Solar Power Boom

After many seemingly false starts, it seems the solar power is edging towards boom. A confluence of high oil prices, concerns about global warming dictating need to move towards low carbon economy and technological advances suggest that we may be moving towards an era of solar power. A 354 MW solar thermal power plant operating in California for almost two decades, new solar thermal plants of total capacity of upto 2000 MW in the pipeline to supply power at an unbelievable competitive cost of 10.4 cents per kwh, thus competing with the mainstream sources and technological advances making it possible to increase the efficiency of photovoltaic cells to upto 50% or potentially even higher are some of the indications of this boom. India can benefit a lot from these developments if the govt were to come out with right policies & incentives including appropriate tariff.

"Our analysis convinces us that a massive switch to solar power is the logical answer" wrote an article in the Scientific American on Dec 16, 2007. "A confluence of political will, economic pressure (oil prices) and technological advances suggests that we are on the brink of an era of solar power", wrote New Scientist in an article in Dec 2007. The Political will has clearly come under pressure of global warming impacts. This has been helped by mushrooming investment & steady advances in their efficiency.

In a very significant development, based on a new technology, a new company called Ausra will build a 177 MW Solar-Thermal Plant. The plant, expected to deliver power to PG&E in the summer of 2010, will be built in San Luis Obispo, Calif. Ausra claims it can deliver electricity at a cost of 10.4 cents per kilowatt-hour, comparable with tariff of power from a coal fired plant. The Power purchase agreement was signed in early Nov 2007. It will need 1 sq mile land for this.

Global Scene According to the REN21 Renewables Global Status Report 2007, Grid connected solar PV continues to grow at 50-60% annually and now accounts for 8000 MW. Solar hot water systems provide water to over 50 million households worldwide. Global demand for solar technology was $ 2 billion 2003, $ 15 billion 2006 and likely to reach $ 100 billion in 2015.

Solar Thermal In 1988, nine parabolic-trough energy farms were built in the Nevada desert. Together covering just over 1 square kilometer, they produced 354 MW electricity. An Israeli company, Luz Corp., built the power stations in the Mojave Desert. Now, with energy prices on the rise, plans are being drawn up to revive the technology. The parabolic troughs work well. But the mirrors, among other things, have to be very precise, making them difficult and expensive to build. The original series of plants in the Mojave managed to bring the cost down from 28 cents per kwh to 16 cents, while the newer ones are a penny or two cheaper. In Dec 2005 the first trough system built in the US since 1988 was switched on in Seguaro, Arizona. It is capable of generating 1 MW power. Meanwhile, Spain's Acciona was building an updated 64-MW project costing USD 226 million in the Nevada desert. In July 2007, Israel-based Solel Solar Systems announced it was building a large solar park in California after PG&E agreed to buy all 553 MW of the park's capacity. Brightsource, a solar-thermal startup based in Oakland, Calif., has filed an application in Oct 2007 to build a 400 MW power station in the Mojave Desert and also is negotiating with PG&E.

One of the new methods uses dish-shaped mirrors around 10 m in diameter to focus solar energy onto an engine, which contains a gas that expands under heating and so drives a generator. At 24 per cent, its efficiency beats all other solar concentrator systems. In 2005, the California Public Utilities Commission, the state body responsible for regulating private power stations, gave the go-ahead for the world's biggest solar dish concentrator farm to be built in the Mojave desert, north-east of Los Angeles. When completed in 2010, its 20,000- dish array will generate 500 MW.

The article in Scientific American in Dec '07 presented a grand plan that could provide 69 percent of the U.S.'s electricity and 35 percent of its total energy (which includes transportation) with solar power by 2050, to be sold to consumers at rates equivalent to today's rates for conventional power sources, about five cents per kWh.

A paper by University of Sydney professor David Mills describes a field of almost flat mirrors focusing the sun's rays on fixed tubes held by poles above the mirrors. Such mirrors are easier and cheaper to build than the parabolic troughs, and can be made strong enough to withstand hurricanes like those in Florida. And rather than using the troughs' oil-filled tubes, which sap power to pump the oil, Mills uses the sun's heat to turn water directly into steam. The cost of power from such plants is comparable with those from coal plants, it is claimed.

Based on this technology, Ausra, a company promoted by Vinod Khosla (co founder of Sun Microsystems) among others, will build a 177 MW Solar-Thermal Plant. The plant, expected to deliver power to PG&E in the

summer of 2010, will be built in San Luis Obispo, Calif. The startup claims it can deliver electricity at a cost of 10.4 cents per kilowatt-hour. The Power purchase agreement was signed in early Nov 2007. It will need 1 sq mile land for this.

