Solar Electricity Sunny and Cloudy in US cents per kWh		
Residential Installed System	$13,829	-0.3%
Sunny Climate	28.91	-0.3%
Cloudy Climate	63.60	-0.3%
Commercial Installed System	$247,312	-0.4%
Sunny Climate	19.42	-0.5%
Cloudy Climate	42.73	-0.4%
Industrial Installed System	$1,796,857	-0.4%
Sunny Climate	15.15	-0.4%
Cloudy Climate	33.32	-0.4%

The solar electricity index draws exclusively upon the high power band (>125 watts) solar module prices in our survey. This price segment was down 2 cents per watt in March from the prior month. The charge controller index was down, but the inverter and battery indexes held steady. **Overall, the high solar condition industrial industry index was down to 15.15 cents per kWh in March 2012.**

About the Indices

The residential index is based upon a standard 2 kilowatt peak system, roof retrofit mount. It is connected to the electricity grid and has battery backup to allow it to operate during electricity downtime. It is therefore also suitable as an index for off-grid residential uses.

The commercial index is based on a 50 kW ground mounted system that is connected to the electricity grid. It provides distributed energy and excludes any backup power.

*****The industrial index is based on a 500 kilowatt flat roof-mounted system, suitable for large buildings.** It is connected to the electricity grid and excludes back up power. The price index includes full system integration and installation costs.

Notes:
The commercial and industrial solar electricity indices benefit from discounts against retail prices that can be secured on volume purchases. When purchasing a residential solar energy system through large government or utility programs, it may be possible to secure a price more consistent with the industrial price index.

Solar energy rebate programs have not been built into the data. Many governments and utilities have incentives to reduce the cost of solar electricity, recognizing the broad economic benefits of stimulating a self-sustaining local solar energy market.

Financing cost is a significant factor in the index and is assumed to be 5% per annum, amortized over a 20-year life. The economic payback page on this site includes a discussion on ways to enhance solar energy's economic equation.

The high solar insolation index is based upon a climate with 5.5 hours of sunshine average over the year. This is typical of locations like US sunbelt states, much of Latin America, most of Africa, the Middle East, India, and Australia. Mediterranean countries, followed by Japan and then Northern Europe, have progressively lower average hours. Saharan and southern Africa, and the areas centered on Saudi Arabia, central Australia, Peru, and Bolivia are higher.

Solarbuzz Retail Pricing

	unit	Oct 11	Nov 11	Dec 11	Jan 12	Feb 12	Mar 12
Module	US $/Wp (≥125 W)	2.6	2.49	2.43	2.42	2.3	2.29
	Euro €/Wp (≥125 W)	2.37	2.33	2.33	2.31	2.28	2.17
Inverter	US $/Continuous Watt	0.714	0.714	7.130	7.120	7.110	7.110
	Euro €/Continuous Watt	0.528	0.528	0.534	0.548	0.540	0.526
Battery	US $/Output Watt Hour	0.213	0.213	0.213	0.213	0.213	0.213
	Euro €/Output Watt Hour	0.158	0.158	0.160	0.164	0.162	0.158
Charge Controller	US $/Amp	5.93	5.93	5.93	5.93	5.93	5.93
	Euro €/Amp	4.39	4.39	4.45	4.57	4.51	4.39
Solar Systems*	Residential c/kWh	29.38	29.25	29.2	29.14	29.00	28.91
	Commercial c/kWh	19.85	19.72	19.68	19.63	19.51	19.42
	Industrial c/kWh	**15.47**	**15.37**	**15.34**	**15.31**	**15.21**	**15.15**

http://www.solarbuzz.com/facts-and-figures/retail-price-environment/solar-electricity-prices

Retail Price Index Methodology

Solarbuzz tracks thousands of online retail prices for the primary components of a solar energy system, including solar modules, batteries, inverters and charge controllers (regulators). Updated monthly, these indices provide a guide to overall price movement.

Solarbuzz also compiles pricing for the appropriate basket of products into a set of indices that track total system cost in terms of electricity measures (kilowatts hours) for residential, commercial and industrial installations.

The majority (about 80%) of the companies surveyed are based in the United States, but most market globally. European dealers are the second largest surveyed group.

