

# CSTEP'S SOLAR TECHNO- ECONOMIC MODEL FOR PHOTOVOLTAICS (CSTEM PV)

User Guide



Center for Study of Science, Technology & Policy (CSTEP)  
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## 1. Introduction

The Center for Study of Science, Technology and Policy (CSTEP) built the CSTEP's Solar Techno-Economic Model for Photovoltaics (CSTEM PV). It is an open-access, Web-based tool which can serve as a useful model to perform prefeasibility analysis for utility-scale and mini-grid solar plants from a techno-economic standpoint. To establish ease of access and utility, the researchers at CSTEP built this model based on *publicly available/open data*. It is aimed to cater to policymakers, researchers, and industry-trackers for informed decision-making.

This tool is available at <http://cstem.cstep.in/cstem/>

It has two access options:

- Registered User – Access to all features of the tool for case simulation, including download of outputs in excel and image formats
- Guest User – Access to all features of the tool for case simulation; no provision for download of outputs in any format

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Ease of access and use has been a cornerstone in the design-thought process. The user interface of the tool has been designed to be intuitive and informative to the best possible extent. This manual covers the following topics to provide additional guidance to the user via screenshots:

- Creation of user account and log-in
- Building a new case
- Means to download outputs

## 2. Homepage and User Access

The landing page of the tool presents an introductory video and provisions for registration / login. The menu options provide the following information:

- **About** - Brief details about CSTEP and the features of the CSTEM tool
- **Publications** – Support publications like the manual for the tool, technical reports detailing the mechanics of the tool and some additional relevant publications
- **Credits** – List of team members who contributed to the development of the tool
- **Feedback** – Section to provide feedback, post queries and comments
- **Contact Us** – Contact information of CSTEP
- **Disclaimer** – User code of conduct, terms and conditions for using the tool

Figure 1 to Figure 3 provide some guiding information about the landing / homepage



Figure 1: Home page: Pre-login

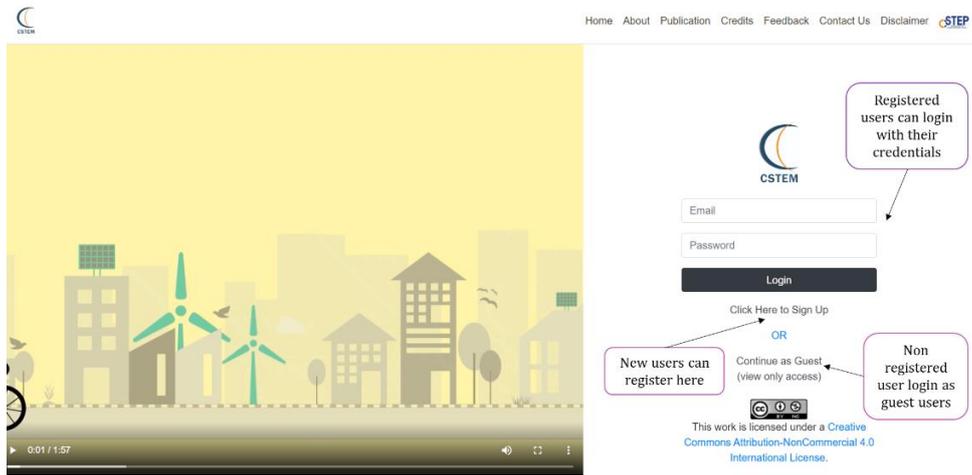


Figure 2: Access for existing users

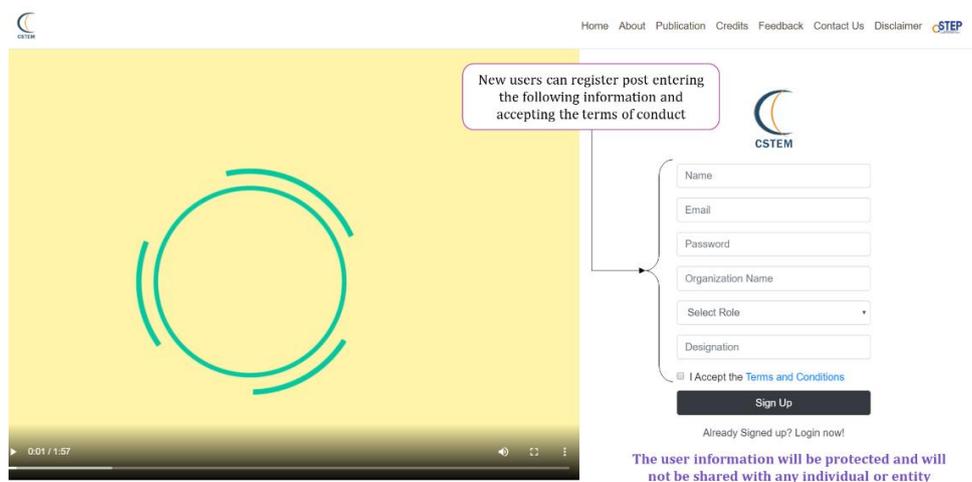


Figure 3: Registration for new users

### 3. Building a Case for Analysis

Figure 4 illustrates the post-login landing page. The users can choose to:

- Check a demo-case to understand the various kinds of outputs presented post-simulation for a preset case definition
- Simulate their own case of interest

