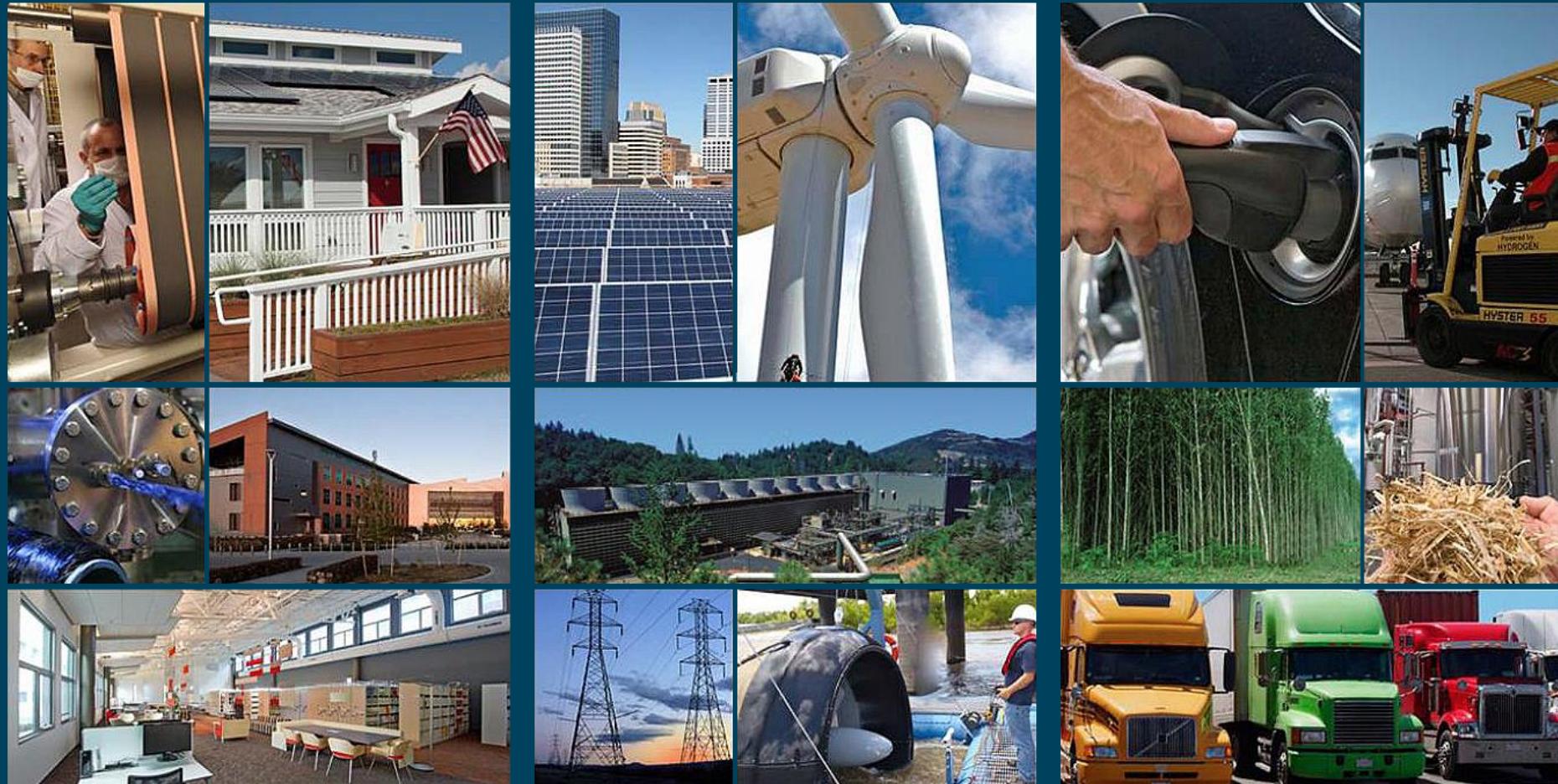


Steam System Modeling Tool

Overview and Tour



How to use this Document

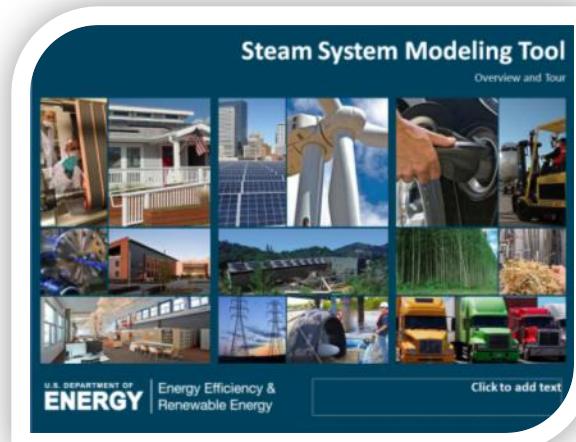
This document is designed to be used as both a comprehensive presentation and a quick reference for the **Steam System Modeling Tool (SSMT)**

To use as a quick reference:

- The [table of contents](#) provides links to all of the key topics covered.
- Each page also includes a direct link back to the table of contents
- A direct link to SSMT is also provided at the bottom of every page



[GO TO SSMT ONLINE](#)



How to use SSMT

SSMT is designed to be easy to use with significant built-in documentation and detailed calculations. Specifically the examples, and pop-up hints allows users to test all features instantly and get immediate feedback:

Examples are available in all calculators and the modeler. When selected, they demonstrate the functions of the calculators by being loaded just as though it had been entered by the user. Almost all examples are randomly generated, allowing users to evaluate numerous examples.

Pop-Up Hints appear for all data fields

Every data field has a pop-up hint that provides details about the field units, description, acceptable range, and where the entered value is valid.

