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ENERGY AND NATURAL RESOURCES

# The Rising Sun

## Point of View on Solar Energy Sector in India

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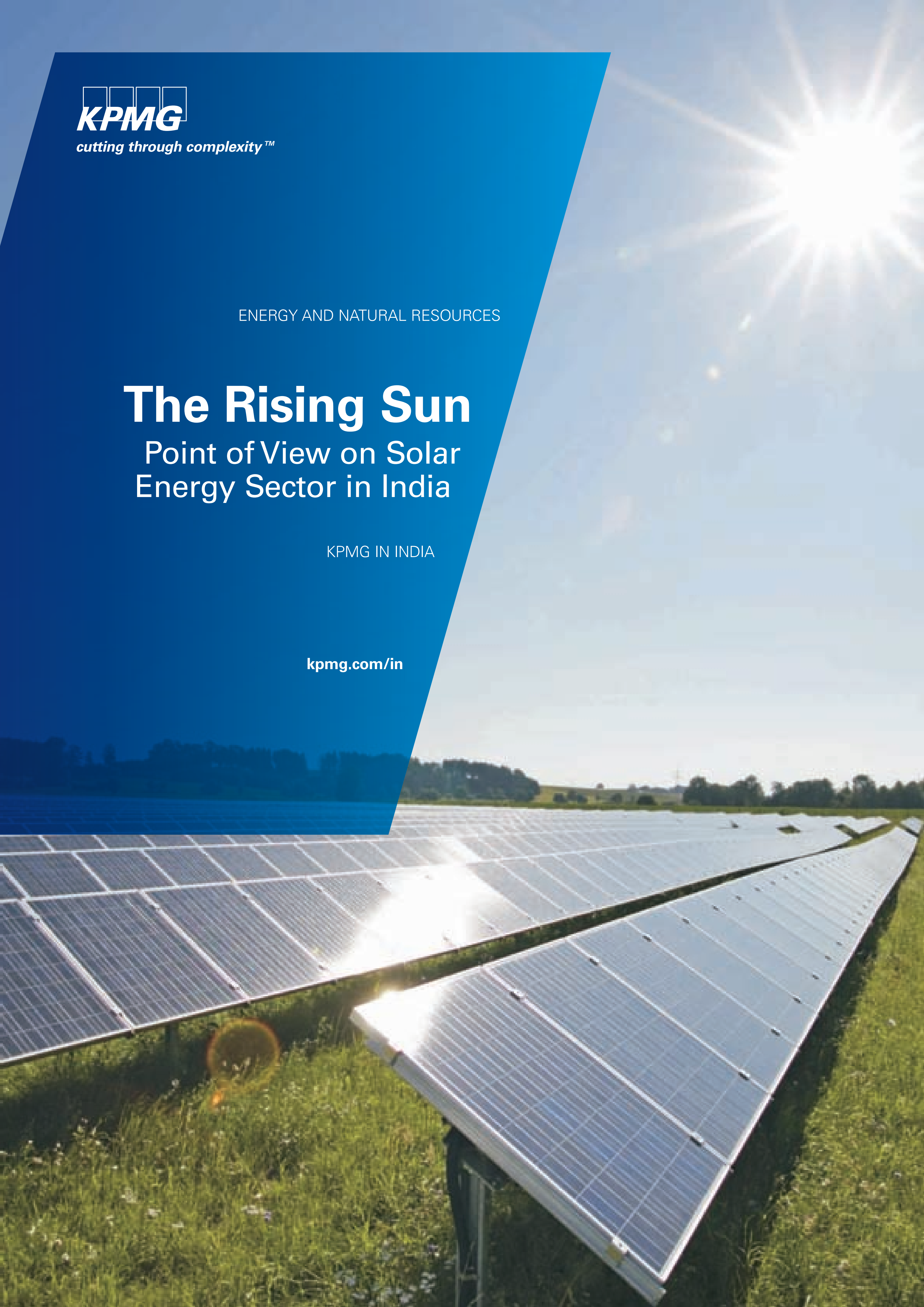

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# Foreword

As one looks to the future, India faces significant challenges of energy security, responding to the call for action against climate change and importantly addressing the issue of inclusive growth within the country. Our coal import requirement is expected to exceed 30 percent of our coal demand by 2017; India will need to show some action towards its voluntary target of 20-25 percent reduction in carbon emission intensity of GDP by 2020; and look at ways to electrify over 40 percent of rural households with reliable electricity.

The Government of India launched the Jawaharlal Nehru National Solar Mission (JNNSM) in late 2009 as one of the eight national missions under the Prime Minister's National Action Plan on Climate Change (NAPCC). Various states, notably Gujarat and Rajasthan, have come forward with state level policies as well. These, indeed, are far sighted steps and can contribute in a significant way to the three challenges mentioned above. In this report, KPMG has analyzed how solar power can contribute to addressing these challenges and why it is important for policy makers to keep the momentum going into the future. Persistence in policy and resilience in action is needed if the true potential of this sector is to be achieved.

The fruits of this persistence will be obtained in the latter part of this decade and that is the time we would look back and be thankful for the actions we are taking today. Solar power has the potential to meet almost 7 percent of our power needs by 2022, mitigate 2.6 percent of our carbon emissions in that year and save over 71 MTPA of imported coal in that year (equal to USD 5.5 bn of imports). Clearly, the imperative for action today is strong and therefore is the case for persistence and consistency on part of the Government. For the industry, this represents a significant investment opportunity. Investment opportunities across the value chain from manufacturing to EPC to project development exist with an estimated total project investment of USD 110 bn over the next decade. Opportunities in both grid and off-grid segments will be strong and industry should focus on these areas. I would also urge a strong emphasis on innovation and R&D by Indian industry to make applications that suit Indian needs while using the technological achievements in rest of the world as a platform to leap-frog to next level.

We hope this study will show to different stakeholders the true potential of this great source of energy and instigate the action and commitment that this sector deserves.

**Arvind Mahajan**
Executive Director and Head
Energy and Natural Resources

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# Key terminology

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# 01

# Key terminology

### Solar Photovoltaic Technology (PV)

Solar PV plants generate electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect. Photovoltaic power generation employs solar panels comprising a number of cells containing a photovoltaic material.

### Concentrating Solar Power Technology (CSP)

Focuses the sun's energy to boil water which is then used to produce power. CSP plants produce electricity by converting the infrared part of solar radiation into high temperature heat using various mirror/reflector and receiver configurations. The heat is then channeled through a conventional generator. The plants consist of two parts: one that collects solar energy and converts it to heat, commonly known as 'solar field' and the other that converts heat energy to electricity, known as 'power block'

### CSP - Parabolic Trough Technology

A parabolic trough structure is constructed as a long parabolic mirror (usually coated silver or polished aluminum) with a receiver tube running along its length at the focal point. Sunlight is reflected by the mirror and concentrated on the receiver tube. The trough is usually aligned on a north-south axis, and rotated to track the sun as it moves across the sky each day. A thermal transfer fluid, such as synthetic thermal oil, is circulated in these tubes. The fluid is heated to approximately 400°C by the sun's concentrated rays and then pumped through a series of heat exchangers to produce superheated steam. The steam is converted to electrical energy in a conventional steam turbine generator, which can either be part of a conventional steam cycle or be integrated into a combined steam and gas turbine cycle.

### Levelised Tariff

The tariffs for each year during a term of a PPA (Power Purchase Agreement) are discounted by applying the discount factors (based on the Discount Rate) and such aggregate discounted value for the term of the PPA is divided by the sum of such discount factors to calculate the Levelised Tariff.

### LCP

Landed cost of power is the total cost of delivering power at the consumer premises and includes the cost of power purchase, the power losses at transmission and distribution (T&D) levels and the cost of servicing and maintaining the T&D assets till the particular consumer premises.

### Grid Parity

Threshold at which solar power system supplies electricity to the end user at the same price as grid-supplied electricity. Grid parity will be different for different States and different end user applications.

### Feed-in-Tariff

A feed-in tariff (FiT, feed-in law, advanced renewable tariff or renewable energy payments) is a policy mechanism designed to encourage the adoption of renewable energy sources. Under a feed-in tariff, eligible renewable electricity generators (which can include homeowners and businesses) are paid a premium price for any renewable electricity they produce.

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### National Renewable Energy Laboratory (NREL)

The U.S. National Renewable Energy Laboratory is a part of the U.S. Department of Energy (DOE) and is a leading laboratory for renewable energy and energy efficiency research and development within the US.

### ‘Off-grid’ solar applications

Are generally meant to refer to a set of applications that provide solar power to end-users through routes other than the electricity grid. These routes, for example, could be to deliver water heated through solar power to a consumer through water pipes at his residence or street lights illuminated through a battery bank charged using solar power.

### Solar Water Heating (SWH)

Is generally meant to imply the use of solar energy to heat water. Solar heating systems are generally composed of solar thermal collectors, a water storage tank or another point of usage, interconnecting pipes and a fluid system to move the heat from the collector to the tank.

### ESCO

Implies an Energy Service Company that would install, own and operate a system with a fees-for-service model where people buy a service from the company. Typically these companies are characterized by the following features:

- Guaranteed energy savings and/or provision of the same level of energy service at lower cost
- Remuneration directly tied to the energy savings achieved
- ESCO finances or assists in arranging financing for the installation of project

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# Executive summary

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# 02

# Executive summary

The Indian economy faces significant challenges in terms of meeting its energy needs in the coming decade. The increasing energy requirements coupled with a slower than expected increase in domestic fuel production has meant that the extent of imports in energy mix is growing rapidly. Oil imports already constitute nearly 75 percent of our total oil consumption. Coal imports which were negligible a few years back are likely to rise to around 30 percent of the total coal requirement by 2017. Globally, there is intense competition for access to energy resources. This is a serious cause for concern as the Indian economy gets exposed to the global fuel supply market which is volatile and rising. Moreover, being amongst the top five greenhouse gas (GHG) emitters globally[1], India has a responsibility to achieve the growth trajectory in an environmentally sensitive and responsible manner. India has set a voluntary target to cut the emissions intensity of GDP by 20-25 percent by 2020 compared to the 2005 level.

In this backdrop, the thrust on renewable sources of energy is a step in the right direction. The Prime Minister's National Action Plan on Climate Change (NAPCC) released in June, 2008 envisages meeting 15 percent of our power requirements from renewable energy sources by 2020. One of the eight missions under the NAPCC is the Jawaharlal Nehru National Solar Mission (JNNSM) which was launched in late 2009. The mission targets 22,000 MW of solar power by 2022. The first phase of the program has been initiated and projects amounting to 704 MW have already been allocated. The policy goals and the steps taken to achieve it have been in the right direction. We must compliment the Government of India for taking this far sighted and strategic initiative with full earnest. In addition, some states, notably Gujarat, have taken visionary steps to support the program at the State level. Furthermore, the Renewable Energy Certificate (REC) mechanism which is already operational can play a catalytic role in the development of the solar power market in India. We believe the seeds have been sown for a rapidly scalable and a very large solar energy sector in the near future. As we will explain later, we believe that the potential of this sector and its impact on our strategic considerations of energy security and GHG mitigation can be far greater than is generally believed.

1. United Nations Greenhouse Gas emissions

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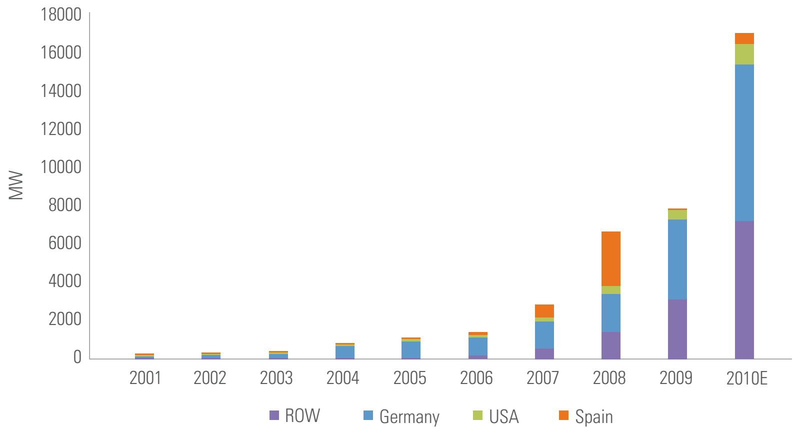
Globally, the solar power industry has been growing rapidly in recent years. In 2010, an estimated total capacity of 17,000 MW was installed globally. Germany leads the race with more than 40 percent[2] of the total global market.

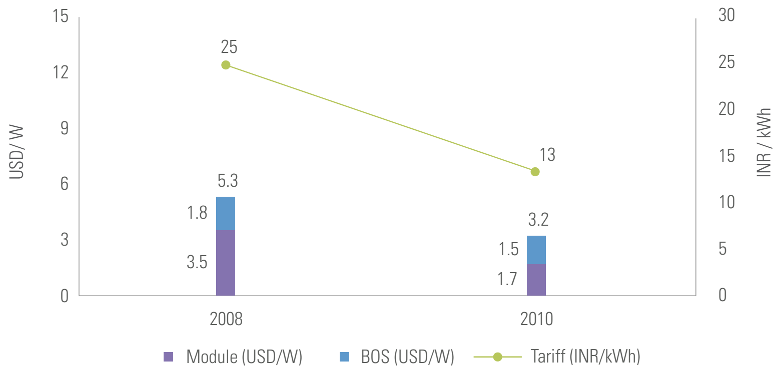
Global Annual Installations - Germany is the Market Leader




**Source:** EPIA, KPMG Analysis

The exponential growth is expected to continue and projected to be in excess of 40 percent annually in the coming years. This growth rate has been accompanied by rapidly declining cost curves as shown in the exhibit:

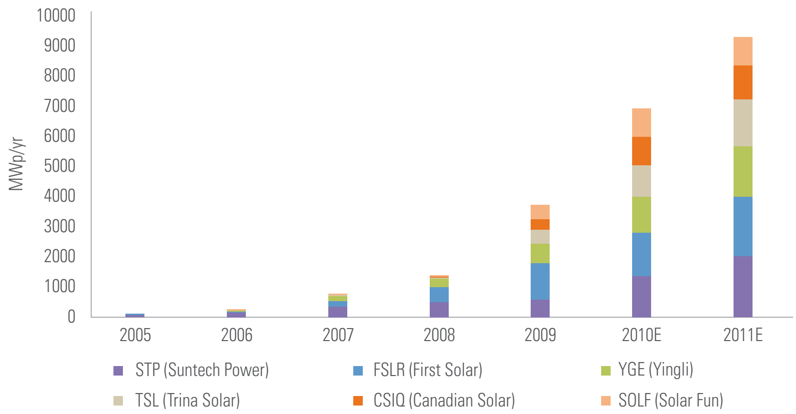
Globally, solar PV system prices have dropped significantly...




**Source:** Analyst Reports KPMG Analysis

The main drivers for this cost reduction are achievement of economies of scale, technological advancements and emergence of low cost manufacturing locations.

Significant scale up in manufacturing capacity - Select players




**Source:** Company Reports, KPMG Analysis

2. Solar Energy Industries Association & Germany's Federal Network Agency, IMS Research

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These trends are definitely very encouraging and have positive implications for our energy security and future energy requirements. Solar energy potential is virtually infinite and if cost economics work out favourably, it can be tapped to meet a significant part of our needs. Here is an interesting statistic – a square piece of land in the Rajasthan desert with each side of 55 km can be tapped to generate enough solar power to equal the existing power generation quantum in India. A path-breaking initiative called the Desertec initiative actually targets to meet 17 percent[3] of Europe's power requirements by large scale solar plants in the North African region with power transported across the Mediterranean. Such is the potential of this vast energy source.

The key driver of the growth of this sector is a concept called grid parity. This refers to the point when the cost of solar power equals the cost of conventional power. In the recent round of reverse auctioning process for the solar projects under the National Solar Mission, the price discovery for levelized tariff was in the range of INR 10.49 /kWh to INR 12.24 /kWh for solar-thermal and between INR 10.95 /kWh and INR 12.76 /kWh for solar PV projects. As against these discovered solar prices, the conventional power at grid level, including the interregional transmission charges and losses, is available at INR 4.00 /kWh[4] on a levelized tariff basis. Moreover, the average landed cost of power at consumer end in 2010-11 is estimated to be as high as INR 5.42 /kWh[5], which factors the costs of the transmission and distribution network and includes the transmission and distribution losses. The pace at which the gap between solar power tariffs and the landed cost of power will be bridged will determine the pace at which solar power will take off. The point at which grid parity occurs is a function of two variables – the rate of increase in conventional power prices and the rate of decrease in solar power prices. Based on data from external sources and KPMG's own analysis, we believe the following could be the key trends:

- We expect landed cost of conventional electricity to consumers to increase over the next decade at the rate of 4 percent per annum in the base case and 5.5 percent per annum in an aggressive case. This factors in an increasing proportion of raw material imports, cost of greenfield generation and network assets and improvements in operational efficiencies of utilities.
- We expect solar power prices to decline at the rate of 5 to 7 percent per annum over the next decade. This is after factoring in ever increasing economies of scale in equipment manufacturing and advancements in product technology thereby improving solar-to-electricity conversion efficiencies. Emergence of low cost manufacturing locations are expected to aid this trend.

With these assumptions, we expect grid parity to occur in the years as mentioned in the table below:

| | Aggressive Case | Base-Case |
|---|---|---|
| Grid Parity – All India | 2017-18 | 2019-20 |

**Source:** KPMG's The Rising Sun, 2011

3. http://www.desertec.org
4. While recent Case 1 bids have shown a levelized tariff in the range of INR 3.50 / kWh to INR 4.0 / kWh, we have taken the higher end of the range because utility scale solar plants are likely to be located in the north-western states and parts of peninsular India where the transmission penalty for conventional plants from the pithead is high. Further, medium scale solar plants can be connected at sub-transmission voltage levels and therefore have benefit of lower network losses.
5. PFC report on performance of State Utilities, KPMG Analysis

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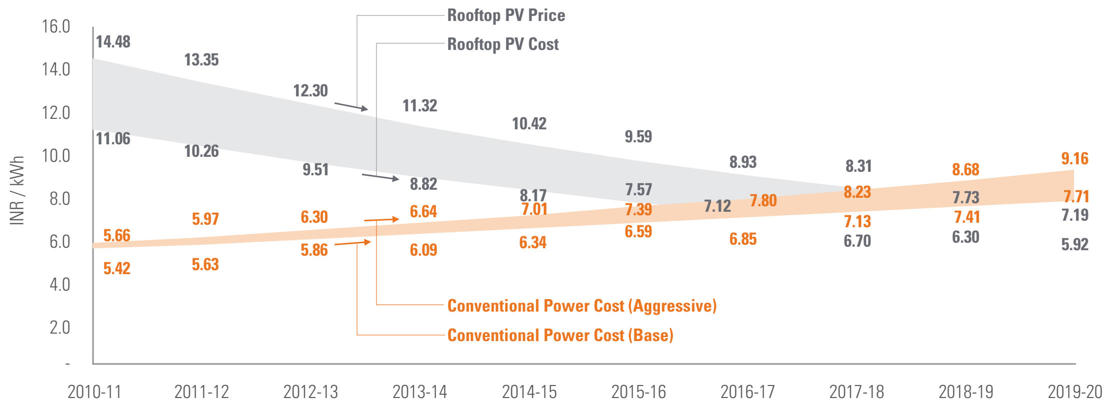
A similar conclusion is reached for distributed solar PV generation at consumer premises. In the exhibit below, we have showcased a band representing solar rooftop costs. The band variation signifies the margins, i.e. the difference between cost and price (includes margins across the value chain). We expect the solar tariff to lie anywhere within this band depending on the bargaining power of the developers.

The exhibit below captures the comparison between landed cost of power (LCP[6]) to residential or agriculture consumer categories in a particular year against the levelized solar tariffs in that year*.

## Rooftop PV Costs vs. Conventional Power Cost at Consumer-end




| Grid Parity Year | Aggressive Case | Base-Case |
|---|---|---|
| Rooftop PV Price | 2017-18 | 2019-20 |

**Source:** KPMG's Solar Grid Parity Model

While we expect grid parity for these consumer categories – domestic and agriculture - in 2019-20, based on state-specific and end-use specific cost economics, the adoption for solar is likely to happen earlier.

We expect high-end residential consumers to be proactive in adopting solar rooftop given their higher power tariffs. A large number of these consumers are likely to start adopting solar power from 2017-18. However, government involvement will be required in encouraging non- high-end residential and agriculture consumers to use solar power from 2017-18. Roof-top PV will spur other intangible benefits. Being highly "visible" in the public eye, it will contribute to generating a great deal of awareness among the population about clean energy and benefits of distributed generation. This, we expect, will contribute to a culture of energy conservation and environmental responsibility which is very important from a national perspective.

6. LCP would include the power losses at transmission and distribution (T&D) levels and also the cost of servicing and maintaining the T&D assets.

* Note that the CDM benefit of INR 0.60 / KWH has been factored in the Solar Costs

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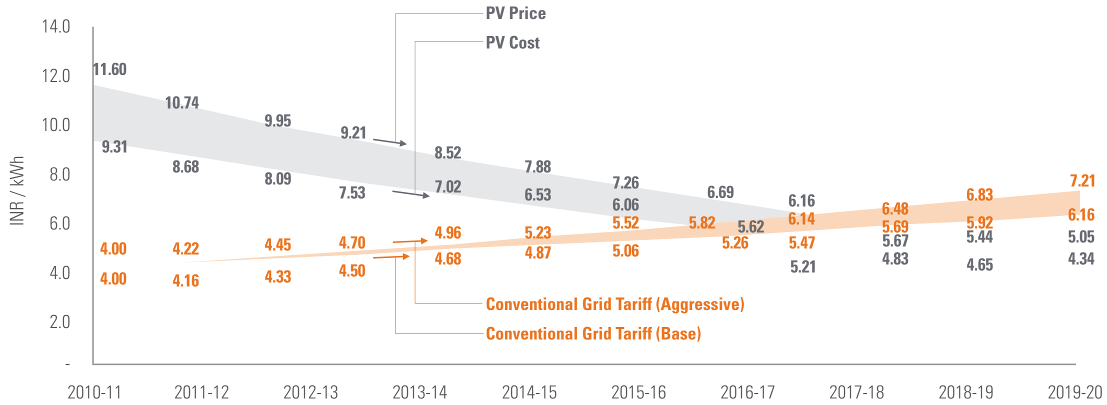
The large scale utility power can be procured either from Solar PV or from CSP depending on the cost economics. In the exhibits below, we have captured various scenarios in which grid parity could occur for both CSP and PV technologies[7].

## Levelized Cost Comparison of Utility-scale PV and Conventional Power at Grid

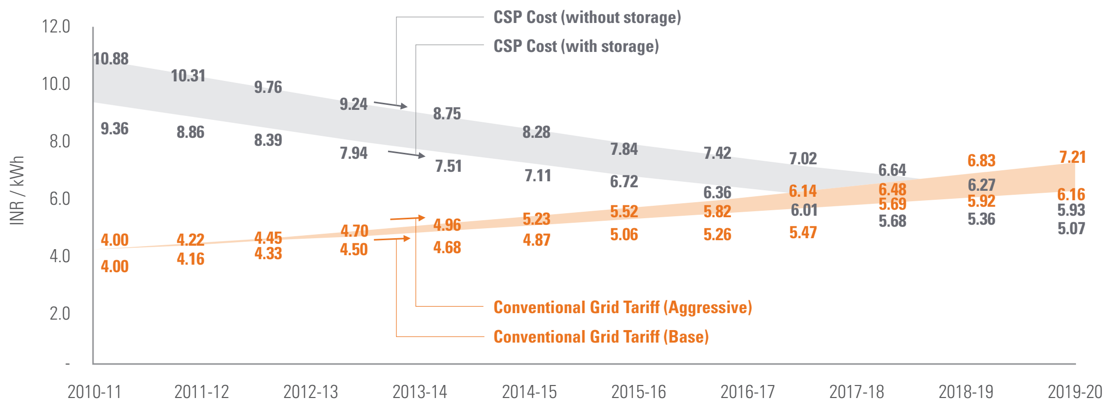



| Grid Parity Year | Aggressive Case | Base-Case |
|---|---|---|
| Utility PV Price | 2017-18 | 2019-20 |

**Source:** KPMG's Solar Grid Parity Model

However, solar CSP, due to the storage factor, can be instrumental in meeting the evening peak requirements and therefore be potentially more attractive from a utility scale perspective.

