User Manual

Hybrid Storage Decision Model (HSDM)

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# 1. Introduction

## 1.1 What This Model Does

The Hybrid Storage Decision Model (HSDM) is designed to assist engineers, planners, and other stakeholders in designing renewable energy grids that combine solar power, battery energy storage systems (BESS), and hydrogen storage systems (HSS). It determines the lowest-cost mix of these technologies to meet user-defined hourly energy demand profiles. The model formulates this as a linear programming optimization problem. Users provide inputs such as system location, hourly demand data, and cost/performance parameters for each technology. The model outputs optimal installed capacities, dispatch profiles, and cost metrics such as levelized cost of energy (LCOE).

If you are looking for a quick way to get started, the Quick Start Guideon page 5 will provide you with step-by-step instructions on running this model.

## 1.2 Who Should Use It

The HSDM has been designed to be accessible to a wide range of users interested in renewable energy and hybrid energy storage system planning. Typical users include energy system modelers, consultants, academic researchers, and students, as well as non-technical stakeholders seeking high-level insights into renewable system planning.

The user interface and quick start guide have been specifically curated to be easy for all users to run basic scenarios and interpret high-level results with minimal background knowledge. At the same time, the model provides the depth and flexibility required by technical users interested in customizing technology cost and performance parameters and additional constraints.

In short, the tool is designed to be valuable to all users, both technical and non-technical, to inform renewable energy system decision making.

## 1.3 Core Limitations

The HSDM has some core limitations, and it is important that this model is not the sole basis for decision making. Please keep in mind the following core limitations when utilizing this model:

* The model assumes perfect foresight and makes hour-by-hour decisions based on 100% accurate future renewable availability and energy demand data. In real system operation, both weather and energy demand data can only be forecasted with less than perfect accuracy. As a result, the model will consistently provide optimistic results.
* The model does not include transmission constraints (as of now) and any additional losses due to transmission from energy production or storage to the source of energy demand is neglected.
* The model outputs continuous decisions variables such as installed capacities. However, small scale systems may be constrained to discrete installed capacities.
* Green hydrogen storage requires water to produce hydrogen; total water consumption and cost have been neglected in the model.

More detailed discussion of the limitations of this model can be found in the Model Limitations section on page 11.

# 2. System Requirements and Installation

## 2.1 Supported Platforms and Hardware

|  |  |  |
| --- | --- | --- |
| Category | Windows 10 or later (64-bit) | MacOS 13 (Ventura) or later |
| Distribution | Folder with application files and an executable (.exe) | Native application package (.app) |
| Processor | 64-bit Intel or AMD CPU | Apple Silicon (ARM) OR Intel (x86) |
| Memory (RAM) | 4 GB minimum (16 GB recommended) | 4 GB minimum (16 GB recommended) |
| Storage | 1 GB for application and cached files | 1 GB for application and cached files |
| Internet | Required for solar weather data | Required for solar weather data |
| Admin Privileges | Required to run | Required to run |

## 2.2 Installation Instructions

1. Download the latest version of the HSDM from <https://github.com/avandenhende/Hybrid-Storage-Decision-Model/releases>.
2. Extract the download to your preferred location on your computer.
   1. Windows: Right click the download, select “Extract All…,” choose your preferred location, select “Extract.”
   2. Mac: Right click the download, select “Open.”
3. Double click the .exe (Windows) or .app (Mac) file in your newly extracted folder.

*\*The application may request folder access or internet access as it runs, and application startup may take a few seconds.*

## 2.3 Installation Troubleshooting

If you are running into issues during installation or application runtime, here are some steps to take to troubleshoot, or you can find more detailed troubleshooting tips in the Troubleshooting & FAQs section on page .

**General installation or runtime issues:**

* Make sure that your operating system and hardware are supported (Supported Platforms and Hardware).
* Check that you have downloaded the correct installation for your operating system.
* Ensure that you have computer admin privileges when running the application.