In late September 2007, Ausra, Pacific Gas & Electric (PG&E), and Florida Power & Light (FPL) announced commitments for 1,000 MW of solar thermal power. The details are still in negotiation. The current plan is to start with a 10 MW demonstration plant in Florida, then expand to 300 MW. These facilities could be ready earliest by 2010.

The Scientific American wrote in Dec 2007, "the least expensive modules today are thin films made of cadmium telluride. To provide electricity at six cents per kWh by 2020, cadmium telluride modules would have to convert electricity with 14 percent efficiency, and systems would have to be installed at $ 1.20 per watt of capacity. Current modules have 10 percent efficiency and an installed system cost of about $4 per watt. "

Ausra says it can potentially cut costs to 7.9 cents per kilowatt-hour in three years. That compares with an estimated 16 to 18 cents per kwh for other solar-thermal electricity and about 9.7 cents per kwh for coal-fired power plants today. Ausra doesn't have a large plant in place yet, but it already has installed its 1 MW plant in Australia and is growing that project to 5 MW by Jan 2008 and up to 12 MW later. Ausra also is working on installing a 6.5 MW project in Portugal that it expects to finish in 2009. And it is building a 5 MW demonstration plant in California as a "scale test".

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Photovoltaic Cells Ever since the first PV cell was created by Bell Labs in 1954, the efficiency with which a cell can convert light into electricity has been the technology's Achilles' heel. Photons from the sun arrive at the semiconductor sporting many different energies, not all of which will liberate an electron. Each semiconducting material has a characteristic "band gap" -- an energy value which photons must exceed if they are to dislodge the semiconductor's electrons. The movement of the electrons thus dislodged creates the current. If the photons are too weak they pass through the material, and if they are too energetic then only part of their energy is converted into electricity, the rest into heat. Some are just right, and the closer the photons are to matching the band gap, the greater the efficiency of the PV cell.

Bell Labs discovered that silicon, which is cheap and easy to produce, has one of the best band gaps for the spectrum of photon energies in sunlight. The past decade has seen a sea change as inexpensive cells with an efficiency of 20 per cent have become a commercial reality, while in the lab efficiencies are leaping forward still further. Last year, Allen Barnett and colleagues at the University of Delaware, Newark, set a new record with a design that achieved 42.8 per cent energy conversion efficiency. Barnett says 50 per cent efficiency on a commercial scale is now within reach. Such designs, married to modern manufacturing techniques, mean costs are falling fast too. According to Martin Green at the University of New South Wales, Australia, it should be possible to create cells from other materials with a 74 per cent efficiency limit.

One of the cheapest cells to manufacture is the thin-film cell, in which semiconductor compounds are sprayed onto a flexible substrate. Thin-film cells use as little as 1 per cent of the volume of materials that ordinary PV cells demand (thus slashing the costs substantially), and the band gap of the cells can be improved by adjusting the proportions of the ingredients that form the film. For example, cells that use a low-cost blend of copper, indium, a pinch of gallium, and selenium (CIGS), have already achieved an efficiency of around 19 per cent in lab tests. The material's efficiency is so high that researchers have shifted their attention to slashing the cost of producing the cells.

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technology is advancing quickly; commercial efficiencies have risen from 9 to 10 percent in the past 12 months. The efficiency of the cadmium telluride cells at the National Renewable Energy Laboratory are now up to 16.5 percent and rising. Installations already in place indicate that the land required for each gigawatt-hour of solar energy is less than that needed for a coal-powered plant when factoring in land for coal mining.

"The big limiting factor of solar power is that it generates little electricity when skies are cloudy and none at night. Excess power must therefore be produced during sunny hours and stored for use during dark hours. Most energy storage systems such as batteries are expensive or inefficient. Compressed-air energy storage has emerged as a successful alternative. Electricity from photovoltaic plants compresses air. The pressurized air is released on demand to turn a turbine that generates electricity, aided by burning small amounts of natural gas. Compressed-air energy storage plants have been operating reliably in Huntorf, Germany, since 1978 and in McIntosh, Ala., since 1991. The turbines burn 40 percent of the natural gas they would if they were fueled by natural gas alone, and that figure can be lowered to 30 percent… Indeed, a compressed-air energy storage system would look similar to the U.S. natural gas storage system. The industry stores eight trillion cubic feet of gas in 400 underground reservoirs… these facilities would add three or four cents per kWh to photovoltaic generation, bringing the total 2020 cost to eight or nine cents per kWh" writes Scientific American.