## Levelized Cost Comparision of Solar CSP and Conventional Power at Grid




| Grid Parity Year | Aggressive Case | Base-Case |
|---|---|---|
| CSP with Storage | 2017-18 | 2019-20 |

**Source:** KPMG's Solar Grid Parity Model

We expect the grid parity to happen in 2019-20 when the levelized tariffs from solar power are comparable with the levelized tariffs of grid power in this year.

7. Note that the CDM benefit of INR 0.60 / KWH has been factored in the Solar Costs

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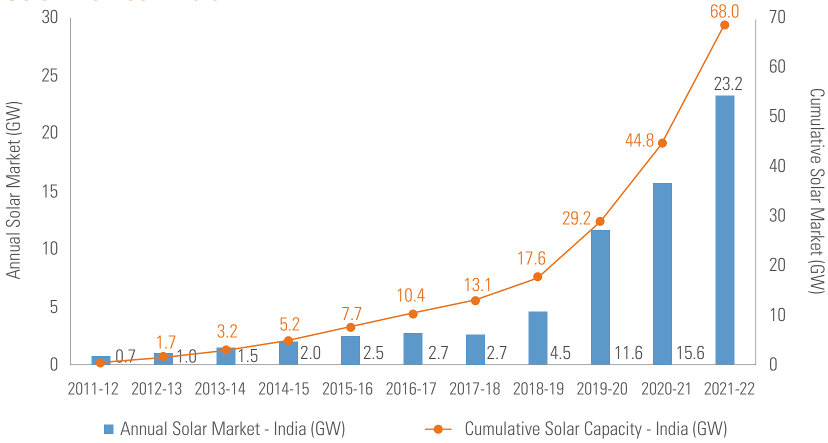
It is important to state here that these conclusions are for broad-based grid parity across the country. Certain states will reach this point earlier. For example, the states of Rajasthan, Gujarat and Tamil Nadu are expected to reach this point earlier not only because they have higher solar insolation, thereby reducing the cost of solar power, but also because the cost of conventional power in these states is higher as they are located far away from coal resources and have little local reserves.

This conclusion has significant implications for market offtake of solar power. We expect significant offtake to start occuring in the years immediately preceding grid parity. The exhibit below captures our estimate of the solar market in India:

Solar Market - India




**Source:** KPMG's Solar Market Potential Model

In the table below, we have summarized the offtake trajectory from 2017-18 (the year from which we expect the cost economics to work in favor of solar power in India) from various segments – grid-connected and off-grid applications:

| Annual Solar Market Off-take (MW) | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 |
|---|---|---|---|---|---|
| **Grid-connected Solar Potential** | | | | | |
| Residential Rooftop | 1,024 | 1,356 | 3,600 | 5,341 | 7,677 |
| Utility Scale Solar Power (CSP and PV) | 1,043 | 2,229 | 3,570 | 5,084 | 8,146 |
| **Off-grid Solar Application Potential** | | | | | |
| Solar-powered Agriculture Pumpsets | 268 | 563 | 3,969 | 4,639 | 6,730 |
| Solar-powered Telecom Towers | 318 | 380 | 414 | 562 | 612 |
| **Total Annual Solar Market** | **2,653** | **4,528** | **11,553** | **15,626** | **23,165** |

**Source:** KPMG's The Rising Sun, 2011

This is significantly in excess of the targets under the National Solar Mission – cumulative capacity of 22,000 MW by 2022. The cumulative installations in the period 2017-2022 itself could be approximately 57,500 MW. In the period upto 2017, the market will continue to be policy driven. This phase of the market is extremely important if we are to achieve the rapid scale up post 2017.

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In the off-grid space, solar power is already cost competitive with alternatives in certain applications. For example, telecom towers are an attractive market for solar PV installations. A large number of telecom towers are located in areas with limited or no grid connectivity and have to depend on diesel gensets for meeting their power requirement. Depending on the tower configuration and connected load, the price of diesel power can vary from around INR 15/ kWh to as high as INR 30/ kWh for low load towers in remote areas. Today, India has about 3.6 lakh[8] telecom towers that are likely to grow to 7 lakh towers by 2020 – a large proportion of the new towers would be coming up in rural / semi-urban areas reflecting the much higher pace of new consumer addition in rural / semi-urban areas compared with urban areas going forward. This would result in diesel consumption increasing from about 2 Billion liters / annum (comprising about 3.5 percent of India's annual diesel consumption) today to about 3.5 Billion liters / annum by 2020.

Solar PV installations are well suited to replace diesel consumption for the following reasons – solar power price is already competitive with the effective price of diesel based power for a large proportion of telecom towers and land availability for solar panel installations is generally not a constraint in rural / semi-urban areas.

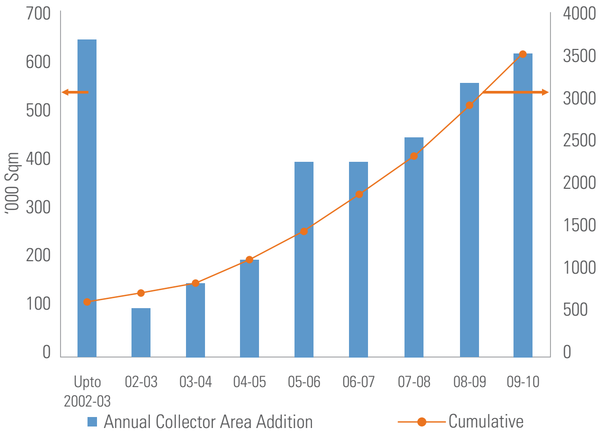
While solar power would not be able to completely replace diesel consumption, we believe that it has the potential to replace about 30 percent of diesel consumption. This implies a diesel saving of 5.4 Billion liters between now and 2022. This would also mean about 3,500 MW of solar panel installations that would create an industry (comprising of solar panels, inverters, battery banks and associated components) of USD 12.5 Billion in the same period.

Another off-grid application where solar power is well suited is the agricultural pumping segment. Presently, the power supply to agriculture segment is staggered and partially supplied during inconvenient night times when grid power is available. Solar power, with its ability to provide day time power, can meet the agricultural power demand from the farmers without the need to be connected to the grid. Moreover, unlike industrial and residential loads, the water pumping loads can tolerate a certain level of intermittency in power output, which is a characteristic of solar PV power.

The other segment of the energy market which can use solar energy is the solar water heating (SWH) segment. Solar water heating applications could be used in residential, commercial as well as industrial sectors.

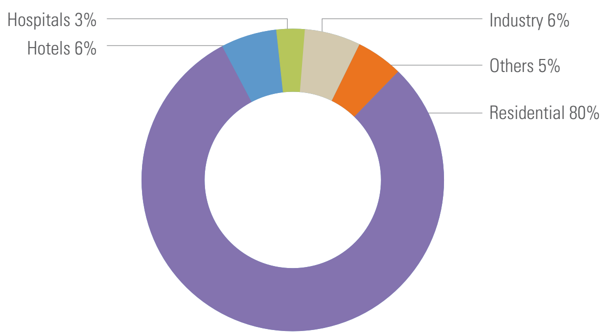
Internationally, SWH is a well developed technology and promises significant fuel savings and emissions reduction. China, European Union, Turkey, Japan and Israel are the leaders and cover about 90 percent of the global installed SWH capacity. While India is well endowed with solar insolation, the cumulative installed capacity in India in 2009-10 was only 3.53 million square meter. As a comparison, China with relatively lower insolation has 125 million square meters of SWH collector capacity.

## Growth of SWH in India




**Source:** MNRE Estimates

## Category wise break-up of SWH installation in India




**Source:** Greentech Report on Solar Water Heaters in India

8. IDBI report on Telecom Infrastructure

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Residential SWH comprises ~80 percent of the total installed capacity. One of the biggest drivers of SWH offtake for residential applications is the favourable cost economics which works out to a payback period of 2.71 years. However, the barriers to this are the following:

- High upfront cost of the SWH systems. This can be potentially addressed through a consumer financing solution.
- Presently, the cost to consumer of alternates such as electric geysers do not fully reflect the true cost of these alternatives since electricity prices for the residential segment are mostly subsidised.

We believe that while the potential for SWH exists in residential, commercial as well as industrial segments, SWH implementation would remain a challenge in industries until robust technical solutions emerge for industry. This is because industrial applications require a high level of customisation and performance reliability which current commercial products do not offer. We have discussed SWH implemetation issues in more detail in the main report. The table below summarises the potential for residential and commercial segments:

| SWH Market Size | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Collector Area - Mn Sqm[9] | 4.4 | 5.8 | 7.9 | 11.3 | 16.1 | 22.3 | 30.5 | 40.8 | 51.1 | 61.4 | 71.7 |
| Incremental Market Size – USD Mn | 219 | 230 | 363 | 635 | 915 | 1,212 | 1,664 | 2,143 | 2,207 | 2,273 | 2,342 |

**Source:** KPMG's The Rising Sun, 2011

Hot water / steam are also vital inputs for a variety of industries including dairy, pulp and paper, textiles and leather among others. If solar installations were to replace fuel to an extent of 30 percent in industrial processes running below 250 deg C (where the solar solutions are relatively simpler) today, we believe that about 70 Mn Sqm solar collector area would be required. This would result in a saving of 4.8 Mn tons of oil per annum that is equivalent to USD 3.5 billion[10].For solar power to find a place in industry, we believe that emergence of solution providers who provide performance assurances is necessary. These solution providers would customize the product to meet each industry's specific need and provide assurances around hot water / steam requirements – duration of availability, temperature and pressure conditions, etc. We believe that solar equipment vendors would need to invest in technology as well as adapt to a more services driven model (similar to an Energy Services Company model) to be able to penetrate the industrial segment. However, we are confident that if and when such models evolve, the solution providers will find significant demand from the industrial segment.

To summarise, solar energy has immense potential to meet our energy requirements. If the potential as described earlier is achieved, solar energy has the following significantly positive implications for our energy security and climate goals:

- Solar energy can contribute to about 7 percent of our total power needs and displace ~16,900 MW[11] of marginal conventional power by 2022 implying a saving of 61 MTPA of coal / annum. Additionally, 72 Mn sqm of solar collector area can save about 11 MTPA of coal / annum. Since this reduction would spare the marginal requirement which is likely to be imported coal, this would mean a saving of 71 MTPA of imported coal which is a reduction of more than 30 percent of our coal imports.
- Furthermore, solar power can save 95 Million Tonnes of CO2 per annum by 2022. This is ~2.6 percent of India's total emissions in that year and will be a very useful contribution to our voluntary target of 25 percent reduction in the carbon intensity of GDP.

9. Usage of solar power for telecom towers and capturing solar heat through collector area installation are already economically viable options. Hence, from an economic viability perspective, these applications do not have to wait till 2017-18 for a self-sufficient market to get created.
10. BP Statistical Review - Conversion factor from MTOE to MBOE is 7.33. Assumed oil price is USD 100 per barrel
11. This calculation factors the PLF of conventional plants and solar plants.

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However, for all this to be achieved, the Government has an important role to play in the coming five years. These include the following:

- Keep the market stimulus going
  The first phase under the JNNSM is the right beginning. The Government has to keep the market going so that the supply chain and ecosystem continue to evolve for the rapid scale up. A graduated scale-up is desirable rather than a fits-and-starts approach. The scale-up should be calibrated based on trade-off analysis between current affordability and long term benefits.

- Get the funding in place and channelise it to the utilities
  The Indian power utilities are highly cash strapped and reeling under the burden of rising fuel costs and greenfield investments. They need to be given the full support to absorb the cost of this program. A more direct support from the Centre to the state power utilities is the need of the hour. In the absence of this, the program has a serious risk of derailing. We understand that steps are being taken to utilise the fund created by the cess on coal (National Clean Energy Fund) to assist states in building the evacuation infrastructure. While this is welcome, we suggest a more broad based utilisation of this fund that will support states in meeting their RPO (Renewable Purchase Obligation) targets for solar power.

- Government should play an active role in giving the requisite support to the lending community
  In the first phase of the program, the lending community is likely to have concerns related to technology risk and power off-take and payment security. The Central Government has indeed evolved innovative steps under the National Solar Mission such as the bundling program wherein the solar power is pooled with conventional power and the bundle is sold to state utilities at an average rate. This softens the impact of the higher price of solar power and gives comfort to lenders that payment default is less likely to occur. However, we believe the following steps can be taken to further strengthen the environment for financing: 1) Classify renewable energy and cleantech areas as a separate sector for measuring sectoral exposure limits for banks; currently they are considered part of power sector for measuring exposure limits leading to sectoral limits emerging as a constraint 2) Grant priority sector lending status to solar sector and 3) Allow banks to issue tax free solar bonds which will enable access to a long tenure stable interest rate source of finance. Further, for the first phase of the National Solar Mission projects, it would be prudent to provide a calibrated back-stop arrangement (atleast for a certain time frame) in the event of payment default by states utilities. We understand that such a mechanism is being worked out and that will indeed be a very supportive measure. It is important that the first phase of NSM receives the necessary financing to be successful. This has serious implications for the long term.

- Support domestic R&D through public-private collaboration
  While vendors may be able to indigenize certain low value components of both grid and off-grid applications by themselves, high value technology intensive components may require R&D support from Government agencies / institutions for indigenization. Some examples of such components are absorber tubes for parabolic trough plants and collector dishes for high temperature / pressure industrial processes. Institutes such as the Indian Institutes of Technology could collaborate with the industry under a Government driven R&D funding framework to engineer products in the country. There are successful examples from the US where the National Renewable Energy Laboratory (NREL) collaborates with the private sector for collaborative research.

- Look at innovative possibilities for large scale solar powering of agriculture pumpsets
  The total connected load of agriculture pumpsets is expected to be in excess of 100 GW by 2020. We believe that this could be a very large market for solar-powered pumpsets and could commence earlier than expected if the Government adopts an innovative execution model that provides scale to manufacturers to bring down costs and a viable service delivery chain to provide a reliabe solution to the farmers. To start with, diesel replacement can commence immediately due to favourable cost economics. Pilots in this direction should commence immediately.

- Push Solar Water Heating (SWH) in residential catergory
  Various State Governments and Municipal Corporations have implemented policy measures such as mandating SWH installations by amendment of building bye-laws, rebate in property tax, rebate in electricity bills etc. Additionally, MNRE has programmes for providing interest rate / capital subsidies for SWH installation. In our view, while these programs have met with success in a few regions, the potential is far from realised. Reasons for this could be lack of awareness of policy measures among users, lack of interest among banks to actively fund SWH installations and certain concerns in the mechanism of capital subsidy disbursement. We believe that the schemes / policy measures need to be strengthened through an effective dialogue between stakeholders (end users, Government , Municipal Corporations and Financial Institutions). Also, mandatory implementation policies need to be followed up with effective monitoring to ensure compliance.

From an industry standpoint, the solar sector presents an immense opportunity. The total investment requirement in only the "projects" or "applications" space (not including manufacturing ) is an estimated USD 110 billion in the period 2012-22. This could provide tremendous potential for solar-specific product markets (inverters, parabolic mirrors etc.) to develop in India during the corresponding period, which could be around USD 30 billion.

For mainstream solar companies, we believe that the following are the key imperatives in the near term:

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- Since there is intense competition among the players to get access to projects which are limited in number, it is necessary to work out a model which gives a cost advantage and thereby enables a higher chance of winning projects. Sources of cost advantage could be a certain level of vertical integration into the manufacturing or EPC value chain, access to land sites where solar insolation is superior and access to low cost financing.
- Solar companies should also keep a slightly broad based focus and include segments like off-grid applications and other renewable technologies in their portfolio. This will enable them to optimise their resources in an environment where access to new projects may be uncertain.
- Indian companies should also look at overseas solar markets in the US and Europe for access to projects. In the immediate future, these markets will offer more opportunities and help Indian companies to move up the learning curve and be poised to capitalise on the Indian market when it scales up rapidly. Transaction opportunities to access these markets should be explored.

On the supply chain front, industry will have to gear up to meet this massive requirement and this presents an opportunity from manufacturing to system integration to installation services. The manpower requirements will also be very large and more than one million direct jobs are likely to be created by 2022.

We believe that the solar energy sector is going to have a discontinous impact on our energy sector and certainly a positive and welcome one. The impact will come sooner than most people expect and therefore a readiness to respond to this opportunity needs to be developed if we are to capitalise on it in a timely manner.

It is fair to say that as far as harnessing energy from the sun is concerned, "The Sun Is Rising" and we must equip ourselves to make the most of it.

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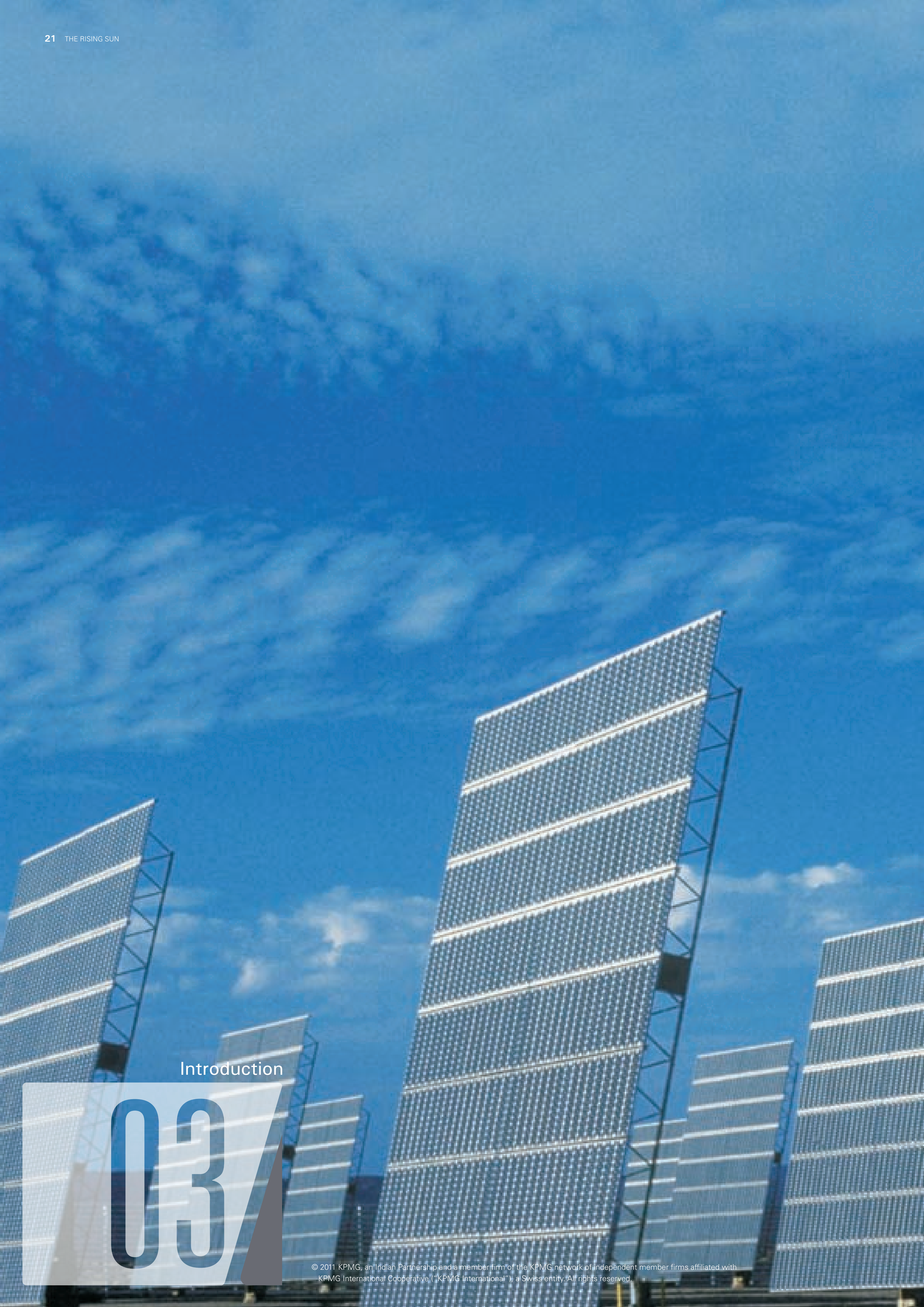

# Introduction

# 03

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# 03 Introduction

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# 03

# Introduction

## Key Questions:

- Why is solar power important for India?
- Globally, how has the solar power market evolved?
- What role has the Indian Government played in supporting the solar programs?

## 3.1 Importance of solar power – energy security and emission mitigation

India is a rapidly growing economy which needs energy to meet its growth objectives in a sustainable manner. The increasing energy requirements have meant that the extent of imports in the energy mix is growing rapidly. Oil imports already constitute nearly 75 percent of our total oil consumption. Coal imports which were negligible a few years back are likely to rise to around 30 percent of the total coal requirement by 2017. Globally, there is intense competition for access to energy resources.. This is a serious cause for concern as the Indian economy gets exposed to the global fuel supply market which is volatile and rising. Moreover, being amongst the top five greenhouse gas (GHG) emitters globally[1], India has a responsibility to achieve the growth trajectory in an environmentally sensitive and responsible manner.

Given this backdrop, alternate fuels like nuclear fuel and renewable energy technologies have been gaining in prominence lately. However, there are several sensitivities related to costs and environment when it comes to nuclear technology. In fact, the recent Japanese experiences at the Fukushima nuclear reactor following a devastating earthquake and tsunami has reignited the debate around safety of nuclear energy and triggered the usual "NIMBY" (Not in My Backyard) syndrome. These developments further strengthen the case for Renewable Energy and particularly that for Solar Energy.

India is a tropical country with abundant sunshine. From time immemorial, Indians have idolized the Sun as the Visible God that provides vital energy for sustenance of life. It is time we utilize this immense potential of solar power which addresses the twin objectives of Energy Security and Carbon Mitigation for India. Moreover, being modular in nature, solar power can meet demand for wide ranging market applications where the size of installations can vary from as low as KWp to MWp scale projects. Further, solar power can meet requirements in areas where conventional power was unable to reach economically due to infrastructure bottlenecks.

The global solar radiation map as shown in the exhibit overleaf clearly shows that India has a radiation advantage compared to several European nations which have the maximum solar installations today.