**MacOS “Not trusted” or “Cannot verify” warning:**

This message appears because the application has not been signed with an Apple Developer certificate. To open the app safely, you can either:

1. Option A (Recommended):
   1. Open System Settings > Privacy & Security.
   2. Scroll to the bottom of the Security section and select Open Anyway next to the app name.
2. Option B (Terminal):
   1. Open Terminal (press ⌘ + Space, type “Terminal,” press Enter).
   2. Enter the following command to remove the security flag:

“xattr -cr <path\_to\_application\_folder>”

*\*Drag and drop the app folder into Terminal to automatically fill in the path.*

# 3. Quick Start Guide

## 3.1 Installing

Install and run the application (see Installation Instructions and Troubleshooting on page for more details):

1. Download the latest version of the HSDM from <https://github.com/avandenhende/Hybrid-Storage-Decision-Model/releases>.
2. Extract the download to your preferred location on your computer.
3. Double click the .exe (Windows) or .app (Mac) file in your newly extracted folder.

*\*The application may request folder access or internet access as it runs, and application startup may take a few seconds.*

## 3.2 Inputting Data

To run the model, you must provide (1) system location data and (2) an hourly energy demand profile.

**Location Data** – Enter latitude and longitude coordinates in the “Solar Resource Data” tab.

*\*This version of the application uses the NREL NSRDB Americas dataset (Figure 1), coordinate inputs must lie within this dataset.*

A map of the world

AI-generated content may be incorrect.

Figure : NREL's NSRDB data regions (National Renewable Energy Laboratory, NSRDB graphic update [Image], 2021).

**Demand Data** – Upload 1 year of hourly energy demand in units of kW. Data must be submitted as a .csv file via the “Demand Data” tab.

Don’t have demand data? You can generate demand profiles for U.S. Balancing Authorities:

1. Click the “Download Location Specific Demand Profiles” button in the “Demand Data” tab.
2. Select the Balancing Authority (and subregion if applicable).
3. Enter your system’s annual energy demand (MWh) or leave as “None” to use total regional demand.
4. Click “Get Demand.”
5. A download prompt will appear (data is usually saved to your Downloads folder).
6. Return to the model by clicking the “Return to Capacity Expansion Model” button.

For additional information on parameter adjustment, See Data Inputs on page 12.

## 3.3 Running the Model

Click “Submit” to run the optimization model. The model may take several minutes, depending on internet speed and CPU performance.

Results will include:

1. Levelized cost of energy (LCOE)
2. Installed capacities (solar, BESS, HSS)
3. Option to “Download Results” (hourly .csv file with dispatch data and system outputs).

## 3.4 Plotting Results

Additionally, below the results table the application includes result plotting options. To plot:

1. Select the hourly data you are interested in plotting (solar production, electric storage…).
2. Select colors for your hourly data or leave to use the default colors.
3. Input the range of hours you would like to plot.
4. Click the “Submit” button.

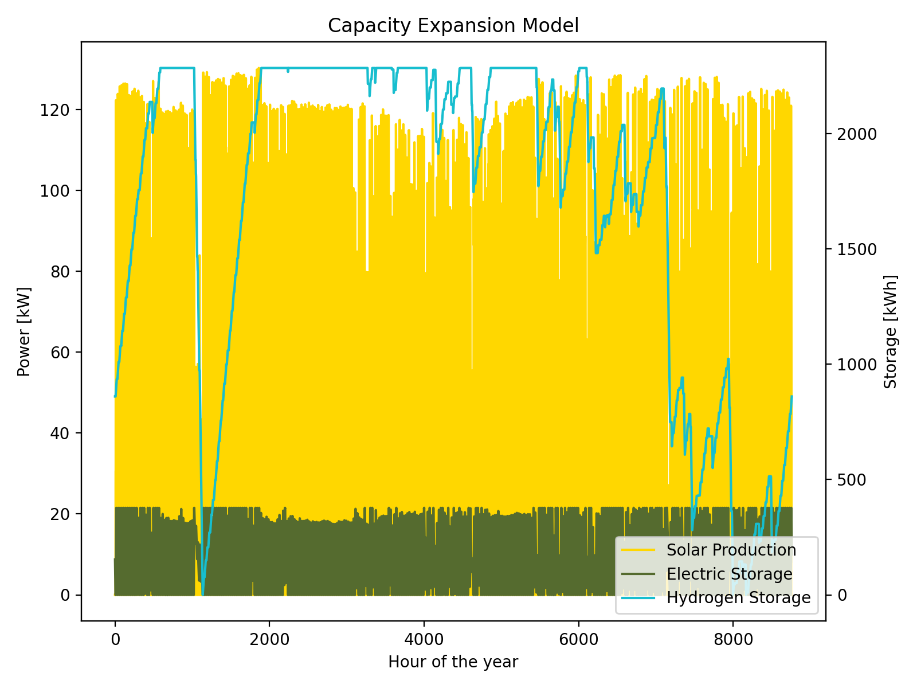


Figure : Example plot of model results.