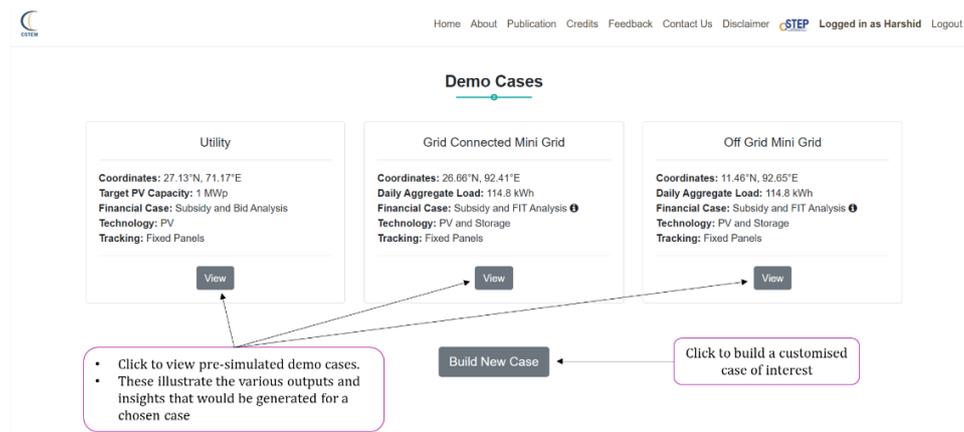


Figure 4: Post-login landing page

The inputs template differs for simulation of utility-scale and mini-grid systems. These are illustrated in sections 3.1 and 3.2. The output template however is similar for both utility and mini grid systems. The broad details and information pertaining to download of outputs is presented in section 4. Default benchmark numbers and valid ranges have been provided at every step to guide the user for building the case.

#### 3.1 Inputs: Utility-Scale PV plant

Figure 5 to Figure 14 illustrate the details of the inputs sequence for simulating a utility-scale PV plant after clicking the 'Build New Case' button in Figure 4. The broad sequence of inputs for simulating the case is as follows:

- Case definition (Figure 5)
- Input-output mapping for a utility-scale PV plant (Figure 6)
- Choosing location of interest and additional details (Figure 7 and Figure 8)
- Plant-design details (Figure 9)
- Choice of technology (Figure 10)
- Loss and related details (Figure 11)
- Capital-cost-related components (Figure 12)
- Operation cost, bid and subsidy information (Figure 13)
- Financial parameters including loan, tax, etc. (Figure 14)

