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RAJASTHAN CONCENTRATING SOLAR POWER

A Multi-stakeholder Partnership That Maximizes Solar Power to Fuel India's Economy

India is now tapping the vast potential of solar power to diversify its energy mix while meeting rapidly increasing energy demand.

- India's energy sector faces major challenges, including increasing energy demand amidst energy poverty, dependence on fossil and imported fuels, and heavy pollution.
- The Jawaharlal Nehru National Solar Mission, which aims to maximize solar energy to stimulate India's economy, is a timely response to the problems of its energy sector.
- A multi-stakeholder partnership among the Government of India, the Asian Development Bank, and private companies helped develop the Rajasthan Concentrating Solar Power Project, the world's largest project using compact linear Fresnel reflector technology.
- This technology reflects and concentrates the sun's rays onto solar steam generators that boil water into super steam and drive turbines to produce more than 240,000 megawatt-hours of clean energy per year, helping India secure energy supply while reducing its dependence on fossil fuels.

CONTEXT

India has a vast potential for solar power generation. About 1.89 million square kilometers of its total land area (about 58%) receive an annual average insolation[1] totaling 5 kilowatts per square meter per day (kW/m^2/day). With today's solar technology, 1% of India's land can adequately meet the country's energy needs until 2031.[2]

The Government of India recognizes the immense potential of solar energy. In 2011, it launched the Jawaharlal Nehru National Solar Mission (NSM), which established a national energy target to deploy 20,000 megawatts (MW) of grid-connected solar power by 2022. The NSM aims to harness solar energy to ensure energy efficiency and less reliance on fossil fuels.

Several energy-related challenges make this policy track very timely. India is experiencing a rapid increase in energy demand while nearly a quarter of its population still lacks access to energy.[3] Moreover, India depends heavily on fossil and imported fuels that pollute many of its cities. In May 2014, the World Health Organization listed four Indian cities among 1,600 with the dirtiest air worldwide. With an average 153 micrograms of $PM_{2.5}$ per m^3 (i.e., particulate matter less than 2.5 micrometers in diameter), New Delhi topped the list. $PM_{2.5}$ is highly hazardous because it can penetrate and lodge deep in the lungs.[4]

PROJECT SNAPSHOT

LOAN APPROVAL DATE:
March 2012

LOAN AMOUNT:
$103 million

BORROWER:
Rajasthan Sun Technique Energy Private Limited

GEOGRAPHICAL LOCATION:
Rajasthan, India

TYPE OF ENERGY PROJECT:
Solar power generation

EXPECTED PROJECT COMPLETION DATE:
April 2015 (partially completed in November 2014)

A diversified energy supply mix is crucial in India. Therefore, the NSM set targets to promote solar power aiming to install 2 gigawatts (GW) of capacity by 2013, 10 GW by 2017, and 20 GW by 2022. NSM also aimed to develop a diversified manufacturing base of solar power components. The government initially invited private companies to bid for the right to develop 470 concentrating solar power (CSP) projects. Rajasthan Sun Technique Energy Private Limited (RSTEPL), a subsidiary of Reliance Power Limited, approached the Asian Development Bank (ADB) for financing after winning one bid. The subsequent partnership between ADB and RSTEPL yielded the Rajasthan Concentrating Solar Power Project, the world's largest CSP project using compact linear Fresnel reflector technology (CLFR).

1 The amount of solar radiation reaching a given area.
2 Clean Energy. 2012. *Rajasthan Concentrating Solar Power.* http://www.cleanenergyactionproject.com/CleanEnergyActionProject/Solar_CSP___Concentrating_Solar_Power_Case_Studies_files/Rajasthan%20Concentrating%20Solar%20Power%20Project.pdf
3 International Energy Agency. 2012. *Understanding Energy Challenges in India.* http://www.iea.org/publications/freepublications/publication/India_study_FINAL_WEB.pdf
4 G. Harris. 2014. Cities in India among the World's Most Polluted, W.H.O Says. *The New York Times.* 8 May. http://www.nytimes.com/2014/05/09/world/asia/cities-in-india-among-the-most-polluted-who-says.html?_r=0

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Full commissioning of the Rajasthan solar farm will help the country transition to a renewable energy source and reduce emissions and pollution.