# 4. Model Overview

## 4.1 Purpose and Capabilities

The HSDM provides a flexible capacity expansion and operational modeling framework for energy systems with integrated solar generation, battery storage, and hydrogen storage. It is designed for rapid scenario testing, allowing users to:

* Evaluate system performance under varying solar resource conditions or energy demand profiles
* Estimate Levelized Cost of Energy (LCOE)
* Determine optimal solar and storage capacities
* Analyze hourly dispatch and net system energy balance

The model leverages publicly available datasets, including:

* **National Renewable Energy Laboratory (NREL)** – *National Solar Radiation Database (NSRDB)* for solar and meteorological resource data
* **U.S. Energy Information Administration (EIA)** – *Form EIA-930* for historical U.S. energy demand data

## 4.2 Model Architecture

The HSDM combines four key model components into a seamless user interface:

**Data Acquisition Modules** – Retrieve weather and demand datasets from NREL and EIA resources based on user inputs.

**Solar Performance Simulations** – Estimate solar performance using NREL’s PySAM library (PySAM Version 7.0.0).

**Capacity Expansion Optimization** – Formats energy system inputs as a linear program and optimizes total cost using the HiGHS Solver.

**Results Processing** – Processes hourly data to produce summary statistics, downloadable CSV outputs, and plots.

# 5. Data Inputs

The HSDM takes user inputs as parameters for a capacity expansion model. As discussed in the Quick Start Guide, locational solar resource data and energy demand data are necessary inputs for user-specific systems. In this section, we will explore locational solar resource data and energy demand data inputs in more detail, as well as provide additional information about other user inputs. Accurate system inputs are key to an accurate model output.

## 5.1 Solar Resource Data

Solar resource data inputs are necessary to simulate accurate weather conditions for your system’s solar generation. The model accesses NREL’s NSRDB data for historical weather conditions over the past 20 years at the location of the user input coordinates. Then, the model selects a specific year to leverage based on the user input weather severity. Finally, the selected weather data is processed by NREL’s PVWatts module (PySAM Version 7.0.0) to inform the capacity expansion model with solar resource availability data.

|  |  |  |  |
| --- | --- | --- | --- |
| Data Input | Units | Expected Data Type and Range | Description |
| Latitude | Degrees | Decimal  [-21.2, 60] | Latitude informs accurate location-based weather simulations for solar generation |
| Longitude | Degrees | Decimal  [-180, -22.5] | Longitude informs accurate location-based weather simulations for solar generation |
| Weather Severity | Unitless | Decimal  [0, 1] | Weather severity ranges from least severe at 0, to most severe at 1 |

*\*Coordinates must lie within the Americas dataset shown in Figure 1*

## 5.2 Demand Data

Demand data inputs provide the model with information about your system’s energy demand. Data must be input to the model as a .csv file listing hourly energy demand in units of kilowatts. Demand data for US Balancing Authorities can be accessed by clicking the “Download Location Specific Demand Profiles” button.

|  |  |  |  |
| --- | --- | --- | --- |
| Data Input | Units | Expected Data Type and Range | Description |
| Energy Demand | kW | Decimal  (-∞, ∞) | .CSV file with 8760 numerical entries |

## 5.3 Solar

Solar data inputs provide technical information about your system’s specific solar panels. CapEx and OpEx inputs provide cost information to the model, initial values are potential estimates but may not be accurate to your system or circumstance.

|  |  |  |  |
| --- | --- | --- | --- |
| Data Input | Units | Expected Data Type and Range | Description |
| CapEx | $/kW installed | Decimal  (-∞, ∞) | The capital expense (upfront cost) of solar generation per kW of installed capacity |
| OpEx | $/kWh produced | Decimal  (-∞, ∞) | The operational expense (O&M costs) of solar generation per kWh produced |
| Tilt | Degrees | Decimal  [0, 90] | The tilt angle of your system’s solar panels assuming an optimal azimuth angle |
| Lifetime | Years | Decimal  (0, ∞) | The expected lifetime of your solar panels, utilized to annualize capital expenses |
| Efficiency | Unitless | Decimal  [0, 1] | The efficiency of your solar generation system, excluding DC to AC conversion losses |
| Maximum Capacity | kW | Decimal  [0, ∞) or “None” | An upper limit on the installed capacity of solar generation for your system |

