HARNESSING THE POWER OF THE SUN

The development of megawatt-capacity solar power plants

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The total installed power capacity in the country as on 31 March 2008 is 1,43,061 MW. Out of this, the respective shares of thermal power and hydropower are 64.2% and 25.1%. The share of power from renewable energy technologies is about 7.8%, which is incidentally more than double the share of power obtained from nuclear energy. A capacity addition of nearly 78,520 MW has been planned by the Ministry of Power during the Eleventh Five-year Plan period (2007–12). As of now, about 52.5% of the total power production takes place in the state sector, while the central and private sectors produce 34% and 13.5%, respectively. There is an urgent need to increase participation from the private sector in the area of power generation from all possible sources. The all India AT&C (aggregate technical and commercial) losses are pegged at 34.54%, which is no small number considering an increasing gap between the demand and supply of conventional power.

Presently, a total of 4,87,338 villages (82.1%) stand electrified. There is a target of increasing the per capita power consumption to about 1000 units from the existing 681 units. Importantly, there is a need for large-scale power generation from both the non-renewable and renewable energy sources to sustain a targeted GDP annual growth of about 8%–10%. Considering all this, there is a need to exploit solar energy for power generation through financial and fiscal measures as far as possible.

Renewable power targets

Wind energy continues to be the dominant source of renewable power in the country. About 8000 MW of wind power capacity has been installed in the country so far. As against this, the share of solar power is abysmally low mainly due to its high initial capital cost and thus, a higher cost of per unit power generation. The MNRE (Ministry of New and Renewable Energy) has drawn up an ambitious plan of adding about 14 500 MW during the current plan period. Out of this, the grid-interactive power derived from wind, biomass, and small hydro particularly will account for 13,500 MW. The share of distributed RE power will be in the range of 1000 MW. Expectedly, the share of renewable power will cross the 10% mark of the total installed power capacity by the year 2010. However, just a very small percentage of it will come through solar power.

The private sector investment of about 97% has been the mainstay of power generation through the RE route so far. It has mainly been possible through the nearly favourable policies of both the central and state governments over the last decade or so.

Of late, solar power investments in the country are registering a fast increase. In fact, India is becoming a chosen destination for many national and international bigwigs for setting up large-scale PV manufacturing facilities. There is growing optimism on the fact that solar power may well attain the much-needed grid parity within the next few years or so.

Status of PV-grid power systems in India

India has limited experience in the demonstrational use of solar PV-grid interactive power plants. In all, about 33 such power plants have been put up solely with government assistance. These plants have a cumulative capacity of 2.12 MW and are expected to produce about 2.55 million units of electricity per annum. Compare this with an off-grid use of PV, where about 14.5-lakh decentralized systems (that is, for lighting, water pumping, and battery charging) installed across the country have a potential of producing about 150 million units annually. The capacity of the largest PV power plant in the country is just 225 kWp, which is definitely lower in comparison to the installed capacities of wind and small hydro power plants, for example.

Rationale for large-capacity solar PV power plants

Large-scale PV manufacturing facilities are now being planned by many big names in the PV industry. These may subsequently provide the oft spoken benefit of economies of scale. The most recent example is of MBPV (Moser Baer Photovoltaics), which is optimistic of achieving the much-needed grid parity of solar power within the next few years. Till such time, it has become absolutely essential to gain some useful experience via the use of megawatt-capacity power plants. It also makes sense to feed the PV produced power to the grid directly minus the presence of an expensive battery bank. One of the major benefits is that the cost of replacement of the battery bank, after a period of four to six years, is avoided and it is easy to maintain the system on a year-round basis. Also, a centralized control system can help in keeping a close tab on several key performance indicators under the actual field operating conditions. In cumulative terms, the MNRE policy of encouraging the use of megawatt-capacity solar grid power generation seems to be a well-timed move aimed at some long-term gains.

Summary indicators of one-MWp PV grid power plants

It is quite clear from Box 1 that a megawatt-capacity PV power plant does not come cheap. The cost per unit of producing power via this route is much more than the power produced through either coal or water or even wind for that matter.

