Solar Thermal Energy Planner (STEP 1): User Manual

Jeffrey Gifford[1], Jeremy Sment[2], Jaret Kadlec[1], Kaden Plewe[2], Alexander Zolan[1], Janna Martinek[1], Shaker Alaqel[2], Ben Bean[2], and Zhiwen Ma[1]

[1]National Renewable Energy Laboratory
[2]Sandia National Laboratories

This is a temporary cover page. A final cover page will be generated by comms with current style and formatting.

v2.0.4, November 2022

Executive Summary

Acknowledgments

Table of Contents

List of Figures

List of Tables

1 Getting Started

Solar Thermal Energy Planner (STEP 1) web tool aims to help you make decisions about deploying on-site solar+storage systems to reduce your energy costs. STEP 1 compiles the necessary information about your industrial facility and then computes the optimal, least-cost solar+storage system. The optimal system can include (or not) fuel heating as supplemental and can include (or not) storage depending on your scenario. The optimal solar+storage system costs are compared to your business-as-usual scenario, and metrics such as levelized cost of heat or net present value can help you make decisions about how to source your energy demands. The goal of this user manual is to guide you through the tool and provide helpful definitions of all possible inputs you can provide to tailor the tool's solution.

STEP 1 can be accessed from any web browser at the following web address: https://step1.nrel.gov. First, you will be greeted by a home page that explains the aim and purpose of this tool as well as contact information for the STEP 1 Project leads whom you can contact with questions, feedback, and/or other issues you encounter.

Throughout the tool, you will see these help icons ( ). Click on them whenever you need directions and/or a definition to understand what STEP 1 is look for that input.

Click on the "STEP 1 Webtool" tab to get started.

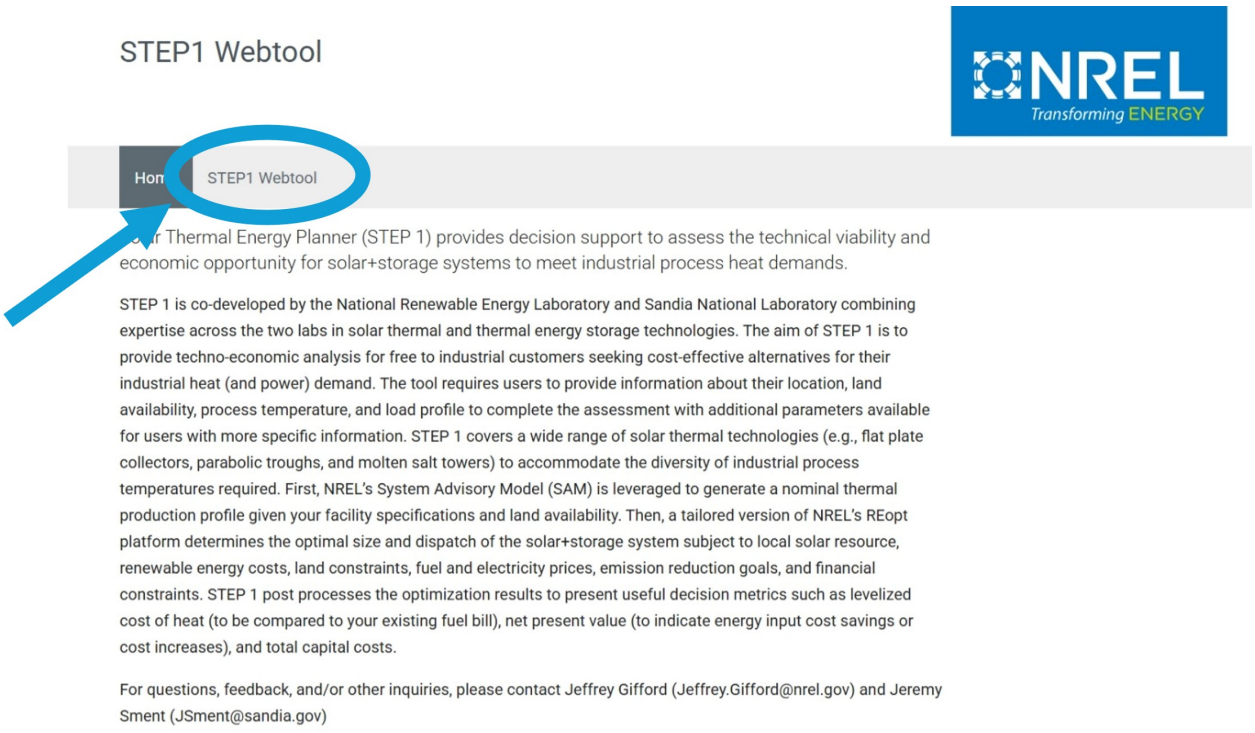

Figure 1. How to navigate to STEP 1 Webtool from Home Page.

2 Inputs

The STEP 1 webtool is broken down into four tabs, three Input tabs and a Results tab. The three Input tabs are (1) Site, (2) Process, and (3) Financial. The first tab, Site, is the tab with which you are automatically navigated to after clicking on the ”STEP 1 Webtool" tab.