1. United Nations Greenhouse Gas emissions data

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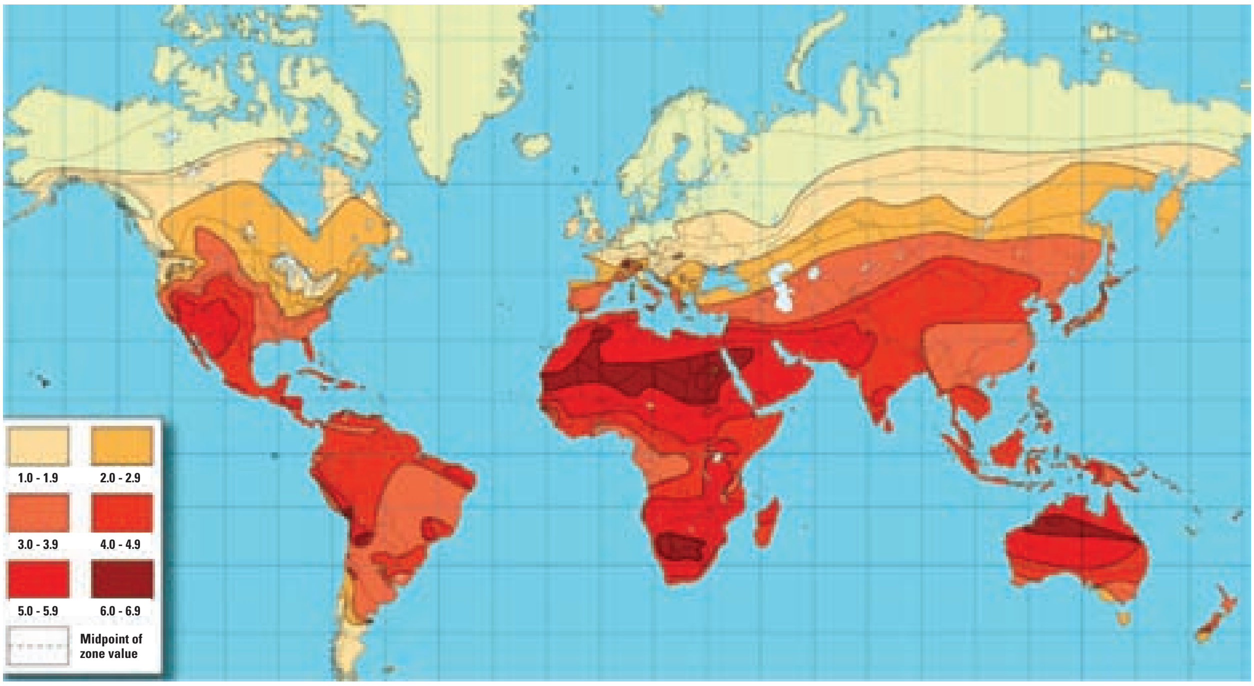
Global Solar Radiation Map (Figures in kWh / Sqm / Day)




**Source:** http://www.oksolar.com/abctech/images/world_solar_radiation_large.gif

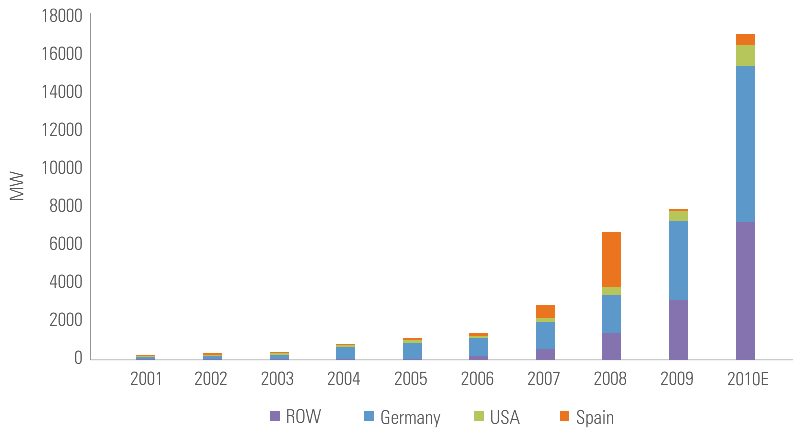
However, high costs have come in the way of solar energy reaching its true market potential. While solar power costs remain costlier when compared to other conventional sources of energy, the cost curves for solar power are declining rapidly.

All in all, besides reducing carbon emissions, solar power can play an important role in sustaining the energy needs of the country.

## 3.2 Solar power market trends – Europe dominates the global market

Globally, Europe has taken the lead and has already installed significant solar based capacity. Germany is the largest solar market globally with total installations of around 17,000 MW. In fact, solar PV provided 12 TWh (billion kilowatt-hours) of electricity in Germany in 2010, about 2 percent of total electricity in that country[2]. A point to note is the fact that the solar insolation in Germany, at about 3.15 units per sq. meter per day, is very low when compared to India's average of 5.50 units per sq. meter per day.

Global annual installations - Germany is the market leader




**Source:** EPIA, KPMG Analysis

2. German Network Agency

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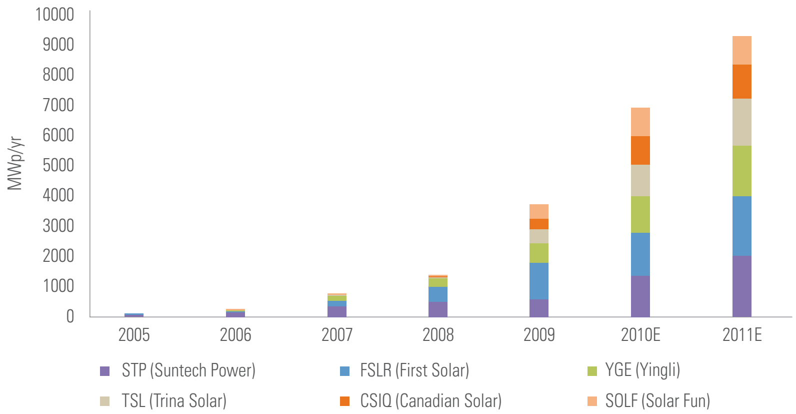
The industry has seen significant capacity additions to meet the growing demand. Hitherto unknown names few years back are billion dollar companies today with GW scale manufacturing capacities.

Significant scale up in manufacturing capacity - Select players




**Source:** Company Reports, KPMG Analysis

## Photovoltaic Solar Power (SPV) Market

Globally, the solar PV market had installations of more than 17,000 MW in 2010 recording a growth of more than 130 percent over 2009[3]. While India's share at around 1 percent is very low at present, it is likely to increase substantially in the future.

## Concentrating Solar Power (CSP) Market

The CSP market picked up globally after more than a decade of dormancy with active Government support that incentivized solar installations. For example, Spanish legislation put in place incentives for CSP fostering the development of this technology. Creation of incentives through Feed-in-Tariff (FiT) mechanism and Investment Tax Credit (ITC) route in several countries also contributed to increase in deployment of this technology. Currently, over 1,400 MW of CSP plants are operational worldwide and over 6,400 MW of plants are under construction[4]. The total capacity of plants in the pipeline is much larger. In fact, CSP projects in arid and desert regions are expected to play an increasingly important role in meeting the electricity requirements for the future. The DESERTEC initiative is a path breaking USD 560 billion project underway in North Africa to meet 17 percent of total electricity requirements of Europe using only 2500 square-kilometer of land (less than 0.02 percent of total MENA area).

The solar market today is dominated by Europe and in the medium term is likely to be dominated by Germany and USA. The emerging markets like India and China will join the race as solar costs continue to drop.

3. German Network Agency, IMS Research

4. Solar Power and Chemical Energy Systems (an implementing agreement of the International Energy Agency), KPMG Analysis

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## 3.3 Government support to solar sector – a right framework has been put in-place

The Government has proactively supported development of sustainable energy solutions as part of the eight missions under the National Action Plan for Climate Change Initiative. A snapshot of the market support available to solar sector is shown below:

**Power Purchase Agreement (PPA) - FiT Driven**

**1 Jawaharlal Nehru National Solar Mission (JNNSM)**

- **Grid-connected:**
  **Phase – 1:**
  - 1,000 MW by 2013 (500 MW of Solar thermal)
  - 20,000 MW by 2022
- **Rooftop & Small-scale Solar Power Generation**
  100 MW already allotted
- **Off-grid & Decentralized Solar Applications**
  Market size of 200 MW by 2013

**2 State level solar programs**

Several states have come out with solar power policies to encourage deployment of solar power.

- **Gujarat:**
  - Signed PPA's for about 965 MW of solar power.
- **Rajasthan:**
  - Phase-1 (up to 2013) Maximum Capacity to be developed 200 MW
  - Phase-2 (2014 -2017) Maximum Capacity to be developed 400 MW (Additional)

**PPA - Market Driven**

**3 Renewable Energy Certificate (REC) Market**

- Developers can trade REC with utilities that are short of the mandated quota of renewable energy in the power exchange
- REC market started trading in India

**Source:** Ministry of New and Renewable Energy, RRECL, GEDA

### 3.3.1 PPA driven support

The Jawaharlal Nehru National Solar Mission (JNNSM) is a transformational initiative for solar energy development in India. The mission targets to propel India as a solar hub with 20,000 MW of grid connected solar power capacity by 2022. The program has been envisaged to be a three stage process with targets set under each phase. Under Phase-1 of the program, to be implemented by March 2013, a target to set up 1,100 MW grid-connected solar plants, including 100 MW as rooftop and other small-scale applications, has been set. Besides the national program, State level solar programs also exist.

The policy framework has generated tremendous interest in this space. In fact, the response JNNSM program has received from the market is overwhelming. The table below summarizes the competitive bidding rates discovered for the Phase-1 projects.

| Solar CSP Projects (470 MW) | Solar PV Projects (150 MW) |
|---|---|
| • Max discount – INR 4.82 per unit (32 percent)<br>• Range of discounts of the top 7 bidders are ~ 20 percent to 32 percent<br>• Applications amounting to 3,100 MW received | • Max discount – INR 6.96 per unit (38 percent)<br>• Range of discounts of the top 30 bidders are ~ 28 percent to 38 percent<br>• More than 300 applications each for 5 MW were received |

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These discounts reflect the rapidly declining cost curves for solar modules.

Even under the Gujarat policy, where the levelized tariff is less than INR 13 / kWh, the response has been overwhelming with close to 965 MW of PPAs (Power Purchase Agreements) signed. The declining cost curves are also reflected in the fact that Germany recently announced feed-in-tariff cuts with tariffs for ground mounted installations in Q1, 2011 at EUR 0.21 – which translates to INR 13.68 per unit. Given the lower labour costs, lower sourcing / EPC costs and better insolation, the costs in India are even lower. While it would not be possible to generalize the statement for all the projects, we believe that the tariffs offered under the NSM program are within the range of being achievable.

Successful completion of the Phase -1 under NSM and Gujarat state policy would accelerate the process of achieving grid tariff parity for solar power.

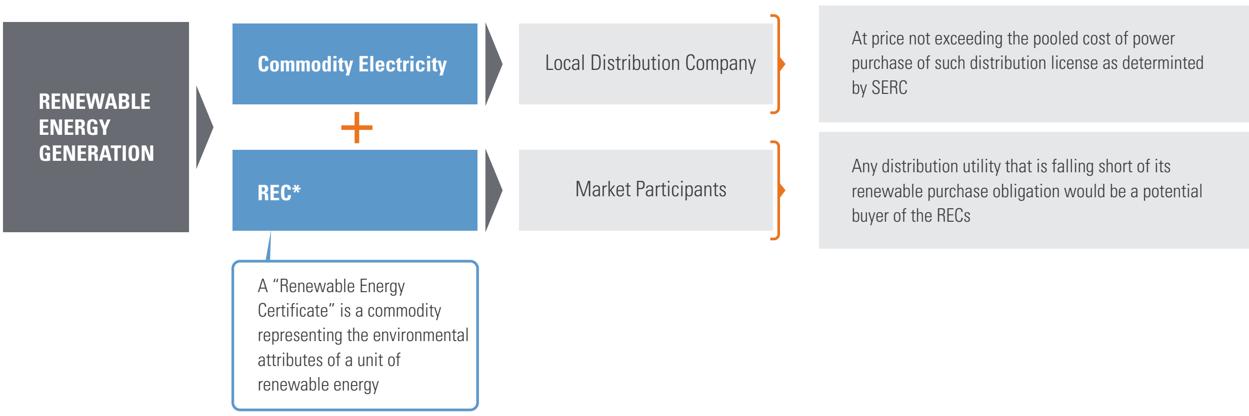
### 3.3.2 REC market

Renewable Energy Certificate (REC) mechanism provides a market opportunity for players who do not have PPAs for renewable energy with state utilities.

Under this mechanism, cost of electricity generation from renewable energy sources is classified as cost of electricity generation equivalent to conventional energy sources and the cost for environmental attributes. These environmental attributes can be exchanged in the form of Renewable Energy Certificates (REC). Thus, RE generators will have following options:

- To sell the renewable energy at preferential tariff or
- To sell electricity generation and environmental attributes associated with RE generations separately.

These RECs will be traded in the power exchange[5]. The concept of REC has been explained in brief in the diagram below:




**Source:** KPMG's The Rising Sun, 2011

The REC market has already started functioning with demand for RECs exceeding the supply. In fact, IEX received 30,001 purchase bids for solar RECs with no offers as no solar energy projects have been accredited so far and hence no solar REC was available. Trading takes place last Wednesday of every month. As liquidity improves and market deepens, the frequency of trading days will go up.

We believe that going forward enforcement of RPO (Renewable Purchase Obligations) will create the volumes needed for the REC market. Demand for REC will come from obligated entities that include not just utilities but also Captive and Open Access consumers. With increase in liquidity and market depth, the REC mechanism can play a catalytic role in development of solar power market in India. Additionally, the REC market can go a long way in encouraging development of merchant solar power plants in India.

5. One REC is equivalent to 1 MWH of electricity generated from renewable energy source and injected into the grid.

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# Solar power cost drivers

04

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# Solar power cost drivers 04

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# 04

# Solar power cost drivers

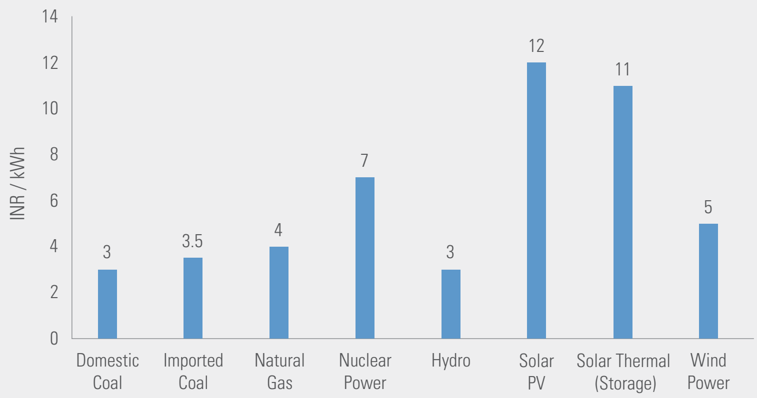
**Key Questions:**

- What are costs of solar power today?
- How are the key cost drivers evolving for solar PV and CSP?

## 4.1 Solar power costs – relatively higher when compared to other fuels

Solar power is expensive when compared to conventional sources of power and hence the solar market development is currently dependent on Government support.

Indicative levelized cost comparison of power from different fuels




**Source:** Industry Estimates, KPMG Analysis

During the last few years, there has been significant cost reduction in solar power and the cost curves of solar power are declining. On the other hand, costs of power from conventional sources are increasing due to higher fixed costs and rising fuel prices. Moreover, there is considerable research that is underway to further explore cost reduction possibilities for solar power.

While there are multiple solar technology options, particularly two technologies viz. solar crystalline and solar parabolic trough are considered mature and likely to reach grid parity faster.

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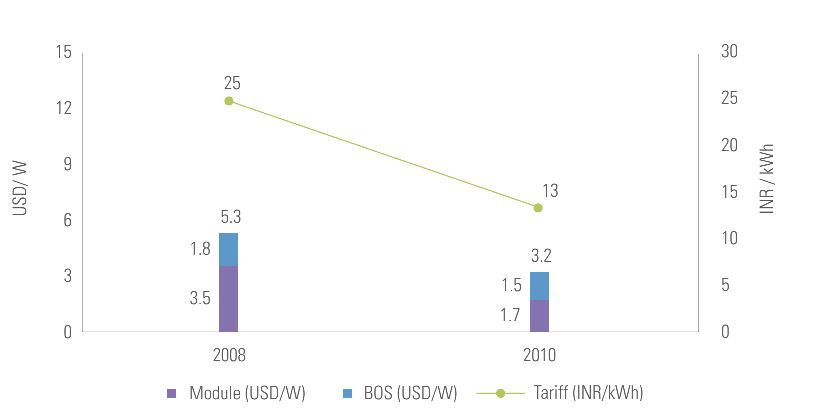
## 4.2
## Solar PV

### 4.2.1
### Crystalline Silicon technology – costs are declining rapidly

The solar crystalline PV technology dominates the market for solar PV installations globally. Dynamic cost reductions have accelerated deployment of Solar C-Si (crystalline silicon) technology in the recent past. The module prices have dropped from around USD 3-4 per W about two years back to under USD 1.5-1.8 per W today. Consequently, the proportion of module prices in the total system price has come down significantly. The corresponding price of electricity which was upwards of INR 25 has dropped to around INR 13 per unit.

Globally, solar PV system prices have dropped significantly...




**Source:** Analyst Reports KPMG Analysis

Some of the drivers that have contributed towards this price reduction are mentioned below:

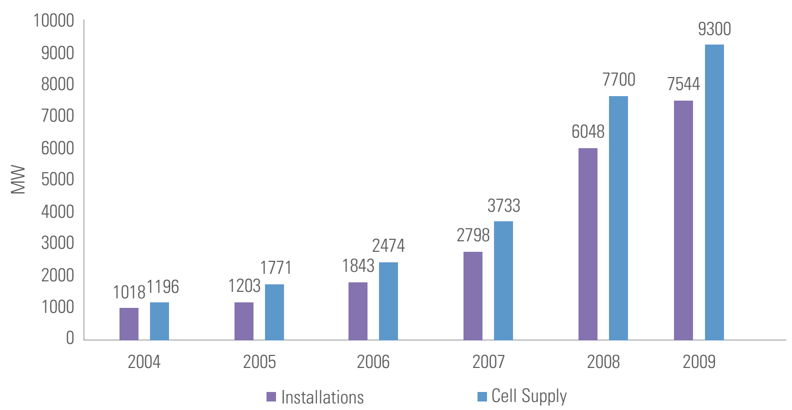
| | | |
|---|---|---|
| **Polysilicon Costs** | **~400 USD/ Kg** | ~ 50-60 USD/ Kg |
| **Silicon Usage** | **> 8 gm/ W** | ~ 6-6.5 gm/ W |
| **Processing Costs** | **> 1.2-1.3 USD/ W** | ~ 0.7-0.8 USD/ W |

**Source:** DOE, NREL, KPMG Analysis

Beside the aforementioned factors, the solar module prices have also been affected by the global market supply scenario. The entry of China into the solar manufacturing space has contributed significantly to lower costs. Economies of scale and global recession in 2008 coupled with oversupply of modules resulted in the squeeze on margins across the board, triggering a sharp fall in prices.

Going forward, while poly-silicon prices continue to be an important determinant factor, other key elements like processing costs and silicon usage will gain prominence. Fully integrated Chinese manufacturers have attained cost leadership position today in C-Si and are likely to continue producing modules with global cost leadership.

Market Scenario - Oversupply




**Source:** EPIA, Industry Estimates, JP Morgan Report, KPMG Analysis

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It may be mentioned here that within the overall system costs, the proportion of the non-module system costs is increasing. In fact, the cost reduction possibilities in the non-module segment of the system costs could well determine the timing of grid parity.

The cost reduction trends for non-module system costs are listed here:

| Balance of system (~45-50 % of total solar system cost) | Inverters | Transformers, switch gears and cables | Civil and General Works | Installation and Commissioning | IDC and Financing charges |
|---|---|---|---|---|---|
| Key Considerations | • Majority of Inverters are imported currently<br>• Players are looking at assembly of inverters in India which could contribute towards cost reduction | • Market and technology already establised<br>• Driven by prices of commodities like copper and CRGP coil | • Driven by localized site conditions and low labour costs | • Availability of manpower for design engineering<br>• Local sourcing of materials | • Driven by low cost innovative financing options<br>- Exim route<br>- Tax free solar bonds |
| Potential for cost reduction | LOW | LOW | HIGH | HIGH | HIGH |

**Source:** IEA-PVPS, Industry Estimates, NREL, KPMG Analysis

Given this backdrop, we have looked at overall system costs from a utility scale perspective as well as from a residential rooftop perspective. While module costs may not be significantly different, the non-module and balance of system costs could be cheaper at a utility level when compared to the small-scale residential rooftop segment. Further, the constraint of higher land availability which would be there for utility scale project does not exist for small-scale roof top projects where unutilized space can be effectively used.

Overall, we estimate that PV system prices could decline at the rate of 7 percent per year over the next decade.

## 4.2.2 Thin-film PV

Thin film modules are constructed by depositing extremely thin layers of photosensitive materials onto a substrate such as glass, stainless steel or flexible plastic. Correspondingly, thin-film has less raw material consumption. However, the typical efficiencies between 7 and 10 percent[1] are much lower when compared to crystalline PV. Moreover, global market for thin-film has been driven significantly by First Solar.

1. Industry Estimates

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A brief snapshot of the comparison among the thin-film technology options is shown below:

| | Amorphous Silicon A-Si | Cadmium Telluride - CdTe | Copper Indium Gallium Selenide - CIGS |
|---|---|---|---|
| **Industry Stage** | • Easy to access technology and find partners<br>• Median scale of players – (50 MW) | • Process innovation stage - Proprietary technology access | • Product innovation stage - CIGS is still in infancy stage<br>• Lowest cost potential exists |
| **Players** | • Many established players like Sharp, Q cells and Schott Solar have diversified into A-Si | • First solar is the largest thin-film manufacturer in the world<br>• Some industry players have exited this space | • New entrants and start-ups are focused |
| **Concerns** | • Efficiency degradation<br>• Lower conversion efficiency | • Feedstock limitation -Availability of telluride<br>• Cadmium is carcinogenic | • CIGS is limited by availability of Indium , a rare earth metal that could cause supply bottleneck |

**Source:** KPMG's The Rising Sun, 2011

After nearly two decades of technology development efforts, the share of the Thin Film solar cell technology is still low. There is significant research afoot with focus on improvement of efficiency along with reductions in cost. Meanwhile, silicon crystalline technology continues to have an edge over Thin Film technology.

## 4.3 Concentrating Solar Power (CSP)

The technologies under solar thermal can be broadly classified as Parabolic Trough, Solar Power Tower, Linear Fresnel and Dish Sterling. Among the Solar Thermal technologies, only Parabolic Trough technology has seen large scale installations globally. Dish Sterling and Power Tower technologies are well established but still to experience large scale commercial implementation. While Dish Sterling has capacity limitations, Power Tower has higher capital costs. Hence, parabolic trough has clear edge over others in the global solar thermal market.

| Key Parameters | Parabolic Trough (Most commercially proven technology) | Central Receiver Systems - includes Power Tower (Prototype, Semi Commercial ) | Parabolic Dish (Prototype testing) |
|---|---|---|---|
| Solar Concentration Ratios[2] | 50-100 kW/sqm | 600-1,000 kW/sqm | 1,500-4,000 kW/sqm |
| Key Advantages | • High system reliability<br>• Low materials demand<br>• Proven hybrid concept<br>• Storage capability<br>• Best land use factor | • High temperature (around 800°C)<br>• High efficiency possible<br>• Hybrid operations possible | • Potential for low capex<br>• High efficiency<br>• Modularity |
| Applications | Grid-connected plants, mid-to-high process heat | Grid-connected plants, high temperature process heat | Stand alone, small off-grid power systems or clustered to larger grid-connected dish-parks |

**Source:** KPMG's The Rising Sun, 2011

About 95 percent of the operational or under constructions plants are based on parabolic trough technology. In India, under Phase I of JNNSM and the Gujarat state policy, Power Purchase Agreements (PPA) have been signed for 525 MW of Solar CSP power projects which provides a major impetus to the solar CSP market in India.

2. Analyst Reports, Industry Estimates

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## 4.3.1
## Drivers for cost reduction in Parabolic Trough technology

The key component market for parabolic trough technology has oligopoly characteristics dominated by a small number of players. The market in Europe has been dominated by technology players who are integrated across the value chain right up to project development. In fact, access to technology besides project design and execution becomes important to ensure cost competitiveness. Further, from an Indian market context, the cost reduction could be driven primarily by the following factors:

1 Localization – Extent of indigenization

2 Economies of Scale – Direct impact on cost per MW

3 Manufacturing innovations and value engineering – Increasing efficiency and reducing cost

4 Usage of storage system – Higher availability

### 1. Localization

High value components such as trough structures, parabolic mirrors and the complete power block lend themselves to savings through localization and competition intensity.

| Trough Structure | Parabolic Trough Mirrors | Molten Salt Storage Components | Power Block | Engineering Design/ Execution |
|---|---|---|---|---|
| • Most fabrication requirements – welding, casting etc available<br>• Localization possible with design transfer and hand-holding | • Most raw materials available locally<br>• Manufacturers with required competence present in India<br>• Manufacturing machines need to be imported | • Requires fabrication of pipes, tanks<br>• Manufacturers with required competence present in India<br>• Pumps may still be imported | • Turbines are specialized but global suppliers have Indian presence – can localize<br>• Heat exchangers – Local designs available | • Limited capabilities with Indian vendors. However, required CAD/ CAM facilities available<br>• Local manpower available |

**Source:** Based on KPMG local market survey

Most components can be localized readily or with limited assistance. The pace of localization would depend on industry development based on market size visibility. Certain complex items (e.g. Absorber tubes, Heat transfer fluid, Control and Instrumentation (C&I) components, specialized pumps) may take time to localize due to limited suppliers, requirement for scale and concentration of technology. We believe a total cost savings of 20-25 percent is possible due to localization and competitive sourcing of certain components.