- The solar energy system product indices represent retail pricing for a single component.
- Discounts are typically available for larger commercial customers, such as utilities and large OEMs. Therefore typical discounting has been taken into account in the solar electricity system indices, but not in the product pricing data.

- Solarbuzz tracks retail pricing data in US dollar and euro equivalents. Only true price changes are accounted for in the data, not price changes due solely to currency exchange rate fluctuations.

Product pricing:

- The module survey is weighted to take account of the fact that the majority of market demand occurs in the high power (>125 MW) module segment.
- The module survey separates US-based from Europe-based dealers for the index computation. All other product indices pool all dealers into a single index and converts to dollars or euros regardless of originating currency.

Solar electricity pricing:

- The index calculation includes a number of elements. Pricing covers the solar module and the other major components, other electrical components, assembly and installation costs, transportation and ongoing maintenance.
- System output is also a factor, including the system size in Watt peak, the life of the system and kilowatt hours generated.

Assumptions include:

- Financing charges of 5% on the purchase of the system
- Impact of sunlight conditions
- The index is based on retail prices for system components but includes typical discounting for commercial and industrial system sizes.
- Tax is excluded
- Local government or utility incentives or subsidies are excluded

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Ivanpah Solar Thermal Project

BrightSource's LPT solar thermal system is currently being deployed at the Ivanpah Solar Electric Generating System (ISEGS) in California's Mojave Desert. Ivanpah, which started construction in October 2010, is the first project that will deliver power to serve the company's signed contracts with PG&E and Southern California Edison. The project - which counts NRG Solar, Google and BrightSource as equity investors - is currently the largest solar plant under construction in the world. The project is being constructed by Bechtel.

For more detailed information, visit **www.IvanpahSolar.com**.

Ivanpah Fact Sheet

Project Overview

A 392 megawatt gross solar complex using mirrors to focus the power of the sun on solar receivers atop power towers.

- The electricity generated by all three plants is enough to serve more than 140,000 homes in California during the peak hours of the day.
- The complex will reduce carbon dioxide (CO2) emissions by more than 400,000 tons per year.
- Located in Ivanpah, approximately 50 miles northwest of Needles, California (about five miles from the California-Nevada border) on federal land managed by the Bureau of Land Management.
- The complex is comprised of three separate plants to be built in phases between 2010 and 2013, and will use BrightSource Energy's LPT solar thermal technology.

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Coalinga

Chevron/Brightsource Solar-to-Steam Oil Recovery Demonstration Facility

Chevron Technology Ventures and BrightSource have partnered to build the world's largest solar thermal enhanced oil recovery demonstration facility. The **29 megawatts thermal solar-to-steam facility will support enhanced oil recovery efforts at Chevron's oil field in Coalinga, California.** The solar facility demonstrates solar thermal technology's ability to cleanly and cost-effectively support enhanced oil recovery efforts in California and around the world. BrightSource's LPT technology was selected through a competitive process and the project began construction in 2009.

Extracting heavy-oil reserves, like the ones found at Coalinga, is a global challenge. According to a recent report by SBI, conventional oil recovery methods are only able to extract about 10% - 30% of the original oil from any given reservoir, leaving nearly 70% - 90% of the reservoir's oil untouched. The report estimates that an additional 241.7 billion barrels of oil could be added to worldwide proven reserves with the implementation of enhanced oil recovery methods.

Coalinga Fact Sheet

Fast Facts

- Location: Coalinga, CA – approx. 60 miles SW of Fresno, CA or 200 miles NW of Los Angeles
- Facility Size: 100 acres
- Steam Production: 29 MWt (megawatts thermal)
- Electrical Output Equivalent: Approx. 13 MWe (megawatts electric)
- Tower Height: 327 feet
- Number of Heliostats / Mirrors: 3,822 heliostats; 7,644 mirrors

Enhanced Oil Recovery Resources

- BCC Research *"Enhanced Oil Recovery: Technologies and Global Markets"* –
  (Technology Market) - Released July 2010
- SBI Energy *"EOR Enhanced Oil Recovery Worldwide"* –
  (Global Market) - Released April 2010

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Federal Incentives/Policies for Renewables & Efficiency

USDA - Rural Energy for America Program (REAP) Loan Guarantees

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Last DSIRE Review: 01/23/2012
Program Overview:

Incentive Type:	Federal Loan Program
Eligible Efficiency Technologies:	Unspecified Technologies
Eligible Renewable/Other Technologies:	Solar Water Heat, Solar Space Heat, Solar Thermal Electric, Photovoltaics, Wind, Biomass, Hydroelectric, Geothermal Electric, Geothermal Heat Pumps, CHP/Cogeneration, Hydrogen, Anaerobic Digestion, Small Hydroelectric, Tidal Energy, Wave Energy, Ocean Thermal, Renewable Fuels, Fuel Cells using Renewable Fuels, Microturbines, Geothermal Direct-Use
Applicable Sectors:	Commercial, Agricultural
Amount:	Varies
Maximum Incentive:	$25 million per loan guarantee
Start Date:	FY 2003
Web Site:	http://www.rurdev.usda.gov/rbs/busp/bprogs.htm
Authority 1:	7 USC § 8106
Date Enacted:	5/13/2002
Date Effective:	FY 2003

Summary:

Note: The U.S. Department of Agriculture's Rural Development issues periodic Notices of Solicitation of Applications for the Rural Energy for America Program (REAP). The deadline to apply for loan guarantees under the most recent solicitation is June 29, 2012, though combined grant and loan guarantee applications and grant only applications have an earlier deadline of March 30, 2012. For more information, see the NOFA in the Federal Register. Grants and loan guarantees will be awarded for investments in renewable energy systems, energy efficiency improvements and renewable energy feasibility studies.

The Food, Conservation, and Energy Act of 2008 (H.R. 2419), enacted by Congress in May 2008, converted the federal Renewable Energy Systems and Energy Efficiency Improvements Program,* into the Rural Energy for America Program (REAP). Similar to its predecessor, the REAP promotes energy efficiency and renewable energy for agricultural producers and rural small businesses through the use of (1) grants and loan guarantees for energy efficiency improvements and renewable energy systems, and (2) grants for energy audits and renewable energy development assistance. Congress has allocated funding for the new program in the following amounts: $55 million for FY 2009, $60 million for FY 2010, $70 million for FY 2011, and $70 million for FY 2012. REAP is administered by the U.S. Department of Agriculture (USDA). In addition to these mandatory funding levels, there may also be discretionary funding issued each year.

Of the total REAP funding available, approximately 88% is dedicated to competitive grants and loan guarantees for energy efficiency improvements and renewable energy systems. These incentives are

available to agricultural producers and rural small businesses to purchase renewable energy systems (including systems that may be used to produce and sell electricity) and to make energy efficiency improvements. Funding is also available to conduct relevant feasibility studies, with approximately 2% of total funding being available for feasibility studies. Eligible renewable energy projects include wind, solar, biomass and geothermal; and hydrogen derived from biomass or water using wind, solar or geothermal energy sources.

These grants are limited to 25% of a proposed project's cost, and a loan guarantee may not exceed $25 million. The combined amount of a grant and loan guarantee may not exceed 75% of the project's cost. In general, a minimum of 20% of the funds available for these incentives will be dedicated to grants of $20,000 or less. The USDA likely will announce the availability of funding for this component of REAP through a Notice of Funds Availability (NOFA).

The USDA will also make competitive grants to eligible entities to provide assistance to agricultural producers and rural small businesses "to become more energy efficient" and "to use renewable energy technologies and resources." These grants are generally available to state government entities, local governments, tribal governments, land-grant colleges and universities, rural electric cooperatives and public power entities, and other entities, as determined by the USDA. These grants may be used for conducting and promoting energy audits; and for providing recommendations and information related to energy efficiency and renewable energy. Of the total REAP funding available, approximately 9% is dedicated to competitive grants for energy technical assistance.

**The Renewable Energy Systems and Energy Efficiency Improvements Program was created by the USDA pursuant to Section 9006 of the 2002 federal Farm Security and Rural Investment Act of 2002. Funding in the amount of $23 million per year was appropriated for each fiscal year from FY 2003-2007. In March 2008, the USDA announced that it would accept $220.9 million in applications for grants, loan guarantees, and loan/grant combination packages under the Renewable Energy Systems and Energy Efficiency Improvements Program. The application deadline was June 16, 2008.*

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