2.1 Site

The goal of the Site tab is to gather information related to where your facility is located, namely: your location, available land, and utilities.

1. Enter your address into the Google Maps API search box. A blue location marker will automatically appear. Note: The marker only needs to be within your property lines to be accurate enough for the calculations.

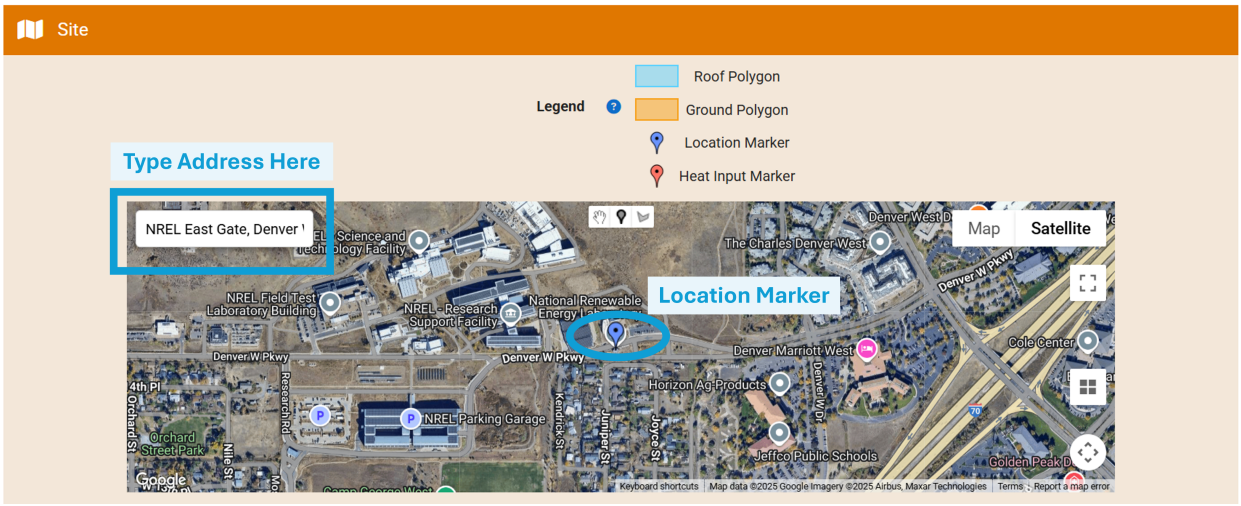

Figure 2. Caption

2. Select the polygon tool and draw a shape over the land that is available for solar resources. STEP 1 will automatically calculate the area of the shape. If needed, you can draw multiple, unconnected shapes and STEP 1 will calculate the total area.