India has huge potential for using solar power. The government needs to come out with encouraging policies, including subsidies, soft loans and most importantly, right feed in tariffs to push solar energy in India. Such units can also get Carbon Emission Reduction Credits under UNFCCC's Clean Development Mechanism, which will be an added advantage in India. This will also be a better option than going for the costly and unsafe big hydro or nuclear power mirage.

SunFab film, an innovation from California based Applied Materials Inc, is only 10 nanometers thin, it has the thickness of three atoms or is 10 000 times thinner than human hair. Similarly, in 2007, Silicon Valley-based Nanosolar has created the manufacturing technology that could make the promise of thin film cell a reality, with backing from Google's founders and $20 million from the U.S. Department of Energy. In San Jose, Nanosolar has built what will soon be the world's largest solar-panel manufacturing facility. CEO claims that once full production starts early next year, it will create 430 MW worth of solar cells a year. California recently launched the Million Solar Roofs initiative, which will provide tax breaks and rebates to encourage the installation of 100,000 solar roofs per year, every year, for 10 consecutive years (the state currently has 30,000 solar roofs).

Comparable power cost In parts of Japan, California & Italy, where the retail price of electricity is among the world's highest, the cost of solar-generated electricity is now close to, and in some cases matches, that of electricity generated from natural gas & nuclear power. In the US the average price of conventionally generated electricity is around 10 cents per kwh. The cost of solar-generated electricity has fallen to roughly 20 cents. This has created a booming market for PV cells – now growing by around 35 % annually.

Booming market First Solar Inc, a Phoenix based company in US that makes modules used in solar panels, reported its third quarter profit up 10 times to $ 46 m, as sales more than tripled to $ 159 m. The company that went public a year ago at $ 20 a share, closed at $ 215 on Nov 30. Its total market value exceeds that of General Motors or Ford Motors. Q Cells AG in Germany reported third Q profit of $ 50 m and forecast 2009 sales of $ 2.5 billion compared with $ 700 m in 2006. Suntech Power Holdings in China had a third Q profit of $ 53 m.

The value of stocks in companies whose business focuses primarily on solar power has grown from $40 billion in Jan 2006 to more than $140 billion today, making solar power the fastest-growing sector in the global marketplace.

Germany In Nov 2003, amid rising oil and gas prices and growing concern over global warming, the German parliament agreed a "feed-in tariff" programme, which guarantees a market for solar power. Anyone who produces electricity from solar power can sell it to the national grid for $0.45 - 0.57 per kilowatt-hour, which is almost three times what consumers pay for their electricity, roughly $0.19 per kilowatt-hour. The feed in tariffs are locked in for 20 years. Germany's power-generating companies are required by law to pay this premium, which is guaranteed until 2024. Today there are over 300,000 PV systems in Germany, mostly on the rooftops of homes and small businesses, and Germany is the world's fastest-growing PV market. It has 55 per cent of the world's installed base of PV panels and can generate around 3000 MW of electricity from solar energy. On Nov 27, '07, the German minister announced that the German government plans to speed up its planned cuts in support for rooftop photovoltaic energy from 2009 (by 7% per annum) and again from 2011 (by 8% per annum).

Last year, following in Germany's footsteps, Italy and Spain launched their own tariff programmes, while the California Solar Initiative earmarked $2.8 billion for cash incentives that will subsidise new PV installations to the tune of up to $2.50 per watt, with the aim of creating 3000 MW capacity by 2016.

Recently, Spanish clean-energy giants Abengoa Bioenergy and Acciona have jumped in with solar thermal projects in Spain, Algeria, and the US. Israel's Solel Solar Systems has contracted with PG&E to deliver 553 MW from future solar thermal plants.

Algeria An Algerian company is planning to build a power cable to Germany to export solar-generated electricity from the Sahara. The 3,000 km cable would be laid from the Algerian town of Adrar to the German city of Aachen under a project provisionally entitled "Clean Power from the Desert".

China Solar wafer maker Peng Xiaofeng (worth USD 4.4 B dollar in share market) from China is proof that there is money in protecting the environment. Peng is chief executive of China's LDK Solar, a company founded two years ago, which has cashed in on government subsidies and soaring public demand to go green. The company recently announced a major contract with solar cells manufacturer Germany's Q-Cells AG.

Germany-based Conergy AG, a leading solar energy company in Europe, is looking to tap China's budding renewable energy market. The company estimates that by 2015, renewable energy will evolve into a market of over $300 billion across the world, with much of it coming from China. Since June 2006, the company has been rapidly expanding across Asia-Pacific and now has offices in Singapore, South Korea, India, Australia, Thailand and Malaysia.