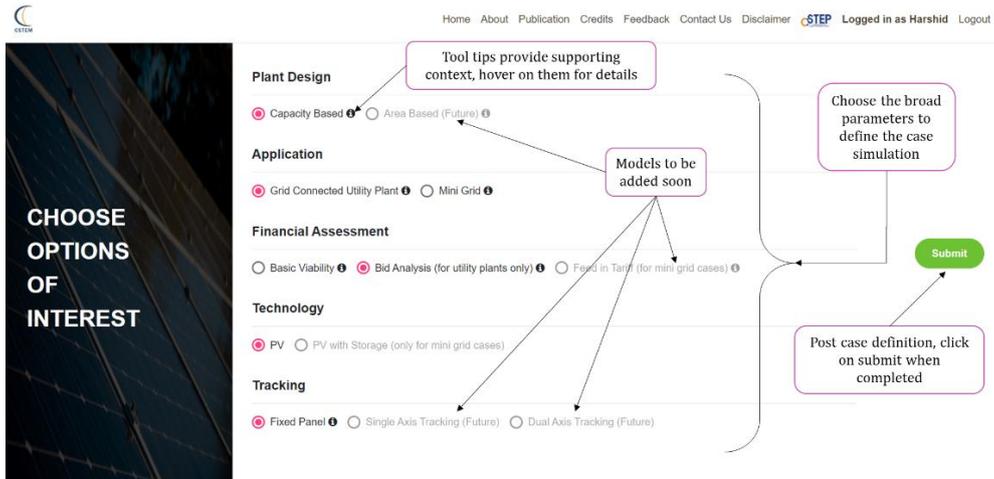


Figure 5: Case definition – utility plant



Figure 6: Input-Output map for simulating a utility scale PV plant

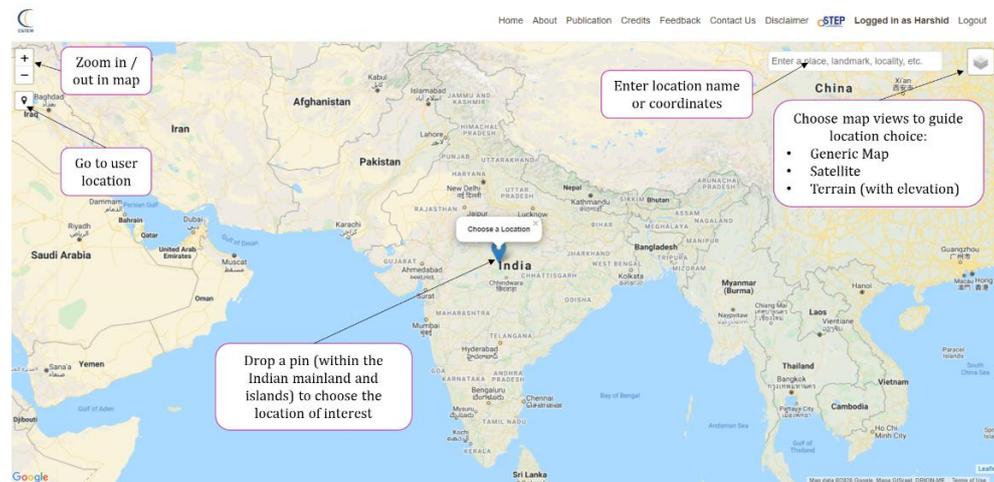


Figure 7: Choosing the location of interest

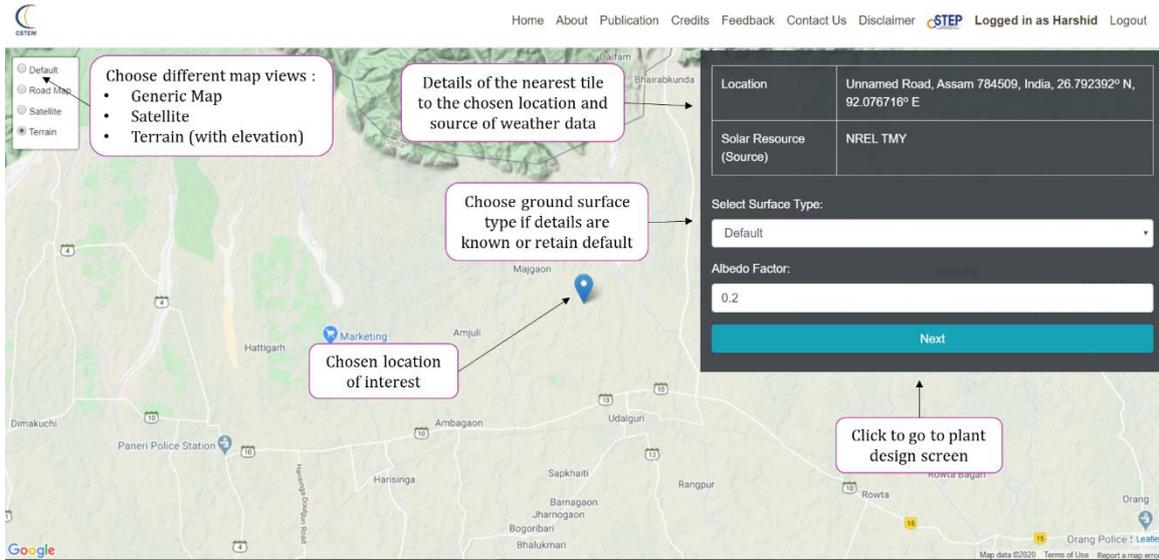


Figure 8: Choice of surface area

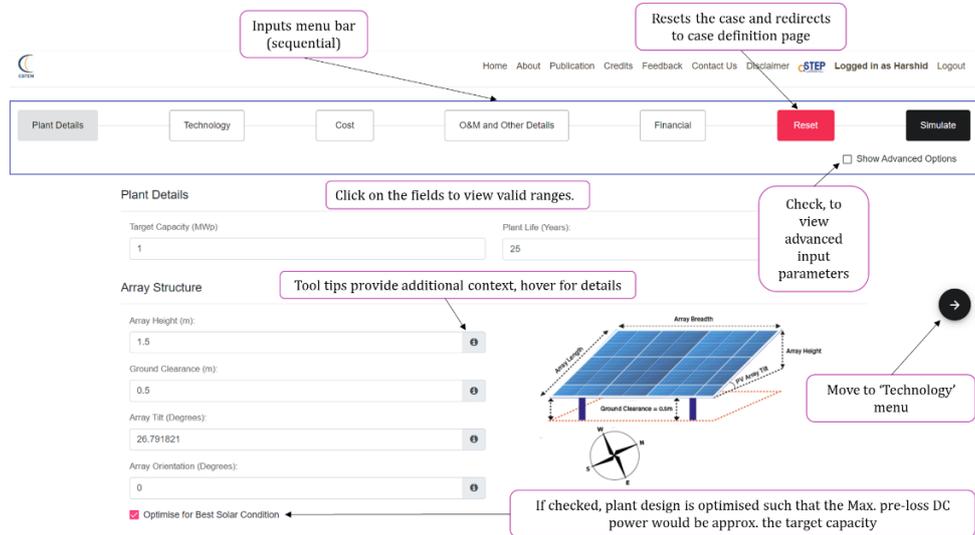


Figure 9: Utility PV plant design

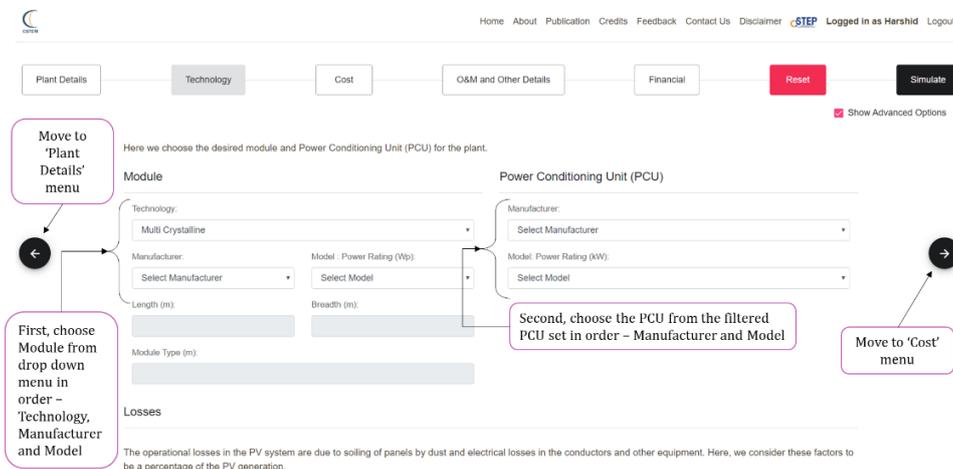


Figure 10: Choice of technology

**Losses**

The operational losses in the PV system are due to soiling of panels by dust and electrical losses in the conductors and other equipment. Here, we consider these factors to be a percentage of the PV generation.

