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SECTION C -
Energy Security in India:
Integrated Approach to Solar Energy

ENERGY SECURITY IN INDIA:

INTEGRATED APPROACH TO SOLAR ENERGY

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C.1 INTRODUCTION

The looming energy crisis in India

In 2009, India had the third largest energy demand in the world after China and the United States and just ahead of Russia. As World Energy Outlook (WEO) 2011 shows, India's energy demand more than doubled from 319 million tonnes of oil equivalent (Mtoe) in 1990 to 669 Mtoe in 2009. Notably, India's per-capita energy consumption is still at a much lower level than that of developed countries and even of some developing countries.

With a growing economy and a 1.24 billion population aspiring for a better quality of life, India's energy demand growth is inevitable. The question is at what scale and speed India's energy demand will expand and which fuels and technologies it will use. It is important to note that in 2009, 289 million Indians lived without access to electricity and 836 million people without modern fuel for cooking and heating (IEA 2011a). Unsatisfied energy demand is the key source of projected growth of demand in India, which will accelerate in tandem with the country's economic growth.

The NPS projects that India's demand continues will grow quickly, reaching 1 464 Mtoe in 2035, increasing by a compound annual growth rate (CAGR) of 3.1% from 2009 to 2035, which is more than double the world's energy demand at a CAGR of 1.3% for the same period. India's share in world energy demand increases from 5.5% in 2009 to 8.6% in 2035. The growth would come from all fuels.

Renewable energy is becoming an increasingly important part of India's energy mix. With vast potentials, renewable energy is no longer seen as an alternate energy source to conventional energy, but as a critical element in pursuit of key policy objectives (MNRE, 2011a). It enhances India's energy security by diversifying its energy mix and reducing import dependence on fossil fuels. Solar power, especially, is seen as having the potential for India possibly to attain "energy independence in the long run" (PC, 2006). In providing energy access to India's people, renewable energy is expected to "supplement conventional power generation and meet basic energy needs, especially in the rural and remote areas" (PC, 2007). Mitigating climate change is also one of the reasons India seeks to promote renewable energy, but not the primary force behind it.

The renewable sector features strong private investments, which are essential to materialize the potential of renewables for supplying a clean and modern energy, particularly in rural areas. However, government policy that imposes mandatory domestic-content requirements, particularly for the solar industry, will most likely hinder the expansion of the sector. growth of strong local manufacturing capacities can be achieved through more open market policies and investment in R&D, rather than relying on import substitution policies[1]

The installed capacity of renewable power generation was 23 GW in January 2012, which is equivalent to nearly 12% of total power capacity (MNRE, 2012a; CEA, 2012a). Wind comprises the largest capacity with 16 GW or 70% of total renewable capacity, followed by small hydro at 14% and bagasse cogeneration at 9%. However, Solar PV with 481 MW capacity represented only 2% of total renewable installation.

The JNNSM was launched in 2010 as one of eight missions under the National Action Plan on Climate Change. It has three implementation phases:

• Phase 1: 1.1 GW of grid-connected PV and 0.2 GW of off-grid PV by 2013.

[1] The OECD/ International Energy Agency, " Understanding Energy Challenges in India: Policies, Players and Issues", 2012