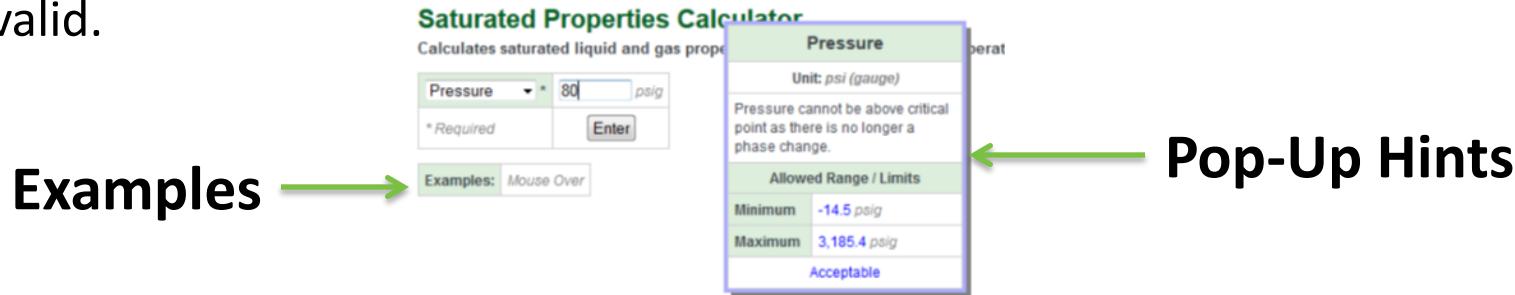


Table of Contents (1/2) (click links to jump to section)

[Introduction to SSMT](#)

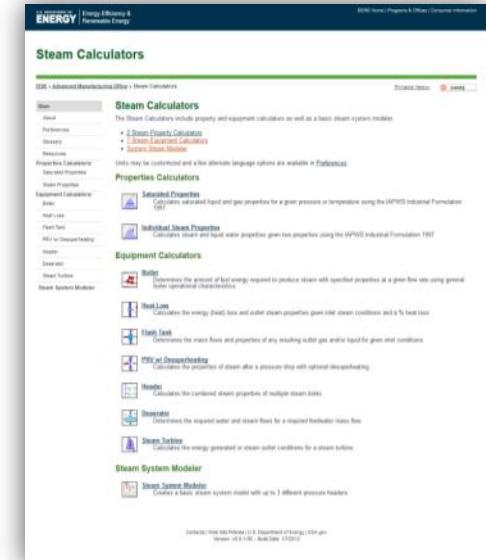
[General Layout](#)

[Customizing Units and Language](#)

[Steam Properties and Calculators](#)

Equipment Calculators [description structure]:

- **Boiler:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **Heat Loss:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **Flash Tank:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **PRV:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **Header:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **Deaerator:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)
- **Steam Turbine:** [Overview](#) [Inputs](#) [Calculation](#) [Results](#)



Main Entry Page of SSMT

Steam System Modeler:

-SEE FOLLOWING PAGE

[GO TO SSMT ONLINE](#)

Table of Contents (2/2) - Modeler

Steam System Modeler :

[Overview](#) [Key Terms](#)

[Using the Steam System Modeler](#)

Generating a Base Model: [Overview](#)

Sections: [Boiler](#) [General](#) [Headers](#) [Steam Turbines](#)

Reviewing the Model: [Overview](#)

[Diagram](#) [MouseOver Equipment] [Steam Balance](#) [Energy Flow](#)

Creating an Adjusted Model: [Overview](#)

Adjustments: [General](#) [Unit Costs](#) [Steam Demand](#)
[Boiler](#) [Steam Turbines](#) [Condensate](#) [Heat Loss](#)

[Comparing the Models](#)

[Reloading and Savings:](#) [Download Spreadsheet](#) [Reloading a Model](#)

[Export to AMO eCenter](#)

[Tips and Tricks](#)

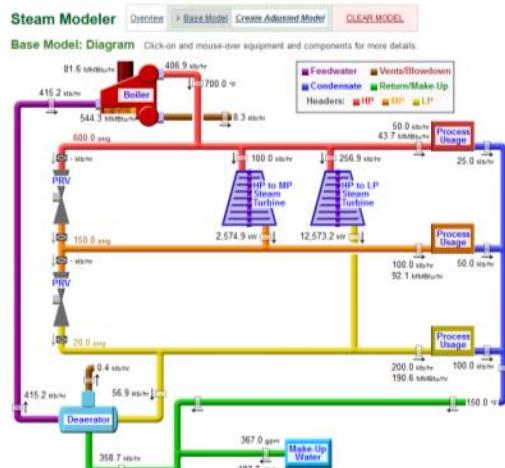
[GO TO SSMT ONLINE](#)

Introduction (1/2)

The **Steam System Modeling Tool (SSMT)** is designed to enable steam system operators to both better understand their systems and provide the tools to evaluate potential improvements.

Key features include:

- **Custom Steam Property Tables**
- **Equipment Calculators**
- **Steam System Modeler**
- **Web-based**
- **Customizable Units**
- **Transparent Calculations**



Introduction (2/2) - Key Feature Details

Custom Steam Property Tables

Users can generate customized steam tables based on specific operating conditions of their steam system.

Equipment Calculators

Basic steam system equipment can be independently modeled and evaluated without creating a complete model.

Steam System Modeler

A 1-3 header steam system model can be generated with the associated PRVs, steam turbines, flash tanks, heat losses, and condensate return conditions. Users can then evaluate the impact of a significant number of adjustments to the model.

Web-based

Only an internet connection and the current version of any major browser are required to immediately start using SSMT. *There are no installation requirements.*

Customizable Units

Users can select and switch between a number of different units at any time.

Transparent Calculations

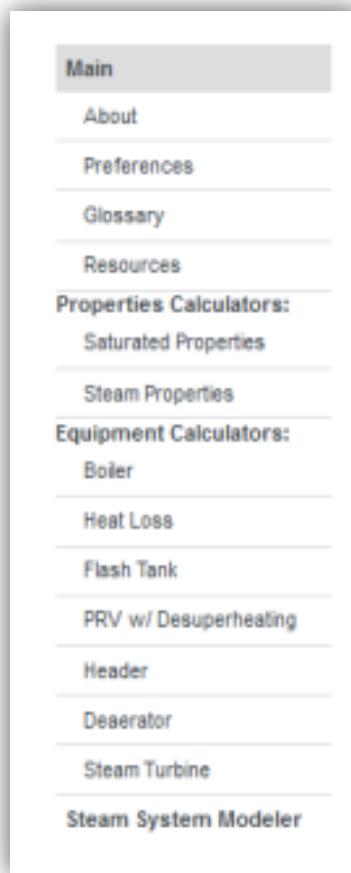
Calculations details are provided through tool to allow users to verify results.

General Layout and Structure

Major Sections of SSMT:

- General Information
- Property Calculators
- Equipment Calculators
- Steam System Modeler

All calculators follow a similar format *detailed on the following page.*



Properties Calculators

- Saturated Properties** Calculates saturated liquid and gas properties for a given pressure.
- Individual Steam Properties** Calculates steam and liquid water properties given two pressures.