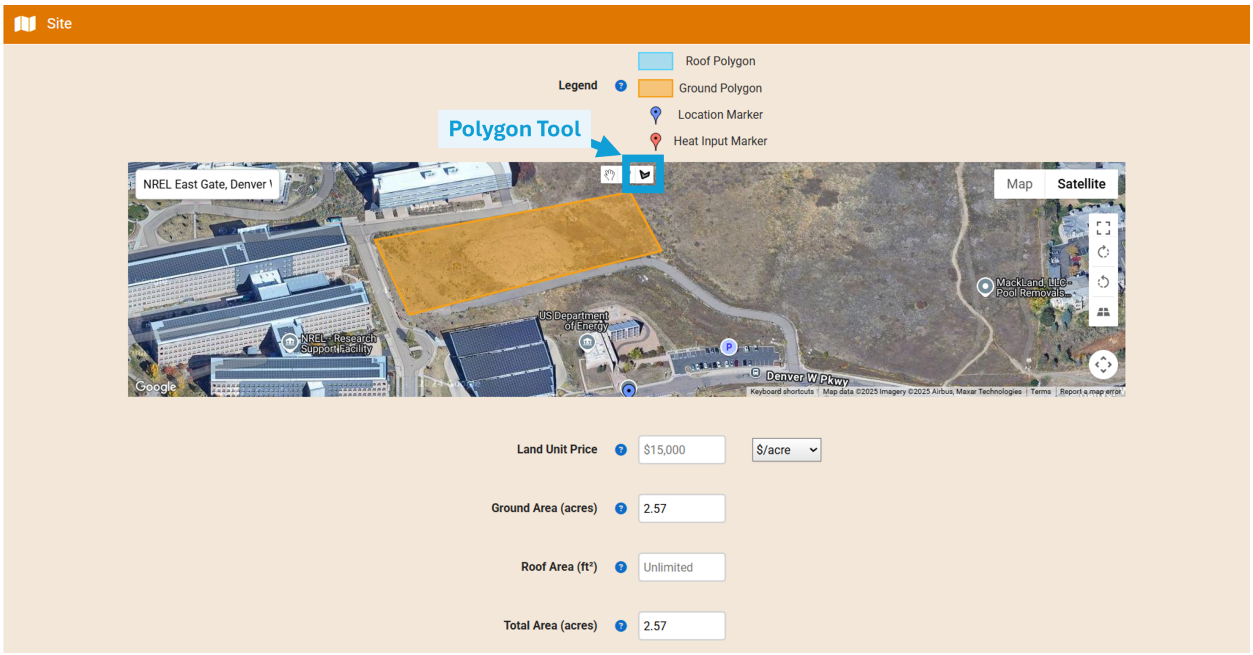

Figure 3. Caption

3. Label the shape as "roof" (blue) or "ground" (orange) as some, but not all, solar technologies can go on a roof. For example, solar PV and flat plate collectors can go on roofs, but solar tower technologies cannot. Once you have drawn your polygon, you can use the Selector Tool to modify the category of polygon as well as delete the polygon if you made a mistake.

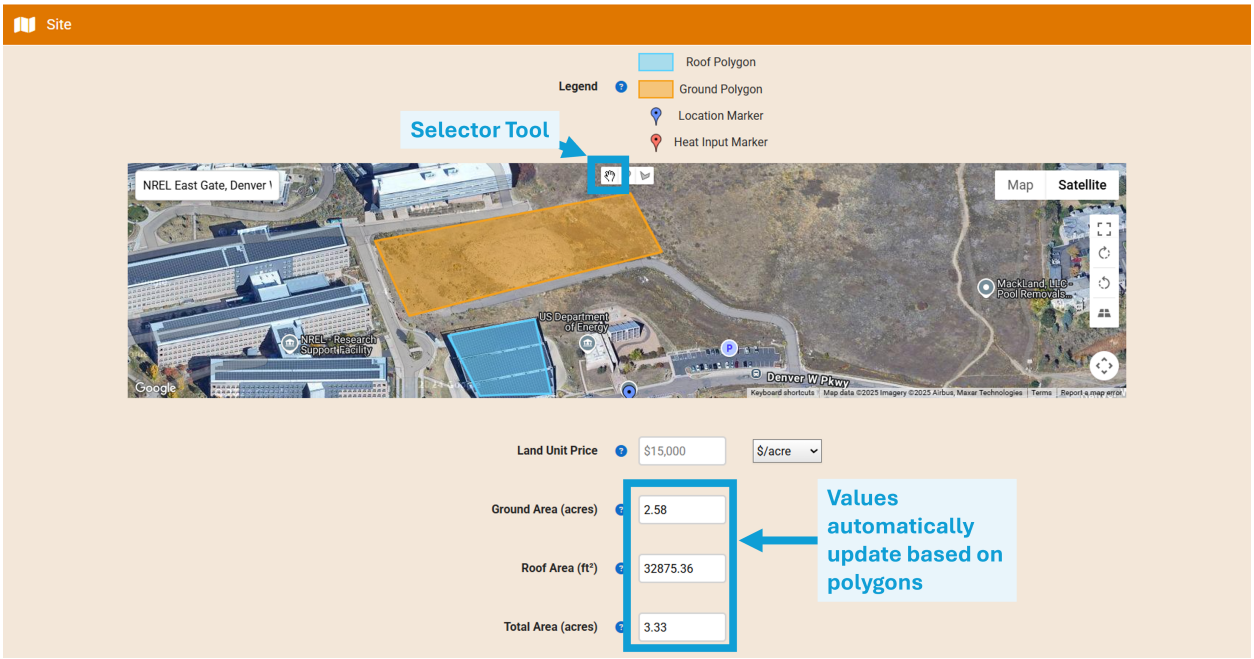

Figure 4. Caption

4. Next, you can revise "Location Type" if needed. "Location Type" is used to assess whether tower technologies are realistic in your location as they are often unable to be cited near population centers. Please use your own discretion here.

5. Emissions Reduction Goal is the minimum amount of emissions you wish to eliminate by building a solar+storage system. 0% corresponds to no emission reduction requirement and 100% corresponds to a complete phase out of fossil fuels. This is the *minimum* reduction goal. Therefore, if 0% is selected, then STEP 1 will simply find the least cost solution regardless which might still yield some emission reductions.