The moot question is why should PV power be considered at all? Well, there are several compelling reasons favouring its use—the abundant sunshine available being the predominant reason. There is also a growing recognition of the fact that cost of PV technology is sure to tumble down more as new capacities

Economics of installing a megawatt-capacity power plant

Capital cost	Rs 200 million
Debt-equity ratio	2:1
Financing cost	7%–12%
estimated generation	1500–1900 units per kWp per year
Operation and maintenance cost	1%–2%
Return on equity	9%–14%
Cost of power generation	Rs 15

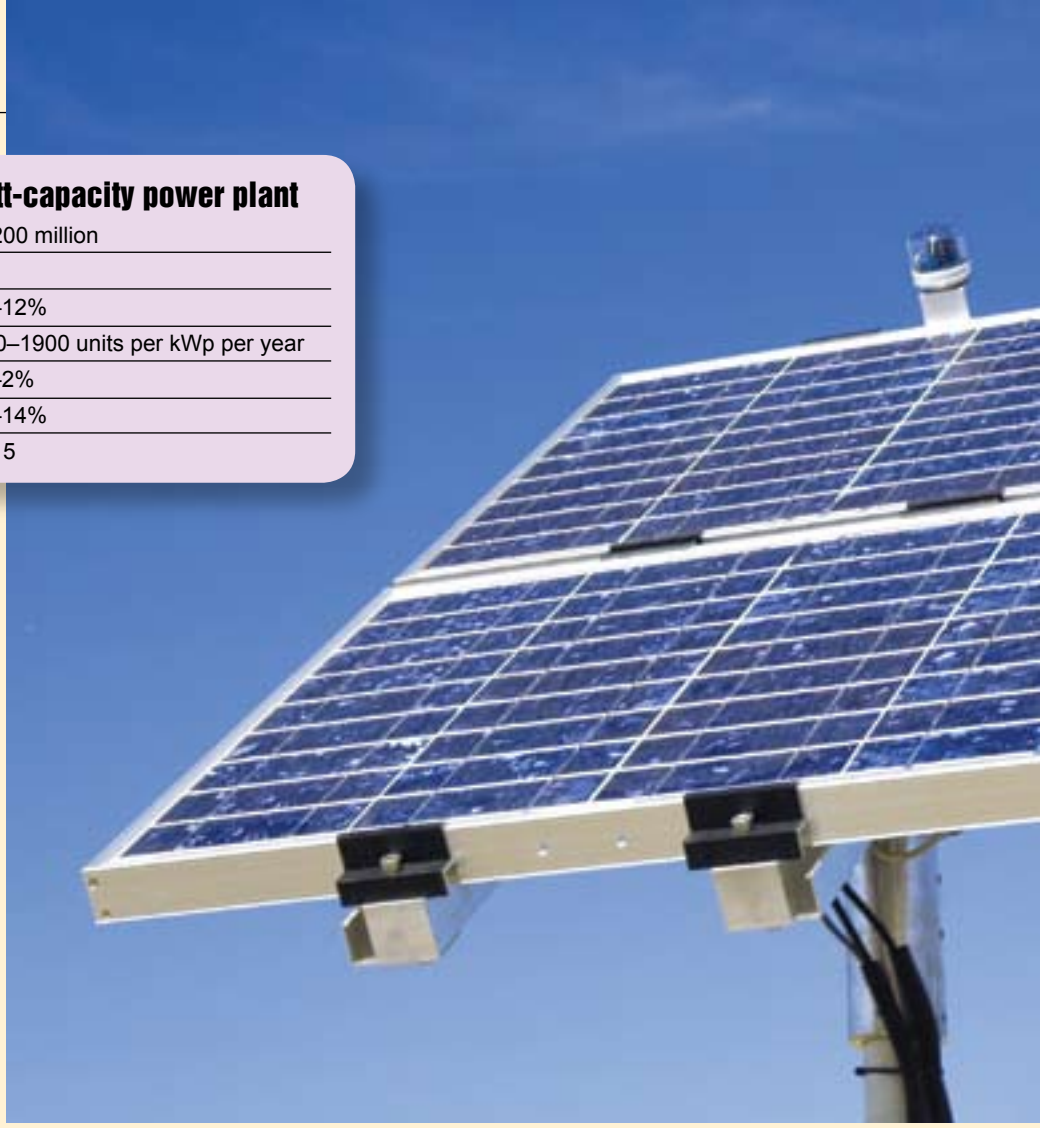
based on the most modern processing techniques come up. However, there is no denying the fact that the support from the government is a pre-requisite to push forth the newly emerging concept of generation-based incentive for solar power. Prior to examining such a scheme in its entirety, let us take a look at the existing promotional measures for the market development of solar energy sector in the country.