Equipment Calculators

- Boiler** Determines the amount of fuel energy required to produce steam given boiler operational characteristics.
- Heat Loss** Calculates the energy (heat) loss and outlet steam properties given inlet steam properties and heat loss conditions.
- Flash Tank** Determines the mass flows and properties of any resulting liquid and vapor streams.
- PRV w/ Desuperheating** Calculates the properties of steam after a pressure drop through a valve with desuperheating.
- Header** Calculates the combined steam properties of multiple parallel streams.
- Deaerator** Determines the required water and steam flows for a deaeration system.
- Steam Turbine** Calculates the energy generated or steam outlet conditions given inlet steam properties and turbine characteristics.

Steam System Modeler

- Steam System Modeler** Creates a basic steam system model with up to 3 different components.

General Calculator Layout

Data Inputs
with pop-up tips and data validation

Examples
for a few common configurations with random data

Assumptions
specific to the calculation

Steam Calculators

Heat Loss Calculator

Calculates the energy (heat) loss and outlet steam

Inlet	
Pressure*	929 psig
Temperature	440.9 °F
Mass Flow*	23.6 kib/hr
Percent Heat Loss *	7.95 %

* Required

Enter Reset

**Example Liquid

Examples: Mouse Over

Calculation Details and Assumptions below

Inlet Steam		Mass Flow
Pressure	929.0 psig	23.6 kib/hr
Temperature	440.9 °F	Sp. Enthalpy 420.4 btu/lbm
Phase	Liquid	Sp. Entropy 0.615 btu/lbm/R
		Energy Flow 9.9 MMbtu/hr

Outlet Steam		Mass Flow
Pressure	929.0 psig	23.6 kib/hr
Temperature	410.3 °F	Sp. Enthalpy 387.0 btu/lbm
Phase	Liquid	Sp. Entropy 0.578 btu/lbm/R
		Energy Flow 9.1 MMbtu/hr

Heat Loss 7.95 %

Heat Loss 0.8 MMbtu/hr

Calculation Details

Step 1: Determine Inlet Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

- Pressure = 929.0 psig
- Temperature = 440.9 °F
- [Steam Property Calculator] => Specific Enthalpy = 420.4 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
[Inlet Energy Flow = 9.9 MMbtu/hr = 420.4 btu/lbm * 23.6 kib/hr]

Step 2: Determine Outlet Energy Flow after Heat Loss

- Outlet Energy Flow = Inlet Energy Flow * (1 - Heat Loss (%))
[Outlet Energy Flow = 9.1 MMbtu/hr = 9.9 MMbtu/hr * (1 - 0.0795)]

Step 3: Determine Outlet Properties
The outlet specific enthalpy is determined from energy and mass flows:

- Outlet Mass Flow = Inlet Mass Flow
- Outlet Energy Flow = Outlet Mass Flow * Outlet Specific Enthalpy
- Outlet Specific Enthalpy = Outlet Energy Flow / Inlet Mass Flow
[Outlet Specific Enthalpy = 387.0 btu/lbm = 9.1 MMbtu/hr / 23.6 kib/hr]

Using the Steam Property Calculator, properties are determined using Pressure and Specific Enthalpy:

- Pressure = 929.0 psig
- Specific Enthalpy = 387.0 btu/lbm
- [Steam Property Calculator] => Temperature = 410.3 °F

Assumptions

- Inlet Mass Flow equals Outlet Mass Flow.
- Baseline (0 Energy Flow) is set at the triple point for water.
- % Heat Loss is relative to the Baseline.

Contacts | Web Site Policies | U.S. Department of Energy | USA.gov
Version: v0.9.1-RC - Build Date: 1/7/2012

Diagram of Equipment
with Complete Steam Property Details

Calculation Details
populated with data from current calculation

[GO TO SSMT ONLINE](#)

Customizing Units and Language

The **Preferences** page allows users to customize the following at anytime:

- Unit Types
- Language
- Currency Symbol

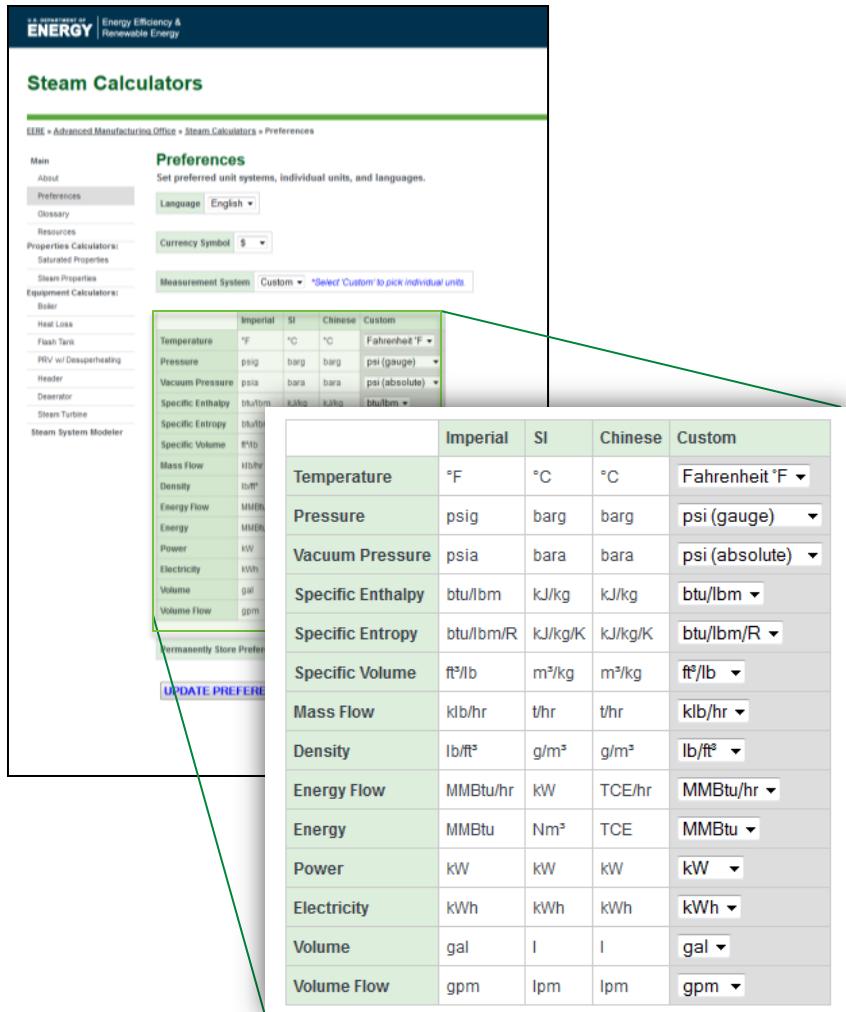
By default, NO information will be stored about the users preferences. If a user wishes to store their preferences between sessions they must switch the “Permanently Store Preferences” Option to “Yes”