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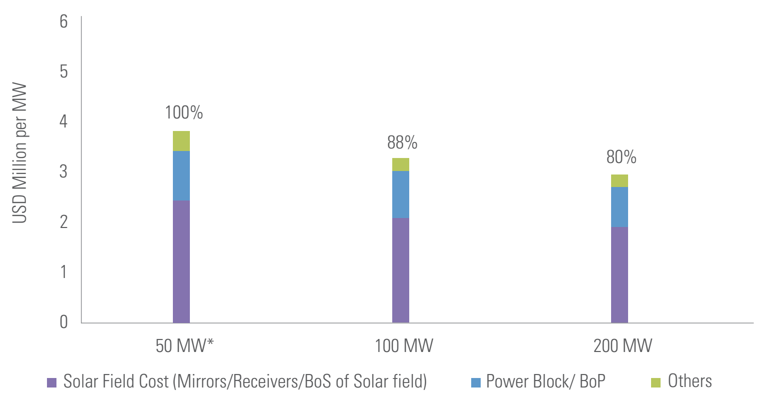
## 2. Economies of scale

Economies of scale resulting from increase in size of the solar CSP plant contribute towards reduction in the investment cost of the plant. As per industry estimates, when a solar CSP plant of 50 MW in size is scaled up to 150-200 MW, the investment costs reduce by 15-25 percent.

### Scale Benefit-Reduction in Capital Costs




**Source:** Industry Estimates, Fichtner Solar, NREL, KPMG Analysis

## 3. Manufacturing innovations- cost and efficiency improvements

Manufacturing innovation can lead to reduction in costs of core components. Some of the drivers are mentioned below:

| Mirrors | Absorber tubes | Heat Transfer Fluids | Solar Field |
|---|---|---|---|
| • Design Optimization-Larger solar collectors with bigger mirror facets and larger tube diameters can lead to a lower number of trough rows, reducing the cost per mirror surface.<br>• Usage of Alternative mirror material with higher reflectivity like thin glass mirrors, polymer reflector on aluminum substrates etc. | • Technological advancements like greater absorber diameter to capture lost radiation, improved optical values of absorber tube coating, abrasion resistant anti reflective coating etc.<br>• Drop in the break rate of receiver from 4 percent to 1 percent through new kind of glass-metal seal. | • Improved synthetic aromatic fluid with better heat transfer coefficient<br>• Alternative HTF fluid options that can increase the temperature beyond 400 C | • Enlargement of collector area, reduction of steel usage and usage of alternative materials may lead to cost reduction. |

**Source:** NREL, KPMG Analysis

## 4. Usage of storage system

Storage systems can play an important role in increasing solar CSP installations. In fact, storage is the differentiating factor that works in favour of solar CSP when compared to solar PV. Besides lending grid stability, the solar CSP systems can be designed to meet the peak power requirements. A storage system, say with nine hours of storage, in a grid-connected Solar CSP plant increases the capital cost ~ 1.8-1.9 times, but at the same time the Capacity Utilization Factor (CUF) increases ~ 2-2.1 times, thus, decreasing the cost per unit of electricity generated[3].

3. Note: Prices of salts used in storage are volatile and have witnessed significant movements in the past. This analysis is based on the conventionally established prices of these salts.

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Grid parity projections

05

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# 05 Grid parity projections

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# 05

# Grid parity projections

## Key Questions:

- When is the grid parity likely to happen for solar power?
- Which segments of the market are likely to reach grid parity?

The market for Solar will grow exponentially as costs of generating solar power inches closer to conventional power sources. Grid parity is said to occur when the landed cost of solar power reaches the same level as the cost of conventional power. This phenomenon is state specific as well as end-use application specific. This is because the cost of conventional power is different for different applications. We believe grid parity will happen in stages for India. Within States, there is significant variation between the costs of power at utility input level and at the residential level. The cost of power is lower in energy resource rich States while import dependent States have higher cost of power. Additionally, cost of solar power is dependent on level of solar radiation in a state. Accordingly, we have looked at costs of power for various States in the country and analyzed the likely cost trends to estimate which states are likely to reach grid parity earlier.

Furthermore, the solar power tariffs at the consumer segment would be lower once the benefits from CDM[1] are taken into account. In the long run, it is possible that there could be a mechanism that is different from the prevailing CDM mechanism. However, the carbon emission market is expected to remain given the increasing environment awareness. In our calculations, we have factored in the benefit from CDM and have projected the solar power tariffs at the grid level and at the users end. For computation purposes, this benefit has been quantified to be equivalent to INR 0.60 per unit.

1. The landed cost of solar would be INR 0.60 / kWh lesser than the solar price.

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## 5.1 Power costs from conventional sources

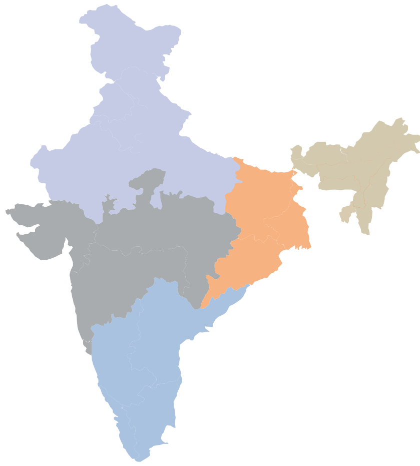
The major demand centers lie in the Northern, Western and Southern regions of the country and are projected to contribute ~85 percent[2] of the total energy requirement in 2021-22. In these regions, the major demand-centric states are as shown in the exhibit.

### Major states contributing to Indian energy demand

| Energy Requirement (% Wrt India) | 2021-22 |
|---|---|
| Punjab | 6% |
| Rajasthan | 5% |
| Uttar Pradesh | 8% |
| Northen Region | 29% |

| Energy Requirement (% Wrt India) | 2021-22 |
|---|---|
| Gujarat | 8% |
| Madhya Pradesh | 5% |
| Maharashtra | 11% |
| Western Region | 29% |

| Energy Requirement (% Wrt India) | 2021-22 |
|---|---|
| Andhra Pradesh | 9% |
| Karnataka | 6% |
| Tamil Nadu | 10% |
| Southern Region | 27% |



| Year | Energy Requirement (MU) | % CAGR |
|---|---|---|
| 2011-12 | 968,663 | – |
| 2016-17 | 1,392,151 | 7.5% (on 2011-12) |
| 2021-22 | 1,915,629 | 6.6% (on 2016-17) |

**Source:** 17th Electric Power Survey, CEA; KPMG Analysis

Historically, the landed cost of power (LCP) (or cost-of-service to consumers) has increased at an average annual growth-rate of 4-5 percent[3]. However, going forward, the power purchase costs are expected to rise at a higher rate given the increasing contribution of imported coal in the Indian energy mix. For our analysis, we have looked at two scenarios. In the first scenario, we have estimated the LCP to increase at the historic levels of 4 percent. In the other scenario, we have taken a higher percentage increase.

2. 17th Electric Power Survey (EPS) Estimate, KPMG Analysis
3. PFC Report on performance of State Utilities, KPMG Estimates

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## Base scenario

The historical year-on-year growth rate in LCP for India in the last decade has been more than 4 percent. Going forward, the rate of increase in LCP for States would depend on internal efficiency drives towards reducing losses. Hence, States with very high loss levels today will see a relatively lower increase in LCP growth assuming that they will improve their efficiency levels. Accordingly, we have assumed the LCP for states with low AT & C losses (less than India's loss levels (~29 percent)) to grow at 4 percent, with moderate AT & C losses (greater than India's loss levels but less than 50 percent) to grow at 3 percent, and for others with high AT & C losses (greater than 50 percent) at 2 percent.

The table summarizes the likely LCP for a particular year between five year time horizons for key states along with an All-India estimate.

| | Actual | Forecast | | |
|---|---|---|---|---|
| States | Average Landed Cost of Power (2006-07) | Average Landed Cost of Power (2011-12) | Average Landed Cost of Power (2016-17) | Average Landed Cost of Power (2021-22) |
| Punjab | 3.70 | 4.54 | 5.52 | 6.72 |
| Rajasthan | 4.38 | 5.91 | 7.18 | 8.74 |
| Uttar Pradesh | 4.07 | 4.75 | 5.50 | 6.37 |
| Gujarat | 3.73 | 4.57 | 5.56 | 6.76 |
| Madhya Pradesh | 4.11 | 4.88 | 5.38 | 5.94 |
| Maharashtra | 4.05 | 4.22 | 4.89 | 5.66 |
| Andhra Pradesh | 2.95 | 3.91 | 4.76 | 5.79 |
| Karnataka | 3.59 | 4.39 | 5.34 | 6.49 |
| Tamil Nadu | 3.45 | 4.65 | 5.66 | 6.88 |
| **India** | **3.86** | **4.70** | **5.71** | **6.95** |

**Source:** PFC Report on performance of State Power Utilities, KPMG Analysis (Units: INR / kWh)

## Aggressive scenario

In this case, we have assumed a higher percentage growth in year-on-year LCP of 5.5 percent. For individual states, we have assumed the LCP for states with low AT & C losses (less than India's loss levels (~29 percent)) to grow at 5.5 percent, with moderate AT & C losses (greater than India's loss levels but less than 50 percent) to grow at 4.5 percent, and for others with high AT & C losses (greater than 50 percent) to grow at 3.5 percent.

The table summarizes the likely LCP for a particular year between five year time horizons for key states along with an All-India estimate.

| | Actual | Forecast | | |
|---|---|---|---|---|
| States | Average Landed Cost of Power (2006-07) | Average Landed Cost of Power (2011-12) | Average Landed Cost of Power (2016-17) | Average Landed Cost of Power (2021-22) |
| Punjab | 3.70 | 4.81 | 6.28 | 7.79 |
| Rajasthan | 4.38 | 6.26 | 8.18 | 10.13 |
| Uttar Pradesh | 4.07 | 5.03 | 6.27 | 7.48 |
| Gujarat | 3.73 | 4.84 | 6.32 | 7.83 |
| Madhya Pradesh | 4.11 | 5.17 | 6.14 | 7.05 |
| Maharashtra | 4.05 | 4.47 | 5.57 | 6.64 |
| Andhra Pradesh | 2.95 | 4.15 | 5.42 | 6.71 |
| Karnataka | 3.59 | 4.65 | 6.07 | 7.52 |
| Tamil Nadu | 3.45 | 4.93 | 6.44 | 7.98 |
| **India** | **3.86** | **4.97** | **6.50** | **8.50** |

**Source:** PFC Report on performance of State Power Utilities, KPMG Analysis (Units: INR / kWh)

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As shown in these tables, there is significant variation in the LCP for different States. For example, in the base-case scenario, the LCP for different states is likely to be in the range of INR 4.8 – 7.2 / kWh in 2016-17 and INR 5.7 – 8.7 / kWh in 2021-22. However, in the aggressive-case scenario, the LCP for different states is likely to be in the range of INR 5.4 – 8.2 / kWh in 2016-17 and INR 6.9 – 10.7 / kWh in 2021-22.

Further, based on the LCP calculations, the cost of power at utility/grid level and cost of power at domestic/residential level have been estimated as explained below:

- The levelized tariff of electricity at grid level for 2010-11 has been assumed at INR 4.00 / kWh. While recent Case 1 bids have shown a levelized tariff in the range of INR 3.50/kWh to INR 4.0/kWh, we have taken the higher end of the range because utility scale solar plants are likely to be located in the north-western states and parts of peninsular India where the transmission charge for conventional plants from the pithead is high. Further, medium-scale solar power plants can be connected at sub-transmission voltage levels and therefore have benefit of lower network losses.
- The landed cost of power at LT (Low-tension) network catering to residential, agriculture, commercial and other categories = (100 percent + 20 percent) * Average Landed Cost of Power[4] to account for cost of the distribution network and higher losses at lower voltages.

### 5.1.1 Tariffs expected to be cost reflective

With increasing LCP, the utilities would have two options to improve their financial performance (as most states have subsidized tariffs):

- Increase consumer tariffs – Reflect cost of power
- Depend on higher Government Subsidy

Close to 50 percent[5] of the total Indian power demand is expected to come from tariff sensitive consumer segments - residential and agriculture. In most Indian states, these consumer categories are heavily subsidized, with residential consumers paying an average tariff of INR 2.75 / kWh and agriculture consumers paying an average tariff of INR 1.07 / kWh as compared to the LCP at LT of INR 5.42 / kWh[6]. However, it may be mentioned here that the Government of India's National Tariff Policy mandates linkage of tariffs to cost of service. Further, the policy stipulates that the tariffs should be within ± 20 percent of the average cost of supply for all the categories.

It becomes economically viable to shift from conventional power to solar power as and when solar costs reach the level of cost of serve tariffs.

In the subsequent sections, the projections for grid parity have been developed based on cost trends from solar technologies.

4. Based on cost of service estimates in certain State utilities, KPMG Analysis
5. 17th Electric Power Survey, KPMG Estimates
6. PFC Report on performance of State Utilities, KPMG Estimates

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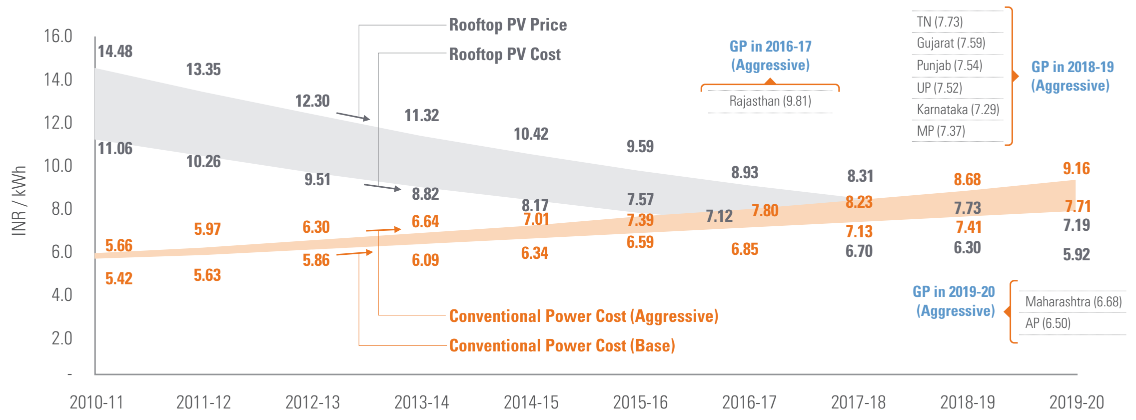
## 5.2
## Grid parity projections for small-scale - domestic and agriculture segments

The LCP for domestic and agriculture segments is higher when compared to large scale utility power segment. This is due to the fact that the utility incurs additional network costs of providing the necessary infrastructure for meeting the last mile power requirements besides high losses. Hence, this segment is likely to reach grid parity first. Solar PV due to its modular nature is more suitable to meet the requirements of the domestic small-scale applications. Accordingly, the computations have been developed taking into account the higher cost of solar power due to the smaller scale.

In the exhibit below, we have showcased a band representing solar rooftop costs. The band variation signifies the margins, i.e. the difference between cost and price (includes margins across the value chain). We expect the solar tariff to lie anywhere within this band depending on the bargaining power of the developers.

### Rooftop PV Costs vs. Conventional Power Cost at Consumer-end




| Grid Parity (GP) Year | Aggressive Case | Base-Case |
|---|---|---|
| Rooftop PV Price | 2017-18 | 2019-20 |

**Source:** KPMG's Solar Grid Parity Model

While we expect grid parity for these consumer categories – domestic and agriculture - in 2019-20, based on state-specific and end-use specific cost economics the adoption for solar is likely to happen earlier.

## 5.3
## Grid parity projections for large scale - utility power

The large scale utility power can be procured either from Solar PV or from CSP depending on the cost economics. However, solar CSP, due to the storage factor, can be instrumental in meeting the evening peak requirements and therefore be potentially more attractive from a utility scale perspective.

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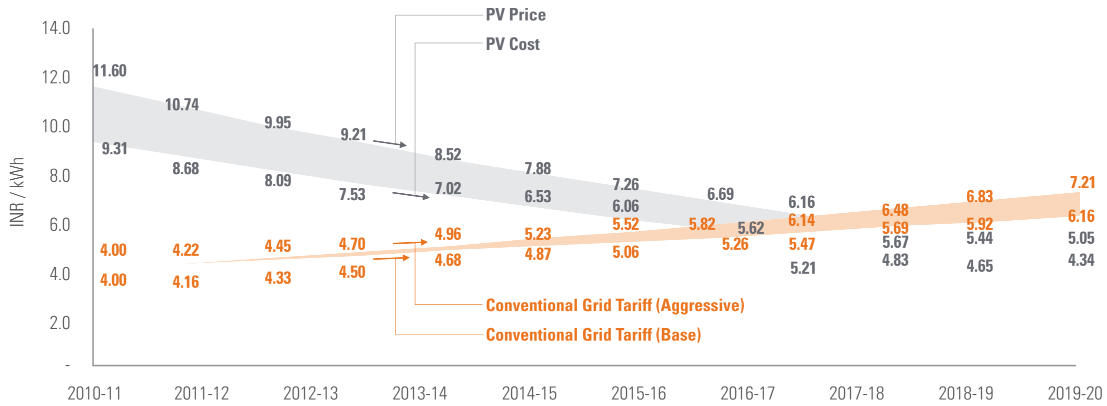
## 5.3.1
## Solar PV - utility scale projections

The figure below represents the likely timeframe when solar PV could reach grid parity:

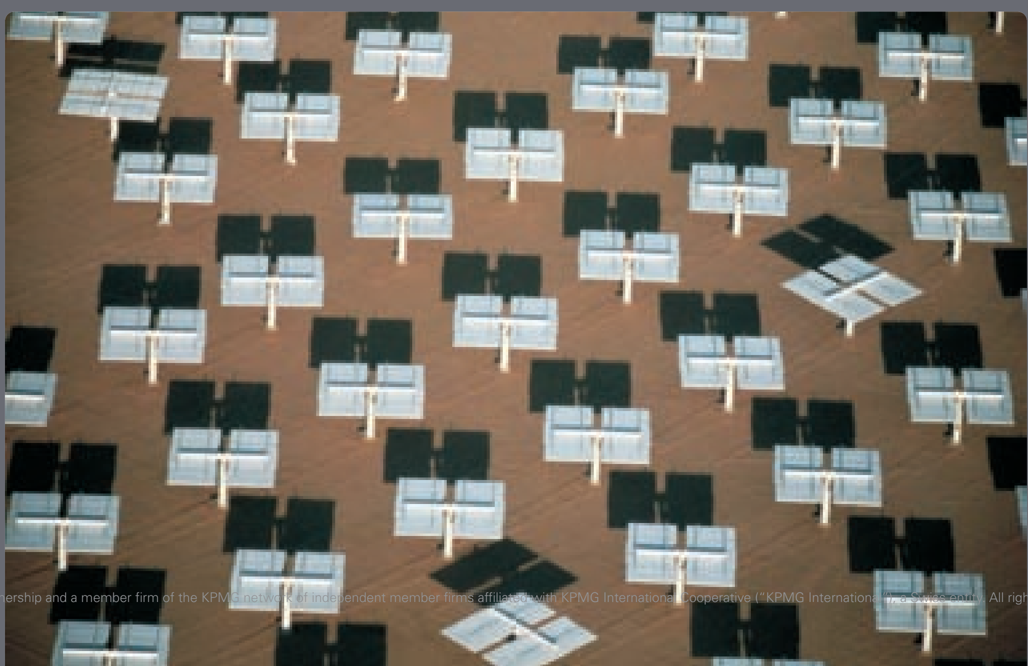
### Levelized Cost Comparison of Utility-scale PV and Conventional Power at Grid




| Grid Parity Year | Aggressive Case | Base-Case |
|---|---|---|
| Utility PV Price | 2017-18 | 2019-20 |

**Source:** KPMG's Solar Grid Parity Model

As shown in the exhibit above, the grid parity is likely to happen between 2017-18 and 2019-20. Here, the solar utility band represents the margins – difference between cost and price - that are likely to vary depending on the bargaining power of the developers. We have compared the levelized tariffs from solar power with respect to the levelized tariff of electricity at grid-level for the corresponding year. Similar to what we have shown in the grid parity projections for small-scale applications, we expect certain states like Rajasthan to achieve grid parity well before the rest of India.



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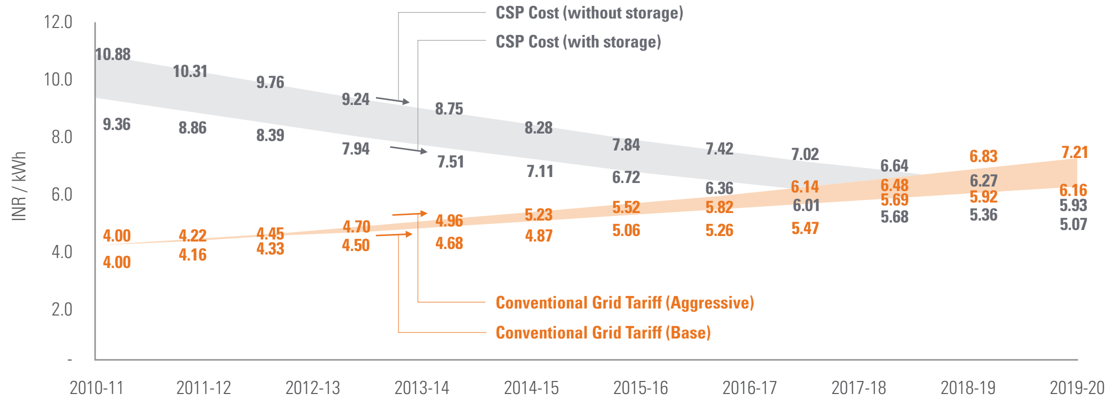
## 5.3.2
## Solar CSP – utility scale projections

The figure below represents the likely timeframe when solar CSP could reach grid parity. The solar CSP costs are likely to be lower for systems with storage due to the higher PLF.

### Levelized Cost Comparision of Solar CSP and Conventional Power at Grid




| Grid Parity Year | Aggressive Case | Base-Case |
|---|---|---|
| CSP with Storage | 2017-18 | 2019-20 |

**Source:** KPMG's Solar Grid Parity Model

As shown in the exhibit above, the grid parity is likely to happen between 2017-18 and 2019-20. We have compared the levelized tariffs from solar power with respect to the levelized tariff of electricity at grid-level for the corresponding year.

Similar to what we have shown in the grid parity projections for small-scale applications, we expect certain states like Rajasthan to achieve grid parity well before the rest of India.

## 5.4
## Summary of grid parity projections

As discussed above, the grid parity is likely to happen at different stages for different consumer segments and States. The table summarizes the likely time-frame when solar power costs reach grid parity level.

| Grid Parity – All India | Aggressive Case | Base-Case |
|---|---|---|
| Small-scale - Domestic Rooftop and Agriculture Segments (Considering parity in landed cost of power to these consumers and the levelized tariff of small-scale solar PV prices) | 2017-18 | 2019-20 |
| Large Scale - Utility Power (either Utility-scale PV or CSP with storage) (considering parity in levelized tariffs of electricity at Grid-level and CSP Costs (with storage) or Utility PV prices) | 2017-18 | 2019-20 |

**Source:** KPMG's The Rising Sun, 2011

Some States in India would reach the grid parity levels before the timeframes mentioned in the table above. The demand shift is likely to be driven by cost economics of solar power and conventional power sources. However, initiatives such as enforcement of solar purchase mandates; cess on conventional power; CDM benefit and other incentives would provide impetus to this sector in the interim.