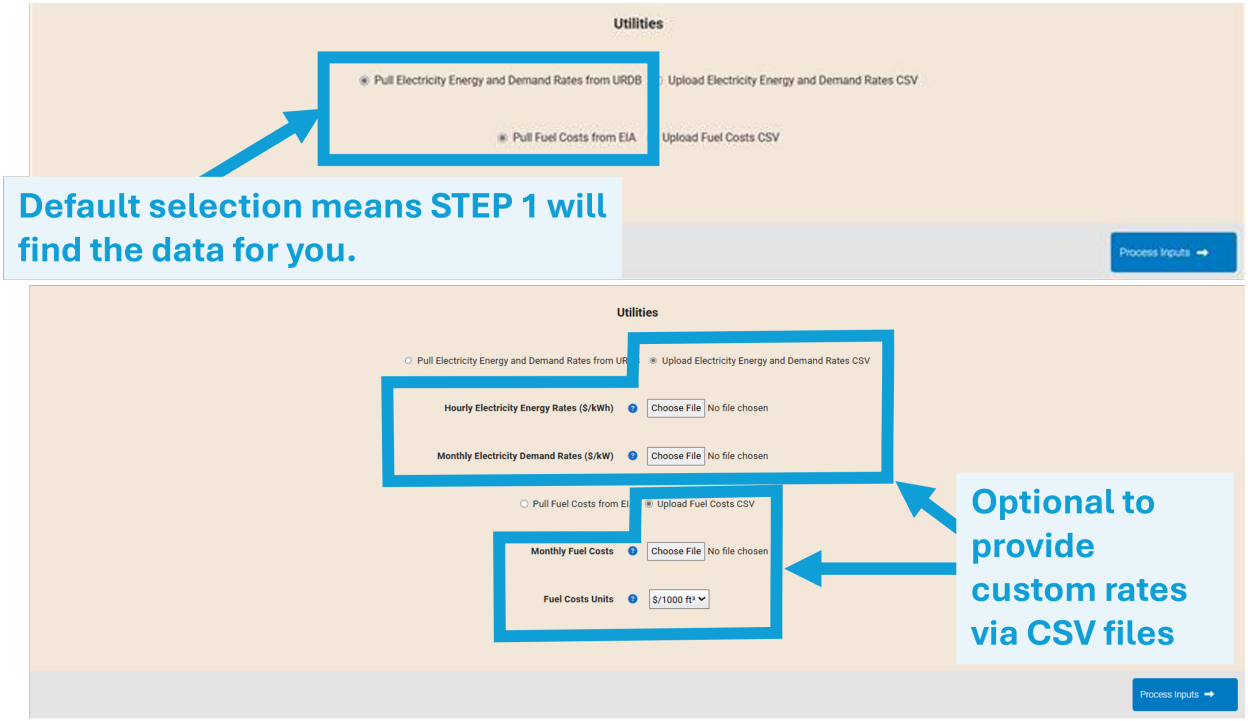

Figure 5. Caption

6. The “Utilities" sub-section gathers your electricity and fuel costs. By default, STEP 1 will leverage open-source data for these. For electricity rates, STEP 1 will pull the latest industrial customer energy (hourly) and demand (monthly) rate structures based on your location from the Utility Rate Database (URDB). For fuel costs, STEP 1 will reference the Energy Information Administrations (EIA) data which publishes industrial natural gas costs by state by month. However, you can override either and/or both with your specific data. For electricity, two CSV files are required: (1) energy rate [$/kWh] (hourly, N = 8760) and (2) demand [$/kW] (monthly, N = 12). For fuel costs, one CSV file (monthly, N = 12) is required and you can select the appropriate units.

7. Once required inputs (i.e., location and area) are provided, you can click the "Process Inputs" button at the bottom right of the page.

2.2 Process

The STEP 1 tool requires requires the user to have some level of access to process heat demand information for the existing or planned system. There are four general inputs that are required: process fluid media, process inlet temperature, process outlet temperature, and the existing fuel type (or fuel type that would be used if a solar thermal system was not in consideration for a planned system). The general process inputs are described in Figure 6. There are four different sets of inputs that can individually define your site’s process heat demand (kW_{th}). The four options are designed to support users with varying levels of available process details, ranging from access to monthly fuel bills to detailed process state points. It is suggested that the user chooses the most detailed option possible, because the process heat demand strongly influences the relevance of the STEP 1 results for the users process. The order, from least to most detail is (1) Fuel Bill, (2) Fuel Consumption, (3) Energy Demand, (4) State Points, and (5) Custom Load Profile. The first three options require the user to define the process operating schedule (or a default constant schedule will be user), which is shown in Figure 7. The user should also select the most accurate option for the shift

schedule. If there is an electrical component in the process that the user would like to replace, then the electrical load for the process of interest can be defined. If the electrical load is greater than zero then STEP 1 will include photovoltaic solar in the design optimization.