Permanently Store Preferences

The screenshot shows the 'Steam Calculators' preferences page from the U.S. Department of Energy's Energy Efficiency & Renewable Energy website. The page includes a sidebar with links like Main, About, Preferences (which is selected), Glossary, Resources, Properties Calculators, Saturated Properties, Steam Properties, Equipment Calculators, Boiler, Heat Loss, Flash Tank, PRV w/ Desuperheating, Header, Deaerator, Steam Turbine, and Steam System Modeler. The main content area is titled 'Preferences' and contains sections for Language (set to English), Currency Symbol (\$), and Measurement System (set to Custom). Below these are tables for Temperature, Pressure, Vacuum Pressure, Specific Enthalpy, Specific Entropy, Specific Volume, Mass Flow, Density, Energy Flow, Energy, Power, Electricity, Volume, and Volume Flow, each comparing Imperial, SI, Chinese, and Custom units. At the bottom are buttons for 'Permanently Store Preferences' (set to No) and 'UPDATE PREFERENCES'.

Customizing Units

- Users may select between predefined units sets or customize each individual unit.
- This may be done at **any time**, even if a model has already been generated. The model and entered values will all be updated to match the new units.
- SSMT remembers which units were selected when any values are entered. This ensures that entered values are at most converted only 1 time regardless of how many times a user switches units.



Customizing Languages

- SSMT is design to support alternate languages options. It currently includes:
 - Chinese
 - Russian
- To further support international use of the tool, users can also select an alternate currency symbol.
 - This is used in the steam system modeler which includes steam related costs and cost savings calculated from various system adjustments.



[GO TO SSMT ONLINE](#)

SSMT calculates all steam properties using the *International Association for the Properties of Water and Steam's Thermodynamic Properties of Water and Steam Industrial Formulation, IAPWS-IF97, 2007*, www.iapws.org

Calculated properties include:*

- Pressure
 - Temperature
 - Specific Enthalpy
 - Specific Entropy
 - Phase
 - Quality
 - Specific Volume

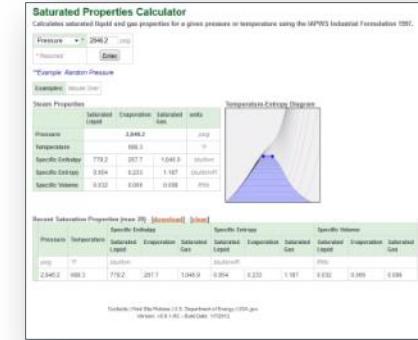
**Due to the complexity of the steam calculations, they are not displayed by SSMT.*



SSMT Steam Property Calculators

SSMT provides 2 steam property calculators:

- Saturated Properties Calculator
 - Determines saturated liquid and gas properties for a given pressure or temperature
- Steam Properties Calculator
 - Determines steam and liquid water properties given two properties that fix the state



Both calculators include:

- Steam Property Details
- Temperature-Entropy Diagram (Vapor Dome)
- History of 20 most recent property calculation
- Downloadable properties (*custom steam tables*)

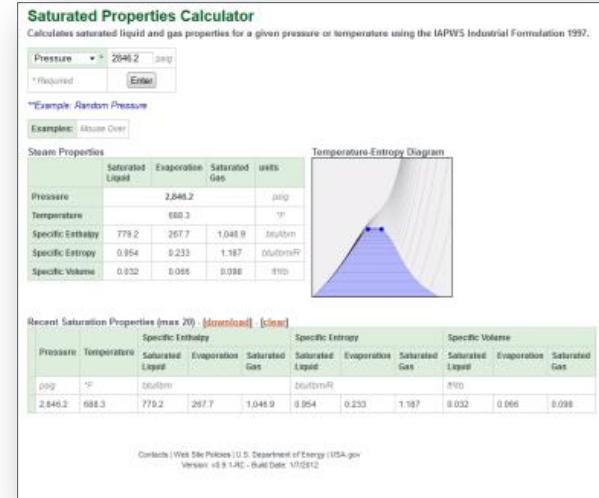
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Saturated Properties Calculator

Saturated Properties Calculator

Determines saturated liquid and gas properties for a given pressure or temperature

- Saturated liquid and gas refer to the 2 separate states of water that co-exist when boiling
- Both the saturated liquid and the gas will be the same temperature and pressure
- Quality refers to the portion of the total mass of water that is a gas/vapor (0 to 1). A quality of 1 indicates that it is entirely a saturated gas/vapor
- Saturated properties can be determined given only the temperature or pressure as they both correspond to the boiling temperature at a given pressure

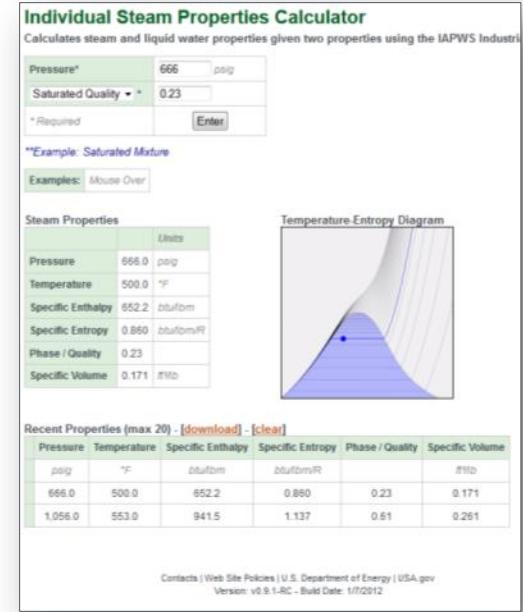


Steam Properties Calculator

Steam Properties Calculator

Determines steam and liquid water properties given two properties that fix the state