Soiling Loss (%)  Electrical Loss (%)  Range: 0 - 25, Default value = 10

**Module Degradation**

During the lifetime of the plant, PV modules like any equipment degrade and hence contribute to the energy loss in the plant.

As per datasheet  Degradation details: default - as per datasheet; uncheck this to input custom values

Module Rating at End of 1st Year (%)  Year on Year Degradation Rate (% / Year)

**Auxiliary Consumption**

Refers to the in-house energy consumed by the plant for its operation. Here, we consider it as a percentage of the annual generation at the end of year 1.

PV Plant (%)

Figure 11: Loss and related details

**Cost**

Fill in the cost related parameters as per user discretion. Click on the fields to view valid ranges. Click on tooltips for additional context

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Plant Details Technology Cost O&M and Other Details Financial Reset Simulate

Show Advanced Options

We now define the various costs and expenses. These are categorised under Machinery, Infrastructure and Other expenses.

**Machinery**

This includes the core electrical components like the PV modules, Inverters or Power Conditioning Unit (PCU) and (Batteries for mini grid cases only).

PV Module (₹ / Wp)  PCU or Inverter Price (₹ Lakhs / MWp)

**Infrastructure**

Land (₹ Lakh/Acre)  Civil and General Works (₹ Lakh / MWp)

PV Module Mounting Structure (₹ Lakhs / MWp)  Preliminary and Pre-operative Costs (₹ Lakh / MWp)

Power Evacuation Infrastructure (₹ Lakhs / MWp)  Miscellaneous (₹ Lakh / MWp)

Figure 12: Capital cost-related components

Fill in the cost related parameters as per user discretion. Click on the fields to view valid ranges.

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Plant Details Technology Cost O&M and Other Details Financial Reset Simulate

Move to 'Cost' menu

Operation and Maintenance Cost

This accounts for all expenses governing the day to expenses such as salaries, bills and spares.

O&M Cost For 1st Year (₹ Lakh/MWp): 6 O&M Escalation Rate Per Annum (%): 5.72

Subsidy

Bulk Capital (%): 0

Target Bid

Bid (₹ / kWh): 0

Check this and enter the subsidy percentage to simulate the impact

Enter the target bid value, to assess its viability. (Field provided only if 'Bid Analysis' is chosen in case definition)

Move to 'Financial' menu

Show Advanced Options

Figure 13: Operation cost, bid and subsidy components

Fill in the cost related parameters as per user discretion. Click on the fields to view valid ranges. Click on tooltips for additional context

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Plant Details Technology Cost O&M and Other Details Financial Reset Simulate

Move to 'Financial' menu

Loan Related

Debt (%): 70 Loan Term (Years): 10

Moratorium Period (Years): 1 Term Loan Interest Rate (%): 8.5 Working Capital Interest Rate (%): 8.5

Return on Equity

During Loan Term (%): 20

Post Loan Term (%): 24

Taxes

Income Tax Rate (%): 34

Minimum Alternate Tax (%): 20

Depreciation

During Loan Term (%): 5.8

Simulate Case

Simulate

Show Advanced Options

Figure 14: Financial parameters including loan, tax etc.

## 3.2 Inputs: Mini-Grid PV Plant

Figure 15 to Figure 26 illustrate the details of the inputs sequence for simulating a mini-grid plant post clicking 'Build New Case' button in Figure 4. The broad sequence of inputs for simulating the case is as follows:

- Case definition (Figure 15)
- Input-output mapping for simulating a mini-grid PV plant (Figure 16)
- Choosing location of interest and additional details (Figure 17 and Figure 18)
- Load, losses and plant-capacity details (Figure 19 and Figure 20)
- Choice of technology: PV module, PCU, battery & other details (Figure 21 and Figure 22)
- Plant-design details (Figure 23)
- Capital-cost-related components (Figure 24)
- Operation cost, subsidy, feed in tariff components (Figure 25)
- Financial parameters including loan, tax, etc. (Figure 26)

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**CHOOSE  
OPTIONS  
OF  
INTEREST**

**Plant Design**

Capacity Based  Area Based (Futures)

**Application**

Grid Connected Utility Plant  Mini Grid

**Mini Grid**

Grid Connected Mini Grid  Off Grid Mini Grid

**Financial Assessment**

Basic Viability  Bid Analysis (for utility plants only)  Feed in Tariff (for mini grid cases)

**Technology**

PV  PV with Storage (only for mini grid cases)

**Tracking**

Fixed Panel  Single Axis Tracking (Future)  Dual Axis Tracking (Future)

[Submit](#)

Choose the broad parameters of interest for plant design and click on submit when completed