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# Solar power market in India

06

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# 06 Solar power market in India

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# 06

# Solar power market In India

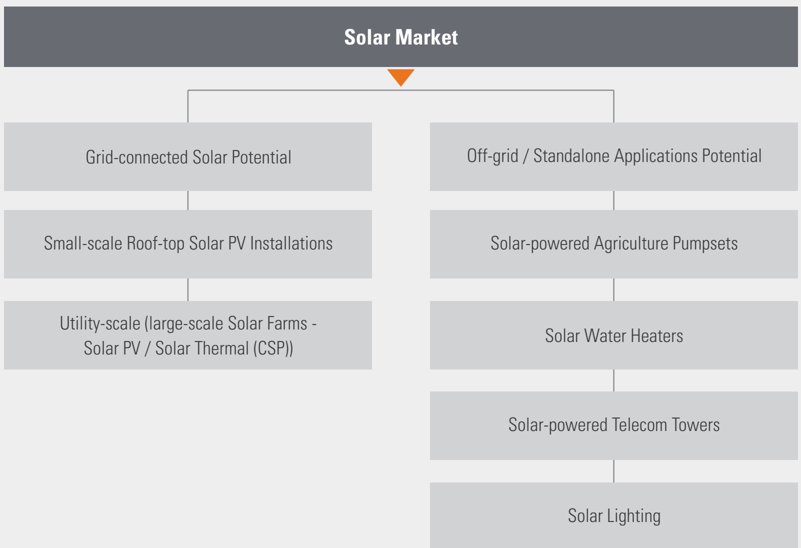
## Key Questions:

- What is the likely solar market potential in the medium term and long term for grid-connected power?
- Which key consumer segments are likely to switch to solar?

The last few years have seen significant developments in the solar sector. There is growing recognition for the adverse impacts of global climate change. The importance of encouraging renewable energy technologies is well established.

Globally, governments of various countries have announced market support initiatives targeted at increasing the share of renewable energy technologies in the overall energy mix. This increase in support is reflected in the increase in size of solar market with annual installations increasing from less than 1,000 MW[1] in 2003 to more than 17,000 MW in 2010. The global market size will increase significantly in the future with decreasing solar power costs.

As we approach grid parity, consumers are likely to evaluate the option of adopting solar power due to its cost economics. There are multiple applications that would make solar power potentially attractive.




**Source:** KPMG's The Rising Sun, 2011

1. Analyst Reports – Global Solar Demand

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## 6.1 Demand for solar power - grid-connected consumer segments

The likely potential from different consumer segments depends on the tariffs and the pattern of usage. Solar power could become attractive for the high-end consuming segments in the residential category where the tariffs are reflective of the cost to serve. The Agriculture sector has been testing the finances of the utilities due to its low paying capability. Moreover, the supply hours are staggered and service quality is poor. Solar power has a good fit with agriculture as the power will be available when the sector needs it the most. During the monsoon, the agriculture sector would use lesser power since their water requirements would be rain fed. Therefore, once grid parity is achieved, solar power can be an economic and convenient alternative to grid power for the agriculture sector even without storage solutions. For the industrial segment that requires continuous demand, the shift is not likely to happen without cost effective storage solutions. However, utilities can plan for solar installations at suitable sites.

In the exhibit below, we have summarized the solar attractiveness for various customer segments and the mode of solar power that could be supplied to each of them.

| Consumer Segment | Solar Attractiveness | Reasons | Solar Application |
|---|---|---|---|
| Residential | High | • High-end residential consumers are likely to adopt solar rooftop to offset likely high residential tariffs (cost-to-serve reflective)<br>• Government involvement would be required to encourage other residential consumers to adopt solar rooftop as they would likely to be a subsidized segment | • Small-scale and Grid-scale<br>• Off-grid / standalone applications |
| Commercial Establishments | Low | • Accessibility (installation constraints)<br>• Tariffs would likely reflect Landed Cost of Power<br>• Some potential exists for schools / educational institutions and other stand-alone commercial establishments | • Grid-scale Solar Power<br>• Solar-powered telecom towers |
| Agriculture | High | • Governments likely to encourage hybrid models to reduce increasing subsidy payout<br>• Agriculture consumers may not resist as they will get reliable supply during day time | • Solar-powered Agriculture Pumpsets |
| Low-tension Industries | Low | • Accessibility (installation constraints)<br>• Tariffs would likely reflect Landed Cost of Power<br>• Some potential exists in stand-alone LT industries | • Grid-scale<br>• Solar water heating devices |
| High-tension Industries | Low | • Will require reliable & continuous supply<br>• Tariffs would likely reflect Landed Cost of Power<br>• May not prefer solar unless storage solutions are viable | • Grid-scale<br>• Solar water heating devices |

Low Medium High

**Source:** KPMG's The Rising Sun, 2011

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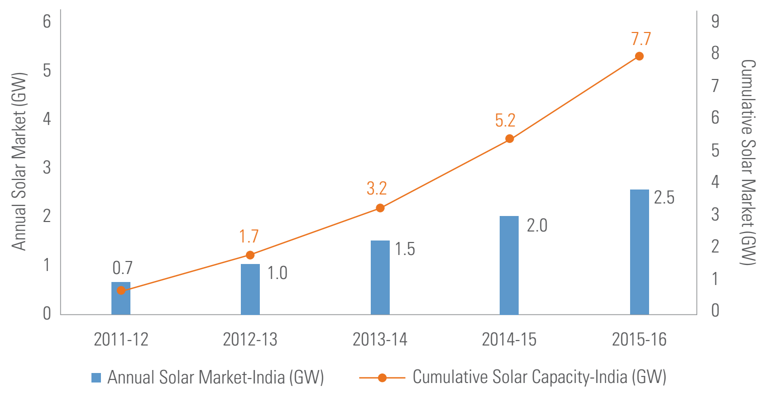
Our approach for estimating the market potential has been detailed in the following sections.

## 6.2 Grid-connected market opportunity – medium term

The market will be driven in the medium term by Government support at the Centre and at the State level. Our estimate of the likely market potential is shown in the exhibit.

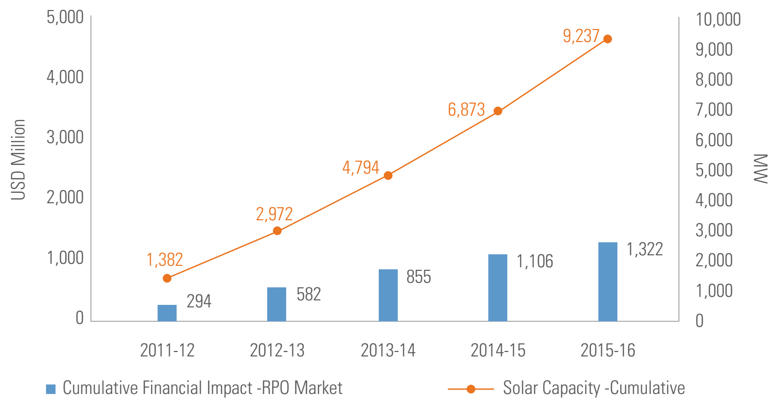
### Solar Market - India




**Source:** KPMG's Solar Market Potential Model

Furthermore, the amended tariff policy stipulates the solar power purchase obligation to go up to 3 percent by 2022. Accordingly, the solar power requirements and the corresponding estimates of the additional financial cost on the sector have been computed and are as shown in the exhibit.

### Cumulative solar grid-connected estimates - Based on solar power purchase obligations




**Source:** MNRE, KPMG Analysis

Unless this burden is shared through a credible funding plan, it would be difficult to sustain the solar power quantum. As is explained in the later part of this report, this stage is extremely important if we are to achieve the longer term potential once grid parity is achieved. This makes the case for Governments at the Central and State levels to continuously support the solar program in the medium term.

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## 6.3
## Grid-connected solar potential – long term

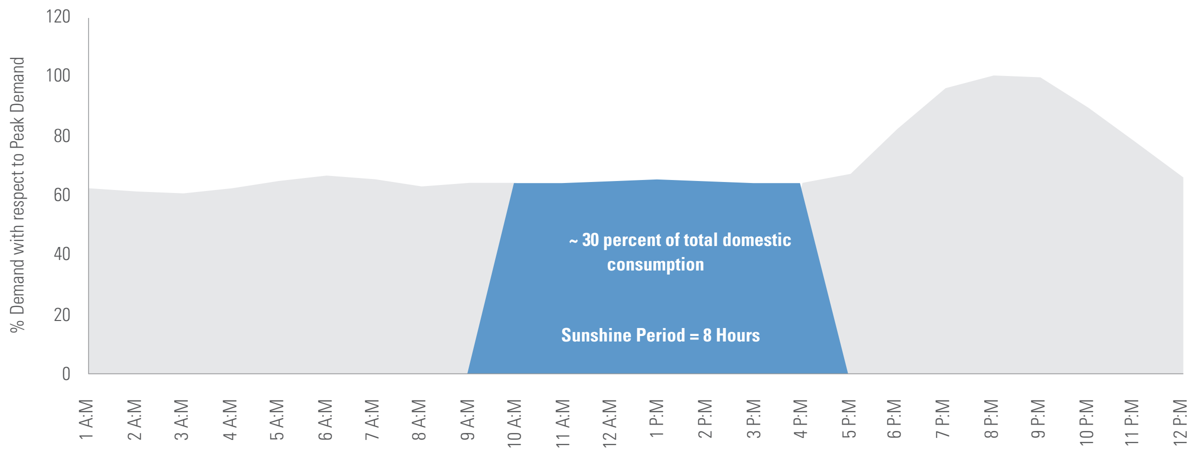
Grid-connected solar power potential has been estimated by looking at utility scale potential as well as grid-connected residential rooftop systems.

### 6.3.1
### Solar PV roof-tops

The residential consumer category contributes to about 29 percent[2] of the total Indian power requirement. This is expected to increase to 34 percent by 2021-22. Cost economics could drive the high-end residential consumers[3] to adopt solar rooftops a few years before the actual grid parity. We have segregated the residential consumption as the high-end (more than 200 units per month) and the non-high end (less than 200 units per month).

To estimate the solar rooftop potential in the residential segment during sunshine hours, we have considered a typical load curve of the residential category as shown in the exhibit below:

Load Curve of Domestic Category (for Andhra Pradesh)




**Source:** KPMG's Load Curve Model for the state of Andhra Pradesh

As can be seen from the exhibit above, the sunshine consumption corresponds to around 30 percent of the total daily consumption of a typical household. Solar power can be used to meet this consumption for a typical household.

#### 6.3.1.1
#### High-end residential segment

In 2017-18, we forecast the levelized tariff based on the cost to serve at INR 9.29 / kWh vis-à-vis the levelized tariff of rooftop PV at INR 8.31 / kWh. This differential is expected to motivate the high-end residential segment to use a solar rooftop for day time power consumption to reduce dependence on utility power. Also, due to telescopic nature of tariffs (i.e. higher levels of consumption are charged a higher tariff) for residential category in most states, the high-end residential consumers end up being a cross-subsidizing category (i.e. pay more than their cost-to-serve). Hence, we expect the high-end residential segment, which is expected to consume around 30 percent of the total residential energy in 2017-22, to adopt solar first in the residential consumer category.

2. 17th Electric Power Survey, KPMG Estimates
3. High-end residential consumers are those consuming greater than 200 kWh (units) per month

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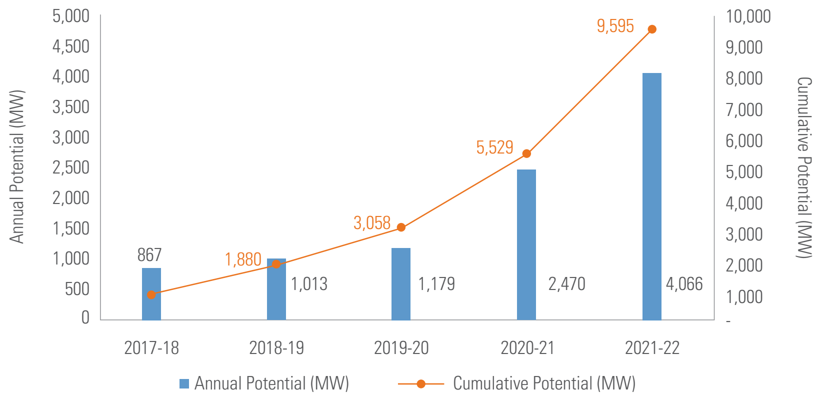
We expect the shift from this segment to be gradual during the years preceding grid parity and to fasten post 2019-20. The solar rooftop potential from this segment from 2017-18 is as summarized in the exhibit.

The total solar rooftop potential that could emerge in the period 2017-22 is ~9,600 MW from the high-end residential segment.

High-end Residential Solar Rooftop Potential




**Source:** KPMG's Solar Market Potential Model

### 6.3.1.2
### Non- high-end residential segment

This segment is more sensitive to solar rooftop capital cost and hence would evaluate the suitability and acceptability of solar rooftops before adoption. For this reason, government intervention will be required, in terms of soft loans or easier financing options, to encourage consumers to adopt solar rooftops. The Government should encourage all the new houses built from 2017-18 to use solar rooftops for their daytime consumption. From the year of grid parity, certain non- high-end residential consumers may themselves find it economical to use solar rooftop.

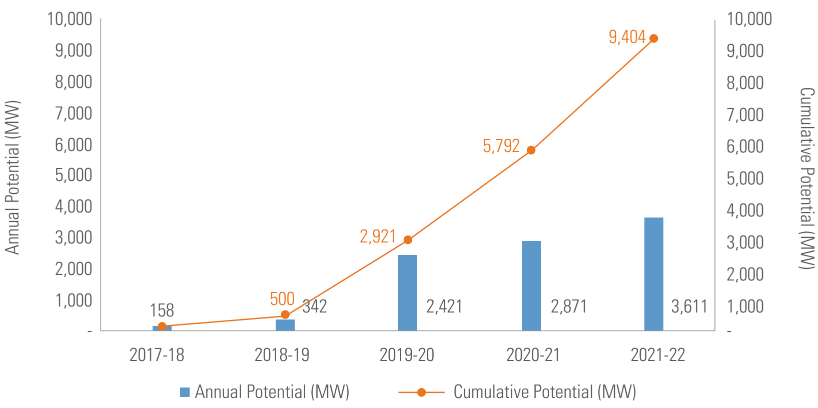
Hence, the solar rooftop potential from the non- high-end residential segment has been estimated as per the formula mentioned below:

**Non- high-end solar rooftop potential = Potential from New demand from 2017-18 (driven by government policies on financing options) + Potential from existing demand from 2019-20 (driven by cost economics of solar power)**

The solar rooftop potential from this segment, arising from both the new demand and the existing demand, from 2017-18 is as summarized in the exhibit.

The total solar rooftop potential that could emerge in the period 2017-22 is ~9,400 MW from the non- high-end residential consumer segment.

Non- high-end Residential Solar Rooftop Potential




**Source:** KPMG's Solar Market Potential Model

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A breakthrough in storage technology will be a game-changer for the overall solar PV market. The potential from both the high-end and non- high-end segments could triple if cost-effective storage solutions are available. At present, batteries dominate the small-scale energy storage segment with lead-acid battery capturing more than 60 percent of the market-share. However, a substantial cost reduction of more than 80 percent would be required in cost of battery storage to encourage households to install solar rooftop capacity to be independent of grid power.

If storage solutions are able to achieve this cost reduction potential – then a total solar potential of more than ~ 55 GW from the residential segment from 2019-20 is theoretically possible. This can lead to stranded assets - the distribution network and several other conventional power stations, to an extent of ~28 GW[4]. This would also mitigate ~165 Million tonnes of electricity sector CO2 emissions.

**Is this extent of cost reduction in batteries possible? – Maybe not!**

National Renewable Energy Laboratory (NREL) estimates that the cost of lead-acid batteries is unlikely to reduce in the next 10 years. Even though other battery technologies may see some cost reduction, these would only reach the current lead-acid battery costs.

Cost effective small-scale energy storage solution remains a major challenge to achieve the disruptive solar rooftop potential.

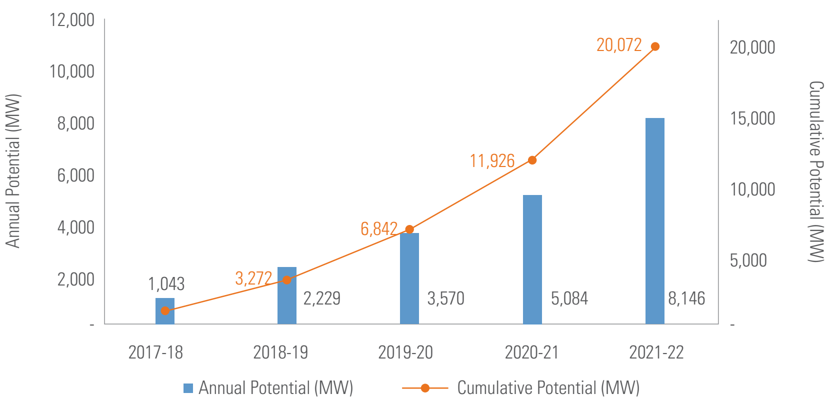
## 6.3.2 Utility-scale solar farms

In the base-case scenario, the grid parity for large-scale solar installations is expected in 2019-20. From the utility scale perspective, a portion of the incremental power demand can be met by solar power. The amount of solar power in the energy mix will increase considerable post grid parity.

Though the economics for a shift is likely to happen in 2019-20, the year in which the levelized tariff of electricity at grid-level would exceed the levelized cost of CSP–with storage or Utility PV price, we expect the market to take off from 2017-18 itself because the gap between grid tariff and solar tariff would have narrowed significantly and certain states would have already achieved parity. However, taking a conservative position, in our estimation, we have assumed nominal percentages of new demand to be met from large-scale CSP / PV installations in the years preceding grid parity.

The grid parity for both solar PV and CSP technologies is likely to happen in 2019-20 in India. While storage makes CSP attractive from a grid perspective – the land and water accessibility could remain a concern. A summarized working of our estimate of large-scale solar installation potential to meet the new demand requirements is as shown in the exhibit below:

### Utility-scale Solar Farm Potential




**Source:** KPMG's Solar Market Potential Model

4. Assuming 85 percent Plant load factor of base-load plants

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In our calculations for new demand, we have excluded the new demand from residential segment and agriculture category because small-scale solar solutions are likely to be economically attractive to these segments.

Utility-scale solar power could be used as a complementary solution along with hydro and gas based power sources. There could be significant constraints on natural resource availability in the future. This is where solar power can play an important role in conserving the resources by meeting the day time power requirements. Gas and hydro stations or solar thermal with storage solution can potentially be used for meeting the peak requirements.

## Key challenges

While there is significant potential to be achieved, certain important issues such as water requirement, land availability and cost effective storage technologies need to be addressed.

- Water Requirement in solar thermal plants

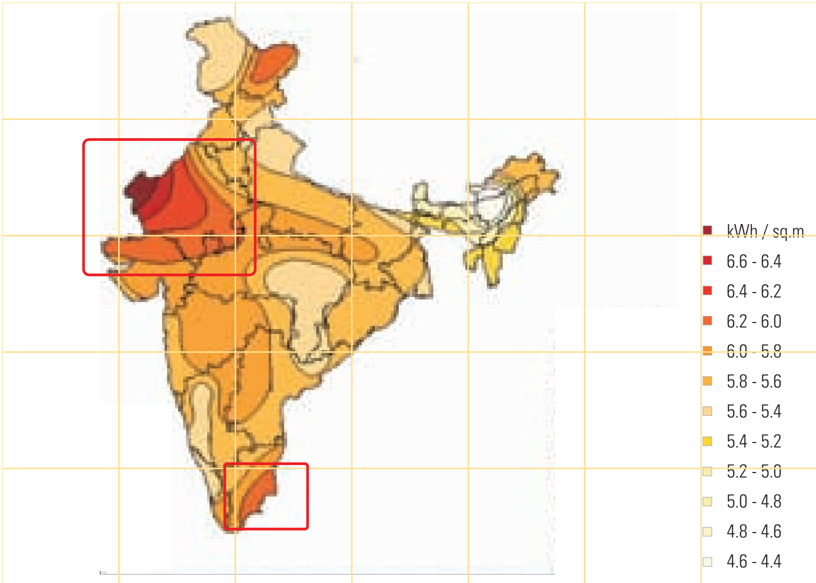
  In the present scenario, thermal (coal, gas, and oil) power plants account for ~85 percent of the total industrial water consumption. The shortfall in freshwater supply to the industry segment is expected to be ~16 percent[5] in 2015 and the same is expected to increase going forward. As CSP (solar thermal) plants consume about the same proportion of water (~4 liters for every unit generated) as thermal power plants, we see water availability as a barrier in extensive expansion of solar thermal technology in India.

As freshwater is a concern for thermal plants too, in the recent past, we are witnessing most of the thermal units being setup near coastal regions to utilize desalinated water.

### But, can CSP plants be set-up in any location in India?

CSP plants typically use direct irradiation and require sites with annual DNI (direct normal irradiation) larger than 1800 kWh / sq. m.[6] (or 6 kWh / sq. m. / day assuming 300 sunny days in India). Based on insolation levels – Rajasthan is best suited for solar thermal power plant location closely followed by Gujarat and Tamil Nadu.

### Solar Thermal Radiation of India




**Source:** Solar Thermal Federation of India

Water availability could still remain an issue in these regions. However, air cooled technologies that reduce water usage or public-private partnership models could be worked out in utilizing waste water and desalinated water for CSP plants. This may however increase the project cost of CSP plants as these plants would not in all cases be near demand centers, thereby limiting the profitability and expandability of CSP technology in India.

Solar thermal plants based on air cooled technologies could potentially be a more suitable solution from an Indian perspective. Cost and efficiencies of air cooled compressor technology need to be looked at aggressively.

5. NCIWRD, NIH, KPMG Analysis
6. Report of Sub-group II & III on Integration of Solar Systems with Thermal / Hydro Power Stations, CEA, January 2010.

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- Land requirement
  CSP requires large tracts of even land, typically around four to five acres per MW with a land gradient less than 1-3 degrees. Though solar PV can be installed in scattered patches of land unlike CSP, it would require about 5 acres / MW. Simply put, to generate the same quantum of power as conventional power sources during the year – solar power installations would require 20 times[7] the land required for coal plants.

  Is land a constraint for grid-scale solar technologies?

  Rajasthan has more than 51 Million acres of desert land that could be used to produce solar power. Gujarat has allocated more than 50,000 acres of wasteland in four major potential areas for developing solar plants. Even if 1 percent of this desert land were to be used for solar plants, we could install around 100,000 MW of solar power. Desert regions in Rajasthan are an ideal location from the solar insolation perspective. Similar to the pit head concept for conventional power sources – the desert belt could become the centre for "pit-head" solar power generation in the country!

  This would result in Rajasthan and Gujarat becoming the Solar-valleys of India on the lines of what Silicon Valley is for IT.

- Storage solutions
  Currently, we have certain large-scale energy storage technologies such as Adiabatic Compressed Air Energy Storage, Hydrogen Storage, Pumped Hydro and large-scale stationary batteries. While large-scale energy storage options exist, we believe challenges such as capital costs, scalability, and disposal of wastes in a large-scale exist. Increased focus on R & D would be required to reduce the capital costs and certain pilot demonstrations of each of these technologies could help the utilities understand the pros and cons of each of the technology type. Thermal storage in CSP plants are currently economically viable and thus can be used to meet the baseload and peakload power requirements.

## 6.4
## Summary of grid-connected solar market potential

The potential that has been estimated in this section is from an All- India perspective. Different States will have different potentials which would depend on the grid parity year and the Government support.

- Domestic Rooftop = Conversion of high and non- high-end residential demand + New Incremental Demand from non- high-end residential segment

| Solar Potential (MW) | 2021-22 | 2018-19 | 2019-20 (Grid Parity Year) | 2020-21 | 2021-22 |
|---|---|---|---|---|---|
| Annual Solar Rooftop Potential | ~1,100 | ~1,300 | ~3,700 | ~5,300 | ~7,800 |
| Cumulative Solar Rooftop Potential | ~1,100 | ~2,400 | ~6,000 | ~11,300 | ~19,000 |

**Source:** KPMG's The Rising Sun, 2011

- Large-Scale Utility Power = Incremental Demand from non-residential and non-agriculture categories

| Solar Potential (MW) | 2021-22 | 2018-19 | 2019-20 (Grid Parity Year) | 2020-21 | 2021-22 |
|---|---|---|---|---|---|
| Annual Solar Capacity Required to meet certain percentage of Incremental consumption (MW) | ~1,000 | ~2,200 | ~3,600 | ~5,100 | ~8,100 |
| Cumulative Utility-scale Solar Farm Potential (MW) | ~1,000 | ~3,300 | ~6,800 | ~11,900 | ~20,100 |

**Source:** KPMG's The Rising Sun, 2011

7. Coal plants typically require about 0.30-1.50 acres / MW; Coal PLF is ~80-85 percent unlike Solar technologies PLF of about 19-22 percent.