- Pressure and a secondary steam property are required to determine the exact state of the steam
- Potential secondary properties include:
 - Temperature
 - Specific Enthalpy
 - Specific Entropy
 - Quality
- This calculator can evaluate:
sub-cooled liquid, saturated liquid, saturated mixture, saturated gas, superheated gas, and supercritical properties



SSMT Equipment Calculators:

Boiler Calculator

Heat Loss Calculator

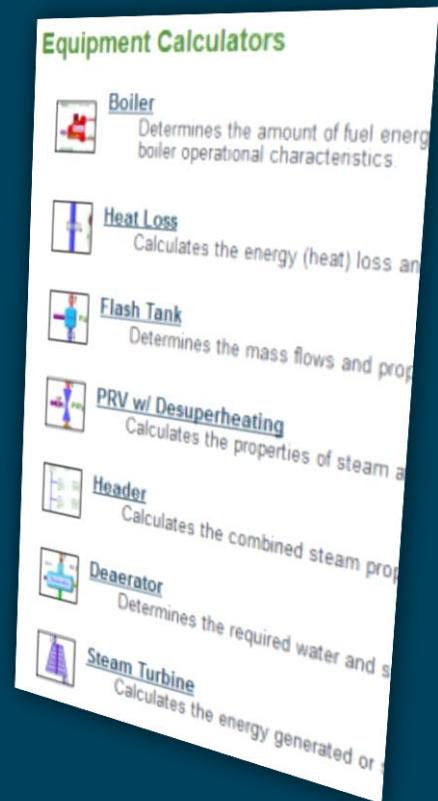
Flash Tank Calculator

PRV w/ Desuperheating Calculator

Header Calculator

Deaerator Calculator

Steam Turbine Calculator



OVERVIEW

Description of the calculator and key features

INPUTS

Each input listed in the following format:

INPUT NAME [property type]:

description of input type

CALCULATIONS

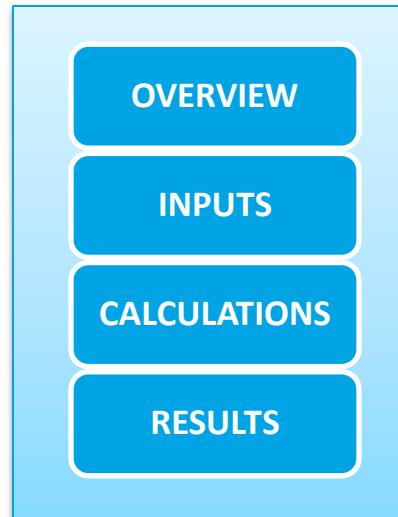
Each step listed in the following format:

Step #: Description

additional details

RESULTS

Listing of all calculations results provided by the calculator



The Boiler Calculator determines the amount of fuel energy required to produce steam with the specified properties at a given flow rate using general boiler operational characteristics.

Capable of evaluating generation of:

- Saturated Steam
- Superheated Steam
- Supercritical Steam

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Energy Efficiency & Renewable Energy
EEI Home | Programs & Offices | Consumer Information

Steam Calculators

[EEI Home](#) > Advanced Manufacturing Office > Steam Calculators > Boiler Calculator

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[Flash Tank](#)

[PRV w/ Desuperheating](#)

[Header](#)

[Deaerator](#)

[Steam Turbine](#)

[Steam System Modeler](#)

Boiler Calculator

Determines the amount of fuel energy required to produce steam with specified properties at a given flow rate using general boiler operational characteristics.

Deaerator Pressure*	35.2	psig
Combustion Efficiency*	79.9	%
Blowdown Rate*	3.7	%
Steam		
Pressure*	853.4	psig
Saturated Quality *	1	
Steam Mass Flow *	85.1	kg/hr
* Required	<input type="button" value="Enter"/>	<input type="button" value="Cancel"/>

Examples: Mouse Over

Calculation Details and Assumptions below

Steam	Mass Flow	85.1 kg/hr	
Pressure	853.4 psig	1.197.2 btu/lbm	
Temperature	527.8 °F	1.407.1btu/lbm/R	
Saturated	1.00	Energy Flow	101.9 MBtu/hr



Blowdown	Mass Flow	3.3 kg/hr	
Pressure	853.4 psig	Sp. Enthalpy	521.5 btu/lbm
Temperature	527.8 °F	Sp. Entropy	0.723.1btu/lbm/R
Saturated	0.00	Energy Flow	1.7 MBtu/hr

Feedwater	Mass Flow	88.4 kg/hr	
Pressure	35.2 psig	Sp. Enthalpy	250.1 btu/lbm
Temperature	280.9 °F	Sp. Entropy	0.411 btu/lbm/R
Saturated	0.00	Energy Flow	22.1 MBtu/hr

Calculation Details

Step 1: Determine Properties of Steam Produced
 Using the Steam Property Calculator, properties are determined using Steam Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

- Pressure = 853.4 psig
- Quality = 1.00
- [\[Steam Property Calculator\]](#) => Specific Enthalpy = 1.197.2 btu/lbm
- Steam Energy Flow = Specific Enthalpy * Mass Flow

$$[\text{Steam Energy Flow} = 101.9 \text{ MBtu/hr} * 1.197.2 \text{ btu/lbm} * 85.1 \text{ kg/hr}]$$

Step 2: Determine Feedwater Properties and Mass Flow
 The feedwater flow rate can be calculated from steam mass flow and blowdown rate.

1. Blowdown Mass Flow = Feedwater Mass Flow / Blowdown Rate
2. Steam Mass Flow = Feedwater Mass Flow - Blowdown Mass Flow
3. Steam Mass Flow = Feedwater Mass Flow - Blowdown Mass Flow / Blowdown Rate
4. Feedwater Mass Flow = Steam Mass Flow / (1 - Blowdown Rate)

$$[\text{Feedwater Mass Flow} = 88.4 \text{ kg/hr} = 85.1 \text{ kg/hr} / (1 - 0.037)]$$

Using the Steam Property Calculator, properties are determined using Deaerator Pressure and Quality = 0 (Saturated Liquid). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

- Pressure = 35.2 psig
- Quality = 0.00
- [\[Steam Property Calculator\]](#) => Specific Enthalpy = 250.1 btu/lbm
- Feedwater Energy Flow = Specific Enthalpy * Mass Flow

$$[\text{Feedwater Energy Flow} = 22.1 \text{ MBtu/hr} * 250.1 \text{ btu/lbm} * 88.4 \text{ kg/hr}]$$

Step 3: Determine Blowdown Properties and Mass Flow
 Using the calculated feedwater mass flow and blowdown rate.