## 5.4 Battery Electric Storage Systems

BESS data inputs provide technical information about your system’s battery electric storage systems. CapEx and OpEx inputs provide cost information to the model, initial values are potential estimates but may not be accurate to your system or circumstance. Discharge time describes the length of time your storage system can provide power at maximum output (4-hour storage is common for lithium-ion BESS).

|  |  |  |  |
| --- | --- | --- | --- |
| Data Input | Units | Expected Data Type and Range | Description |
| CapEx | $/kWh installed | Decimal  (-∞, ∞) | The capital expense (upfront cost) of battery storage per kWh of installed capacity |
| OpEx | $/kWh stored | Decimal  (-∞, ∞) | The operational expense (O&M costs) of battery storage per kWh stored |
| Lifetime | Years | Decimal  (0, ∞) | The expected lifetime of your battery storage, utilized to annualize capital expenses |
| Round-Trip Efficiency | Unitless | Decimal  [0, 1] | The round-trip efficiency of your battery storage system |
| Discharge Time | Hours | Decimal  (0, ∞) | The length of time for your battery storage system to fully discharge at maximum output capacity |
| Self Discharge Rate | 1/Hour | Decimal  [0, 1] | The factor of battery storage charge lost per hour: a value of 0.01 indicates that 1% of current charge is lost per hour |
| Maximum Capacity | kW | Decimal  [0, ∞) or “None” | An upper limit on the installed capacity of battery storage for your system |

## 5.5 Electrolyzer

Electrolyzer data inputs inform model decisions for ONLY the production of hydrogen in the hydrogen storage system. CapEx and OpEx inputs provide cost information to the model, initial values are potential estimates but may not be accurate to your system or circumstance.

|  |  |  |  |
| --- | --- | --- | --- |
| Data Input | Units | Expected Data Type and Range | Description |
| CapEx | $/kW installed | Decimal  (-∞, ∞) | The capital expense (upfront cost) of your electrolyzer per kW of installed capacity |
| OpEx | $/kWh consumed | Decimal  (-∞, ∞) | The operational expense (O&M costs) of electrolyzer use per kWh consumed |
| Lifetime | Years | Decimal  (0, ∞) | The expected lifetime of your electrolyzer system, utilized to annualize capital expenses |
| Efficiency | Unitless | Decimal  [0, 1] | The efficiency of your electrolyzer system, including losses due to water purification, electrochemical processes, and aging |
| Maximum Capacity | kW | Decimal  [0, ∞) or “None” | An upper limit on the installed capacity of an electrolyzer for your system |

## 5.6 Hydrogen Storage

Hydrogen storage data inputs inform model decisions for ONLY the storage of hydrogen (hydrogen tanks) in the hydrogen storage system. CapEx and OpEx inputs provide cost information to the model, initial values are potential estimates but may not be accurate to your system or circumstance.

|  |  |  |  |
| --- | --- | --- | --- |
| Data Input | Units | Expected Data Type and Range | Description |
| CapEx | $/kWh installed | Decimal  (-∞, ∞) | The capital expense (upfront cost) of your hydrogen storage per kWh of installed capacity |
| Lifetime | Years | Decimal  (0, ∞) | The expected lifetime of your hydrogen storage, utilized to annualize capital expenses |
| Maximum Capacity | kWh | Decimal  [0, ∞) or “None” | An upper limit on the installed capacity of hydrogen storage for your system |

## 5.7 Fuel Cell

Fuel cell data inputs inform model decisions for ONLY the conversion of hydrogen to electricity in the hydrogen storage system. CapEx and OpEx inputs provide cost information to the model, initial values are potential estimates but may not be accurate to your system or circumstance.