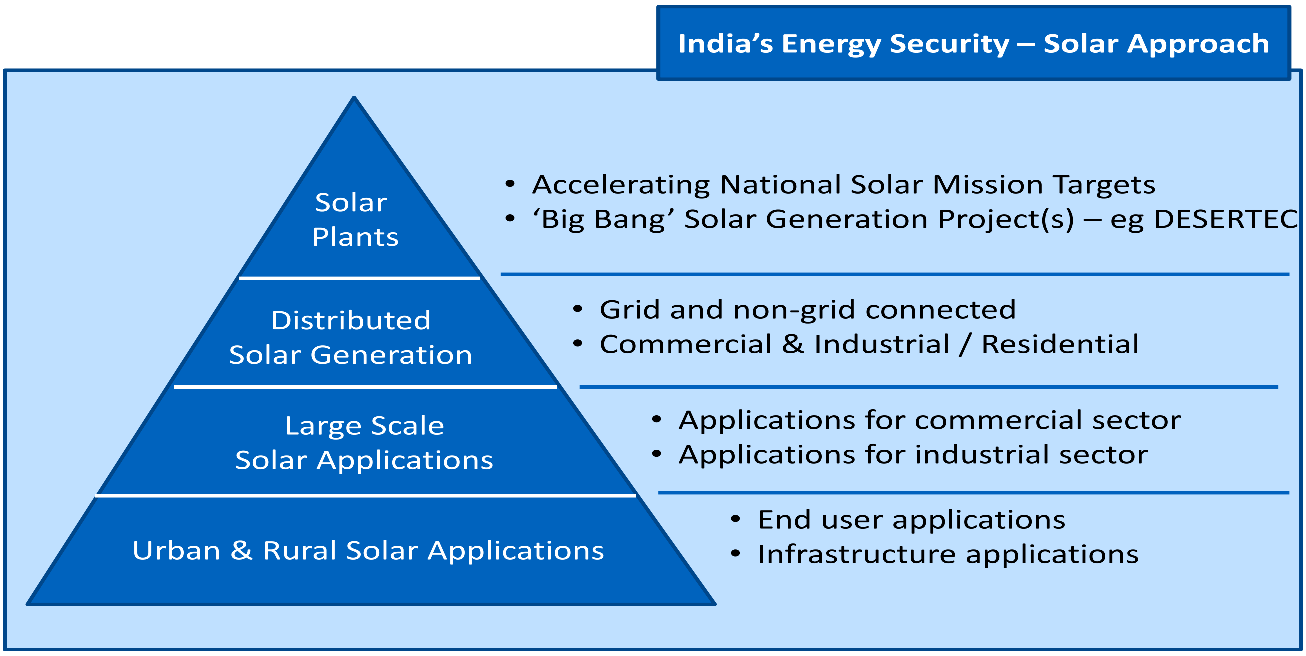
• Phase 2: 4 GW of grid-connected PV and 1 GW of off-grid PV by 2017.

• Phase 3: 20 GW of grid-connected PV and 2 GW of off-grid PV by 2022.

Off-late, solar capacity increased considerably, bolstered by JNNSM. In May 2012, MNRE announced that the installed solar capacity reached 979 MW, implying that the target for Phase 1 would be likely met as planned by 2013 (PIB, 2012e). To accelerate the growth of solar capacity, the JNNSM included a Solar Purchase Obligation (SPO) as part of the RPO and financial incentives, including capital subsidies and custom duty exemptions for "specific capital equipment, critical materials and components" (MNRE, 2009). It anticipates that solar power would achieve grid-parity by 2022 and coal thermal power parity by 2030. In this spirit, the amended National Tariff Policy 2011 included 0.25% of SPO by 2013 and up to 3% by 2022 (MNRE, 2012a). The JNNSM has an ambitious goal to transform India into a global leader in solar manufacturing with a target of a 4GW to 5 GW equivalent of installed capacity by 2020 (MNRE, 2009).

A. Four-pronged approach to achieving Solar Energy based energy security in India

In ascending order of number of stakeholders involved, the following are the four approaches towards helping India secure a solar-energy based sustainable future, are as follows:



- **Solar Energy Power plants** , which are grid-connected and help meet local regional energy needs
- **Distributed Solar Energy Generation**, for off and mini-grid solar power, to serve remote and rural areas
- **Large Scale Solar Applications** – for commercial and industrial users of energy
- **Urban and Rural Solar Appliances** – for the domestic users of energy and households in urban and rural areas

C.2 SOLAR PLANTS

For grid-connected solar, Gujarat (50%) and Rajasthan (33%) represent almost 83% of India's total capacity. An alternative way to acquire the required technical competencies is through strategic partnerships. Italian utility Enel partnered with the Japanese company Sharp to produce thin film solar panels for five solar PV plants, totalling 20 megawatts, as part of Enel's ambitious expansion plans for PV generation. The plants began operating in the south of Italy in 2012.

However, For solar PV projects, especially large-scale projects that are increasingly situated in the desert, dust is a serious problem which can reduce the energy output by up to 30% within a few weeks of installation (Sharma,NK, 2012). As such, water is necessary to clean the solar panels, and its availability close to the project site is essential for optimal operation of solar installation.

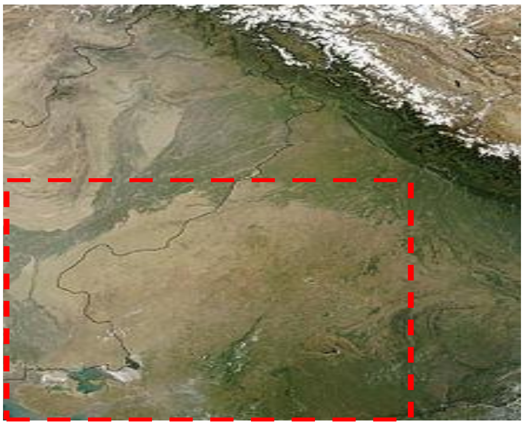
There are some successful case-studies of large-scale solar power plants that can also be replicated.