- Blowdown Mass Flow = Feedwater Mass Flow * Blowdown Rate

$$[\text{Blowdown Mass Flow} = 3.3 \text{ kg/hr} = 88.4 \text{ kg/hr} * 0.037]$$

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Deaerator Pressure [pressure]:

Initial pressure of the feedwater before it is increased to boiler pressure

Combustion Efficiency [%]:

% of the fuel energy that is transferred to the boiler water and steam

Blowdown Rate [%]:

% of feedwater being drained from the boiler as a saturated liquid to reduce the concentration of dissolved solids

Pressure [pressure]:

Operating pressure of the boiler, blowdown, and generated steam

Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the generated steam

Steam Mass Flow [mass flow]:

Mass flow of the steam produced by the boiler

Boiler Calculator

Determines the amount of fuel energy required to boiler operational characteristics.

Deaerator Pressure*	35.2	psig
Combustion Efficiency*	79.9	%
Blowdown Rate*	3.7	%
Steam		
Pressure*	853.4	psig
Saturated Quality ▾ *	1	
Steam Mass Flow *	85.1	kilb/hr
* Required	<input type="button" value="Enter"/>	<input type="button" value="reset"/>

Step 1: Determine Properties of Steam Produced

Steam properties are determined using the **Pressure**, **Secondary Steam Property**, and **Steam Mass Flow**.

Step 2: Determine Feedwater Properties and Mass Flow

Feedwater properties are assumed to be equal to the properties of saturated liquid at **Deaerator Pressure**. The feedwater mass flow is calculated using the **Blowdown Rate** and **Steam Mass Flow**.

Step 3: Determine Blowdown Properties and Mass Flow

The blowdown properties are assumed to be equal to the properties of a saturated liquid at Boiler **Pressure**. The blowdown mass flow is calculated using the **Blowdown Rate** and feedwater mass flow.

Step 4: Determine Boiler Energy

The boiler energy is calculated as the difference between the total outlet (steam, blowdown) energy flows and inlet (feedwater) energy flows.

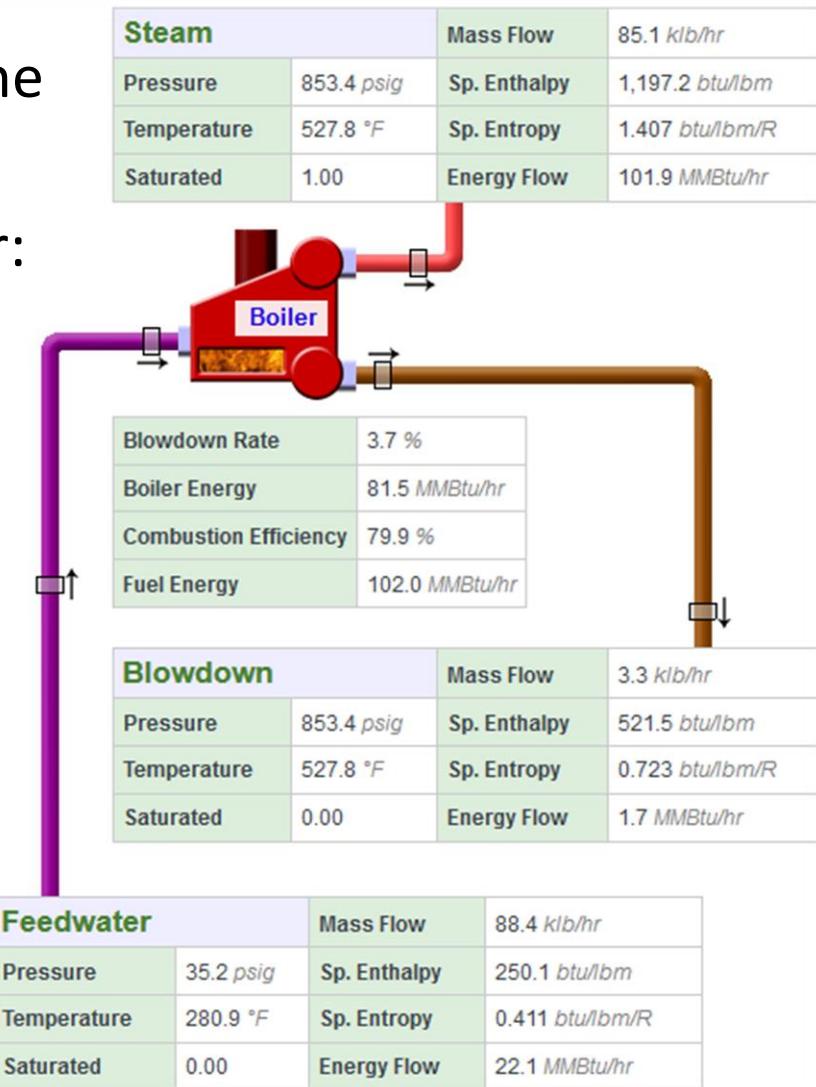
Step 5: Determine Fuel Energy

The total required fuel energy is determined by dividing the boiler energy by the **Combustion Efficiency**.



The Boiler Calculator provides the following results:

- Properties and Mass Flows for:
 - Feedwater
 - Blowdown
 - Generated Steam
- Boiler Energy
- Required Fuel Energy



The **Heat Loss Calculator** determines the energy [heat] loss and outlet steam properties for a steam pipe or header based on specific given inlet steam conditions and a % heat loss.

- % heat loss is relative to the triple point of water at which point the energy content of water is set a 0
- This calculator is primarily used to determine the % heat loss that best approximates the actual heat loss on a specific steam header

Steam Calculators

Heat Loss Calculator

Calculates the energy (heat) loss and outlet steam properties given inlet steam conditions and a % heat loss.