|  |  |  |  |
| --- | --- | --- | --- |
| Data Input | Units | Expected Data Type and Range | Description |
| CapEx | $/kW installed | Decimal  (-∞, ∞) | The capital expense (upfront cost) of your fuel cell per kW of installed capacity |
| OpEx | $/kWh produced | Decimal  (-∞, ∞) | The operational expense (O&M costs) of fuel cell use per kWh produced |
| Lifetime | Years | Decimal  (0, ∞) | The expected lifetime of your fuel cell, utilized to annualize capital expenses |
| Efficiency | Unitless | Decimal  [0, 1] | The efficiency of your fuel cell, including losses due to electrochemical processes and aging |
| Maximum Capacity | kW | Decimal  [0, ∞) or “None” | An upper limit on the installed capacity of a fuel cell for your system |

## 5.8 Economic

|  |  |  |  |
| --- | --- | --- | --- |
| Data Input | Units | Expected Data Type and Range | Description |
| Discounting Rate | Unitless | Decimal  [0, 1] | A discounting rate used to annualize the capital expenses of your system, describing the cost per year of any upfront investments spread over the lifetime of those investments; the initial input is set at 0.04 to account for inflation only |
| Cost of Unmet Demand | $/kWh | Decimal  (-∞, ∞) | A monetary value placed on unmet demand |

## 5.9 Data Initiation

For more complex data inputs, especially when running multiple models subsequently, manually inputting data for every run can become tedious. The data initiation section of the application allows you to input a .csv file containing your data inputs without having to manually type or paste every input into the application.

1. Open the “Data Initiation” block at the top of the application.
2. Download the data initiation template by clicking the “Download Data Initiation Template” button.
3. Open the downloaded template. The template should include multiple columns for input, label, value, units, etc., only the “Label” and “Value” columns are necessary, all other columns will be ignored.

A white sheet with black text and numbers

AI-generated content may be incorrect.

Figure : Data initiation template example.

1. Input your data under the “Value” column and save the .csv document.
2. Upload your data initiation file to the “Upload Data Initiation CSV” box and click the “Submit” button inside of the “Data Initiation” block.
3. Scroll down to the bottom of the application and click “Submit.”

All subsequent runs of the model during each application session will save and update data inputs based on your most recent run.

# 6. Outputs and Results Interpretation

## 6.1 Data Outputs

**Single value output variables or parameters**

Single value outputs include levelized cost of energy (LCOE) and the recommended capacity profile for the system. The LCOE output describes the total system cost (including CapEx and OpEx costs for energy generation, storage, and unmet demand) divided by the total energy demand of the system, effectively describing the average cost per kWh of energy demand. This value is very useful for defining the economic viability of a system.

The recommended capacity profile includes solar, BESS, and HSS capacity values. Note that these values are innately optimistic and should be taken with a grain of salt.

**Time series outputs**

Time series outputs include hourly data points for a multitude of relevant results including: solar production, net power flow, energy demand, battery storage, electrolyzer consumption, hydrogen storage, and fuel cell production.

## 6.2 Results Visualization and Interpretation

The HSDM provides some in-application data visualization through plotting functionality for time series outputs. Time series outputs with units of power are plotted on the left y-axis, while time series outputs with units of energy (battery storage and hydrogen storage) are plotted on the right y-axis. To plot your results:

1. Navigate to the “Plot Model Outputs” section of the application.
2. Select the time series outputs you are interested in plotting. Optionally, you can set a custom color for these outputs.
3. Input the range of hours to plot next to the “Starting Hour” and “Ending Hour.”
4. Click the “Submit” button under the “Plot Model Outputs” section.

*\* You can copy plots to your clipboard by clicking on the “Copy to Clipboard” button.*

A screenshot of a computer

AI-generated content may be incorrect.

Figure : Plot Model Outputs section.

## 6.3 Downloading Results

If you would like to download your results, select the “Download Results” button at the top of the results page. Both single value outputs and time series outputs will be formatted and downloaded as a .csv file. Units are located in the first row of the .csv.

# 7. Model Limitations

The HSDM has some limitations, and it is important that this model is not the sole basis for decision making. Here is a more extensive discussion of this model’s limitations than Core Limitations found on page 4.

## 7.1 Perfect Foresight

Real-world renewable energy systems rely on weather forecasts and energy demand prediction to inform decisions. These forecasts are generally accurate for up to a few days and remain statistical estimates of the future.

The HSDM assumes perfect foresight when solving for an optimal grid profile. This means the model makes hour-by-hour decisions based on 100% accurate weather forecasts and energy demand predictions. Innately, this model presents an overly optimistic output that relies on perfect decision making—unrealistic in the real world.