SOLUTIONS

Multi-stakeholder partnership. The Rajasthan CSP project was a collaborative work among partners with clear roles. By establishing the NSM, the Government of India set the policy framework. Foreign development banks, including ADB, and an export credit agency provided financial assistance with substantially longer maturities than local financial institutions. This arrangement enticed RPL to develop CSP and provide the needed equity. Areva Solar provided the necessary technology.[5]

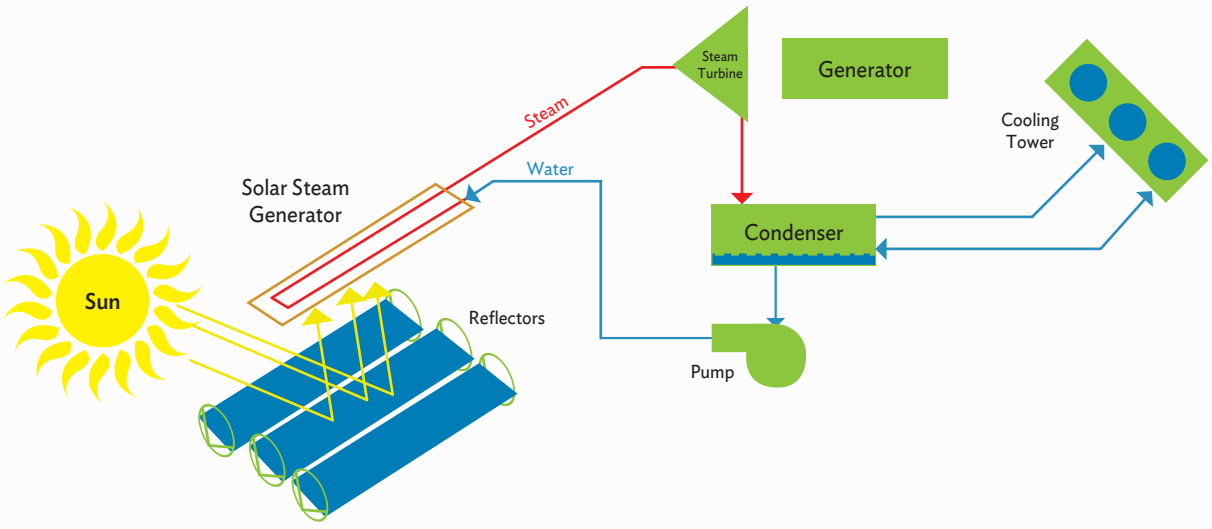
[5] Climate Policy Initiative. 2014. *The Role of Public Finance in CSP Case Study: Rajasthan Sun Technique, India.* March. http://climatepolicyinitiative.org/wp-content/uploads/2014/03/SGG-Case-Study-The-Role-of-Public-Finance-in-CSP-Rajasthan-Sun-Technique-India.pdf

Reliance Power Limited, which established RSTEPL to develop CSP in Rajasthan, has a strong energy portfolio in India and abroad. In March 2011, the company's net worth was Rs168.33 billion (about $3.74 billion). Before approaching ADB for financial assistance, RSTEPL conducted rigid and high-quality preparations for the Rajasthan CSP project. After review and discussions, ADB loaned $103 million to RSTEPL to finance part of the construction of CSP, which has a total cost of about $414.5 million.

Selecting a suitable project site. One challenge in establishing solar power generation plants is finding a suitable tract of mostly level land that is widely exposed to continuous sunlight. The project selected a highly suitable site near Dhursar Village in Pokaran Tehsil, Rajasthan. The site covers about 340 hectares of nearly flat landscape, far removed from highly populated areas but near a national highway, and enjoys long periods of cloudless days. In addition, this site provides higher direct normal irradiance and optimized grid connectivity. Direct normal irradiance at the project site is about 2,071 kilowatt-hours per square meter, one of the highest in India.[6]

Using compact linear Fresnel reflector technology. CLFR technology concentrates the sun's energy to about 40 times its normal intensity onto a steam-generating receiver. Turbines or other engines transform the steam into mechanical energy and then into electricity. CSP uses a series of flat reflectors or mirrors arranged in parallel rows that reflect and concentrate sunlight onto a series of tubes within 35 solar steam generators. The sun's rays heat the water in the tube to 400°C, generating superheated steam, which drives a turbine that produces electricity. The mirrors' position adjusts automatically every day, based on the sun's position, to maximize received sunlight. This technology is the foundation of the 100 MW CSP generation plant in Rajasthan, which is the world's largest CSP plant using linear Fresnel technology and the first completed under the NSM. Figure 2.5.1 illustrates the process of solar power generation.[7]

Figure 2.5.1: Process of Power Generation



Source: Asian Development Bank. 2012. *Final Environmental Examination. Rajasthan Concentrating Solar Power Project.* February. Manila.