Promotional measures

The generation-based incentive announced for the first time by the MNRE is a well-timed policy measure. It is oriented towards a bigger role for solar power via some gainful insights into the actual operation of megawatt-sized solar power plants.

The government has taken several measures to stimulate the growth of the solar energy sector in the country. These mainly include the following few.

- Subsidy on many solar energy systems
- Interest subsidy to provide soft loan to users and manufacturers
- Concessional or zero import duty on some of the raw materials, components, and products
- Excise duty exemption
- 80% accelerated depreciation in the first year



Issues concerning solar PV

- The solar PV grid power segment has just been a very small component of the overall countrywide PV programme so far. This has kept the interest of electrical and electronic companies at a subdued level as far as the commercial production of high-capacity PCUs (power conditioning units) is concerned. Market volumes have not been attractive in this regard.
- There are hardly any indigenous manufacturers of PCUs (higher-end capacities). This could also mean full compatibility of this vital sub-system component with the locally prevalent weather conditions at a given site apart from some cost reduction features as well.
- There is a lack of field data obtained from the traditional small-capacity PV grid power systems (25 kWp mainly) to know how well such systems generate power in a real time situation.

Issues concerning solar thermal

Unlike solar PV, there is no established experience vis-à-vis the use of solar thermal power generation in the country. The SEC (Solar Energy Centre) of the concerned ministry has so far experimented mainly with a 50-kW imported parabolic trough based solar thermal power system. The much talked about 140-MW solar thermal power system planned at Maithania in Rajasthan has still not seen the light of the day due to one reason or the other.

recently. However, it is now actively promoting the establishment of such systems via generation-based incentive for the first time. The purpose is to develop and demonstrate the technical performance of grid-interactive solar power generation so as to bring down the cost of the grid-connected solar systems. Following this, the cost of solar power generation in the country is expected to come down. The financing arm of IREDA (Indian Renewable Energy Development Agency) will manage funds earmarked for the purpose besides being involved in the monitoring-cum-evaluation activities alongside MNRE.

Some additional issues in the sector

- Solar thermal power generation equipment is not manufactured indigenously.
- Fully imported solar thermal power system may not be a techno-economically viable proposition.
- There is little or no solar radiation data available concerning the diffused component of solar radiation. Solar thermal systems do not use the diffused light, but the direct component.

Key objectives of MNRE's generation-based incentive scheme

The MNRE has evolved a generation-based incentive scheme with the specific objective of achieving the following.

- Motivate project developers to establish solar power plants across the country so as to showcase their viability.
- Gather field performance data on power generation in relation to the available solar radiation.
- Assist the regulatory commissions in determining suitable tariff for solar power.
- Inculcate the required awareness among utilities regarding the purchase of high tariff based solar power keeping in view its long-term benefits.

Expectedly, these measures may very well result in reduced cost of solar power generation in the country.