A. Examples of how Utilities and the government hold the key to significant value creation

DESERTEC– Game Changer for Solar Energy in Africa & Europe

- The deserts of the world offer an almost inexhaustible source of energy, especially in the form of direct sunlight and wind. Using appropriate technology this energy can be converted into electricity and transported over long distances with minimal losses to centers of demand. Within a radius of 3000 km around the suitable desert sites about 90% of the world population can be supplied with additional electricity to complement their locally available sources of power
- By harnessing of deserts and arid regions for generation of clean energy , in theory 1% of the earth's deserts would be enough to power the earth + 90% of the world's population lives within 3000 kms of deserts and arid regions
- Thus, abundant quantities of clean power in the future could help promote the electrification of the world. Clean power could in many cases - such as transport and heating of buildings - replace fossil fuels. An electrification of the world with clean electricity from plentiful renewable sources is essential in the future for a massive reduction in CO_2 emissions and the stabilization of our climate.

- Conceptualised by the DESERTEC Foundation comprising of public figures, private individuals, politicians and scientists from North Africa, the Middle East and Europe
- The consistent implementation of the DESERTEC Concept and, in the future, the substitution of fossil fuels with clean energy from desert and arid regions could reduce global CO_2 emissions by 80%
- Based on proven technologies – e.g. Solar PV, and Concentrating Solar Thermal Power Technology



(NASA satellite image of Thar Desert)

Big Bang Solar Project in Rajasthan's Thar Desert

- The Thar Desert extends over portions of North West India (Rajasthan, Gujarat, Haryana and Punjab), and some parts of Sindh and Punjab provinces in Pakistan.
- Bulk of the Thar Desert covers the state of Rajasthan, and particularly the districts of Jaisalmer, Barmer, Bikaner and Jodhpur. The area covered by the Thar in Rajasthan is over 200,000 sq kms
- There is immense potential for harvesting solar power in the Thar Desert. Creating 100,000 MW of large solar capacity would require about 3,300 sq km of land in the Thar, which is only about 1.7% of the area of the Thar in Rajasthan
- This would require an investment of Rs 8 lac crores to Rs 10 lac crores, including equipment and transmission, but excluding land costs. Technology developments and economies of scale could drive this cost down further

C.3 DISTRIBUTED SOLAR POWER GENERATION

Consumers are becoming more energy conscious. Deregulation, unbundling and liberalization are giving them more choice: the UK, for example, now has 17 power retailers and almost one in every five customer changes suppliers each year. At the same time, rising tariffs; detailed, timely consumption data; and environmental awareness are all focusing 'consumers' awareness on their power consumption. Consumers are also adopting new roles. No longer just passive recipients, they are turning into so-called "prosumers": consumers and producers rolled into one. The change is being prompted by subsidies on distributed generation technologies such as rooftop PV, and the penetration of micro combined heat and power and micro storage. Rooftop PV is expanding quickly in the United States, and Germany and Japan already have over one million solar panel covered roofs each.

Although penetration and targets for micro scale renewables vary greatly among countries, several types of distributed generation are rapidly becoming competitive, especially rooftop solar PV and micro scale combined heat and power. Only a minor share of overall installed costs of PV is now attributable to the cells themselves. The remaining balance-of-system costs represent about 40 per cent of the total costs in Germany and close to 70 per cent in the United States.

The intermittency of renewable generation increases price volatility, in turn strengthening the business case for power storage, one of the cleantech areas receiving the most venture capital. Technology selection depends on application: power for voltage support must be dispatched in milliseconds or seconds, as must power that is used for frequency regulation to provide grid reliability and stability. Dispatch can be much slower for power used for energy management and integrating renewables, or for backup power for end users to guard against power cuts. In each case, there must be a method of compensating the owner for the service. Owners can benefit directly by using their storage to buy electricity when prices are low, or by using the stored power themselves. Alternatively, they can be paid by the utility operating the storage equipment: a utility may offer financial incentives for technical services such as voltage support or frequency regulation.

These methods are still under development and most storage options are still too expensive for widespread use. Thermal storage at the customer's premises is currently a more practical alternative, although it cannot easily be turned back into power. The pace of distributed storage growth will depend on the extent to which costs come down over the coming years, but also on the spread between peak and non-peak electricity costs, and the degree of regulatory support it receives relative to demand response and generation.

The provisions under the off-grid Solar Generation under the Jawaharlal Nehru Solar Mission are a reasonable step forward in this direction, but the government must identify the most successful implementation mechanisms and identify means to scale them effectively, particularly in rural areas across India.

