SUMMARIZED BY ENERGETICA INDIA

Solar Thermal Energy's Outlook & Regions

Energetica India summarizes the 4th report on Solar Thermal Energy (STE) from European Solar Thermal Electricity Association (ESTELA) and looks at STE overview in some of the countries across the world.

As of 2015, the installed capacity of Solar Thermal Energy (STE) increased to almost 5 GW with the connection of a number of large-scale solar thermal power plants to the grid, in Spain and the US in particular. Around 61% of the operational STE plants are located in Spain, whereas 18% are located in the US.

Over the past three years, market interest has shifted away from the traditional markets of Spain and the US to emerging markets like South Africa, Morocco and Chile, due to their high solar resources and political commitment to solar energy.

The levelised electricity cost of STE plants depends on both the available solar resource and development costs of investment, financing and operation. Plants under the same price and financing conditions, in the southwestern US or Upper Egypt will have levelised electricity cost 20%-30% lower than in southern Spain or the North African coast. This is because the amount of energy from direct sunlight is up to 30% higher (2,600-2,800 kWh/m^2/yr compared to 2,000–2,100 kWh/m^2/yr). The solar resource is even lower in France, Italy and Portugal. The best solar resource in the world is in the deserts of South Africa and Chile, where direct sunlight provides almost 3,000 kWh/m^2/yr.

The economic feasibility of a project is determined by both the available solar resource at the site and then by power sale conditions. If the local power purchase price does not cover the production cost, then incentives or soft loans can cover the cost gap between the power cost and the available tariff. Environmental market mechanisms like renewable energy certificates could be an additional source of income, in particular in developing countries.

All the STE plants in the US were pre-financed by developers and/or suppliers/builders and received non-recourse project financing only after successful start-up. In contrast, all STE projects in Spain received non-recourse project financing for construction. Extensive due diligence preceded financial closure and only prime EPC contractors were acceptable to the banks, which required long-term performance guarantees accompanied by high failure penalties. In markets like South Africa and India, a reverse bidding system has been used to ensure a competitive tariff for the PPA. STE with storage is increasingly becoming a pre-requisite in government tenders around the world

'Bankability' of the plant revenue stream has been the key to project finance in Algeria, Spain and the US. Different approaches have been long-term power purchase agreements and FITs, but it has taken considerable effort during years of project development to remove the barriers and obstacles to bankability. In Spain, one major barrier for industry development was the right of the government to change tariffs every year, which gave no long-term business plan income security.

International Policy Frameworks

There is one major and still active international policy instrument relevant to STE at the moment – the Mediterranean Solar Plan.

The Mediterranean Solar Plan was announced in mid-2008 under the Union for the Mediterranean with an initial forecast of 10 GW of STE by 2020, reflecting the potential in the region for the technology to provide both local and export power. The MSP is a result of collaboration on promoting renewable energy between the EU and its Southern and Southeast Mediterranean neighbours, involving support to the production of solar energy in North Africa and energy efficiency to support significant energy savings in the Mediterranean region.

Although the 10 GW goal may seem unrealistic, progress has been made, such as in Morocco with three big solar thermal power plants under construction along with ambitious prospects for 2020 mainly for supplying its local demand. Plans for solar thermal power plant deployment for internal consumption have also been announced in other Mediterranean countries in Africa. However, the MSP's success regarding exporting power depends on high- voltage connections between Tunisia and Italy and Turkey and Greece, as well as on the reinforcement of the interconnection of the Iberian Peninsula with France. This last point caused important hesitations for Spain, which are now removed after knowing the priority that has been given to the electrical interconnection in the Juncker's Energy package. On the other hand, political instability in the region remains a major barrier to the implementation of the MSP.

The European Union is supporting the MSP through a number of projects including the "Paving the Way for the Mediterranean" Solar Plan launched in October 2010. Moreover, other projects, such as the "Support for the Enhanced Integration and the Improved Security of the Euro-Mediterranean Energy Market" and the second phase of the project "Energy Efficiency in the Construction Sector"', will help create the conditions for renewable energy development and increased energy efficiency in the Mediterranean region. Additionally, the EU Neighbourhood

Investment Facility provides support to infrastructure investments in the region in cooperation with the European Finance Institutions. For example, regarding financial tools and risk management mechanisms, the UFM Secretariat worked in close collaboration with the European Investment Bank in order to fully trigger the Mediterranean Solar Plan-Project Preparation Initiative by the end of 2014. MSP- PPI aims to provide technical assistance to support project preparation and development in the areas of renewable energy, energy efficiency and renewable energy transmission capacities for connections to the grid in the region. The programme, addressed to the Mediterranean Partner Countries eligible under the European Neighbourhood Investment Facility, is financed by the European Commission, and the UfM Secretariat will be actively involved in the work of its Steering Committee.34

India

India has a very promising solar resource, with annual global radiation of between 1,600 kWh/m^2 and 2,200 kWh/m^2, which is typical of tropical and sub-tropical regions. The Indian government estimates that just 1% of the country's landmass could meet its energy requirements until 2030. On the solar market development front, the National Action Plan on Climate Change puts forwards some specific policy measures, including research and development to lower the cost of solar energy production and maintenance, establishing a solar energy research centre, and a target of least 1,000 MW of STE by 2017.