To overcome this limitation, you should expect that the model’s results are a pretty good representation of the ratio of solar, BESS, and HSS. And slightly larger values than the model outputs are closer to the optimal real-world capacity profile.

## 7.2 Neglected Transmission Constraints

Energy transmission from generation to storage and finally to the source of energy demand will result in some non-negligible losses but have been neglected in this model. These losses are dependent on the material, size, and length of the transmission line, and most importantly the layout of your transmission system. Incorporating transmission constraints into the HSDM could greatly increase the complexity of the model, creating a more complex user experience and increasing model runtime.

If you can estimate the average energy loss due to transmission of your system, you can easily account for these losses after use of the HSDM model. As an example, the EIA estimates that US energy systems lose about 5% of energy production to transmission losses (Eia.gov, 2016).

## 7.3 Continuous Decision Variables

Real-world energy systems are built using discrete pieces of equipment. You may be able to purchase a 2 m2 solar panel, but you most likely will not be able to purchase a 2.21 m2 solar panel. The HSDM treats decisions variables, such as installed capacities, as continuous variables. This means that for small scale systems, the HSDM may output results that are difficult to execute on.

## 7.4 Hydrogen Storage Water Consumption Circularity

Green hydrogen storage systems require water to produce hydrogen. Electrolyzers split water into gaseous hydrogen and oxygen, consuming the water in the process. This water is eventually recovered during fuel cell energy generation, but depending on the system may or may not be circular. The model has neglected any circularity in the hydrogen storage system, estimating water usage as a one-time-use.

## 7.5 Weather Data Availability

As of now, the model is only able to access historical weather data for the Americas, seen in Figure 1 on page 8. Eventually the model will be able to access and process weather data from more locations.

# 8. Troubleshooting & FAQs

## 8.1 How can I download the application?

Navigate to the latest release version at <https://github.com/avandenhende/Hybrid-Storage-Decision-Model/releases>. The release will include versions for:

**Windows**: Hybrid-Storage-Decision-Model-vX.X.X-Windows.zip

**MacOS Apple Silicon**: Hybrid-Storage-Decision-Model-vX.X.X-Mac-ARM.zip

**MacOS Intel**: Hybrid-Storage-Decision-Model-vX.X.X-Mac-x86.zip

Click on the version that matches your computer architecture to download the .zip file.

## 8.2 Why won’t my application run?

If you have downloaded the application and are having issues running the program, some common issues include:

**Incorrect version –** The application is operating system specific and only runs when the application version matches a specific OS and hardware architecture.

* Windows: Make sure that your machine is running Windows 10 or later with a 64-bit processor; download the version labeled “Windows.”
* Mac: Make sure that your machine is running MacOS 13 or later; download the version labeled “Mac-ARM” if your machine has an Apple Silicon processor, or “Mac-x86” if your machine has an Intel processor.

**Missing privileges –** The application requires read, write, and execute privileges as well as internet access to function. In most cases your operating system will prompt you about allowing these privileges, however in some cases a lack of privileges may lead to a silent error or crash.

Windows (run as administrator)

1. Make sure that you have administrator access and can grant privileges to the application.
2. Right click on the application’s .exe file and select “Run as administrator.”

Mac (bypass or remove quarantine attributes)

1. Option A (Recommended):
   1. Open System Settings > Privacy & Security.
   2. Scroll to the bottom of the Security section and select Open Anyway next to the app name.
2. Option B (Terminal):
   1. Open Terminal (press ⌘ + Space, type “Terminal,” press Enter).
   2. Enter the following command to remove the security flag:

“xattr -cr <path\_to\_application\_folder>”

*\*Drag and drop the app folder into Terminal to automatically fill in the path.*

Mac (give execute privileges)

1. Open Terminal (press ⌘ + Space, type “Terminal,” press Enter).
2. Enter the following command to provide execute privileges:

“chmod -R +x <path\_to\_application\_folder>”

*\*Drag and drop the app folder into Terminal to automatically fill in the path.*

## 8.3 What inputs are required to run the model?

All inputs, including location, demand data, and technology parameters are required to run the model. Existing values for technology parameters are a good baseline. As an example, most cost data have been accessed from the Annual Technology Baseline 2024 (NREL, 2024).