A. Key benefits of distributed solar power generation

- In areas that are remote or suffer from high grid losses, distributed generation and storage of solar power can be a valid alternative to extending the grid. This is a promising solution for countries like India, where grid losses often exceed 30 per cent
- It also offers improved supply and demand predictability
- Distributed technologies such as rooftop PV and micro combined heat and power are competing at the retail level with Centralised generation, reducing demand and prices at the wholesale level and creating an increasingly decentralised system.
- Micro grids, virtual power plants and aggregators allow not only local generation but also local storage and balancing, reducing the need for transmission and distribution capacity. This will necessitate changes in the way grid services are charged to both generators and consumers.

B. Taking cue from Germany's Success Story: Energiewende Programme

- Energiewende means "Energy Transition" in German
- At the end of 2011, there were 24,800 megawatts of solar PV installed in the country, an estimated 80 per cent of which was on rooftops
- This was producing enough power to supply 5.2 million homes and employing an estimated 150,000 people
- The German Solar Industry Association estimates a total economic benefit of photovoltaics in the range of EUR 56-75 billion until 2030
- The popularity of solar PV has led RWE, the country's second largest utility, to start offering rooftop PV to commercial clients with the aim to install 1,000 megawatts in 2012

C.4 LARGE SCALE SOLAR APPLICATIONS FOR INDUSTRIAL AND COMMERCIAL USERS

India is consuming over 100 million tones of oil every year for various uses. Out of this, almost 40% is being consumed in the industrial sector alone. Further, 40-50% of this consumption is in thermal form alone with temperature range below 250 C which comes to around 15 million tones of fuel oil per annum. The applications include mercerizing, drying and finishing in textile industry; drying, dissolving, thickening, leaching and distillation in chemical industry; cooking, drying and canning in food industry, craft pulping, bleaching and drying in pulp and paper industry, drying and cleaning in leather industry and various such applications in many more industries. The working fluid required for these applications is either pressurized hot water, steam or hot air in temperature range of 60-250 C. Solar energy can be used for preheating boiler feed water in many plants. Industries can also use captive power plants on rooftops or in parks or other open spaces to meet factories' lighting loads and pumping water requirements.[2]

The Bureau of Energy Efficiency's Perform, Achieve, Trade Scheme, and various voluntary certification mechanisms help organizations consolidate their efforts in this space.

A. Examples of industrial and commercial application of solar energy

Some examples of success stories of large-scale commercial adoption of solar energy are as follows:

- Solar Special Economic Zone in Gujarat- India-based Emmvee Photovoltaic Power Pvt Ltd has commissioned two 100 KWp solar photovoltaic (PV) off-grid plants at Kandla Special Economic Zone (SEZ) in Kutch, Gujarat. Emmvee plant is the latest addition to Gujarat's solar plant line-up and in the coming years, the region will see more investment from manufacturers due to the state government's positive encouragement towards solar energy. The company has also installed around 1,000, 24-watt LED-based solar powered street lighting systems for National Buildings Construction Corporation (NBCC) at the SEZ area
- Solar water heating is an established technology and is in promotion worldwide. It can be used in industries for boiler feed applications in raising water temperature from 25 to 80 C and thereby saving a substantial amount of fuel oil being used in boilers. A 10,000 liters per day capacity system may cost between Rs. 15-18 lakhs and can save around 14,000 liters of fuel oil per year for a period of about 20 years, the life of the system. The largest system installed is of 1,20,000 liters per day capacity at M/s Godavari Fertilizers and Chemicals Ltd., Kakinada, Andhra Pradesh. The system was installed in 1997 through soft loan from IREDA and it recovered its cost in four years.
- A roof integrated solar air heating systems with 700 sq.m. of collector area has been installed in a leading ternary at Ranipet, Tamil Nadu for drying of leather. The system was able to save around 360 tonnes of fire wood used in the boiler apart from replacing a 1.2 tonne capacity steam boiler

C.5 URBAN AND RURAL SOLAR APPLIANCES

The MNRE implements various programmes including solar water heating systems, solar lanterns. The rural population in India is heavily dependent on subsidised kerosene and consumes nearly twice (0.51 litre per month) as much as urban residents (0.29 litres per month) (MOSPI, 2011). Similarly private enterprises and other organizations setting up a business model to sell solar-based appliances in rural and urban areas can provide significant economic and employment benefits, as well as enhance the standard of living of the people, and help reduce the burden on the government on subsidizing kerosene and other combustible materials.