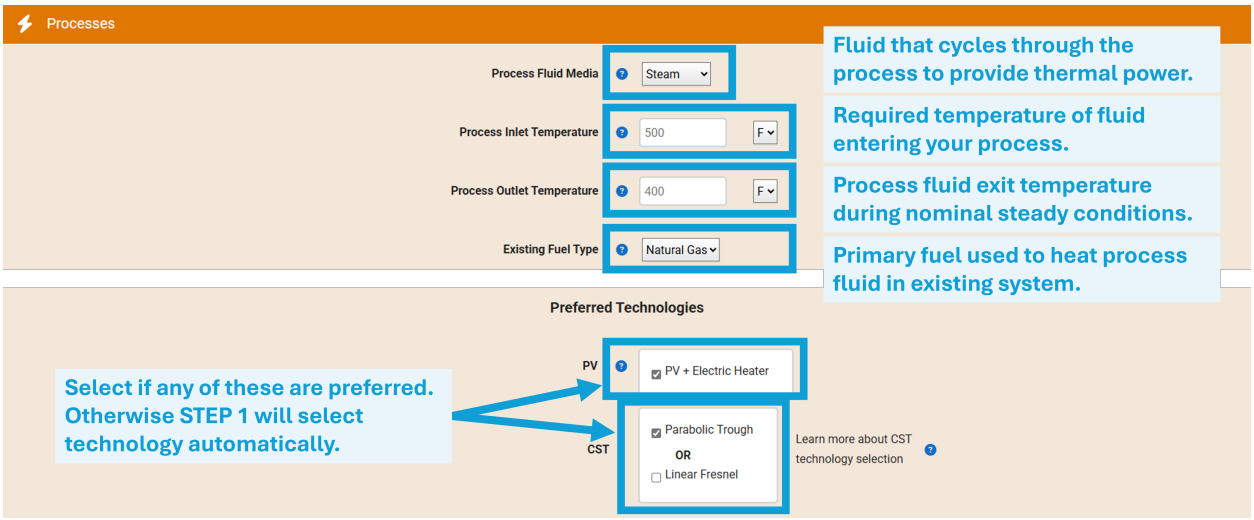

Figure 6. User inputs used to define the general process in its existing or planned state. Optionally, preferred technologies can be selected to cater the STEP 1 optimization to the user's preferences.

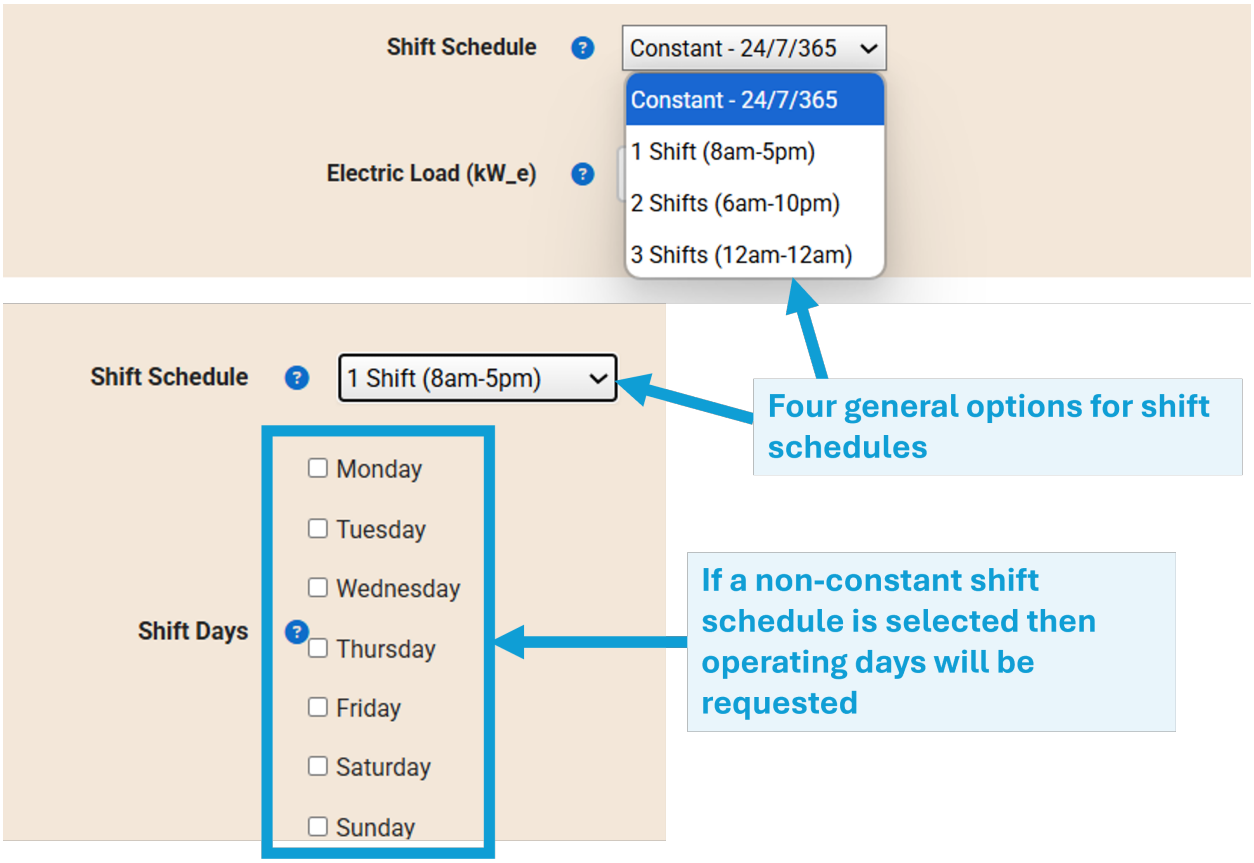

Figure 7. Options for the shift schedule definition to be selected by the user. This is required for some process heat demand definition options, and if left blank, a constant shift schedule will be assumed.

Figure 8. Electric load option for users that would like to consider both thermal and electric loads in the STEP 1 system optimization.