[6] Asian Development Bank (ADB). 2012. *Report and Recommendations of the President to the Board of Directors: Proposed Loan to India for the Rajasthan Sun Technique Energy Private Limited Rajasthan Concentrating Solar Power Project.* March. Manila.

[7] ADB. 2012. *Final Environmental Examination: Rajasthan Concentrating Solar Power Project.* February. Manila.

Connecting to the power grid. To connect to the power grid, CSP shares the 30-kilometer, 220-kilovolt, double-circuit transmission line developed by Dahanu Solar Power Private Limited for the 40 MW Dahanu Solar Power Project, which is near the project site. The transmission line passes through several villages without affecting the right of way, households, or trees. All energy generated by the Rajasthan CSP project will be sold to NTPC Vidyut Vyapar Nigam Limited (NVVN) for 25 years at a fixed rate (i.e., Rs11.97 or $0.24 per kilowatt-hour). RSTEPL had already established a power purchase agreement with NVVN, India's designated nodal agency for the procurement of solar power.

RESULTS

Construction of the CSP plant was partially completed on 11 November 2014. Although full commissioning is not expected until April 2015, it is already connected to the power grid and has begun generating power. This operating power plant helps diversify India's energy mix by using renewable energy and harnessing it better using modern technology. It is now helping India reach its target, reducing dependence on fossil fuels by providing at least 242,756 megawatt-hours of solar-generated electricity per year.

Aside from helping India transition to a renewable energy source, CSP helps reduce emissions and pollution. Solar power eliminates fuel combustion, thus avoiding an average 229,368 tons of carbon dioxide emissions per year. CSP also demonstrates the viability of CLFR technology on a much larger scale. India plans to install at least three other CSP power plants by 2015.

LESSONS

Using technology to maximize solar power. Using CLFR, a relatively new CSP technology, is a huge step in India. Although used for commercial operations since 2009, most CLFR projects are small. More than 450 MW of CLFR-based CSP projects are under development worldwide, but only 16 MW is operational. The largest CLFR project in operation is AREVA Solar's 5 MW plant in California. With a capacity of 100 MW, the Rajasthan CSP project is by far the largest in the world. It demonstrates the viability of CLFR technology for utility-scale power generation. Compared to other CSP technologies, CLFR is less complex because it lacks heat exchangers or transfer fluids, U-shaped or curved reflectors, and complex sunlight-tracking systems.

CSP technology helps many countries experiencing energy deficits and rapidly growing demand for energy. CSP can store the sun's energy as heat, allowing it to deliver power when it is needed, balancing supply and demand gaps arising from the fluctuating supply from other renewables, and helping maintain a stable energy supply (footnote 5).

Stimulating the private sector to help reach targets. Power plants are investment-intensive and may further strain government budgets in countries like India, which subsidizes energy for consumers. It is important to entice private sector participation in large-scale energy projects to help the country reach energy targets without draining government budgets. It is also wise to tap the private sector, not merely for financial investments but also for technology and innovations. Industry leaders can offer innovative products and approaches to help a

country meet its energy supply targets. This project illustrates two concrete ways to engage the private sector: setting a conducive policy climate and offering attractive financing schemes.

The need for more information on concentrating solar power. At a time when countries are searching for stable sources of renewable energy, CSP can become a good alternative. However, compared to solar photovoltaic technologies, CSP has not been commercially applicable. Solar photovoltaic technology-based power plants have become more prevalent around the world, with over 100 GW installed capacity. CSP installed capacity (using CLFR and other technologies) is only 2.2 GW worldwide. Thus, CSP projects are more costly compared to photovoltaic, inhibiting investors. There is a need to disseminate more information about CSP, particularly regarding its ability to maximize sunlight capture and adapt to local contexts. This successful project is one more step toward attracting more investments in CSP, increasing its commercial application and reducing investment cost. In addition, this project increases knowledge about CSP, as it demonstrates the feasibility of establishing a utility-scale CSP plant.

Having realistic timelines. A key lesson gained from CSP is the need for realistic timelines. Introducing a new or complex technology in untested markets requires careful planning. Project implementers should not expect rapid completion, due to a longer learning curve and longer time to construct the infrastructure. Completion date targets should consider these factors, which are inherent in novel or complex technologies.

Keywords

Concentrating solar power, solar power, sun, solar, solar energy, renewable energy, India, Rajasthan, energy

For further reading

- http://www.adb.org/news/adb-help-finance-rajasthan-solar-plant-one-largest-india
- http://www.adb.org/projects/details?proj_id=46900-014&page=overview
- http://www.adb.org/projects/documents/rajasthan-concentrating-solar-power-project

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