Salient features of the incentive scheme

Large-capacity (megawatt-scale) solar grid power generation has not been high on the agenda of the MNRE till very

A plant with a minimum capacity of 1 MWp at a single location will qualify for the above said incentive. However, such capacity may be installed in modular units of at least 250 kWp so as to achieve 1 MWp per location. A sum total capacity of 10 MWp of grid-interactive solar PV power generation projects can be established in a state. Any project developer is allowed to install PV power generation projects up to a maximum of 5 MWp capacity within the country

Type of project developers

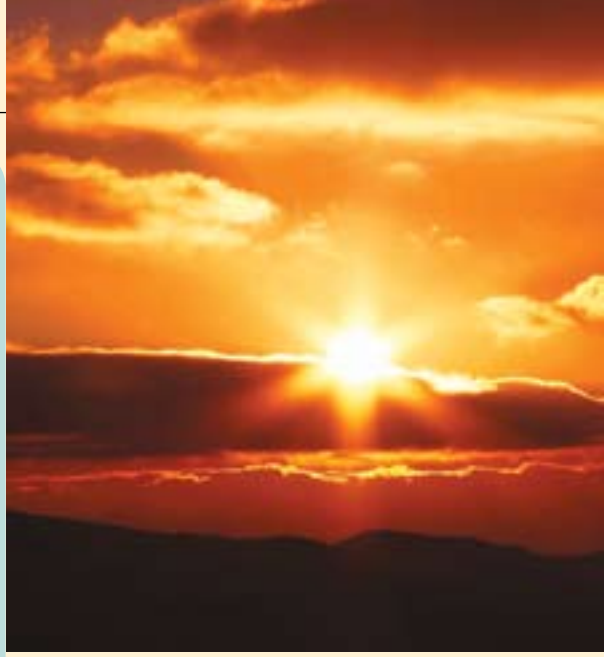
- Any company duly registered is at liberty to avail the generation-based incentive.
- Any public/private sector PV power project developers, who have set up or propose to set up a registered company in India, also qualify for such a concession.
- Both the central and state power generation companies are also included in the category of eligible project developers.
- NGOs (non-governmental organizations), societies, financial institutions, individuals, and other unorganized investors fall outside the ambit of this innovative incentive scheme.

Operational status [A-level]

The grid-interactive solar PV power generation projects will be built on a BOO (build, own, and operate) basis. Setting up of such power plants in a captive mode is not permitted, as is the captive utilization of solar PV power. Simply put, only sale of power to the grid is allowed. These plants will run minus the use of any other source of power and will in no case be transferred to any new management or sold to any other company without prior written approval from the MNRE.

Tariff fixation

In case of availability of a separate tariff for solar power from the SERC, or if the



Generation-based incentives

- MNRE may provide, via IREDA, a generation-based incentive of maximum Rs 12 per kWh to the eligible projects, which are successfully commissioned by 31 December 2009. This will be done after taking into account the power purchase rate (per kWh) provided by the SERC (State Electricity Regulatory Commission) or a utility for that project.
- Any project that is commissioned beyond the above date would be eligible for a maximum incentive with a 5% reduction and ceiling of Rs 11.40 per kWh.
- Further, the incentive will continue to decrease, as and when the utility signs a PPA (power purchase agreement) for power purchase at a higher rate. The proposed annual escalations agreed with the utility, as in force, should be reflected in the PPA.
- The incentive approved for a project may be available for a maximum period of 10 years from the date of approval and regular power generation from that project. This will be subject to the condition that the utility under consideration continues to purchase power from that grid-interactive power plant.
- The project developers are not entitled to avail accelerated depreciation benefit under Section 32 of the Income Tax Act 1961.

tariff gets fixed during the period of availing the incentive, the utilities will offer a minimum of that tariff to the solar PV grid-interactive power projects within their respective states. However, if no such tariff orders are available, the utilities will offer the highest tariff being offered by the utilities for purchase of power to the project developers in their respective states on a medium term—or the highest tariff being provided for the purchase of power from any other energy source, vis-à-vis the orders/guidelines already issued for that state.