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# 07 Potential of off-grid solar applications

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# 07 Potential of off-grid solar applications

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# 07

# Potential of off-grid solar applications

'Off-grid' solar applications are generally meant to refer to a set of applications that provide solar power to end-users through routes other than the electricity grid. These routes, for example, could be to deliver water heated through solar energy to a consumer through water pipes at his residence or street lights illuminated through a battery bank charged using solar power.

While there are large tracts of land that can be used for grid interactive generation in radiation rich states with sparsely populated belts e.g. Thar desert in Rajasthan, there are small Sun exposed pockets available in populated areas e.g. rooftops, unused land in commercial and industrial complexes, space over streetlights etc that lend themselves well to off-grid applications.

## JNNSM program recognizes off-grid potential

The Jawaharlal Nehru National Solar Mission (JNNSM) recognizes the potential of off-grid applications and mentions that

> “…there are a number of off-grid solar applications particularly for meeting rural energy needs, which are already cost-effective and provides for their rapid expansion.”

> “The immediate aim of the Mission is to focus on setting up an enabling environment for solar technology penetration in the country both at a centralized and decentralized level. The first phase (up to 2013) will focus on capturing of the low hanging options in solar thermal; on promoting off-grid systems to serve populations without access to commercial energy and modest capacity addition in grid-based systems.”

Key mission targets relating to off-grid applications are

- "To promote programmes for off grid applications, reaching 1000 MW by 2017 and 2000 MW by 2022
- To achieve 15 million sq. meters solar thermal collector area by 2017 and 20 million by 2022.
- To deploy 20 million solar lighting systems for rural areas by 2022"

## The promise of off-grid applications

Off-grid applications find use in three broad categories: Heating, Cooling and Lighting. Put together, these three categories hold immense potential in a tropical country like India with bright, sunny days for most part of the year. However, despite the promise they hold off-grid applications have not been able to establish themselves significantly in the country for various reasons.

Given the increasing attention of Indian and other Federal Governments on solar power, we believe that the time is opportune to put in place the right environment for off-grid applications to prosper. As we will show in the subsequent sections, off-grid segment holds significant potential – be it investment requirement, fuel savings, greenhouse emissions reduction or beneficial impact on society – for anyone to ignore.

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We have focused on four areas – Solar-powered agriculture pumpsets, Solar Water Heating, solar-powered telecom towers and solar lighting - to estimate the potential of off-grid applications in India. We have discussed each of these applications in details in the following sections:

## 7.1 Solar-powered agriculture pumpsets

Currently, the agriculture category contributes to ~20 percent of the total Indian demand. The electricity tariff for this category is subsidized to an extent of 80 percent of LCP, with the subsidy being borne by the individual state governments. If tariff subsidy to this category were to continue, the total subsidy would increase to USD 50 Billion by 2021-22[1].

Post grid parity, solar power will become an attractive alternate for meeting the agricultural demand. This would reduce the subsidy burden of the government besides being a clean and convenient source of power for farmers.

In this context, solar powered pumpsets could emerge as a large market segment with the following advantages:

- The inefficient distribution network becomes redundant
- Significant savings in T&D losses for utilities
- Reduced expenditure for utilities – Otherwise required for maintaining the distribution network catering to agriculture loads;
- In the present scenario, certain utilities supply power to agriculture loads during the night time. Solar-powered agriculture pumpsets would allow farmers to operate during the day-time, thereby addressing two major problems of night-supply – wastage of power and fatal accidents.
  - Avoid power wastage - Certain farmers keep the pumpset switched-on due to erratic and night hours of supply.
  - Prevent fatal accidents – farmers' coming in contact with electrical systems; snake / insect bites.

1. The LCP for LT category is forecast to increase from INR 5.63 / kWh in 2011-12 to INR 8.34 / kWh in 2021-22. The average tariff for this category is forecast to increase from INR 1.07 / kWh in 2011-12 to INR 2.20 / kWh in 2021-22. Agriculture sales forecast using 17th EPS Report, CEA.

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## Staggered Market Support Program

The levelized tariff of electricity for agriculture segment is likely to be higher than the levelized cost of small-scale solar PV solution in 2017-18. The Government should consider a phased program that enables the transition of conventional powered pumpsets to solar-powered pumpsets. The Government could start this program by encouraging new agriculture connections to use solar-powered agriculture pumpsets a few years before grid parity, say from 2017-18 – the year in which it would make economic sense to use solar power over conventional delivery of power to agriculture consumers.

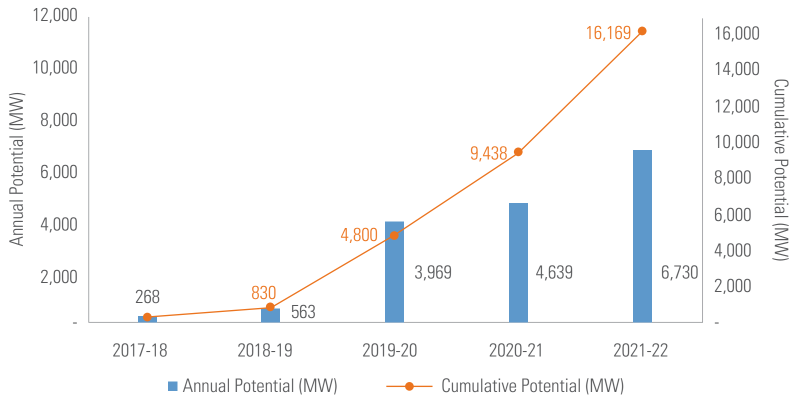
From the year of grid parity, the existing agriculture consumers themselves may adopt solar-powered pumpsets due to advantages such as reliable and safe power, continuous supply, and power during daytime.

Hence, we have estimated the potential for solar-powered agriculture pumpsets as per the formula mentioned below:

Solar-powered Agriculture Pumpsets potential = Potential from new demand in Agriculture category from 2017-18 (driven by government policies and availability of viable financing options) + Potential from existing agriculture demand from 2019-20 (driven by cost economics of solar power and the availability of viable financing options)

The solar-powered agriculture pumpset potential from this segment, arising from both the new demand and the existing demand, from 2017-18 is as summarized in the exhibit.

### Solar-Powered Agriculture Pumpset Potential




**Source:** KPMG's Solar Market Potential Model

The total solar-powered agriculture pumpset potential that could emerge in the period 2017-22 is ~16,200 MW from the agriculture category.

The potential as shown in the above exhibit is likely to be realized depending upon the extent of government support and market conditions.

Meanwhile, Government should actively promote R & D for accelerated development of solar-powered agriculture pumpset solutions from an Indian context. Government interventions with fiscal incentives to support private sector R&D can go a long way in realizing this immense potential.

Furthermore, innovative business models such as integrators of pumpset and solar modules may be required to realize this potential.

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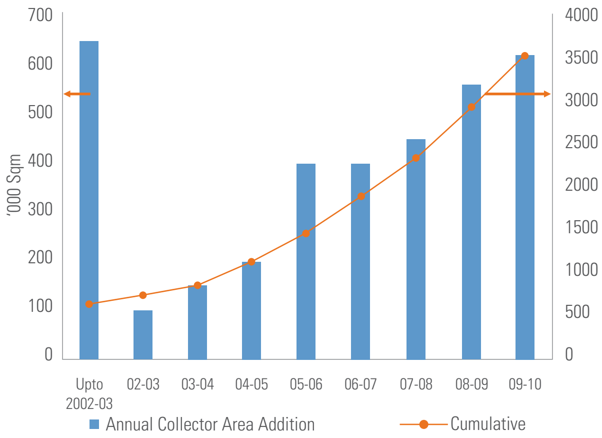
## 7.2
## Solar water heating

Solar water heating (SWH) is generally meant to imply the use of solar energy to heat water. Solar heating systems are generally composed of solar thermal collectors, a water storage tank or another point of usage, interconnecting pipes and a fluid system to move the heat from the collector to the tank. Solar water heating applications find use in residential, commercial as well as industrial sectors.

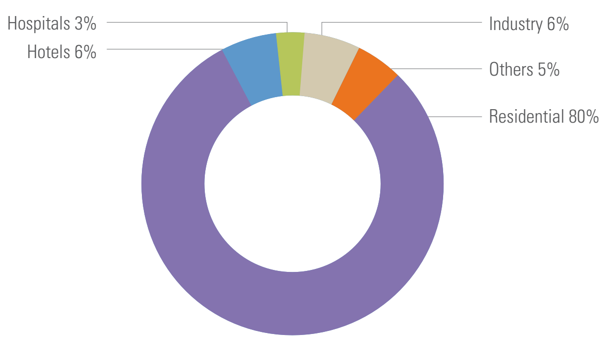
Internationally, SWH is a well developed technology and considered to hold significant promise for fuel savings and emissions reduction. China, European Union, Turkey, Japan and Israel are the leaders and cover about 90 percent[2] of the global installed SWH capacity. In India, as shown in the chart below, the cumulative installed capacity in 2009-10 was 3.53 million sqm. Residential SWH comprises of about 80 percent of the total installed capacity. Within the country, about 65 percent of this capacity is mostly concentrated in Karnataka and Maharashtra largely due to more than 9 months of hot water requirement (as against Northern regions that mostly require heated water for 4-5 months in a year).

### Growth of SWH in India




**Source:** MNRE Estimates

### Category wise break-up of SWH installation in India




**Source:** Greentech Report on Solar Water Heaters in India

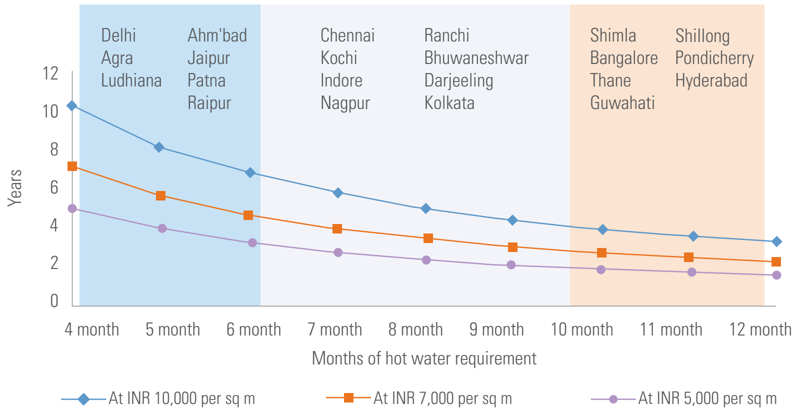
## 7.2.1
## Residential

### 7.2.1.1
### Economic analysis of SWH for residential use

The most crucial factor in an application attaining mass penetration in a price sensitive country like India is the economic benefits expected out of the application. In the chart, we show payback estimates for SWH in different areas of the country at different price points.

The chart shows that in areas with more than nine months of hot water requirement, the payback period is between 2.3 – 4 years. Given that the life of solar water heaters is much more than the payback period and electricity costs escalate with time, solar water heaters do make economic sense.

### Payback Period for Solar Water Heating System at different Price and Water Heating Requirement Levels




**Note:** X-axis denotes the months in a year during which hot water is required. Y-axis denotes the payback period in years. Amber line shows the prevalent prices today for evacuated tube collectors.

2. Greentech Report on Solar Water Heaters in India

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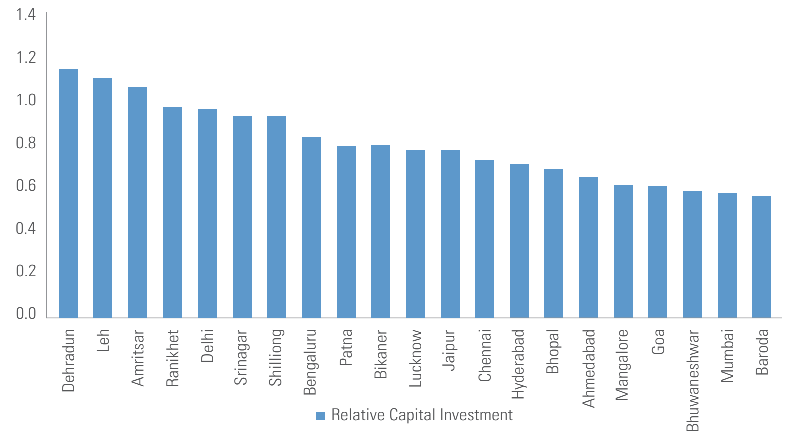
Currently, economies of scale are hard to achieve as the SWH market is fragmented with very few manufacturers having national presence. Also, very few players have SWH as their only line of product – SWH is generally among an array of products handled. We understand from our discussions with manufacturers that the SWH prices are largely a function of prevailing metal (Aluminium and Copper) and glass prices. Going forward, if the market expands enough for economies of scale to be achieved, we believe 10 percent - 15 percent cost reduction should be possible.

### Initial capital investment required

The capital investment for the consumer varies with location and depends on the radiation intensity and ambient temperature. The chart shows relative capital investment considering Ranikhet as the reference point.

### Relative Capital Investment for same water output




**Note:** Chart shows capital investment only for the SWH system; plumbing costs not included. Y-axis shows relative capital investment – this implies that a similar capacity SWH system in Dehradun would cost about 1.2 times the capital cost in Ranikhet. Relative capital cost varies largely due to varying radiation intensity levels.

**Source:** MNRE Handbook on Solar Water Heaters

For a household with, say, 150 LPD[3] of hot water requirement, the capital cost could vary between INR 19,000 and INR 27,000 depending on location. It is to be noted that this analysis is for Evacuated Tube Collector (ETC) type SWH.

A similar capacity electric geyser may cost about INR 7,000 in the current market conditions. ETC SWH is, therefore, 2.7 to 3.8 times costlier than an electric geyser. This is a hurdle for growth of SWH systems in relatively smaller towns and rural areas where upfront cash availability can be an issue.

### Key Drivers and Impediments

| Key Growth Drivers | Key Impediments |
|---|---|
| Growth in new housing coupled with increasing income levels | Relatively higher capital cost coupled with limited options for consumer financing for SWH applications |
| An alternative to electrical geysers in areas with restricted power supply | Lack of prevalent ESCO models that provide pay-per-use options with requisite guarantees |
| Increasing dependence of households on hot water | Fragmented market resulting in low R&D focus for innovations and benefits of scale not being achieved; weak supply chain in most states |
| Increasing awareness among certain sections of the society | Few states have mandatory regulations/ building bye-laws for SWH installation; even where these exist, enforcement is seen to be weak |
| | Capital subsidy administration mechanism for SWH can be made more efficient |
| | Lack of awareness among a broad section on aspects relating to the different technologies available, the selection and sizing of equipment, evaluation of costs, etc. |

**Source:** KPMG's The Rising Sun, 2011

3. Based on discussions with industry experts 150 LPD is considered as the most likely daily hot water requirement for a typical family household.

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### 7.2.1.2
### Economic potential for residential SWH

The JNNSM Mission targets a collector area of 20 mn sqm by end of Phase 3 (2017 – 22).

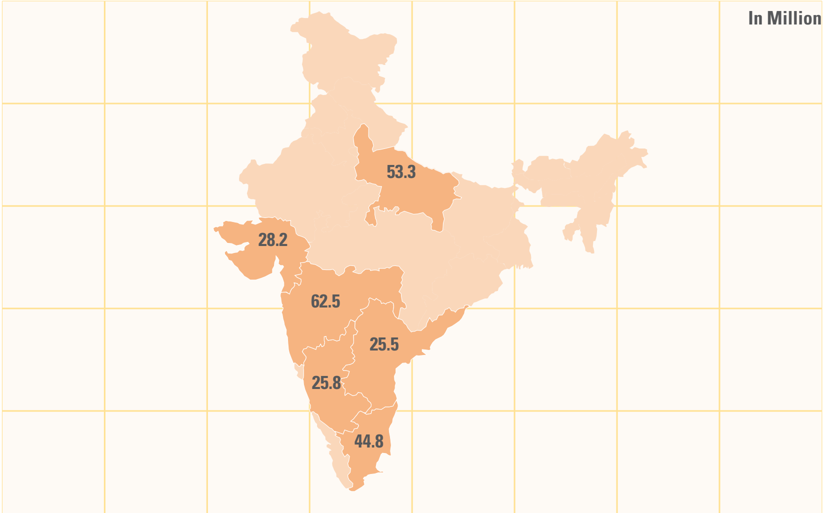
| JNNSM Targets for Collector Area | In mn sqm |
|---|---|
| Phase 1 (2010 – 13) | 7 |
| Phase 2 (2013 – 17) | 15 |
| Phase 3 (2017 – 22) | 20 |

The collector area targets include all segments – Residential, Commercial and Industrial. If we go by the current break-up where 80 percent of the installed collector area is in the residential segment, this segment would have 16 mn sqm of collector area by 2022 of the 20 mn sqm target by 2022.

To put this in perspective, India would have an urban population of around 425[4] Million by 2020. Six states[5] – Karnataka, Maharashtra, Tamil Nadu, Andhra Pradesh, Gujarat and Uttar Pradesh are considered to be frontrunners in residential SWH installations in India. Over the next decade, these states are expected to have more than 70 percent of country's installed residential SWH capacity.

4. Population Projection for India and States by National Commission on Population, May 2006
5. Greentech Report on Solar Water Heaters in India
6. The China Greentech Report, 2009

**Urban Population in 2020 in States expected to have maximum SWH installations**




**Source:** Population Projection for India and States by National Commission on Population, May 2006

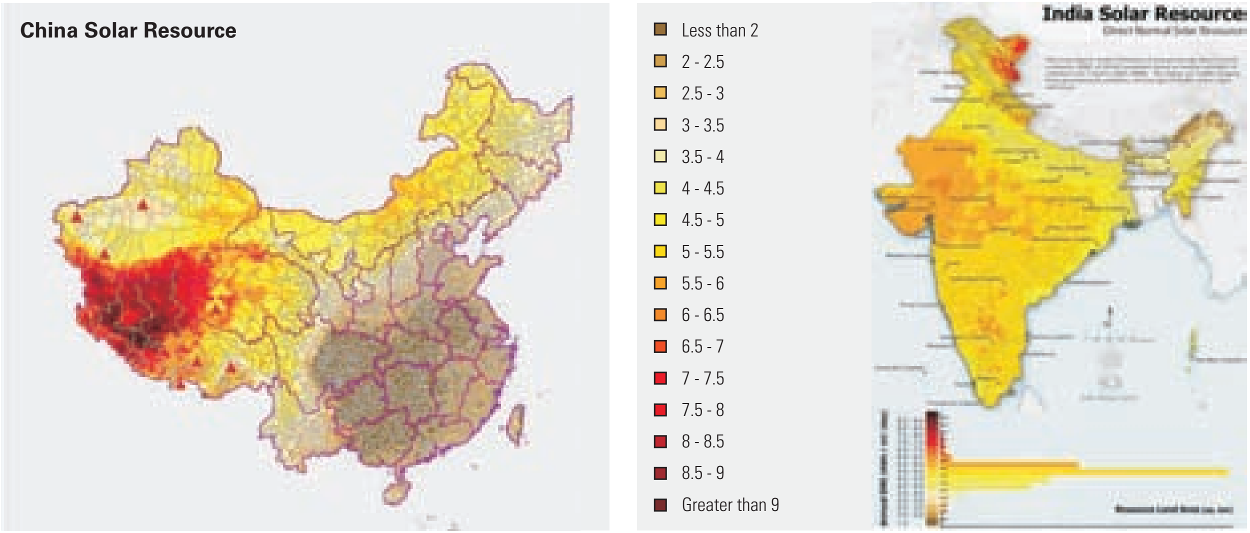
According to our estimates, these states would have around 62 million urban households in 2020. Even accounting for the fact that a proportion of these households would not have clear rooftop access or the necessary financial affordability, we believe that the potential could be as high as 24 Million Households translating into about 70 million Sqm (or 3500 Million LPD) by 2020.

While this might sound optimistic today, such penetration levels are not unprecedented. Numerous Chinese cities have mandated solar water heater systems on new or rebuilt buildings including Shenzhen, eastern Nanjing, Zhengzhou, Xiamen and Shijiazhuang, and the government has set ambitious installation goals for the future. As a result, currently, China boasts the world's largest installed base of solar water heaters, over 125 millions square meters[6], with one in ten families having adopted the technology.

The figures below show insolation intensities of India and China. As can be seen, large parts of India have radiation intensity in excess of 4 kWh/ Sqm/ Day. In contrast, a large part of Eastern and South Eastern China has a radiation intensity lower than 2.5 kWh/ Sqm/ Day.

If with such radiation intensity levels, 10 percent of Chinese families have adopted SWH, we believe that with a more focused strategy, India can also meet with similar success in the residential segment.

Radiation Intensity Map – China and India (Figures in kWh/ Sqm/ Day)[7]




**Source:** The China Greentech Report-2009; NREL

## 7.2.2
## Industry

Hot water and steam are vital inputs for a variety of industries. Important industrial segments are:

- Pulp and paper
- Textile
- Dairy
- Leather
- Food processing
- Electroplating
- Fertilizer
- Drug and pharmaceuticals

### 7.2.2.1
### Potential of solar energy in industrial process heating

Prices at which coal and biomass are available in the country today would not economically justify replacement of these fuels with solar water heating applications. We have, therefore, done a high level estimation of solar potential in the industry considering that solar would only be able to substitute oil and not coal / biomass.

The analysis is further narrowed down to only those industrial processes that require water / steam at sub 250 deg C as there are very few, if any, robust solutions that can address industrial requirements at high temperatures and pressures in the country today. We understand that R&D efforts are being made to target this segment as well but a reliable solution may take some time to develop.

The analysis reveals that solar installations can potentially replace 16 Mn tons of oil. Even if, realistically speaking, 30 percent of this potential can be converted this would imply replacement of 4.8 Mn tons of oil today.

If energy from 4.8 million tons of oil were to be substituted by solar energy, this would translate into a total collector area requirement of around 70 mn sqm.

In the next sections, we have estimated the potential penetration and market size for two industries namely Pulp and Paper, and Dairy.

7. Global Energy Network Institute

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### 7.2.2.2
### Pulp and paper

Paper industry has significant requirement of steam primarily for drying applications. Most of the current heating requirements are done through burning of fossil fuels like heavy furnace oil (HFO), coal etc. We believe that most of these heating requirements can be met by using solar power. While steam requirements during the daytime can be met by sunlight directly, solar storage systems such as thermal salt storage can be used for heating requirements during night.

#### Payback Analysis

Our analysis shows the following payback periods vis-à-vis conventional fuels.

| Payback period for Solar system vis-à-vis conventional fuels | |
|---|---|
| Coal | More than 10 years |
| Natural Gas | 6.5 years |
| Furnace Oil | 4.5 years |

**Source:** KPMG's The Rising Sun, 2011

### 7.2.2.3
### Dairy Industry (Milk Pasteurization Process)

Dairy industry is again a good example of an industry that uses significant quantum of hot water for multiple applications such as utensil cleaning, pasteurization, manufacturing of milk products like Ghee, Butter, and Cheese etc.

#### Payback Analysis

Our analysis shows the following payback periods vis-à-vis conventional fuels.

| Payback period for Solar system vis-à-vis | |
|---|---|
| Coal | More than 10 years |
| Natural Gas | 4.5 years |
| Diesel | 3 years |

**Source:** KPMG's The Rising Sun, 2011

However, for industries such as Pulp and Paper, and Dairy to start using solar power in a feasible manner, certain key barriers listed below would need to be overcome.