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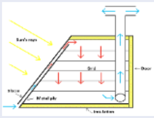
[2] MNRE, "Solar Energy Potential in Industries", http://mnre.gov.in/file-manager/UserFiles/solar_energy_potential_in__industries.pdf

A. Key Solar applications for urban and rural domestic usage

Listed below are some applications of solar appliances for urban and rural populace. These range from simple individual owned and operated appliances, to those that could be deployed and managed by businesses for small – to medium scale usage. Each of these are available in the market in many technological forms, from the most simple to the most technologically advanced application and storage capacities. With multitudes of national and international organizations commercializing these products and technologies, the only challenge that remains is making these products available and comparably priced to the conventional appliances.

	End User	Infrastructure
Urban	 **Solar water heating**  **Local generation**	 **Solar Street Lighting**  **Commercial scale solar cookers**
Rural	 **Personal Solar Cooker**  **Solar Lighting Kits** **Rural solar micro-grids**	 **Solar powered ATMs**  **Solar Drying of Fruits & Vegetables**  **Solar Water Pumps**

B. Business Case for Solar Lighting Kits and Micro-Grids for Rural India

- An estimated 80-85 million rural households do not have electricity
- They mainly depend on traditional fuel sources like kerosene and firewood. On average, a non-electrified household is spending Rs 150 per month (Rs 1800 annually) on these fuel sources

Solar Lighting Kits	Rural Solar Micro-Grids
For $100, a household will get: ▪ 3 bright portable lights (25-100 lumens – 2 to 10 times brighter than kerosene lamps) for 8 hours a day (at normal power) ▪ 2 mobile phone charging points ▪ 5 year battery life Solutions with fan and TV would cost much more due to power requirements of these appliances (under development)	▪ Pioneered by Mera Gaon Micro Grid Power ▪ For about Rs 1500 per year, they can provide 2 lights and a mobile phone charging unit operational for 7 hours per day ▪ It costs them about Rs 50000 ($900) to set up a microgrid for 40 households

- The investment to get 10 million rural households electrified through solar will be Rs. 6,000 cr
- Micro-finance institutions and multilateral agencies can fund this investment and recover it from the rural households over a 5 – 10 year period (payback is 3 years)

Benefits include:

- **Environmental:** Reduced kerosene and firewood through these solar solutions would result in reduction in carbon emissions
- **Health:** It would also enhance the health of rural households due to no inhalation of toxic fumes from burning kerosene and firewood ; no deterioration of eyesight due to bright lighting
- **Standard of Living –** Solar electrification can help companies

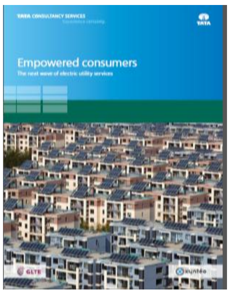
C.6 CONCLUSION

In India, the energy supply mix of the future will be can be made much cleaner and significantly help reduce the nations carbon footprint by switching to sources such as solar energy. The Jawaharlal Nehru National Solar Mission is a good starting point, but the policymakers can take significant steps to determine the role of solar energy in mainstream power policy of India, as they are doing during the German nuclear phase-out, or allow it to evolve out of the interplay between incentives, market forces and emissions standards.

To accelerate market penetration, bring down costs and reduce risks, promotional policies need to both generate innovation and prompt investment and thereby deployment at scale. They must have specific schedules of appropriate duration in order to remove public and private uncertainty. It is vital that policies are consistent, credible and transparent; if not, investors' hurdle rates will build in the associated uncertainty and many investments will never happen.

Through tighter energy efficiency standards for appliances, buildings and the grid, regulators will help create a system that will contribute to a nation's competitiveness and economic productivity. Economic benefits not only include reduced consumer bills, but also higher employment, personal income, economic output and spending in other sectors.

As efficient functioning of market forces can contribute to higher system efficiency, policymakers should encourage competition by helping third party service and technology providers participate in the market, and by stimulating mechanisms such as dynamic pricing at the retail level, and demand response in wholesale markets. In terms of specific policy instruments, feed-in tariffs are proven tools that perform well on all fronts, providing they are guaranteed for long periods to give investors financial security. Quotas can stimulate investment, but for reasons to do with true comparative advantage, they provide only a mixed, or at best mild, stimulus to innovation. Tax credits can be extremely powerful, especially as a means of bringing technologies to scale, but they must be consistently applied over time with schedules independent of political whims, otherwise they can create boom and bust cycles as they fail to generate consistent cost signals.



Some portions of this report are adopted from TCS and Xynteo's Thought-leadership paper,

"Empowered Consumers: The Next Wave of Electric Utility Services".

Click here to access the complete report and read the analysis in detail.