Technical requirements

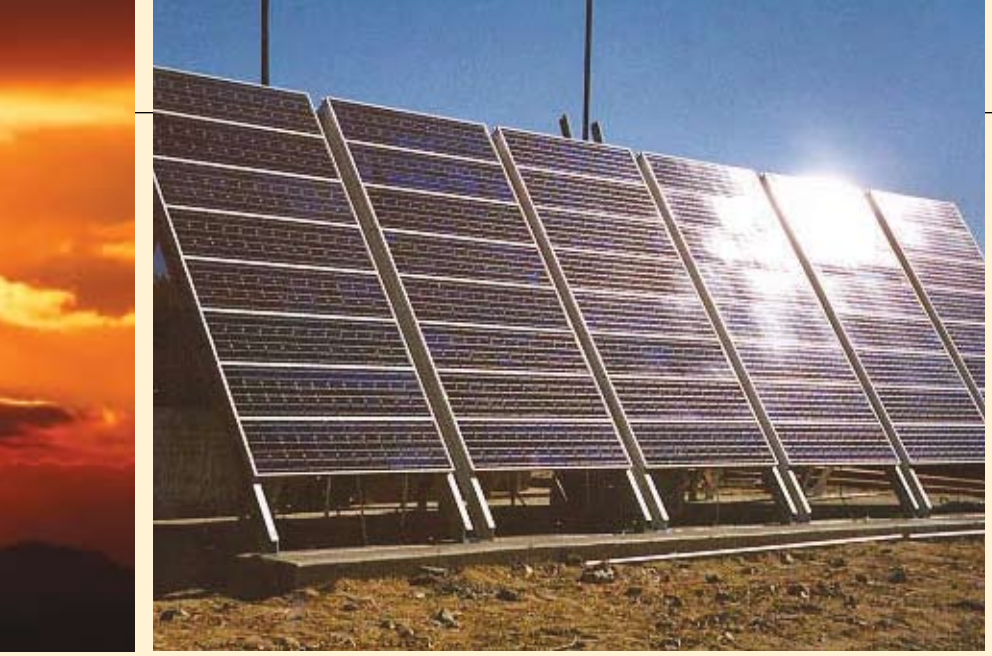
As far as possible, higher power output solar modules should be used and these should conform to BIS Standards or IEC 61215 certification or any other international certification. Optimized generation of electricity in terms of kilowatt-hour generated per MWp of PV capacity installed with regard to available solar radiation at the site is required. The grid-interactive PV power plant may be preferably connected to a 33-kV grid line to reduce the power transfer losses. Key field performance data on daily solar radiation availability, hours of sunshine, duration of plant operation, and amount of power fed to the grid has to be maintained and provided to IREDA as and when reimbursement is needed.

Monitoring and evaluation

A full-fledged team comprising officials from MNRE, IREDA, concerned state nodal agency, and the state utility will undertake an inspection of all eligible projects prior to feeding of power to the grid. The incentive will be approved only after demonstration of satisfactory commissioning of the plant at the project site and its interfacing with the grid of the utility. A dedicated electronic meter or any other meter as specified and approved by the utility will be installed at the point of power evacuation and/or any other point as specified by the utility. The purpose is to monitor the quantum of net electricity being fed to the grid from that project.

Some existing initiatives

- The incentive for generating 50 MW of solar power is assessed close to Rs 900 million. Taking this as an advantage, some states like Rajasthan and West Bengal have already evinced keen interest. Expectedly, such projects may also come up in more states like Maharashtra and Madhya Pradesh. Ideally, west and central India, which receives the maximum sunlight, is well suited for such type of projects.
- MBPV, a wholly owned subsidiary of Moser Baer India, has signed an MoU (memorandum of understanding) with the Government of Rajasthan for setting up of a large solar power project in the state with an estimated generation capacity of one to five megawatt. The project entails an investment of about $25 million (Rs 100 crore) at $4.5 million per megawatt and will be the largest grid-connected solar farm in India.
- PEDA (Punjab Energy Development Agency) has just allocated letters to four project developers (Moser Baer, Power Quality and Electrical Systems Inc., India Bulls Electricity, and Azure Power) for setting up solar PV projects worth about 17



MW on a BOO basis at various locations in the state. Nearly 20 bids were received from both national and international agencies for the said purpose. These projects are expected to be completed and commissioned before December 2009, and the power thus generated would be fed into the grid. A unique feature of these projects is that these would be eligible for carbon credits under CDM and may ultimately pave the way for reduced cost of power generation, build-up of enhanced capacities, and for attaining economies of scale.