The Jawaharlal Nehru National Solar Mission is a major initiative of the Indian government as well as state governments to promote sustainable growth and address India's energy security challenges. The JNNSM seeks to establish India as a global leader in solar energy, by creating the policy conditions for the quick diffusion of solar technologies across the country. The Mission has set a target of 20 GW to be executed in three phases (first phase from 2012 to 2013, second phase from 2013 to 2017 and third phase from 2017 to 2022). The Mission also designates the National Thermal Power Corporation's Vidyut Vyapar Nigam Ltd as the Nodal Agency for procuring solar power by entering into a PPA with solar power generation projects. CERC has set a tariff cap of INR 15.31 for solar thermal power projects.

Under phase one of the NSM, 470 MW of STE was allocated. In April 2014, the Ministry of New and Renewable Energy and the state-run Solar Energy Corp. of India confirmed that the STE target for

2015 would be reduced from 1,080 MW to 100 MW. This came after only one project out of seven successfully met the March 2014 deadline under Phase 1 of the JNSM.

India currently has an installed STE capacity of 235 MW. This includes the 50 MW Godawari plant, the 50 MW Megha plant and the 125 MW Reliance Areva project. The Reliance Areva project is the world's largest operational LFR plant.

UAE

The UAE is another region with great solar potential. The amount of solar radiation received ranges between 2,050 kWh/m^2/yr and 2,800 kWh/m^2/yr, which is among the best in the world.

The UAE began actively promoting the development of solar power generation in April

2008. Both emirates have ambitious initial targets: Abu Dhabi wants solar to account for 7% of its output by 2020, whilst Dubai is aiming for 5% by 2030. Abu Dhabi has launched projects using both PV and STE technologies, whilst Dubai is currently focusing on PV systems.

In January 2013, the UAE inaugurated the largest stand-alone STE plant in the Middle East, Shams 1. At 100 MW, Shams 1 extends over an area of 2.5 km^2, with a solar field consisting of 768 PT collectors. The project generates enough electricity to power 20,000 homes and avoids 175,000 tonnes of CO_2 emissions every tear.

Despite the considerable potential for STE in the UAE, the industry has experienced slower-than- expected industry growth to date, lagging behind other Sun Belt countries. It is expected, however, that the UAE will soon formulate a more concrete local content policy to create a new market as it has the necessary resources, including the infrastructure and labour force needed to localise the STE supply chain.

China

After 20 years of perseverance, a breakthrough was made in China's STE project construction. In August 2012, the first MW level solar power tower plant in China the Beijing Badaling solar thermal power plant was put into full operation.

In September 2014, National Development and Reform Commission set a FIT of RMB 1.2 yuan/kWh for the 50 MW Delingha solar thermal power plant operated by SUPCON Group. The first phase of the project, which has a 10 MW capacity and gas boiler for superheat, has been in commercial operation since July 2013. National Basic Research Programme (973 Programme), National High-tech R&D Programme (863

Programme), National Science Foundation of China (NSFC) and National Technical Innovation Fund for Medium and Small- Size Enterprise all give long-term support to STE technology.

With the support of the government and private sector investment, many PT collector systems have been put into operation, and several LFR and Stirling solar thermal demonstration systems have been built in the past several years.

To promote technical innovation and build an industry technology innovation chain, National Solar Thermal Energy Alliance was established in October 2009. The country is also advancing research into STE and currently has 25 sets of solar thermal collecting experiment facilities. The supply chain for STE has also started developing. A total of 15 companies, for example, can produce PT vacuum receiver tubes; five companies can mass produce trough glass reflector mirrors; two companies could provide the EPC for solar tower type collector systems; two companies can produce turbines for solar thermal electricity, and there is one joint venture company in the country that combines BrightSource's advanced STE technology with Shanghai Electric's leading equipment manufacturing and EPC services.

According to "The 12th Five-Year Plan on Renewable Energy Development", the installed STE capacity by 2015 was expected to be 1 GW. Current installed capacity in the country, however, is about 12 MW. Nevertheless, China has more than 30 solar thermal power projects planned, the total capacity of which (if all realized) would amount to about 3 GW. In December 2014 the National Energy Administration issued the "Notice on Drawing up 13th Five-Year Plan on Solar Energy Development by General Affairs Department of National Energy Administration." STE is an important part of this next plan, which is of great significance for STE industry.