Choose between grid connected and off grid mini grid set-ups

Figure 15: Case definition – mini grid

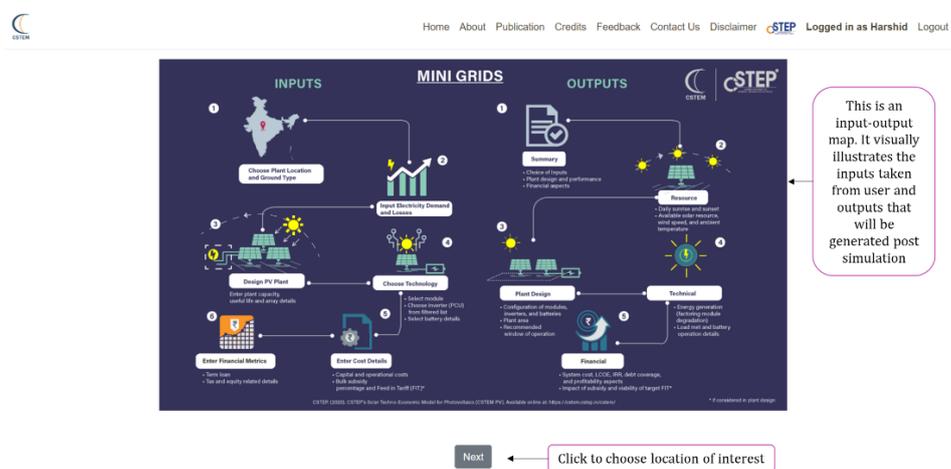


Figure 16: Input-Output map for simulating a mini-grid PV plant

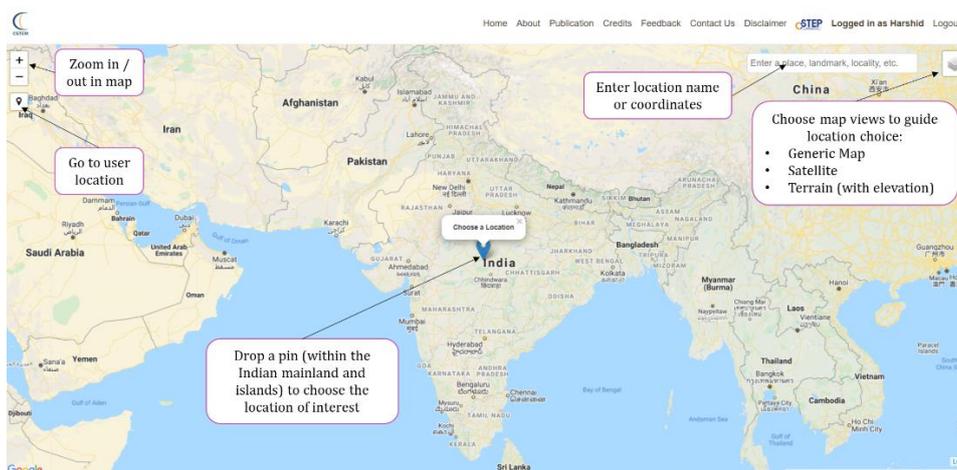


Figure 17: Choosing the location of interest

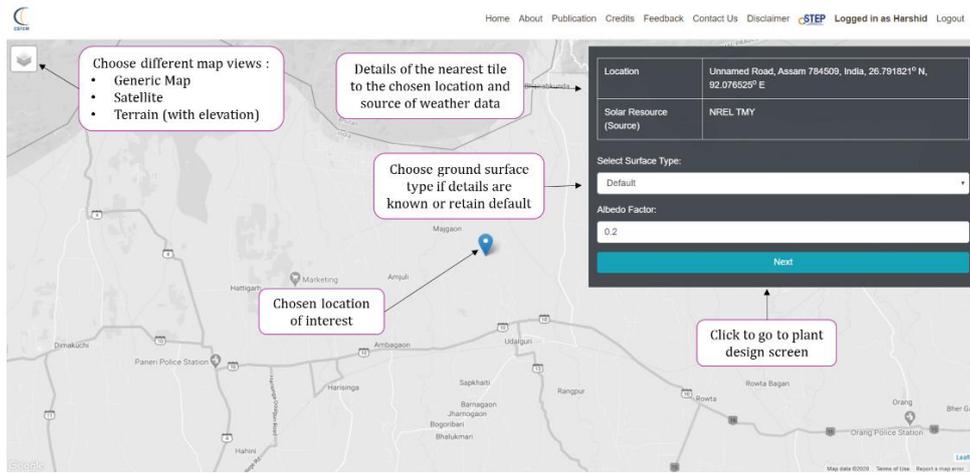


Figure 18: Choice of surface area

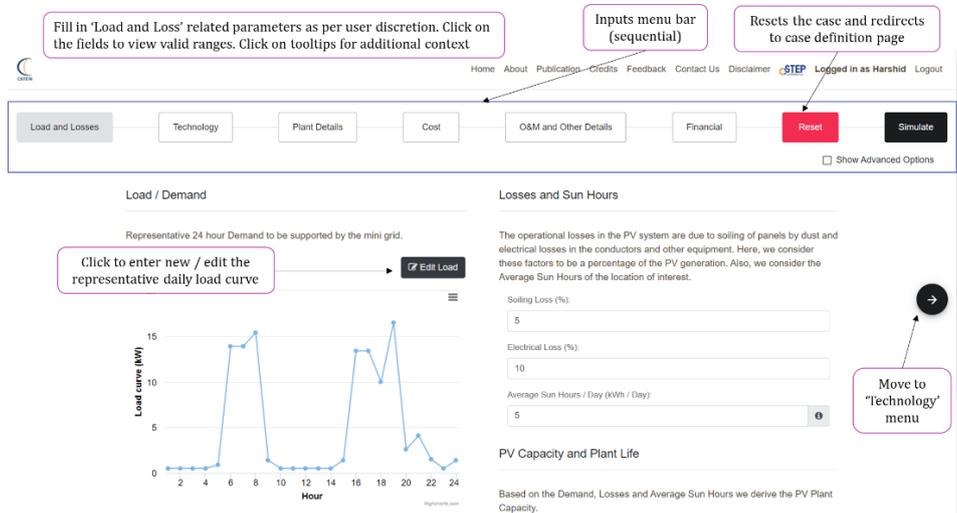


Figure 19: Load- and loss-related details

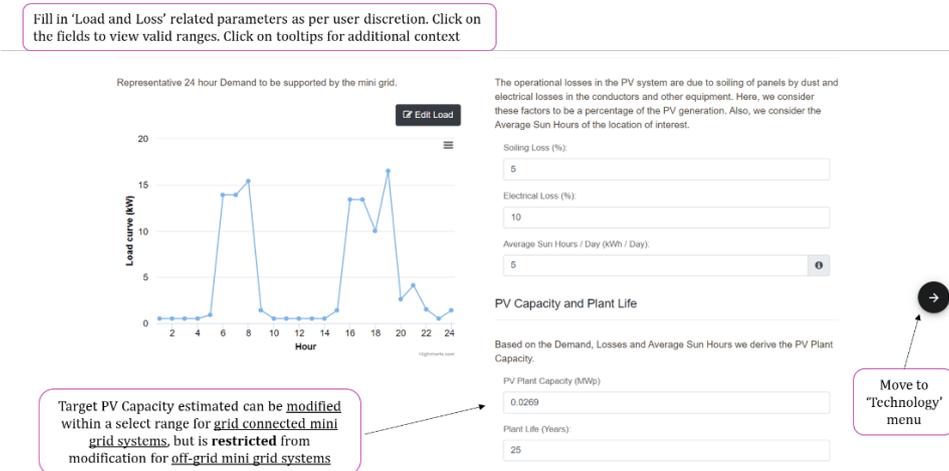


Figure 20: PV capacity and plant life details

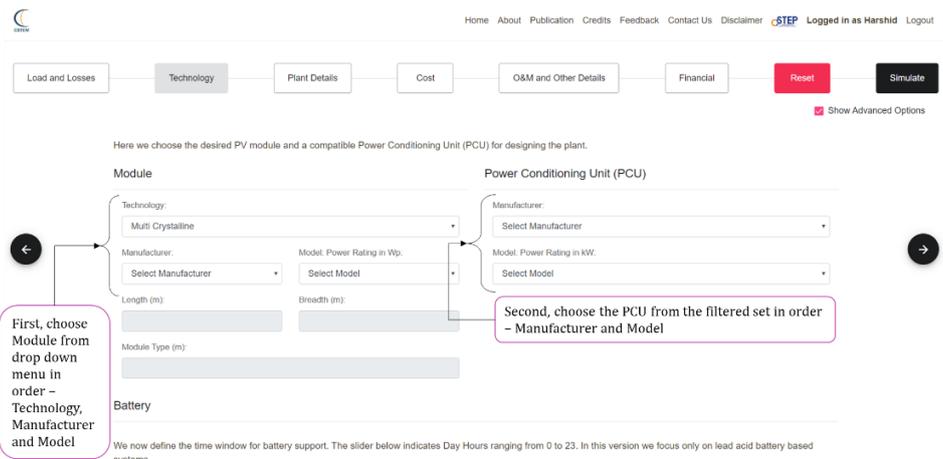


Figure 21: Choice of technology (PV module and PCU)