Feed-in-tariff

One of the major reasons for solar power projects not making much headway so far has been the absence of a proper feed-in-tariff policy from the concerned ministry (that is, MNRE). Solar projects have to be treated at variance from those of wind and small hydro due to their higher initial capital cost. For example, in Germany, solar grid-connected rooftop systems have been put up in huge numbers mainly due to higher feed-in-tariff rates. There is already hope for solar power gaining grid parity within the next few years and the MNRE scheme may well be a precursor to that.

The RERC (Rajasthan Electricity Regulatory Commission) has proposed the following tariff for solar power generation.

- Solar PV power plants covered under the Government of India policy = Rs 15.78/kWh (commissioned up to 31 December 2009)
- Solar PV power plants (not covered under the policy) = Rs 15.60/kWh (commissioned up to 31 December 2009)
- Concentrated solar power plants covered under the Policy = Rs 13.78/kWh (commissioned up to 31 December 2009)
- Concentrated solar power plants (not covered under the policy) Rs 13.60/kWh (commissioned up to 31 December 2009)

* In case of plants commissioned after 31 December 2009 but before 31 March 2010, the above tariff shall be reduced by 60 paise/kWh

Punjab is the first state in the country to provide a tariff for solar power, which starts from Rs 7 per kWh (base year 2006/07) and peaking up to Rs 8.93 per kWh (base year 2011/12) with annual escalation of 5%. A tariff order providing this tariff was given by PSERC on 13 December 2007. It is in accordance with the NRSE Policy 2006 and PSERC tariff order with peaking rate for sale of power from these projects being Rs 8.93/kWh from the year 2011/12. The power purchase agreements shall be signed for a period of 30 years.

The RERC (Rajasthan Electricity Regulatory Commission) produced a concept paper on determination and declaration of promotional tariff from solar power generation plants. This was done with a clear objective of harnessing the available solar power generation potential in the state of Rajasthan. Accordingly, a public notice in this respect was issued on 15 February 2008 in a few prominent newspapers seeking comments from all interested stakeholders in the field. Following this, a public hearing was held on 4 March 2008, wherein representatives of several government organizations and the solar industry put forth their views as under. There were many key points raised during these deliberations.

The recently announced policy on solar grid power generation is peculiar on the ground that more incentive would have to be made available to the power producer in case of the Commission specifying a lower tariff. On the other hand, the higher tariff fixation would put the burden on the consumer, but the incentive available from the ministry would be lower or even negligible. In view of this, reasonable tariff should be put in place so as to protect the investor's interest together with a suitably evolved compensation for the distribution solar power at a higher cost. A different opinion was

that a maximum 5% of the power purchase cost by the discom should be considered. Simply put, this incentive should be passed on to the discom instead of the project developer.

A few members felt that the proposed tariff was reasonable, though it must be operationalized for a longer period to make the project viable. Further, the depreciation benefit should be allowed for the solar projects in this case too. Some members also demanded extension of the applicability date of the promotional tariff vis-à-vis the power plants commissioned up to March 2012. At present, the promotional tariff for solar power project is for 10 years only but the PPA can be executed for 20 years or life of the plant. The promotional tariff is to attract solar power generation, and therefore, has to be for a limited capacity and for a limited period. For setting up of a solar power project, the developer may get the provisional tariff determined on a case-to-case basis, that is, specific for site, technology, and financial package. The tariff can be within the financial parameters of the RERC tariff determination regulations or there can be competitive bidding.

There was an important observation as per which there is no restriction on allowing an open access to non-renewable and renewable power. Interestingly, a suggestion was mooted with regard to integrating the solar power at such places having a rich harvest of wind power. Further the evacuation capacity already in place can be used optimally.