The two options that require the least amount of information to define the process heat demand are based on the user's fuel bill. The first option, Fuel Bill, is simply the total cost of fuel consumption for the process in consideration over some period of time. This option will utilize a unit cost for the appropriate fuel found in a database, which is why this is generally the least accurate option. The Fuel Consumption option directly defines the total consumption, which typically estimates the process heat demand more accurately than the first option. Hence, unless it is not provided on the user's fuel bill, the Fuel Consumption option should be used instead of the Fuel Bill option. Both options are explained in more detail in Figure 9.

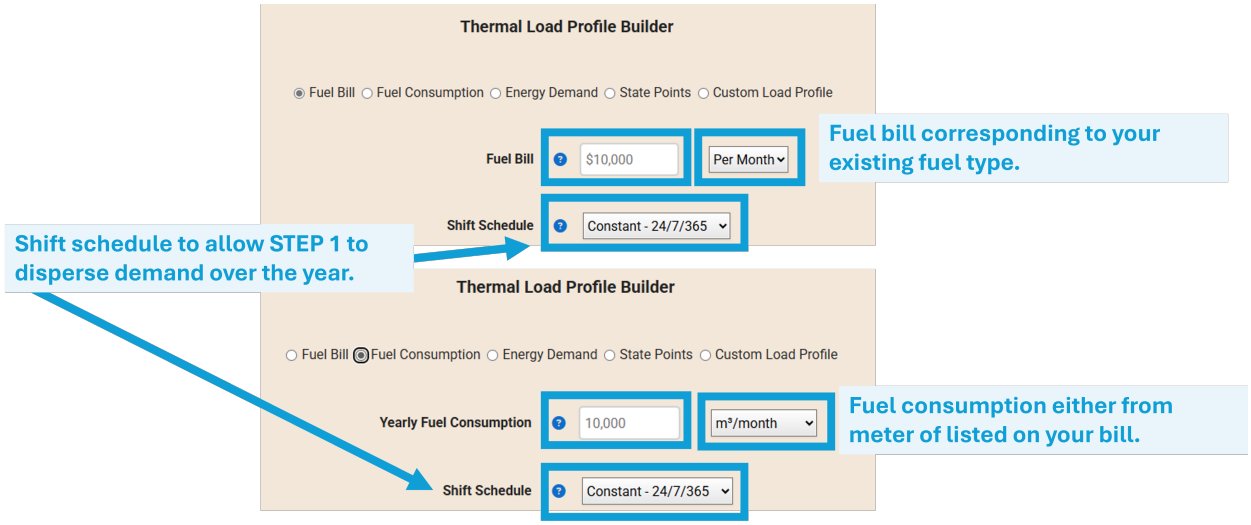

Figure 9. Fuel cost or consumption options that can be used to define the process heat demand if the user only has access to a fuel bill.

The third option, Energy Demand, can be used if the user knows the general trend of the processes thermal demand. It is suggested that the user provides a thermal power that is greater than the peak demand so that the solar thermal system is sized properly. Various units can be used to provide the thermal demand, as shown in Figure 10.

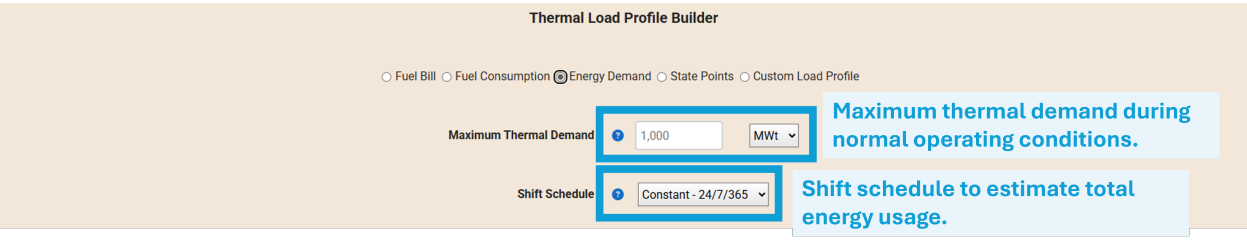

Figure 10. Option for the user to define the maximum thermal demand of the process along with the shift schedule to define the thermal load.

The State Points option allows the user to provide the remaining information required to calculate the thermal demand from temperature and pressure states entering and exiting the process. This input is particularly useful for users who want to rapidly investigate the potential for utilizing solar thermal technology in a new process. Figure 11 gives an explanation for the particular states and information required for this option.