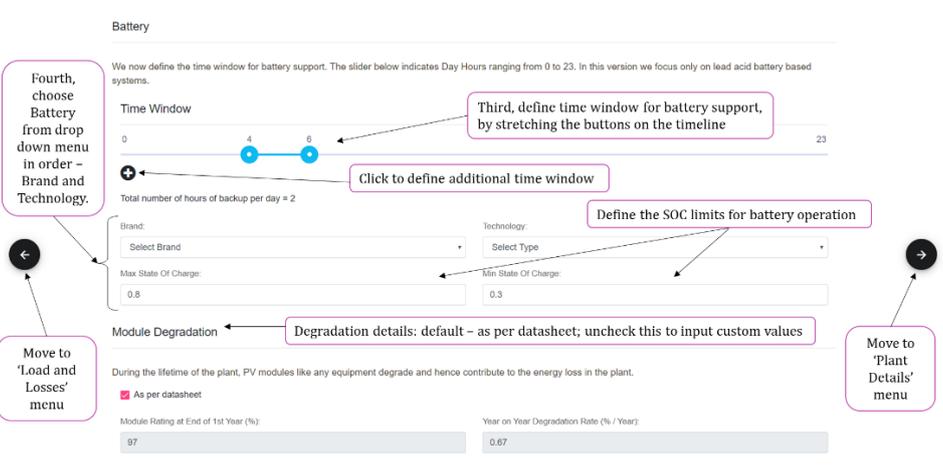


Figure 22: Choice of technology, battery, and other details

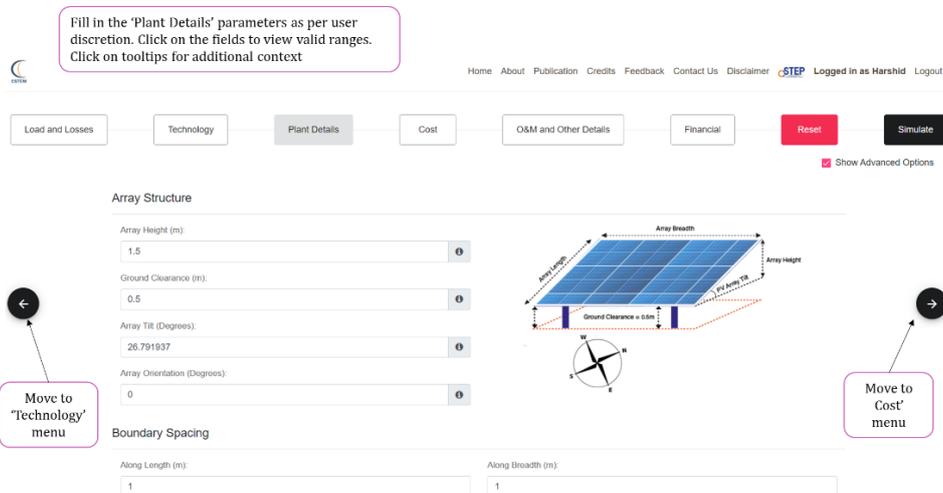


Figure 23: Plant design details

Fill in the 'Cost' parameters as per user discretion. Click on the fields to view valid ranges. Click on tooltips for additional context

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Load and Losses Technology Plant Details **Cost** O&M and Other Details Financial **Reset** **Simulate**

Show Advanced Options

We now define the various costs and expenses. These are categorised under Machinery, Infrastructure and Other expenses.