## Key barriers for solar power use for industrial requirements

- Customization requirements – Each industry has a specific requirement for water / steam at a given temperature and pressure. Even within an industry, manufacturing units might have differing requirements based on their size, number of shifts etc. A "cookie-cutter" product would not be successful in such a scenario. The requirement is for customized products for each buyer.
- Criticality of hot water / steam to industry – Unlike, say, residential SWH where users may be able to cope up with non-performance on a sporadic basis (e.g. not getting enough hot water due to cloudy stretches), industry is critically dependent on hot water / steam and even a short duration of non-availability can bring the processes to a stop.
- High capital costs for certain applications – This is the case especially for steam requirement at high temperature/pressure, where the basic design of solar collectors undergoes a change along with requirement of additional components such as heat exchangers. The capital cost of such systems today is quite high.

We believe that for solar power to be used feasibly in the industry, solution providers would need to emerge. These solution providers could be in the form of ESCOs that not only customize the product to each user's requirements but also provide the requisite performance guarantees on the output.

Added advantages from such solution providers could be to convert capital cost into ongoing costs for users through pay-per-use models and cost reduction through necessary R&D efforts.

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## 7.2.3 Cumulative market size for solar water heating applications

As per the analysis shown in the previous sections, we believe that around 70 million sqm of solar collector area for residential SWH should not be considered as a far stretch of imagination. India is blessed with good radiation levels and urban households of top six states most suited for solar water heating have the potential to reach that level if the right environment for SWH is created in the country. For commercial sector (Hotels, Hospitals and Hostels), a study for MNRE[8] estimates SWH potential of around 2 million sqm by 2022. Since this study considers fairly high penetration levels – 50 percent for hotels and hospitals and 20 percent for hostels, we are inclined to consider the same potential for commercial sector.

A high level estimation for industry shows that industry can deploy around 70 million sqm of collector area for replacing oil for processes below 250 deg C. However, the solar water heating industry would need to overcome certain challenging barriers before it can be used feasibly by the industry.

To come to an estimate of the market size, therefore, we have not considered industry as a target segment for SWH applications for the time being. However, we have reasons to believe that between residential and commercial segments, SWH applications can reach a level of around 72 million sqm of collector area by 2022.

| SWH Market Size | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Collector Area - mn sqm | 4.4 | 5.8 | 7.9 | 11.3 | 16.1 | 22.3 | 30.5 | 40.8 | 51.1 | 61.4 | 71.7 |
| Collector area addition – mn sqm | 1.4 | 4.4 | 2.1 | 3.4 | 4.8 | 6.2 | 8.2 | 10.3 | 10.3 | 10.3 | 10.3 |
| Incremental Market Size – INR crore | 1,009 | 1,059 | 1,668 | 2,919 | 4,210 | 5,575 | 7,656 | 9,858 | 10,153 | 10,458 | 10,772 |
| Incremental Market Size – USD mn | 219 | 230 | 363 | 635 | 915 | 1212 | 1,664 | 2,143 | 2,207 | 2,273 | 2,342 |

**Source:** KPMG's The Rising Sun, 2011

## 7.3 Solar energy for powering telecom towers

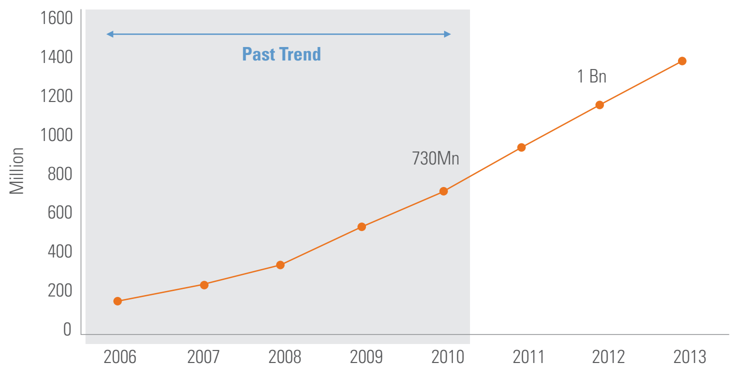
India, one of the world's largest and fastest growing mobile telecom market, now has 730 million[9] subscribers and an overall tele-density of 64 percent. Powering this subscriber base are more than 3.1 lakh cell phone towers that, along with grid power, consume about 2 billion liters of diesel per year.

Analysts estimate that by 2012-13, India will have nearly a billion subscribers being served by about 5.5. lakh cell phone towers. Also, with increasing rural penetration, the subscriber growth over next five years is expected to be led by rural / semi-urban subscribers - growing at around twice the rate of urban subscribers.

Poor availability of grid supply in rural / semi-urban areas requires telecom towers to exceedingly depend on diesel genset power for operations resulting in diesel consumption crossing 3.5 billion liters per annum. This not only has cost implications for the telecom industry but also poses significant environment challenges.

Telecom Industry is taking note of this challenge. TRAI, in a consultation paper issued on 3rd Feb, 2011, has sought stakeholder views on making telecommunications greener. In this paper, TRAI estimates that for every kWh of grid power consumed, 0.84 kg of CO2 is emitted while for every liter of diesel consumed 2.63 kg of CO2 is emitted. This implies that a tower running on diesel emits 3 times more CO2 than while running on grid supply.

### Mobile subscriber growth in India




**Source:** TRAI Data, BMI Telecom Report, Intelligent Energy Ltd, KPMG Analysis

8. Greentech Report on Solar Water Heaters in India
9. Telecom Regulatory Authority of India data as at end of November, 2010

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Increasing competition will require the telecom operators to find the most cost optimized operation structure and power cost in towers is a significant cost centre in the business.

Also, growing desire to control emissions and falling prices of PV power are expected to be key drivers going forward. The CERC, in a Regulation issued in 2009, had determined levelized tariff of solar PV power at INR 17.91/ kWh. JNNSM bidding subsequent to this resulted in competitive tariffs of INR 10.95 – INR 12.76/ kWh[10].

While these tariffs are for MW scale grid connected stations, they point to a distinct trend towards cost reduction possibility due to the emergence of indigenous suppliers. We expect that technological advancement and growing indigenization will continue to drive down costs in the time to come.

Other factors driving adoption of solar power in this industry are depicted below.

**Favourable Economics**

- Govt impetus such as capital susidy, soft loan under JNNSM to spur growth/reduce prices
- Pressure on fuel to favour solar power going forward

**Logistical Convenience**

- Solar Power mitigates/eliminates the need for continuous diesel refill ops
- Makes installation of towers convenient in remote areas beyond grid and road reach

**Desire to Go Green**

- Indian telecom firms are taking steps to become greener-Green Shelter, Bio-diesel etc.
- This is a step in the same direction

**Solution Provider Emergence**

- Gradual emergence of Solution Providers that customize technology and provide warranties/services

**Source:** KPMG's The Rising Sun, 2011

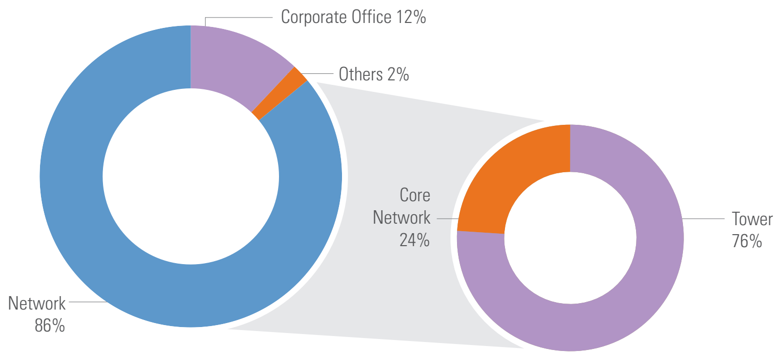
## Tower critical to telecom cost structure

Tower site is the single biggest energy consumer in the entire set up of a telecom firm as evident from the adjacent chart.

It is estimated that switching from diesel to solar power would save Indian telecom firm INR 6,440 Crores in operations cost.

Additionally, every unit of diesel power replaced with solar power should generate CDM benefits of around INR 0.75 / kWh[11] at the current CER prices.

## Energy consumption of telecom firms




**Source:** TRAI Consultation Paper On Green Telecommunications, 3rd February, 2011

10. Bid results released by NVVN
11. TRAI Consultation Paper on Green Telecommunication, 3rd Feb, 2011, KPMG Analysis

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Solar power, especially Photovoltaic (PV) technology, is suited to telecom tower requirements. However, the extent of suitability depends on certain factors that are specific to each tower. Key factors are depicted below.

## Key factors determining viability of solar PV for Telecom Tower


**Source:** KPMG's The Rising Sun, 2011

### Payback analysis

Consider a scenario of solar installation for a grid-connected tower with 12 hours of load shedding

- This analysis does not consider removal of DG set due to solar installation as it is still required for back up purposes
- This analysis considers tax benefits to be accruing assuming that the parent entity has enough PBT to absorb the tax benefits as they become applicable each year.

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Our results show that with the current capital cost of solar installation and diesel prices, the project pays back within 8 years (implying an investment IRR of ~17 percent). Going forward, with falling solar power prices and increasing diesel prices, solar installations would make greater economic sense.

A similar analysis for a non-grid connected tower shows that the payback period can be as short as three to four years.

## Market size

Based on discussions with industry experts and our analysis, we believe that over the long term solar power has the potential to replace about 30 percent of telecom tower industry's diesel requirements.

Today India has about 3.6 lakh telecom towers that are likely to grow to 5.5 lakh[12] towers by 2015. Analysts estimate this number to grow further, though at a slower rate due to increasing tower sharing arrangements, to about 7 lakhs by 2020.

Going forward, with increasing rural penetration, more towers would come up in areas with limited / no grid availability. As a result, if current diesel consumption trends continue, diesel consumption by telecom towers would grow from about 2 billion liters per annum now to about 3.5 billion liters per annum by 2020.

If, gradually, 30 percent of this diesel consumption were to be replaced by solar power, this would imply a solar market potential as shown below

| Time Period | Market Potential (MW)[13] | Market Potential (USD Billion) |
|---|---|---|
| 2011 – 2016 | 873 | 3.5 |
| 2017 - 2022 | 2,635 | 9.1 |

**Source:** KPMG's The Rising Sun, 2011

# 7.4 Solar lighting

An additional area where solar power holds significant potential is the area of lighting. Lighting loads could be residential in nature e.g. CFLs lit up by a battery charged during the day through a solar panel or commercial loads e.g. street lights, billboard lighting, traffic signages.

Solar lighting in residential segments makes special sense in areas that are not grid-connected or grid-connected areas that witness heavy load shedding. The advantage of using solar lighting for the commercial loads mentioned above is that not only do most such loads have unfettered access to the Sun but also they are present in highly visible areas (along roads and important public centers). Solarization of these loads, therefore, also serves to create a high level of awareness among the general public.

## 7.4.1 Solar lanterns

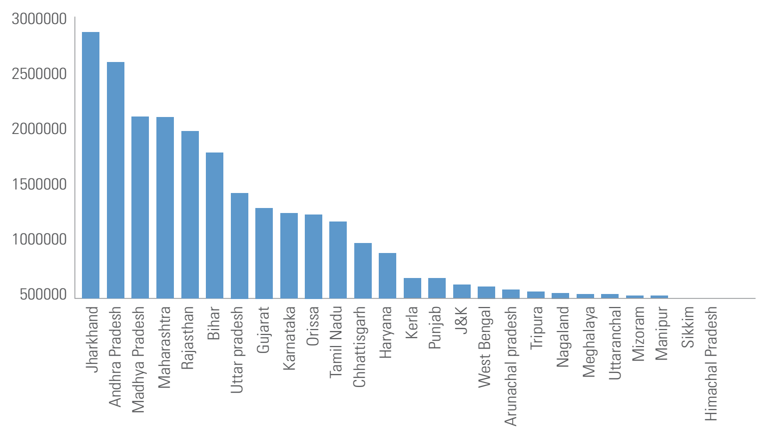
Solar power can be used for lighting in areas with limited or no access to the grid. More than 50 percent of the rural households remain unelectrified today.

Solar lanterns offer a suitable solution to lighting of homes in such households. It goes without saying that the same shall need support from Central and State Governments – e.g. creating the supply chain to reach and service the end users and taking care of subsidy implications to make these available to the rural masses.

Similarly, there are rural, semi-urban and urban areas which experience power cuts ranging from 12-20 hours. Solar Lanterns can also be used in households in these areas as an alternate source for lighting.

We would like to emphasize that a simple cost-benefit analysis where the Government benefits through reduced use of highly subsidized kerosene by providing solar lanterns at subsidized rates would show a break-even period of one to two years for the investments made by the Government. Additionally, the social ramifications like impact on environment, improvement of health of women doing household chores, income generating activity, education, etc. are significant.

### Number of Unelectrified Households in India




**Source:** Ministry of Power

12. IDBI report on Telecom Infrastructure
13. Since Market potential would be a function of the solar configurations adopted for each tower, it would be difficult to arrive at a precise estimate. However, for this analysis, we have considered a 12 hour solar power configuration as the default configuration.

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## 7.4.2
## Solar street lighting

The public lighting provided by municipal corporations is a significant source of electricity consumption in urban and semi-urban areas. For instance, in Delhi alone, it is almost 2-3 percent[14] of total consumption of electricity.

Solar energy can be considered as an alternate for powering such systems. With a panel and battery bank, existing technology provides solutions for the same.

Analysis of top 50 cities in India suggest that power requirement from street-lighting alone is going to increase from the current 1,600 MW[15] to 3,500 MW in 2020.

As far as capital cost is concerned, a typical street light has a connected load ranging from 0.5 KW to 1.5 KW. At a capital investment requirement of about INR 2.7 lakhs / KW, solar power is still not economically viable compared with the tariffs of grid power that street lights currently draw. As shown in the earlier sections, a reduction in solar component prices as well as price of battery banks can open up this potentially large segment to solar application.

It is noteworthy, that irrespective of capital cost there is strong social angle to the usage of such systems. Street lights, at roads and other public spaces, are highly visible entities and solarization of these would create a high level of social awareness among the public at large. Solarization of street light systems will send a strong message to the masses on Government's commitment toward the environment, reduction in carbon emissions as well as the promotion of solar energy.

14. DERC Tariff Orders for FY2009-10
15. KPMG analysis

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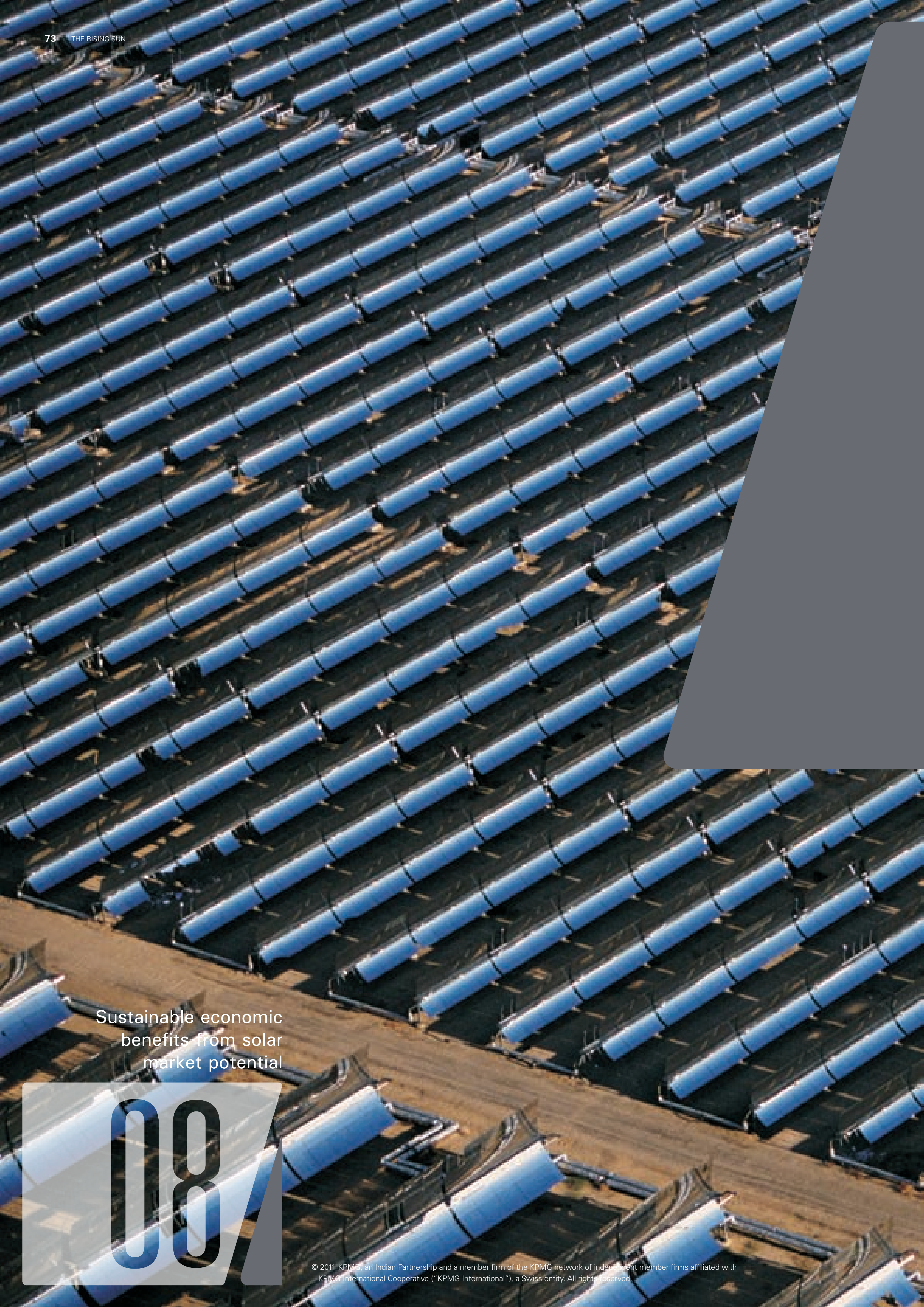

# Sustainable economic benefits from solar market potential

08

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# 08 Sustainable economic benefits from solar market potential

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08

# Sustainable economic benefits from solar market potential

**Key Questions:**

- What is the likely import substitution possible by solar power in the next decade?
- What is the carbon mitigation potential for solar power?
- What is the possible employment generation?

Solar power can play an important role in securing the energy future for India. Moreover, solar power has the potential to drive the economic growth in a sustainable manner by creating large employment opportunities.

## 8.1 Energy security – import substitution

The energy mix of India is currently dominated by coal. With more than 70,000-80,000 MW of coal based capacity getting added in the next 7-8 years – the importance of coal as the dominant fuel will continue. However, the contribution from imported coal will correspondingly increase and is likely to be around 30 percent of the total coal requirement for the power sector. The higher dependence on imported coal will increase the price volatility and energy security risks for the power sector. Solar by virtue of being an abundantly available local resource can play an important role in reducing this import dependence.

Our analysis shows that the solar potential by 2021-22 can displace more than 30 percent of the imported coal quantum. This will result in significant savings of foreign exchange and make India less import dependent and more self sufficient.

| Year | 2017-18 | 2018-19 | 2019-20 (Grid Parity Year) | 2020-21 | 2021-22 |
|---|---|---|---|---|---|
| Total Solar Energy Generated (MU) | ~5600 | ~15,100 | ~40,900 | ~75,400 | ~126,200 |
| % Energy Requirement met by Solar Power | 0.4% | 1.0% | 2.4% | 4.2% | 6.6% |
| Coal substituted from grid-connected and off-grid market (excluding Solar Water Heaters) (Million Tonnes) | 2.7 | 7.2 | 19.6 | 36.2 | 60.6 |
| Coal substituted from solar collector area installations (Million Tonnes) | 3.2 | 4.7 | 6.6 | 8.5 | 10.8 |
| **Total Imported Coal Substituted (Million Tonnes)[1]** | **5.9** | **11.9** | **26.2** | **44.7** | **71.4** |

**Source:** KPMG's The Rising Sun, 2011

1. Station Heat Rate = 2,400 kCal / kWh; Weighted Average Calorific Value of Imported Coal = 5,000 kCal / Kg

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## 8.2
## Carbon mitigation

The emission mitigation possible from solar power varies depending on the actual solar insolation. The higher the solar insolation, the greater is the amount of carbon emissions mitigated. According to industry estimates, the global Solar PV emissions are very low at around 25-65 g CO2 / kWh[2] when compared to the emissions from coal in India at around 850 g CO2 / kWh. Advances in other indirect CO2 emissions of the solar PV systems in the future would lower the total emission of the PV systems as well. In the future, it is expected that the solar PV technology would have even lower emission levels of around 10g CO2 / kWh[3].

Solar potential in India could easily offset close to 7 percent of CO2 emissions in the electricity sector and ~2.6 percent of overall Indian emissions by 2021-22.

Solar energy could help India achieve more than 10 percent of its voluntary target to cut the carbon intensity of GDP by 20-25 percent by 2020.

| Year | 2017-18 | 2018-19 | 2019-20 (Grid Parity Year) | 2020-21 | 2021-22 |
|---|---|---|---|---|---|
| Co2 Emissions Mitigated (Million Tonnes) | 4.3 | 11.6 | 30.8 | 56.7 | 95.1 |
| **% CO2 Emissions Offset by Solar / Total Electricity Sector** | **0.3** | **0.9** | **2.2** | **3.9** | **6.2** |
| **% CO2 Emissions Offset by Solar / Overall Indian Emissions** | **0.1** | **0.4** | **1.0** | **1.7** | **2.6** |

**Source:** KPMG's The Rising Sun, 2011

## 8.3
## Job creation potential

According to National Renewable Energy Laboratory (NREL) estimates, solar power has the highest employment generation potential amongst all sources of power generation[4]. As per their analysis, in 2008 almost 28 jobs/ MW were created in solar PV and 24 jobs / MW were created in solar CSP. Of all the jobs created in PV and CSP, a very large part of the labor force is required during the manufacturing and installations stage of solar projects.

Given the large potential that is expected to come up in the country – we believe there will be significant employment potential in this space. Based on our estimates for market potential within the next decade, an average of 43,000 new jobs would be created annually in the period 2017-22 from the rooftop segment itself. Furthermore, around 42,000 jobs can potentially be created annually in the period 2017-22 from utility scale solar power installations. The agriculture potential could create more than 38,000 jobs annually in the solar industry from 2017-18.

We expect more than 600,000 jobs getting created in the period 2017-22 from rooftop, solar-powered agriculture pumpsets and utility-scale solar installations alone. Moreover, solar water heaters could create more than 420,000 jobs in this period. Hence, the solar industry would create close to a million jobs in the period 2017-22, carving a new industry segment like what IT has succeeded to create in the last decade in India.

2. Energy Analysis of Power Systems – World Nuclear Association, EPIA
3. Parliamentary Office of Science and Technology, IEA.
4. It has been noted that while natural gas and coal create a mere 0.11 job-years / GWh, solar creates 0.87 job-years / GWh.

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# Steps to be taken to enable the market transition

09

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# 09 Steps to be taken to enable the market transition

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# 09

# Steps to be taken to enable the market transition

**Key Questions:**

- What should the Government do to accelerate solar power market development?
- How can Government address the concerns of various stakeholders in the sector?

The Government should play a proactive role in encouraging solar industry for it to achieve the true market potential. It has initiated the right step in the form of the National Solar Mission. It is important to sustain this and convey a consistent message. Some of the measures that need to be pursued on priority are listed here.

## 9.1 Market stability

A consistent market support program would lend credence to investors looking at solar opportunity in India. The roadmap for capacity installations can be determined based on capacity or budget for the next five years. An illustration of the possible difference in market size has been shown here.

### Case - 1: Annual market cap (say, 1000 MW per year)

| Case -1: Fixed Quantum | Units | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|
| Cumulative Capacity | MW | 1,000 | 2,000 | 3,000 | 4,000 | 5,000 |
| Cumulative Subsidy | USD Million | 300 | 559 | 781 | 966 | 1,118 |

### Case - 2: Annual budgetary support (say, incrementally USD 300 Million a year)

| Case - 2 : Fixed Budgetary Support | Units | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 |
|---|---|---|---|---|---|---|
| Cumulative Capacity | MW | 1,000 | 2,155 | 3,507 | 5,121 | 7,100 |
| Cumulative Subsidy | USD Million | 300 | 600 | 900 | 1,200 | 1,500 |

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As can be noted from these illustrations – the quantum of capacity that can be supported by a fixed budget increases over the years, since the cost curves for solar power are decreasing. The Government should devise the roadmap based on its ability to support subsidy. It may be mentioned here that higher capacity additions will lead to a faster learning curve effect.