This means, to run the model at its most basic level, you must provide two data inputs: **location data** (latitude, longitude), and **energy demand data** (.csv file). If you are planning a system and have system-specific technology parameters, it is highly recommended that you incorporate these parameters into the model.

## 8.4 How do I input my own system-specific demand data?

Inputting a custom energy demand profile to the model is not complicated.

1. Input your energy demand profile into a .csv file as hourly demand in units of kWh. You will need 1 year worth of hourly demand data, so 8760 data points.
2. Format these values starting from the first hour of the year (January 1st, 12:00-1:00 am local time) chronologically in the first column of the .csv file.
3. Provide no additional values or information in the .csv file and save the file to your computer.
4. Under the “Demand Data” tab in the HSDM application input your newly created .csv file.

*\*Download and open a US Balancing Authority demand profile as an example of the proper formatting*

## 8.5 How can I utilize the data initiation feature?

The data initiation feature allows you to save and upload a set of input parameters from your desktop instead of manually providing input parameters upon closing and re-opening the application.

1. Under the “Data Initiation” tab in the HSDM application click on the “Download Data Initiation Template.”
2. This file contains all data inputs (except energy demand data) as rows in a .csv file. Replace each value in the template with your own and save the .csv file to your desktop with any name of your choosing.
3. Input this updated .csv file to the application under “Upload Data Initiation CSV” and click the “Submit” button.

# 9. Appendices

## 9.1 References

*Eia.gov*. (2016). Retrieved from How much electricity is lost in electricity transmission and distribution in the United States?: https://www.eia.gov/tools/faqs/faq.php?id=105&t=3

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## 9.2 Software Libraries and Tools

PySAM Version 7.0.0. National Renewable Energy Laboratory. Golden, CO. Accessed May

23, 2025. <https://github.com/nrel/pysam>.

Additional licenses can be found in the **LICENSES.txt** file at <https://github.com/avandenhende/Hybrid-Storage-Decision-Model/releases>.

# 10. Acknowledgements

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# 11. Legal Notices

## 11.1 Disclaimer of Warranty and Liability

This software and accompanying documentation are provided “as is” without warranty of any kind, express or implied. The developers and distributors of this application make no representations or warranties regarding the accuracy, completeness, or suitability of the results generated. In no event shall the authors, affiliates, or contributors be liable for any direct, indirect, incidental, special, or consequential damages arising from the use of this software.

## 11.2 Use of External References

This application incorporates publicly available data and methodologies from both the National Renewable Energy Laboratory (NREL) and the U.S. Energy Information Administration (EIA). These resources are used for renewable energy resource assessment, demand profiling, and related modeling methodologies.

[National Renewable Energy Laboratory (NREL)](https://developer.nrel.gov/terms/):

* This application utilizes data from the National Solar Radiation Database (NSRDB) for solar and meteorological resource data, as well as methodologies adapted from NREL’s System Advisor Model (SAM), including the PVWatts module.
* The NSRDB is maintained by NREL for the U.S. Department of Energy and provides historical solar radiation and weather data for renewable energy analysis.
* The authors of this application are not affiliated with NREL or the U.S. Department of Energy, and neither organization endorses this software.
* Users must comply with the NSRDB Terms of Use and provide appropriate attribution when publishing or distributing results derived from NSRDB data.

[U.S. Energy Information Administration (EIA)](https://www.eia.gov/opendata/terms-of-service.php):

* This application utilizes publicly available grid demand and operational data from the EIA, specifically data products derived from Form EIA‑930.
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## 11.3 Open Source Software Acknowledgement

This software includes third-party libraries distributed under various open-source licenses, including but not limited to BSD, MIT, and Apache 2.0.

* A complete list of included third-party libraries, along with their license texts, is provided in the file **LICENSES.txt** distributed with this application.
* Users are responsible for reviewing and complying with the terms of these third-party licenses when using or redistributing this software.

## 11.4 Solver Notice

This application uses the HiGHS linear optimization solver through its Python interface HighsPy. HiGHS is an open-source software package for solving large-scale linear programming, mixed-integer programming, and quadratic programming problems.

* HiGHS is developed and maintained by the HiGHS development team at the University of Edinburgh.
* The solver is distributed under the MIT License; a copy of this license is included in the file **LICENSES.txt**.
* The use of HiGHS in this application does not imply endorsement by the HiGHS developers or the University of Edinburgh.