Australia

Currently, the cost of STE in Australia is higher than commercially viability will allow. Despite ongoing and active representations from the concentrating solar thermal industry in Australia, at the time of this writing, no material policy initiatives have been proposed by the government to support dispatchable renewable power generation such as STE with large-scale energy storage. However, the government has provided indications that reviews of the renewable energy target for the period beyond 2020 are likely to consider dispatchability and energy storage as key elements.

A parallel initiative, partly funded the Australian Renewable Energy Agency58, has been established with the goal of reducing the cost of STE technology specifically. This initiative, known as the 'Australian Solar Thermal Research Initiative is managed by the CSIRO in a dedicated directorate. ASTRI has received commitments of funding of approximately AUD$ 70 million over eight years, subject to securing partial funding from industry sources. A review of the ASTRI will take place in 2017, the mid-point of the ASTRI programme period.

Presently, only two STE projects are operational in Australia, both partly funded by Australian Renewable Energy Agency. They are:

The Vast Solar Pty limited 6MWth (1.1 MWe) Pilot CR project, located in Central Western New South Wales. Construction of the Vast Solar Pilot Project was completed in May 2015, and commissioning is underway at the time of writing. Once operational, this will be Australia's only electricity grid-connected so- lar thermal power plant with thermal energy storage

The CSIRO Energy Transformed Flagship STE facility, located at West Mayfield, near New- castle in New South Wales. This facility is pri- marily used for research and development, including research into solar chemistry and solar gas synthesis, and is also the location from which the ASTRI programme referred to earlier is managed

Compact Linear Fresnel Reflector technology was proposed for three projects in Australia, however, none are currently in operation.

A 44 MWth CLFR system (utilising the AREVA Solar CLFR system) was planned for the CS Energy Kogan Creek coal-fired power station.Unfortunately, due to contractual issues between the parties, the project has not been completed. No date has yet been set for commencement of operations.

Regarding planned STE projects, Vast Solar has announced plans to develop a 30 MW STE project with four hours of thermal energy storage, also to be located in Central Western New South Wales. At the time of writing, environmental planning approvals and electricity grid connection approvals are progressing for this project, and Vast Solar is planning for commence-

ment of construction around January 2016. The project is intended to have a 22 month construction period, with commissioning planned for early 2018. This project has at a total estimated installed cost under AUD$100 million and LCOE approaching that of wind-power projects. If these capital costs and LCOE levels are achieved, this could potentially open up significant opportunities for uptake of STE in Australia (with implications for cost structure in STE projects internationally) ◂◂

OUTLOOK FOR CUMULATIVE INSTALLED CAPACITY OF STE PER REGION IN 2020 AND 2030

	OECD North America	Latin America	Europe (EU-28)	Africa	Middle East	India	Dev. Asia	China	OECD Pacific	Global Total
Reference (Current Policy)										
2020	4,971	83	2,989	1,010	1,993	307	5	2	22	11,381
2030	8,927	1,007	4,968	4,057	5,024	307	1,005	1,002	1,002	27,319
Moderate										
2020	8,434	207	2,968	2,541	2,229	1,098	1.961	1,449	954	21,840
2030	27,025	1,048	9,636	26,265	16,647	6,867	8,135	31,340	4,004	130,968
Advanced										
2020	9,700	4,917	10,890	3,596	4,503	1,224	1,961	1,449	3,826	42,066
2030	102,677	23,142	34,759	40,542	67,836	11,576	8,135	41,825	19,760	350,252

MARKET PROJECTIONS FOR STE DEVELOPMENT BETWEEN 2015 AND 2050 UNDER REFERENCE (CURRENT POLICY), MODERATE AND ADVANCED (AGGRESSIVE DEVELOPMENT) SCENARIOS

		2015	2020	2030	2040	2050
Investment and employment						
Reference (Current Policy)						
Annual Installation	MW/a	1,171	3,619	5,651	9,500	12,427
Cost	€/kW	4,287	3,485	2,814	2,688	2,674
Investment	€bn/a	1.57	1.34	2.15	4.60	4.53
Employment Job-Year		18,904	16,981	29,180	62,545	70,197
Moderate STE Market growth						
Annual Installation	MW/a	1,075	4,834	18,876	36,652	61,654
Cost	€/kW	4,287	3,485	2,814	2,666	2,637
Investment	€bn/a	4.61	16.85	53.13	97.71	162.61
Employment Job-Year		16,964	70,051	269,733	574,049	935,995
Advanced STE Market Growth						
Annual Installation	MW/a	797	11,950	49,758	75,455	131,143
Cost	€/kW	4,287	3,485	2,814	2,663	2,577
Investment	€bn/a	3.42	41.65	140.04	169.1	209.76
Employment Job-Year		12,985	169,237	712,674	1,072,328	1,443,265