Japan Japan's Sharp Corp said it would invest US$ 200 million to boost output capacity for thin-film solar cells more than tenfold by Oct 2008. Thin-film solar cells use one-hundredth of the silicon needed in conventional solar cells, cutting production time and costs. The world's No. 1 maker of solar cells said it planned to expand output capacity for thin-film cells to 160 MW per year from the current 15 MW at its Katsuragi Plant in western Japan.

India's Achievements According to the website of the Government of India's Ministry of New and Renewable energy (http://mnes.nic.in/), India's achievements in solar energy by Sept 30, 2007 are as follows.

Grid-interactive Solar Power	2.12 MW
Decentralised Energy Systems	
Solar Photovoltaic Programme	110 MW (peak)
i. Solar Street Lighting System	61,321 nos.
ii. Home Lighting System	3,63,399 nos.
iii. Solar Lantern	5,64,931 nos.
iv. Solar Power Plants	2.18 MW (peak)
Solar Thermal Programme	
i. Solar Water Heating Systems	2.00 million sq. m. collector area
ii. Solar Cookers	6.17 lakh
Solar Photovoltaic Pumps	7068 nos.

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Solar Companies in India

⇒ **Roth and Rau**, a Germany-based solar cell manufacturing solutions provider, sees India emerging as the fourth largest generator of solar energy and a key driver of its global business in the coming years. It is expecting orders worth 80 million euros from India in 2008 from two million euros at present. At the current pace of 20 percent annual growth, India can emerge as the fourth largest generator of solar energy after Germany, Japan and China in the coming years. It had entered the solar equipment-manufacturing segment in India in 2004. Currently four Indian solar cell manufacturers including Central Electronics Ltd and Maharishi Solar were sourcing equipment from Roth and Rau.

Conergy Plans The German renewable energy major Conergy has started its business in India in 2007, and has commissioned a manufacturing unit for solar modules and components in Bangalore. The company operates through three divisions globally: Conergy which sells solar modules and solar units, Epuron which plans, finances and executes renewable energy projects and

SunTechnics which plans, implements and installs solar and bio-energy units. SunTechnics have been in India for two years. The company generated revenues of about Rs 13 crore during 2006 and is expecting about Rs 70 crore this year. The plan is to drive triple digit growth in India annually. Conergy is one of the fastest growing renewable energy companies in the world. Its revenues grew more than 40% to hit a turnover of about $1 billion in 2006. The company is expecting 30-33% revenue growth globally this year.

California recently launched the Million Solar Roofs initiative, which will provide tax breaks and rebates to encourage the installation of 100,000 solar roofs per year, every year, for 10 consecutive years (the state currently has 30,000 solar roofs).

⇒ **Moser Baer** Photo Voltaic plans to set up a Rs 330 crore silicon photovoltaic cell manufacturing plant in India and it has tied up with US based Applied Materials for that. It has submitted an application to set up a demonstration solar power project in W Bengal. Applied Materials has also tied up with Signet for solar power business.

⇒ **Solar Seminconductor**, another photovoltaic company, has lined up an investment of $40 m to set up two production units in Andhra Pradesh.

Reliance plans 10 MW plant in W Bengal Reliance Industries Ltd has decided to set up a 10 MW solar plant in W Bengal, possibly in Purulia and sought govt help.

⇒ An unknown Texas (US) based company has offered to set up a 250 MW solar power plant in Punjab if they are given suitable land. They claim to provide power from the plant at the rate of Rs 9 per unit. An Israel based company has been asked to set up a 1 MW PV cell solar power plant in Kapurthala as a pilot plant that can be replicated widely.

Constrains India has huge potential for using solar power. Current focus of the government is to set up solar power panels for lighting and other minimum needs as a means of taking power to the off grid 80 000 villages. But Solar Power has potential beyond that. High prices are the biggest deterrent. Cost price of one kwh of power from solar photovoltaics in India is Rs 15, reported the Economic Times (131107), but this is not based on any large scale plant. Similarly the same paper reported that it would cost Rs 25 crore to set up a 1 MW solar photovoltaic plant.

It is claimed that the cells also needs to be replaced every 7-8 years. But better prospects could be power plant based on solar thermal units the cost of which could be half of that from PV cells, as is being majorly developed in US. Indian government needs to come out with encouraging policies, including subsidies, soft loans and most importantly, right feed in tariffs to push solar energy in India. Such units can also get Carbon Emission Reduction Credits under UNFCCC's Clean Development Mechanism, which will be an added advantage in India. This will also be a better option than going for costly and unsafe big hydro and nuclear power mirage.

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