Inlet		Inlet Steam		Mass Flow	
Pressure*	929.0 psig	Pressure	929.0 psig	Sp. Enthalpy	420.4 lbm/hr
Temperature	440.9 °F	Temperature	440.9 °F	Sp. Entropy	0.815 mbtu/m³R
Mass Flow*	23.6 lbm/hr	Phase	Liquid	Energy Flow	9.9 MBtu/hr

Outlet Steam		Outlet Steam		Mass Flow	
Pressure	929.0 psig	Pressure	929.0 psig	Sp. Enthalpy	387.0 lbm/hr
Temperature	410.3 °F	Temperature	410.3 °F	Sp. Entropy	0.578 mbtu/m³R
Phase	Liquid	Phase	Liquid	Energy Flow	9.1 MBtu/hr

Calculation Details

Step 1: Determine Inlet Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

- Pressure = 929.0 psig
- Temperature = 440.9 °F
- **[Steam Property Calculated]** => Specific Enthalpy = 420.4 lbm/hr
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
[Inlet Energy Flow = 9.9 MBtu/hr * 420.4 lbm/hr * 23.6 lbm/hr]

Step 2: Determine Outlet Energy Flow after Heat Loss

- Outlet Energy Flow = Inlet Energy Flow * (1 - Heat Loss (%))
[Outlet Energy Flow = 9.1 MBtu/hr * 9.9 MBtu/hr * (1 - 0.0795)]

Step 3: Determine Outlet Properties
The outlet specific enthalpy is determined from energy and mass flows:

1. Outlet Mass Flow = Inlet Mass Flow
2. Outlet Energy Flow = Outlet Mass Flow * Outlet Specific Enthalpy
3. Outlet Specific Enthalpy = Outlet Energy Flow / Inlet Mass Flow
[Outlet Specific Enthalpy = 387.0 lbm/hr = 9.1 MBtu/hr / 23.6 lbm/hr]

Using the Steam Property Calculator, properties are determined using Pressure and Specific Enthalpy.

- Pressure = 929.0 psig
- Specific Enthalpy = 387.0 lbm/hr
- **[Steam Property Calculated]** => Temperature = 410.3 °F

Assumptions

- Inlet Mass Flow equals Outlet Mass Flow
- Baseline (0 Energy Flow) is set at the triple point for water
- % Heat Loss is relative to the Baseline

Pressure [pressure]:

Pressure of the input steam

Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Mass Flow [mass flow]:

Mass flow of the steam

Percent Heat Loss [%]:

% of steam heat [*enthalpy*] lost between the inlet and the outlet

Heat Loss Calculator
Calculates the energy (heat) loss and outlet stea

Inlet	
Pressure*	929 psig
Temperature *	440.9 °F
Mass Flow *	23.6 lb/hr
Percent Heat Loss *	7.95 %
* Required	<input type="button" value="Enter"/> <input type="button" value="reset"/>

Step 1: Determine Inlet Properties

Inlet steam properties are determined using the **Pressure**, **Secondary Steam Property**, and **Mass Flow**.

Step 2: Determine Outlet Energy Flow after Heat Loss

The outlet energy flow calculated by reducing the inlet energy flow by the **Percent Heat Loss**.

Step 3: Determine Outlet Properties

The outlet steam properties are determined using the **Inlet Pressure** and the calculated outlet energy flow.



The **Heat Loss Calculator** provides the following results:

- Inlet Steam Properties
- Outlet Steam Properties
- Total Heat Loss

The diagram illustrates the flow of steam through a pipe. A blue vertical bar represents the pipe, with a white rectangular callout box containing two rows of data: "Heat Loss 7.95 %" and "Heat Loss 0.8 MMBtu/hr".

Inlet Steam		Mass Flow	23.6 <i>klb/hr</i>
Pressure	929.0 <i>psig</i>	Sp. Enthalpy	420.4 <i>btu/lbm</i>
Temperature	440.9 °F	Sp. Entropy	0.615 <i>btu/lbm/R</i>
Phase	Liquid	Energy Flow	9.9 <i>MMBtu/hr</i>
		Heat Loss	7.95 %
		Heat Loss	0.8 <i>MMBtu/hr</i>

Outlet Steam		Mass Flow	23.6 <i>klb/hr</i>
Pressure	929.0 <i>psig</i>	Sp. Enthalpy	387.0 <i>btu/lbm</i>
Temperature	410.3 °F	Sp. Entropy	0.578 <i>btu/lbm/R</i>
Phase	Liquid	Energy Flow	9.1 <i>MMBtu/hr</i>

The **Flash Tank Calculator** determines the mass flows and steam properties of any resulting outlet gas and/or liquid from a flash tank based on inlet conditions.

A **flash tank** is used to capture the steam generated when a high pressure, high temperature liquid has its pressure reduced causing some of the liquid to vaporize, as known as flashing.

Steam Calculators

Flash Tank Calculator

Determines the mass flows and properties of any resulting outlet gas and/or liquid for given inlet conditions.

Inlet Water	Outlet Gas	Outlet Liquid
Pressure: 622.0 psig	Pressure: 393.1 psig	Pressure: 383.1 psig
Temperature: 492.7 °F	Temperature: 448.5 °F	Temperature: 448.5 °F
Saturated: 0.01	Saturated: 1.00	Saturated: 0.00
Mass Flow: 47.3 lb/hr	Mass Flow: 3.7 lb/hr	Mass Flow: 43.6 lb/hr
Sp. Enthalpy: 486.5 Btu/lbm	Sp. Enthalpy: 1,205.5 Btu/lbm	Sp. Enthalpy: 406.5 Btu/lbm
Sp. Entropy: 0.686 Btu/lbmR	Sp. Entropy: 1.483 Btu/lbmR	Sp. Entropy: 0.824 Btu/lbmR
Energy Flow: 23.0 MBtu/hr	Energy Flow: 4.4 MBtu/hr	Energy Flow: 18.6 MBtu/hr

Calculation Details

Step 1: Determine Inlet Water Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality).

- Pressure = 622.0 psig
- Quality = 0.01
- (Steam Property Calculated)** => Specific Enthalpy = 486.5 Btu/lbm

Step 2: Determine the Specific Enthalpy and other properties for Saturated Liquid and Gas at Flash Pressure

- Pressure = 393.1 psig
- (Saturated Properties Calculated)** =>
 - Saturated Liquid: Specific Enthalpy = 426.3 Btu/lbm
 - Saturated Gas: Specific Enthalpy = 1,205.1 Btu/lbm

Step 3: Evaluate Flash Tank

> If Inlet Specific Enthalpy is less than the Saturated Liquid Specific Enthalpy, only liquid leaves the flash tank at inlet specific enthalpy and flash point pressure.