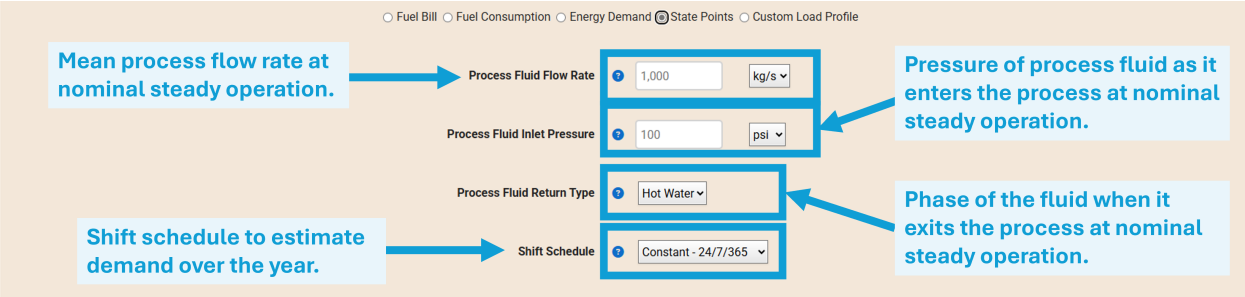

Figure 11. Option for the user to define the process heat demand based on the thermodynamic states entering and exiting the process.

The most detailed option available to the user is a custom thermal demand profile, which can be provided in the form of a .csv file with one column and 8760 rows that defines the thermal energy used over every hour of the year. For example, if 100 kWh_{th} is used on January 1 from 0:00 to 1:00 and 150 kWh_{th} is used from 1:00 to 2:00 on the same day, then the .csv file would be populated with 100 and 150 in the first and second row, respectively. The units for the hourly energy consumption can be defined by the user as shown in Figure 12. **IMPORTANT NOTE:** The .csv file must have exactly 8760 rows for this option to work properly.

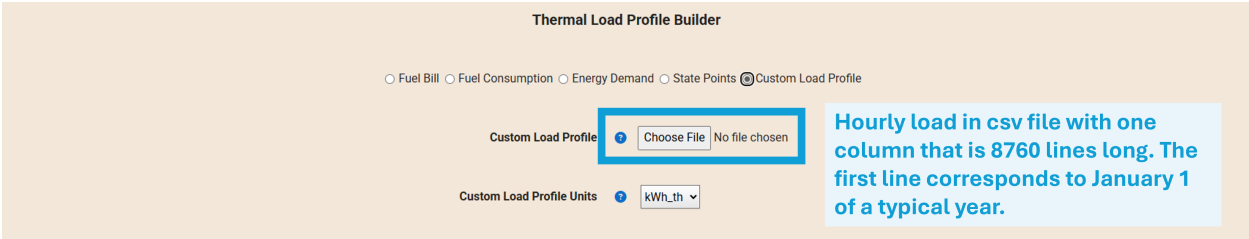

Figure 12. Custom load profile option for users that either have access to hourly consumption data or would like to simulate a representative year with an hourly resolution.

2.3 Financial

The Financial page contains completely *optional* inputs to tailor the economics of the analysis.

1. Maximum Investment Cost is a check box that you can select if you want to limit the total capital costs of the system. If you check the box, you are saying you do want to cap the investment cost, then a text box will appear for you to specify your total budget.

2. Maximum Payback Period is set to 30 years by default. In this text box you can specify a different pay back period.

Figure 13. Caption

3. Pressing the plus (+) button next to Tax Credits expands tax credit options that might apply.
4. By default, STEP 1 assumes a 30% investment tax credit (ITC) applies to any PV, Li-ion, and TES equipment. Hence, the 48/48E ITC (30%) is already checked for you.
5. Current tax credit language is vague regarding the applicability of an ITC for solar thermal systems used for industrial process heat (which is currently classified different than a solar thermal system that is used to produced electricity). If you check "Solar Thermal Tax Credit" a 30% ITC will be applied as well.
6. The remaining check boxes correspond to ITC "bonuses" which add to the base 30% ITC. The applicability of these tax credits to your project should be determined by reviewing the associated tax credit language and/or consulting with the appropriate tax expert. Clicking the help (?) icon next to one of these bonuses shows a helpful link to the tax credit language associated with this bonus.
7. **IMPORTANT NOTE:** Tax credit options are focuses on *Federal* tax credits. *State* and *Local* tax credits can be added by entering an ITC percentage after the federal tax credit options. This ITC percentage should be the sum of *State* and *Local* options and will added to the Federal ITC amount.
8. **IMPORTANT NOTE:** Tax credit language, definitions, applicability, and availability are subject to change based on federal, state, and locally policy changes. STEP 1 will try to update to changing rules as applicable and when possible, but it is on the user to ensure their right tax credits (and their amount) is applied in compliance with the latest policies including any phase-out timelines