Here, the German model, which provides a market feed-in-tariff for a given period, makes for a good case study. The German Feed-in-Tariff (FIT) Law guarantees consumers tariff for 20 years after they are connected to the grid. This tariff is lowered at a constant rate (the rate is predetermined and does not change over the term of the existing 20 year contract). Depending on the response of consumers, the tariff rate for the next time period is dynamically changed. If the market gets an overwhelming response, then the FIT rate for the next year for new contracts changes such that it is inversely proportional to that response. However, if the response is lower than desired, then the FIT rate is raised in order to attract more consumers. This dynamic FIT rate stabilizes the rise in demand. Till date, the response has always been higher than expected and hence, the tariff is being lowered. This constant decline in tariff ensures innovation and rapid growth in the solar sector.

## 9.2 Credible funding plan

### 9.2.1 Support lending community

Availability of credit to the developers for financing solar projects is critical for the success of solar program in India. The lending community should be adequately equipped to understand the sector and play an active role in supporting it. From a lending perspective, there are some concerns relating to the solar sector.

First is technology. The technology is relatively new and there are not enough examples that prove the performance of solar plants from an Indian context. Here, education of the banks is the need of the hour. The Government has initiated steps in this direction and this move is welcome. Banks on their part should spend enough resources to understand this sector well, since the strategic implications for the country are large and this sector provides an enormous funding opportunity in the coming decade.

Second, is the ability of State utilities to afford the bundled power. Given the financial constraints of the State utilities, affordability can be a challenge. We understand that there is some comfort being provided by the Central Government to provide a back-stop in the event the states default. However, we would urge one step further to be taken in this regard through utilization of the National Clean Energy Fund to support states directly for solar power purchase as is explained later.

Third, is the issue relating to sector specific exposure limits on lending. Banks have internal sectoral cap / exposure limits for each sector. A separate solar/renewable energy sector specific exposure/cap can go a long way in increasing the pool of financial resources for solar sector. Further, given the importance of energy security and carbon mitigation potential, lending to solar/renewable sectors should be classified as 'priority sector'.

Fourth, is the issue of asset liability mismatch. Banks typically depend on deposits with tenures of around 2-3 years, while the financing requirements for solar sector would be of longer tenures of up to 15 years. Here, debt mobilization through say - long tenure tax free solar bonds - can go a long way in providing access to low cost debt for developers. This can address the inherent asset liability mismatch of the banking system and lend stability to the interest rates charges on developers. This issue is similar to what is being faced in other infrastructure sectors.

Fifth, is relaxation of ECB norms. The Government has permitted eligible borrowers in the telecommunication sector to avail themselves of ECB route for payment of spectrum fees. Further, the relaxed norms permit the bidders to raise rupee funds from domestic markets and these rupee funds can be refinanced through ECB's at a later date. A similar relaxation can be provided for solar projects. One key challenge here is the transparency / information availability about the projects and developers in the solar sector. To mitigate this, a risk rating mechanism needs to be developed that provides rating to the solar projects and developers and will play an important role in reducing the risk perception of the sector.

### 9.2.2 Support to states

There is a need to devise a credible funding plan to support market creation. This is important to provide assurance to market participants to realize money from this industry. At present, the burden of solar subsidy has been delegated, to a large extent, onto the power utilities, as they are the ultimate buyers of this power. State power utilities are already under severe financial strain. This puts the entire solar program at jeopardy as the bankers are unsure about the ability of the power utilities to foot the bill.

While the creation of the National Clean Energy Fund through a levy of cess on coal at the rate of INR 50 per ton is a step in the right direction, it is important that the State utilities are provided financial support from this fund. Specific budgetary allocation/grants from the Central Government to the State utilities for meeting solar power purchase obligations would come in handy for the cash strapped utilities.

The State utilities should focus on developing a financing mechanism that reduces the burden on the State exchequer. Creation of a State Clean Energy Fund with focus on solar sector could lend credibility to project developers. The budget of the fund could be met through options such as cess on electricity consumption within the State, raising funds through solar bonds etc. The state of Gujarat has already initiated this measure.

### 9.2.3 Support consumer financing models

For wider acceptance of solar among consumers, especially small-scale applications segment like solar water heaters, the high one time investment is a potential deterrent.

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Innovative financing models that provide funding access to small-scale end user segments can potentially enlarge the market size. Government can encourage financial institutions for onward lending at affordable rates to kick–start the small-scale applications market.

## 9.3
## Enforce solar purchase obligations

To support market creation efforts, it is important to enforce solar purchase obligations and take appropriate action where the obligations are not met. The solar mission already lists down the trajectory linked to power consumption, gradually increasing from 0.25 percent to 3 percent by 2022. This enforcement has to happen at the state level by state regulators.

This will ensure that the base market which is required to build the necessary economies of scale will come up. This will also facilitate setting-up of a solar eco-system in the country. Besides the aforementioned benefits, the REC market will get the required boost resulting in new capacities being market driven.

Further, solar power can be mandated for such end-use applications where solar power is economical when compared to the alternative fuel options. For example, diesel generation sets are deployed for meeting the power requirements of telecom towers. In such instances a mandate to use solar power in a calibrated manner can help in market creation besides emission savings.

## 9.4
## Investments in R&D – PPP models

The Government has already taken several proactive measures to promote R&D in renewable energy technologies. The Ministry of New and Renewable Energy has given a mandate to IIT Jodhpur to set-up a Centre of Excellence to complement the existing facilities at the solar energy centre in Gurgaon. This is a step in the right direction.

Investments in renewable R&D are important to accelerate the cost reduction trajectory. R&D efforts with focus on cost reduction, grid interconnection and energy storage are critical to enable large-scale deployment of solar power solutions. Furthermore, specific research that meets the local demand conditions is the need of the hour.

There are some key issues that should be addressed to facilitate India's rise as a global R&D hub for solar power technologies.

First, improve coordination of R&D work in renewable energy technologies. This is important to help maximize efficiency and minimize duplication of R&D efforts. Today, there are many academic and research institutes doing research but there is lack of coordination about who is doing what. A coordinated R&D approach which involves all key stakeholders is the need of the hour.

Second, take steps to further increase private sector participation in R&D. There is a need for higher involvement of private sector in R&D for solar power technologies. For example, solar power is ideally suited to meet many off-grid market applications. Public Private Partnerships (PPP) with market oriented R&D efforts can go a long way in accelerating India's progress as an R&D hub. Besides communicating industry R&D priorities for research focus, PPP results in faster technology transfer back to industry.

Third, an R&D life cycle management approach that monitors the transition of projects from the research stage to commercial deployment is required.

Finally, a solar R&D mission which articulates the framework for collaborative research consisting of all stakeholders is the need of the hour. An example of a goal could be to "achieve a cost of storage system of INR 0.50-1.00 / kWh for a particular size and type of storage in Indian conditions". There is a need for higher involvement of private sector in R&D efforts.

## 9.5
## Focus on off-grid market applications

### 9.5.1
### Agriculture segment

Solar power can potentially transform the agriculture segment by meeting its power requirements optimally. It will be win-win situation for all stakeholders - provides power access to the farmers when it is required the most; results in savings in power purchase costs and network maintenance costs for power utilities; and controls over spiraling power subsidy for the Government.

The need of the hour is a workable model that brings in innovation and meets the local requirements. The workable model needs to have the following elements –

- A technically viable solution under field conditions
- Assurance of large scale off take to manufacturers to bring down cost
- Farmer awareness and education about the benefits
- A delivery model that can install and service the equipment at large scale – an ESCO model can be a potential solution.

Government should start with a pilot on PPP basis and this should then be considered for large scale up.

### 9.5.2
### Solar water heating

Some of the measures that can be undertaken to promote deployment of solar water heating systems are mentioned below:

- Consumer financing / prevalence of ESCO models to take the higher upfront capital cost burden off the consumers. This step can make SWH applications more popular in areas with lower dependence on hot water (say less than 8 months) as well.
- Mandatory building byelaws by Central / State Governments and ensuring compliance – of special relevance to multistory buildings

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where individual houses do not have clear rooftop access. Rational method of distribution of limited water output acts as a barrier today.

- Better subsidy administration – an improvement in our view could be to deliver subsidies directly to consumers rather than to manufacturers. This can incentivize market growth without necessarily distorting the market.
- Increased awareness of SWH and subsidies available – While subsidies such as rebate on electricity bill are well known, people are not aware of other subsidies like reduction of house tax etc that exist in some parts of the country.
- Focus on developing model cities on a pilot basis – While Bangalore has emerged as a role model for other parts of the country to follow, it is also considered as a city where all the elements (water requirement duration during the year, Government incentives, SWH manufacturing supply chain) fall in place. More cities need to be taken up across the country on a pilot basis by Central / State Governments and incentivized to install SWH. This will not only spread broader awareness at a country level but also strengthen SWH supply chain in areas where it is currently missing or is fragmented.

## 9.6 Provide incentives for solar manufacturing industry

Globally, solar manufacturing industry is dominated by China and is highly competitive. Chinese companies are global cost leaders due to the highly favorable policies that exist there. Chinese companies have access to large credit facilities at low interest rates from domestic state-owned banks to expand manufacturing capacities besides access to low cost labour. In the US, given the potential for the industry to generate jobs, the US Government has recently announced a tax credit policy to encourage solar manufacturing industry.

Governments at the State and Central level should actively support development of solar manufacturing industry in India. Some options for consideration include: Facilitate access to long term low cost loans; Duty exemptions for imports of raw material / intermediary equipments; Provide tax concessions similar in nature to what was provided for the IT industry.

In addition, the State Governments could identify potential sites for developing solar parks with all the basic infrastructure in-place. Steps need to be initiated that reduce time delays in getting project approvals.

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# Investment opportunities for the Indian Industry

# 10

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# 10 Investment opportunities for the Indian Industry

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# 10

# Investment opportunities for the Indian Industry

**Key Questions:**

- What should be the key imperatives in the near term?
- What is the potential investment opportunity – services & material supply for private sector in the next 5-10 years?

## 10.1 Imperatives for the near term

For mainstream solar companies, we believe that the following are the key imperatives in the near term:

- Since there is intense competition among the players to get access to projects which are limited in number, it is necessary to work out a model which gives a cost advantage and thereby enables a higher chance of winning projects. Sources of cost advantage could be a certain level of vertical integration into the manufacturing or EPC value chain, access to land sites where solar insolation is superior and access to low cost financing.
- Solar companies should also keep a slightly broad-based focus and include segments like off-grid applications and other renewable technologies in their portfolio. This will enable them to optimize their resources in an environment where access to new projects may be uncertain.
- Indian companies should also look at overseas solar markets in the US and Europe for access to projects. In the immediate future, these markets will offer more opportunities and help Indian companies to move up the learning curve and be poised to capitalize on the Indian market when it scales up rapidly.

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## 10.2

## Investment opportunity for the future

The Indian industry has proved its competence globally through competitiveness in sectors such as IT and automobile. India needs solar power and this sector requires innovation to make it happen on a large scale. There are a multitude of applications that have significant market potential and can transform the energy scenario of the country. The investment required in the sector over the next decade is summarized here:

| Solar Investments (In USD Billion) | 2012-17 | 2017-22 |
|---|---|---|
| Small-scale Solar Market (Rooftops, Agriculture Pumpsets, Telecom, Street Lighting) | 5 | 64 |
| Utility-scale Solar Farms (CSP and PV) | 15 | 28 |
| **Cumulative Investments Required in five-year periods** | **20** | **92** |

**Source:** KPMG's Solar Market Size Model

This would develop the vendor market which is as detailed in the table below:

| Solar Specific Vendor Market (In USD Billion) | 2012-17 | 2017-22 |
|---|---|---|
| **Solar PV Segment** | | |
| Inverter Market | 1.8 | 12.3 |
| **Sub-total PV Vendor Market Potential** | **1.8** | **12.3** |
| **Solar CSP Segment** | | |
| Parabolic Troughs | 0.6 | 1.8 |
| Mirrors | 0.4 | 1.2 |
| **Sub-total CSP Vendor Market Potential** | **1.0** | **3.0** |
| **Total Solar Specific Vendor Market Potential** | **2.8** | **15.3** |

**Source:** KPMG's Solar Market Size Model

In addition, the potential in the non solar-specific vendor market which includes items common with other industries is as shown below:

| Non-Solar Specific Vendor Market (In USD Billion) | 2012-17 | 2017-22 |
|---|---|---|
| **Solar PV Segment** | | |
| EPC Services Market | 1.5 | 7.5 |
| **Sub-total PV Vendor Market Potential** | **1.5** | **7.5** |
| **Solar CSP Segment** | | |
| EPC Services Market | 0.5 | 1.6 |
| Civil Works | 0.2 | 0.6 |
| **Sub-total CSP Vendor Market Potential** | **0.7** | **2.2** |
| **Total Non-Solar Specific Vendor Market Potential** | **2.2** | **9.7** |

**Source:** KPMG's Solar Market Size Model

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Further, some of the potential investment and innovation opportunities are cited below:

One, cost effective storage solutions can transform solar from being a marginal source to a frontline source of energy. This will have an exponential impact on the market potential and opportunity. At present, there are multiple technology options with high costs. Given the fact that costs of solar power are on a steady decline, it is an opportune time for investments in storage technologies that can provide stability to solar power supply.

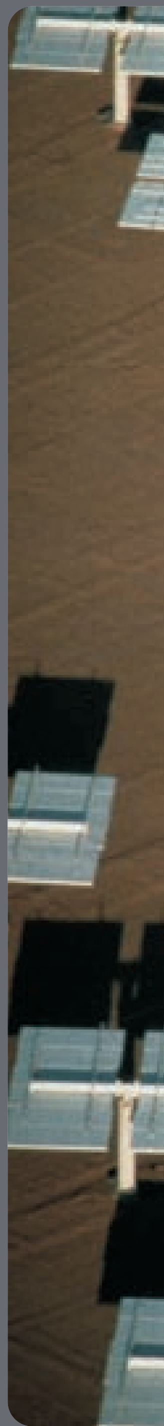
Two, the extent of localization of solar system installations could determine the pace of cost reduction trajectory. Going forward, the non-module system costs (inverters, switchgear, and other electrical equipment) will form a higher share of total solar system costs than module costs. For example, at present inverters are not manufactured in India. With the growing market potential, there will be higher demand for quality inverters. Technology tie-ups and local manufacturing could potentially reduce costs of inverters.

Three, is the opportunity to set up solar manufacturing capacity to meet the Indian and global solar market demand. Solar manufacturing industry is a global industry with aggressive cost reduction trajectories. Here, the ability to be the lowest cost manufacturer becomes the critical success factor. While the manufacturing segment is scale sensitive and global cost leaders have emerged in other parts of the world notably China, we believe India can offer a large market in the next five years. Yet, Indian manufacturers will have to depend on a mix of domestic and export markets to make the business case for entry into this space in the medium term. Companies wanting to enter this area should contemplate on the right business model in terms of scale, level of integration and partnerships for global market access and technology to make this proposition viable.

Fourth, we believe that significant opportunities exist in the downstream space comprising system integration and creating user applications with solar power. This includes areas like powering telecom towers, solar heating applications in Industry, solar-powered agriculture pumpsets, etc. Companies which can evolve suitable business models to address this market can achieve significant scale as the market is very large.

Finally, significant human resource capacity building is required in the solar sector. The solar sector is still at a nascent stage. Given the market potential, the capabilities of the industry need to be built. There will be demand for skilled manpower to construct and operate solar power plants. A million direct jobs are likely to be created by 2021-22. Collaboration with training institutes and research organizations could go a long way in bridging the skill gap.

In conclusion, the solar sector has the potential to transform the Indian economy in a way the IT sector transformed the Indian economy during the 90s. Industry should grab this golden opportunity, thus benefiting themselves and the overall economy.



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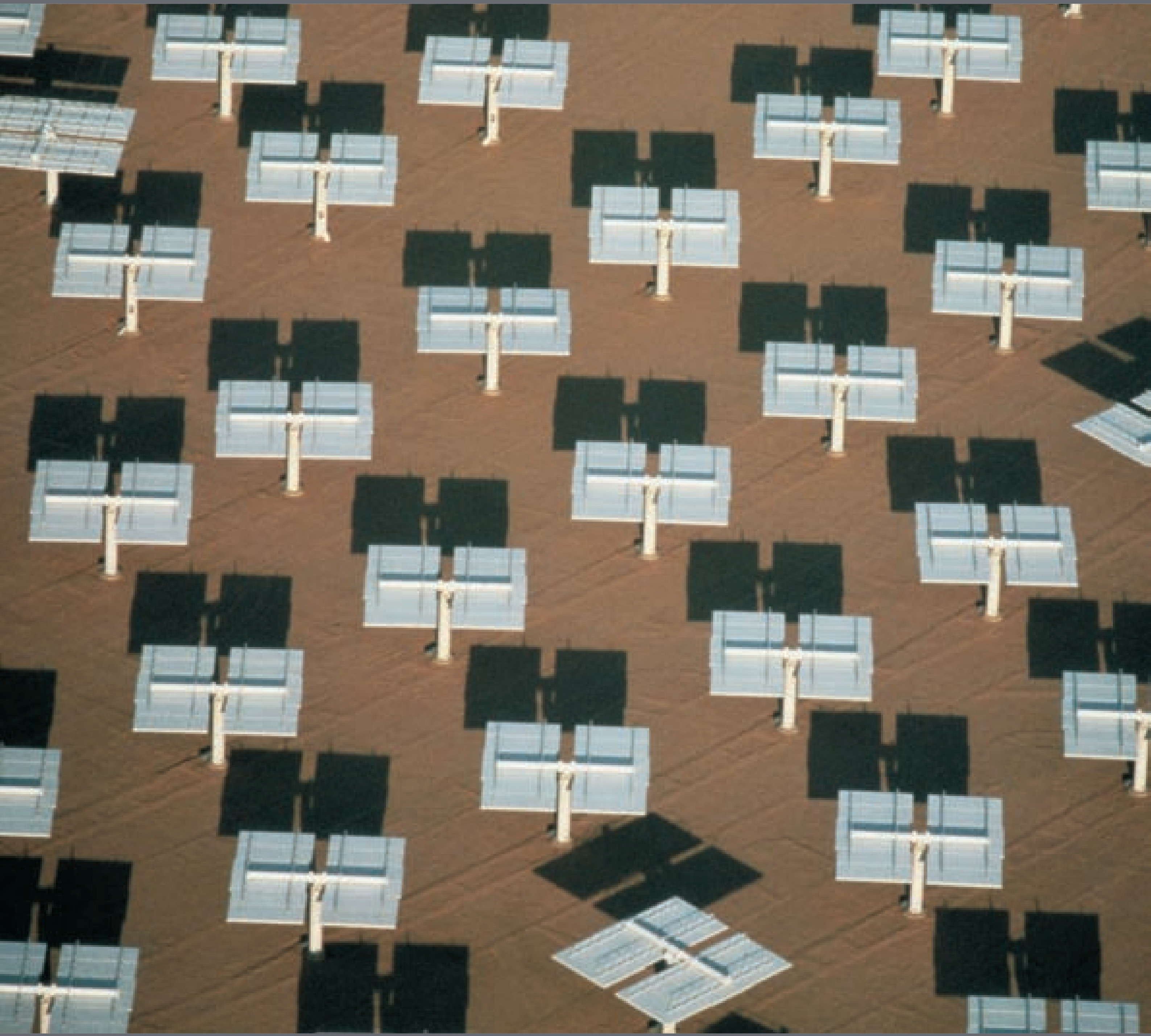

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# Appendix - Taxation

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# 11 Appendix - Taxation

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# 11

# Appendix - Taxation

**The sun is shining bright for players in the solar sector so far as the incentives are concerned.**

## 11.1 Tax and fiscal incentives

There are many tax incentives available to the solar sector in India. Undertakings engaged in generation or generation and distribution of power have been offered a 10-year tax holiday for solar plants if it begins to generate power before 31.03.2012.

Post 31.03.2012, new Direct Tax Code is likely to be effective which provides for expenditure based incentive to business of generation, transmission or distribution of power. As regards this incentive, all revenue and capital expenditure will be allowed as tax deduction upfront instead of claiming amortisation / depreciation on the capital expenditure.

Indirect tax cost forms a substantial part of the overall EPC Project cost, which ranges from 10 percent to 20 percent of the total solar project cost. Considering the special focus on renewable energy, the Central Government has given various incentives on setting up the solar power project which includes exemption from customs and excise duties on specific goods required for setting up the solar power projects. However, these exemptions are subject to fulfillment of prescribed conditions and compliances to be undertaken by the EPC contractor or IPP.

Furthermore, some of the state governments have provided the incentives in the form of levy of VAT at reduced rate (i.e. 5 percent) whereas the other states levies VAT @ 12.5 percent.

Given the vast variety of tax and fiscal incentives available, one needs to quantify the tax cost and explore the structuring options, before investing into the solar sector.

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## 11.2

## Tax planning

At the outset, for a player based overseas, entry strategy would carry a lot of importance. In order to achieve tax efficiency with regard to taxability of gains on sale of shares, many companies opt to route the investments through an intermediate entity in a tax friendly jurisdiction.

Typically, solar companies in India procure the equipment and services from overseas i.e. offshore supply and services. In such a scenario, contract structuring from a tax perspective help Solar companies upfront achieve major tax efficiency. Further, in case of multiple parties coming together and bidding as a consortium, contract structuring assumes deep importance to avoid the risk of the consortium being taxed as an Association of persons.

In India, based on the nature of operation, different forms of entity could be established in India. Operating through a Limited Liability Company i.e. by forming a Joint Venture/ Wholly owned subsidiary could be one of the possible options in a situation where the foreign company is looking at a long term presence in India. However, one needs to rule out other forms before concluding.

Further, solar sector being a capital intensive sector, investing companies would need to strategise the options available for funding the project vis-à-vis the repatriation of profits/ return on investments.

Hence, various tax planning avenues could be explored by the solar sector companies while planning their investments in India in solar sector.

The taxation of EPC contract offers various challenges and opportunities.

The EPC Contract can be structured as a single contract or divisible contracts. The selection of the any of the above option causes a huge impact on the indirect tax costs and working capital of the project.

The selection of schemes for payment of indirect tax liability on construction of solar power plant offers various tax planning avenues for solar power project. Furthermore, the above scheme has various attributes which sometime becomes cumbersome to comply (i.e. restriction on procurement of goods outside the state etc).

The manner of procurement of goods and supply chain structuring plays vital role in the solar power project costs, since the tax rates are different for procurement of goods from outside India, from other state and from the same state.

Generally, EPC contractor also undertakes operation and maintenance of solar power plant. The taxability of O&M contract has been subject matter of disputes in various decisions.

The exemption provided under the customs and excise act are subject to various conditions and compliances. Hence, it is utmost important to ensure compliance of the respective conditions as otherwise the benefits envisaged may not be available.

The proposed introduction of 'Goods and Services Tax' will also play a major role in the costing of solar power project as the government intends to limit the various exemptions available to solar power project.

Given the vast variety of tax and fiscal incentives available, one needs to quantify the tax cost and explore the structuring options, before planning the capex, at the tender\bid stage and also at the time of awarding contracts, so that tax costs are optimized.

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# Standard Conversions

| | |
|---|---|
| Crore | Ten Million |
| Lakh | One Hundred Thousand |
| USD | United States Dollar |
| INR | Indian Rupee |
| USD - INR | 44 |
| EURO – INR | 64 |
| Mn | Million |
| Bn | Billion |
| KWH | Kilowatt-hour ( 1 Unit) |
| MWH | 1000 KWH |
| TWH | Billion KWH |
| MU | Million Units |
| KW | Kilowatt ( 1000 Watts) |
| MW | Megawatt ( 1000 KW) |
| GW | Gigawatt ( 1000 MW) |
| GCV | Gross Calorific Value |
| SHR | Station Heat Rate |
| MTOE | Million tonnes of oil equivalent |
| MTPA | Million tonnes per annum |

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