**Machinery**

This includes the core electrical components like the PV modules, Inverters or Power Conditioning Unit (PCU) and (Batteries for mini grid cases only).

PV Module (₹ / Wp): 21 PCU or Inverter Price (₹ Lakhs / MWp): 30

Battery (₹ / kWh): 8000

**Infrastructure**

Land (₹ Lakh/Acre): 5

PV Module Mounting Structure (₹ Lakhs / MWp): 30

Power Evacuation Infrastructure (₹ Lakhs / MWp): 40

**Other Expenses**

Civil and General Works (₹ Lakhs / MWp): 25

Preliminary and Pre-operative Costs (₹ Lakh / MWp): 35

Miscellaneous (₹ Lakh / MWp): 30

Move to 'Plant Details' menu

Move to 'O&M and Other Details' menu

Figure 24: Capital cost components

Fill in the cost related parameters as per user discretion. Click on the fields to view valid ranges.

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Load and Losses Technology Plant Details Cost **O&M and Other Details** Financial **Reset** **Simulate**

Show Advanced Options

**Operation and Maintenance Cost**

This accounts for all expenses governing the day to day expenses such as salaries, bills and spares.

O&M Cost For 1st Year (₹ Lakh/MWp): 6 O&M Escalation Rate Per Annum (%): 5.72

Subsidy

Check this and enter the subsidy percentage to simulate the impact

Feed in Tariff

Buy of Energy: 6

Enter the Tariff for buying power from grid (Field provided only for grid connected mini grids)

Enter the Tariff, to assess its viability. (Field provided only if 'Feed in Tariff' is chosen in case definition)

Move to 'Cost' menu

Move to 'Financial' menu

Figure 25: Operation cost, subsidy, and feed-in tariff components

Fill in the cost related parameters as per user discretion. Click on the fields to view valid ranges. Click on tooltips for additional context

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Load and Losses Technology Plant Details Cost O&M and Other Details **Financial** **Reset** **Simulate**

Show Advanced Options

**Loan Related**

Debt (%): 70 Loan Term (Years): 10

Moratorium Period (Years): 1 Term Loan Interest Rate (%): 8.5 Working Capital Interest Rate (%): 8.5

**Return on Equity**

During Loan Term (%): 20

Post Loan Term (%): 24

**Taxes**

Income Tax Rate (%): 34

Minimum Alternate Tax (%): 20

**Depreciation**

During Loan Term (%): 5.8

Move to 'O&M and Other Details' menu

Simulate Case

Simulate

Figure 26: Financial parameters including loan, tax, etc.

## 4. Output-Screen Layout and Download

The post-simulation output screens have a generic layout for both utility-scale and mini-grid systems. There is no specific order to view the outputs. Provisions for performing a new simulation, as well as sub-menu tabs to navigate within the current tab, have been provided (mid-right end of the screen), as illustrated in Figure 27. Figure 28 presents a summary of the broad information covered under each tab.

We encourage the users to check the demo cases to understand the various outputs available for different case definitions, prior to building custom cases of interest.

Support text and tool tips (indicated in Figure 29) have been provided to add context to the outputs.



Figure 27: Layout of the output screens



Figure 28: Summary of details covered in each screen

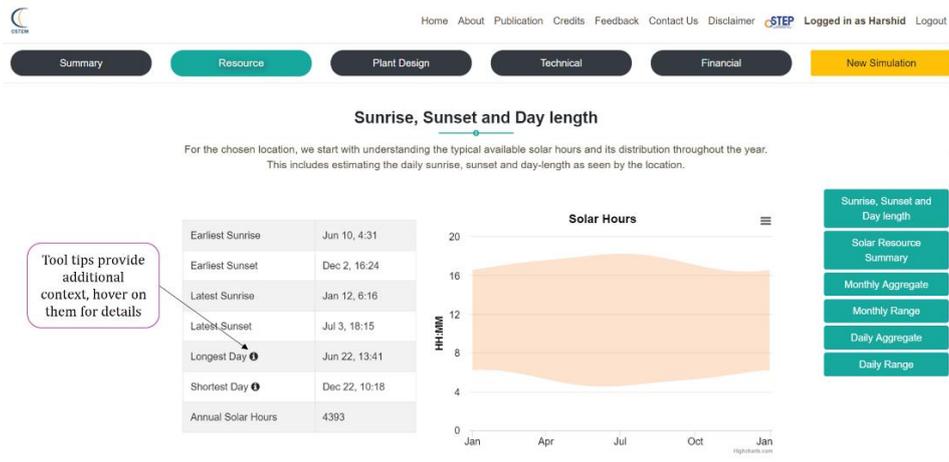


Figure 29: Tooltips for additional context

Registered users can download the various outputs by clicking on the menu icon on the top ends of the graphs of interest. These are encircled and indicated in Figure 30, Figure 31, and Figure 32.