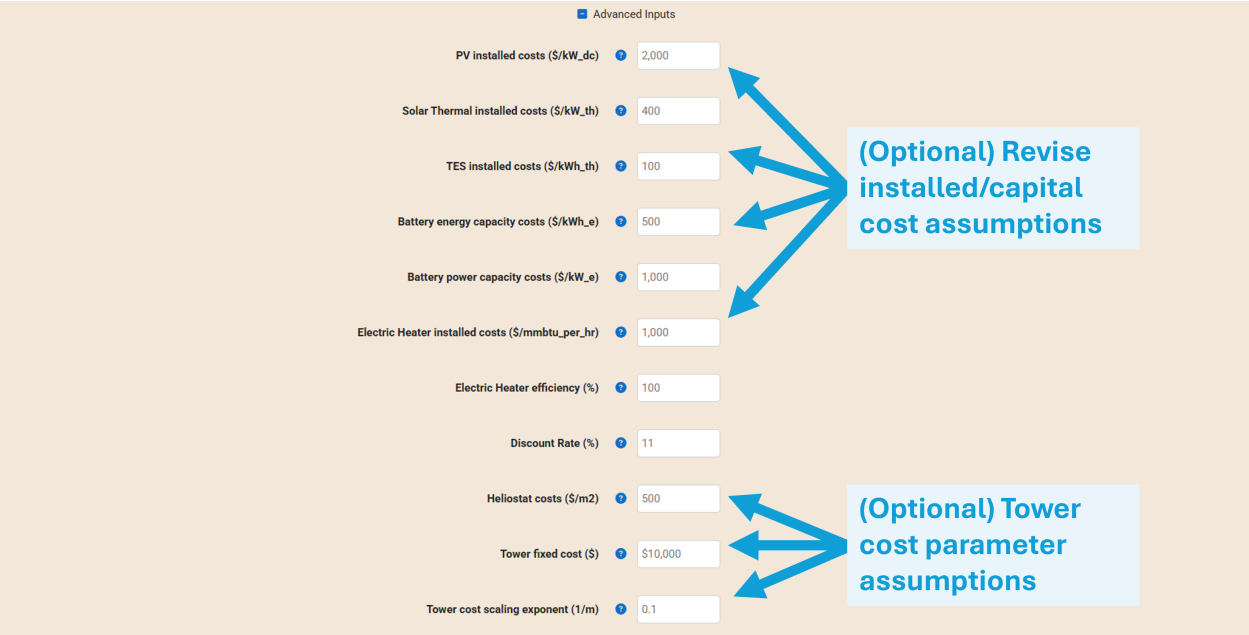

Figure 14. Caption

9. Pressing the plus (+) button next to Advanced Inputs expands additional input options that allow you to tailor some key assumptions.

10. STEP 1 contains generalized defaults for the capital costs (i.e., installed costs) of the PV, Solar Thermal, TES, and Li-ion batteries. However, if you have any specific values for these installed costs based on quotes, internal data, and/or other information, you can modify those assumptions here. Similarly for assumptions regarding heater efficiency, tower costs (for applicable solar thermal technologies), etc.

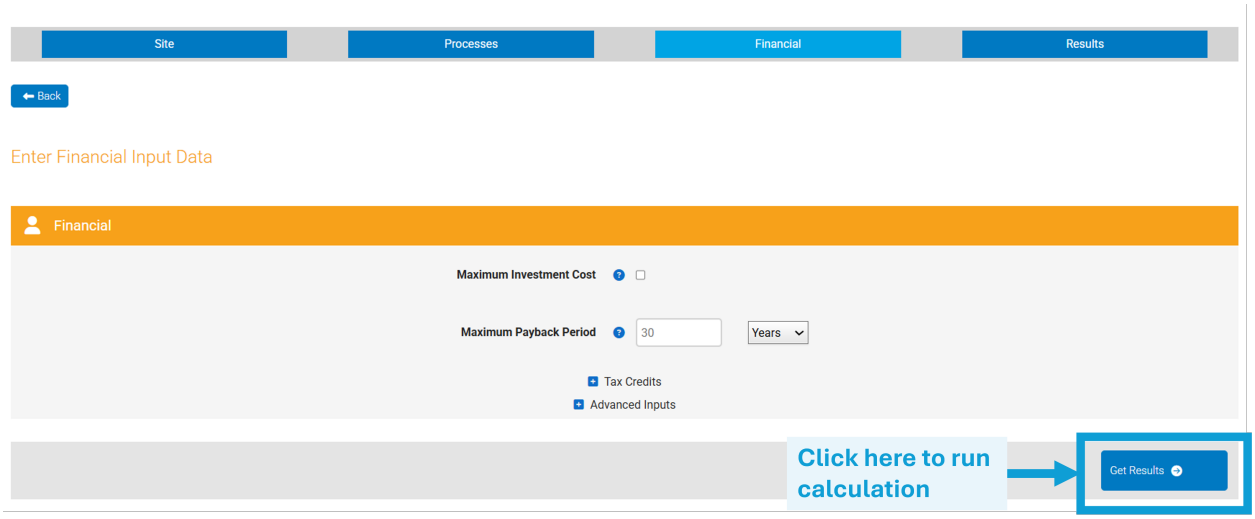

Figure 15. Caption

11. Once, if any, Financial inputs are provided (again, these are completely optional), you can click the "Get Results" button to start the calculation. You will automatically be directed to an intermediate “Loading" page.

3 Loading

1. A loading bar will appear

4 Results

5 Next Steps

6 Other Resources

References

Last1, F., and F. Last2. 2056. “An example article entry.” *A decent Journal* X (Y): pp1–pp2.

Appendix A. Supplemental Information

Appendix B. Even More Supplemental Information