Interesting facts and figures about global PV-grid power generation

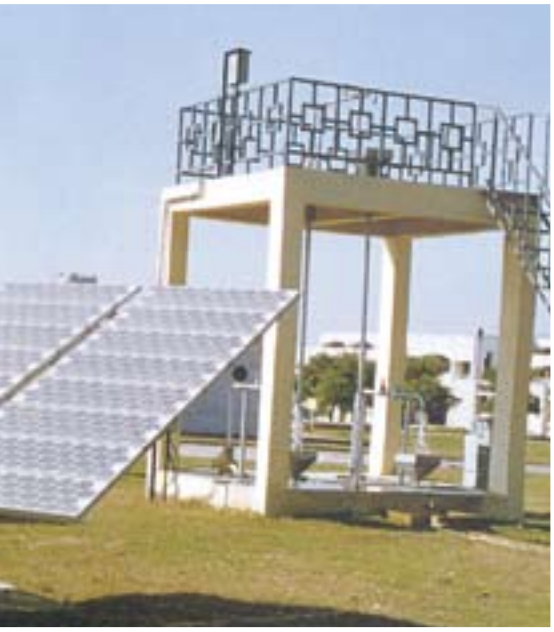
PV grid connected application is the fastest growing application in the world. The table shows the percentage share of this application during 1996–2007.

Percentage share of PV grid-connected applications

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004	2007
Market Share(%)	7.9	21.3	23.5	29.9	41.7	50.4	51.4	55.5	65.9	>70

World's six largest PV-grid power plants

Capacity (MWp)	Location	Year of installation	Power generation (MWh)	GHG abatement (tonnes of CO_2 displaced)
23.0	Spain	2008	41 600	42 000
21.0	Spain	2008	40 000	
20.0	Spain	2008	42 000	
20.0	Spain	2007	30 000	30 000
18.4	Germany	2007		
14.0	USA	2007	30 000	23 000



The facts and figures

- Between 2005 and 2008, the annual growth of large-scale PV power plants with an average peak power of 200 kWp or more has been nearly 100%. The trend is expected to continue with more growth possible in 2009.
- In all, there are more than 800 PV plants worldwide with capacity greater than 200 kW and at least 9 plants larger than 10 MW, in Germany, Portugal, Spain, and the US (United States).
- Almost one half of the global installed large PV power is connected to the German grid. Eight per cent of all large PV plants (power related) are installed in Europe (700 MWp).
- Germany, Spain, and Italy lead the market of large-scale PV power plants in Europe. Almost 60% of all European large PV plants (power related) are located in Germany (403 MW), followed by Spain (245 MW; 35%) and Italy (17 MW; 24%).
- Eight per cent of the world's large PV plants are situated in Europe, 16% in the US, and 4% in Asia. The most dynamic market is Spain, where a steep increase in installed power has been observed in 2007.
- The rest of the world (that is, Africa, South America, and Australia) represents less than 1% of global installed PV power but shows significant potential for future solar energy use.
- Germany leads with more than 400 MW, followed by Spain (almost 250 MW) putting the US (140 MW) at the second position. Italy and Japan (each about 17 MW), Korea (13 MW), and Portugal (12 MW) reached two-digit figures.
- Countries with less than 1-MWp installed capacity are Thailand, France (without overseas territories), United Kingdom, Malaysia, Saudi Arabia, Luxembourg, Rwanda, and Mexico.
- Primary PV world markets are Germany (with about 45% of the installed power), followed by Spain (28%), and the US with 16% market share.
- The average installed capacity of a single large commercial power plant has increased from 400 kWp in 1997 to 1.64 MWp in 2007. The average capacity of sole commercial PV plants accounts for 1.14 MWp.
- Amongst the top 10 largest PV power plants, 50% are operating in Spain.
- At the end of 2007, almost 70% of all large PV power plants (power related) were ground mounted. Twenty nine per cent were installed on roofs.
- Other types of plants (about 1 %) include photovoltaic power plants integrated into building envelopes (BIPV), noise barriers and similar applications.
- Twenty seven per cent of the large power plants (power related) have tracking arrays (single- or double-axis trackers) and 73% have fixed arrays.

This graph shows the percentage of share of PV grid-connected application during 1996–2007