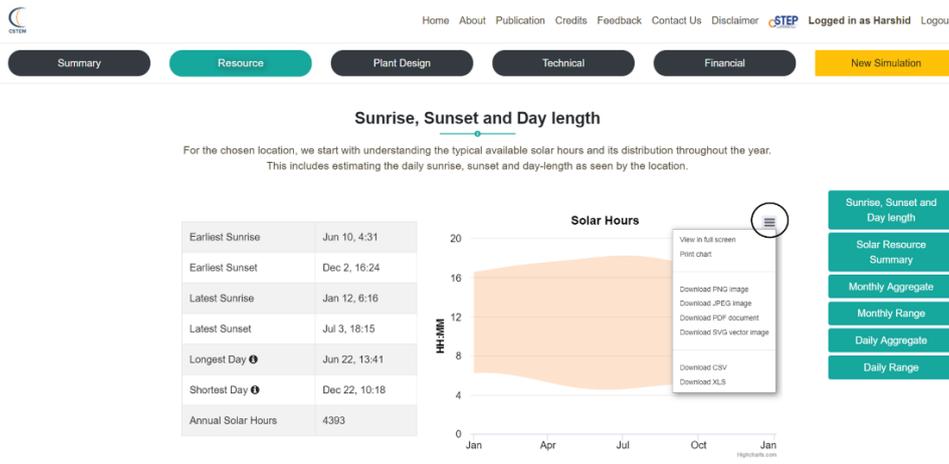


Figure 30: Output download menu icon type 1

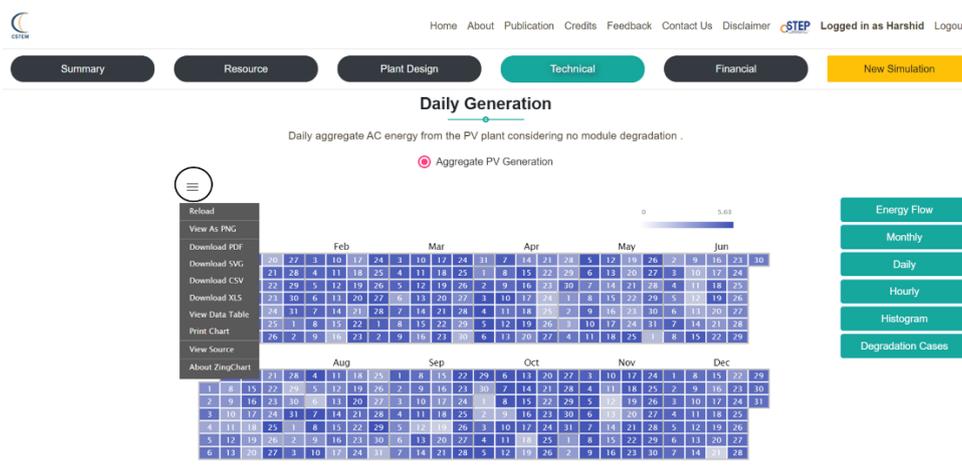


Figure 31: Output download menu icon type 2

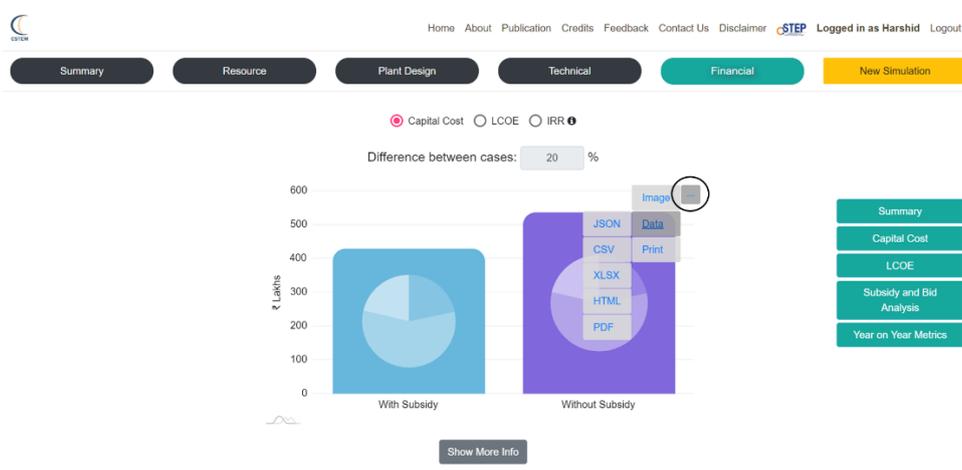


Figure 32: Output download menu icon type 3

Interested users can check the reports in the ‘[Publication](#)’ section for accessing material which detail the mechanics of the tool.

## 5. Acknowledgements

We gratefully acknowledge the generous support provided by various institutions for the development of CSTEM PV. The development of the base version of CSTEM PV was supported by:

- Government of India Institutions: Ministry of New and Renewable Energy, and Department of Science and Technology
- Core Grants: Oak Foundation, and Think Tank Initiative of International Development Research Centre (IDRC)

The mini-grid module and upgrades to the base version was supported by the Good Energies Foundation.

We thank the National Renewable Energy Laboratory, USA, for providing the weather data related to solar-energy modeling.

We also wish to thank our friends in the industry and academia for providing their valuable feedback. It would enable us to think ahead to cater to their respective needs.

## About CSTEP

The Center for Study of Science, Technology and Policy (CSTEP) is one of India's leading think tanks. Our work is in the areas of climate, environment & sustainability, energy & power, AI for social impact, materials & strategic studies and computational tools for policymaking. Our research leverages innovative technology-based ideas to solve developmental challenges. We provide policy advice to Central and State Governments and are a part of various Government Committees. We collaborate with national and international research institutions to build a coherent narrative on policy challenges and solutions for India's sustainable development. CSTEP currently has over 140 employees working out of three offices in India. Our vision is to be the foremost institution for policy analysis in India.

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