Sunny Days with CSTEM PV

Center for Study of Science, Technology and Policy
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Being a tropical country, India is blessed with abundant sunlight — the country receives ~5000 trillion kWh (5,000,000 BU) of the sun's energy annually. Unfortunately, most of it remains untapped. For instance, though India's total energy generation for 2019–20 was ~ 1423 BU, only ~ 50 BU came from solar energy (compiled from monthly CEA reports).

Recognising this immense solar potential, waiting to be tapped into, and the need to realise India's goals through clean energy, the central government set up an ambitious solar capacity target of 100 GWp by 2022. The country's current installed solar capacity stands at ~34.6 GWp. While India's solar installations have seen an impressive growth since 2012, there is still a long way to be covered. To contribute to India's solar ambitions, we have built CSTEP's Solar Techno Economic Model (CSTEM), a tool that assesses the techno-economic aspects for prospective solar plants and provides insights to policymakers, researchers, and industry-trackers for informed decision-making (illustrated in Figure 1).

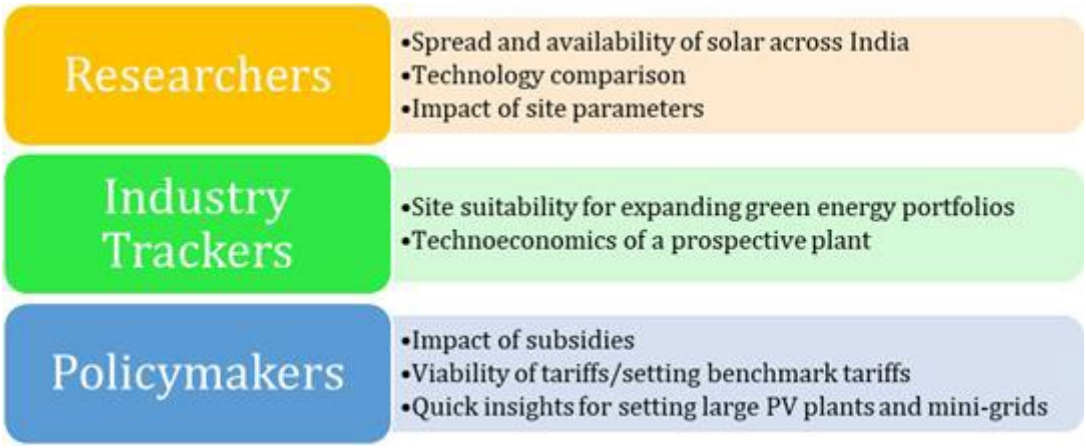

Figure 1: Utility of CSTEM PV

Our journey began in 2017, when we released the first version of CSTEM for Photovoltaics (CSTEM PV) — a tool that makes assessments for utility-scale PV plants

— with support from the Ministry of New and Renewable Energy and Department of Science and Technology. The reception of the tool and support from the Good Energies Foundation, encouraged us to pursue the development of a more comprehensive solar model (utility and mini-grid systems). We decided to revamp our approach from developing an output of research work to a continuously evolving/updated open-access tool. Also, we wished to build a tool that was educative and provide a learning experience rather than just be a case simulator. This required a radical shift in our design thought process — from a process-centric model to a user-centric product — resulting in version 2 of CSTEM PV.

One of the critical challenges was scaling up the tool to increase its scope for pan-India assessments. This required identifying the most appropriate dataset for modelling solar-based energy systems. A joint study with Carnegie Mellon University revealed that in the absence of spatially- and temporally-coincident data, the TMY datasets provided by NREL are suitable for assessment/simulation of solar plants.

The next challenge was to choose appropriate details for the technical model. We knew that the more detailed the model, the greater would be its accuracy. But, this required access to some information that was not in the public domain. We wanted the tool to be accessible to as many people as possible without compromising on the technical rigour. The only way we could do this was to build the tool based on 'publicly available information'. Hence, details from openly accessible datasheets of modules, inverters and batteries were collated. Only those which had sufficient information to perform a credible simulation were considered and updated in the database. We aim to review this in a timely fashion to maintain an updated database.

To ensure further robustness, we took the benchmark tariff model provided by the Central Electricity Regulatory Commission as a reference and augmented our model by including tax considerations, computation of internal rate of return and debt service coverage ratio. A summary of the features of the current version is listed in Table 1.

Feature	Details
Time Reference	Zone Time
Application	• Utility-scale PV • Mini-grids (grid-connected and off-grid)
Accessibility and Scope	• Web-based—Open-access tool • Pan India at approx. 10 km × 10 km resolution*, over 1 lakh locations

	• Simulation resolution—hourly • Downloadable outputs (image, Excel) for registered users
Technology	• PV with storage (for mini-grid systems, lead–acid-based systems) • Power estimates considering effects of radiation, temperature, and wind speed • Plant area estimation (spiral-pattern-based plant design) • Simulations for optimal design conditions • Effect of module degradation • Detailed resource estimation models
Financial Assessment	• Levelised cost of energy, internal rate of return, payback period (for all cases) • Subsidy or reduced bulk capex (for all cases) • Bid analysis (for utility PV) • Feed-in-tariff (for mini-grids)

Features of CSTEM PV

In short, CSTEM PV has been envisioned as a continuing initiative that aims to constructively support and be in line with India's clean energy aspirations.

**Weather Data Source: 2015 — TMY Data, National Solar Radiation Database (NSRDB), National Renewable Energy Laboratory (NREL), USA*

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