> If Inlet Specific Enthalpy is greater than the Saturated Gas Specific Enthalpy, only steam leaves the flash tank at inlet specific enthalpy and flash tank pressure.

> If Inlet Specific Enthalpy is in between, proceed to Step 4.

- Proceed to Step 4**

Step 4: Determine Flash Properties
Using an mass and energy balance equations:

- Mass Flow = \dot{m}
- Specific Enthalpy = h
- Entropy = s
- Inlet Water MF = Outlet Gas MF + Outlet Liquid MF
- [Inlet Water MF] * [Inlet Water SE] = [Outlet Gas MF] * [Outlet Gas SE] + [Outlet Liquid MF] * [Outlet Liquid SE]
- Outlet Gas MF = [Inlet Water MF] - [Outlet Liquid MF] * [Outlet Liquid SE]
- [Inlet Water MF] * [Inlet Water SE] = [Outlet Gas MF] * [Outlet Gas SE] + [Outlet Liquid MF] * [Outlet Liquid SE]
- [Inlet Water MF] * [Inlet Water SE] = [Outlet Gas MF] * [Outlet Gas SE] + [Outlet Liquid MF] * [Outlet Liquid SE]
- [Outlet Liquid MF] * [Outlet Liquid SE] = [Outlet Liquid MF] * [Outlet Liquid SE] + [Inlet Water MF] * [Inlet Water SE]
- [Outlet Liquid MF] * [Outlet Liquid SE] = [Outlet Liquid SE] * [Inlet Water SE - Outlet Gas SE]
- Outlet Liquid MF = \dot{m} * s = \dot{m} * $(406.5 \text{ Btu/lbm} - 1,205.1 \text{ Btu/lbm}) / (426.3 \text{ Btu/lbm} - 1,205.1 \text{ Btu/lbm})$
- Outlet Gas MF = [Inlet Water MF] - Outlet Liquid MF
- [Outlet Gas MF] * [Inlet Water SE] = [Outlet Gas SE] * [Inlet Water SE - Outlet Gas SE]

Assumptions

- Total Inlet and Outlet Mass Flows are equal. No mass is lost or gained.
- Total Inlet and Outlet Enthalpies are equal. No energy is lost or gained.

Pressure [pressure]:

Pressure of the input steam

Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Mass Flow [mass flow]:

Mass flow of the steam

Percent Heat Loss [pressure]:

Pressure inlet steam is reduced to in the flash tank

Flash Tank Calculator

Determines the mass flows and properties of an

Inlet	
Pressure*	622 psig
Saturated Quality *	0.01
Mass Flow *	47.3 lb/hr
Tank Pressure *	393.1 psig
* Required	<input type="button" value="Enter"/> <input type="button" value="reset"/>

Step 1: Determine Inlet Water Properties

Inlet properties are determined using the **Pressure**, **Secondary Steam Property**, and **Mass Flow**.

Step 2: Determine the Specific Enthalpy and other properties for Saturated Liquid and Gas at Flash Pressure

The saturated liquid and gas/vapor properties for the **Flash Tank Pressure** are calculated.

Step 3: Evaluate Flash Tank

- If Inlet Specific Enthalpy is less than the Saturated Liquid Specific Enthalpy, only liquid leaves the flash tank at inlet specific enthalpy and flash tank pressure.
 - If Inlet Specific Enthalpy is greater than the Saturated Gas Specific Enthalpy only Steam leaves the flash tank at inlet specific enthalpy and flash tank pressure.
 - If Inlet Specific Enthalpy is in between, proceed to Step 4.

Step 4: Determine Flash Properties

A mass and energy balance is used to determine the ratio of the saturated liquid and gas that equals the mass and energy flows of the inlet water.

Calculation Details

Step 1: Estimation Properties of Linear Project

Using the linear project, the cash inflows represent the historical cash flow and the selected cost of capital. The projected cash flows for the linear project are the same as the historical cash flows. The specific estimate is then multiplied by the WACC from the Step 1 Cash Flow to get the Energy Plan cash flows.

- Present Value = \$1,000
- Equity = 1.00
- Cost of Capital (Annual) = 10% ▪ Specific Estimate = $\$1,000 \times 1.00 = \$1,000$
- Direct Energy Plan ▪ Specific Estimate = Direct Plan
- Direct Energy Plan = $\$1,000 \times 1.00 = \$1,000$ ▪ $\$1,000 \times 1.00 = \$1,000$

Step 2: Estimation Future Project Properties and Mass Flow

The historical cash flows can be used to project future mass flows and historical rates.

- 1. Historical Mass Flow = Future Mass Flow ▪ DirectPlanRate
- 2. Historical Mass Flow = Future Mass Flow ▪ DirectPlanRate
- 3. Historical Mass Flow = Future Mass Flow ▪ Future Mass Flow ▪ DirectPlanRate
- 4. Future Mass Flow = Direct Mass Flow / (1 + DirectPlanRate)
- 5. Future Mass Flow = $\$1,000 \times 1.00 = \$1,000 / (1 + 10\%)$

Using the Direct Project, the cash inflows represent an intermediate between Historical Project and $(1 + \text{DirectPlanRate})$ (Historical Rate). The type of calculation is similar to the WACC from the Step 1 Cash Flow to get the Energy Plan.

- Present Value = \$1,000
- Equity = 1.00
- Cost of Capital (Annual) = 10% ▪ Specific Estimate = $\$1,000 \times 1.00 = \$1,000$
- Available Growth = 1 ▪ Specific Estimate = Mass Flow
- Future Mass Flow = $\$1,000 \times 1.00 = \$1,000 \times 1.10 = \$1,100$

Step 3: Estimation Future Properties and Mass Flow

Using the calculated historical rates and available growth.

- 1. Historical Mass Flow = Future Mass Flow ▪ DirectPlanRate
- 2. Historical Mass Flow = $\$1,000 \times 1.00 = \$1,000 \times 1.10$

Using the Direct Project, the properties are an intermediate using Energy Premium and Quality = 1 (historical input). The formula is also multiplied by the WACC from the Step 1 Cash Flow to get the Energy Plan.

- Present Value = \$1,000
- Equity = 1.00
- Cost of Capital (Annual) = 10% ▪ Specific Estimate = $\$1,000 \times 1.00 = \$1,000$
- Available Growth = 1 ▪ Specific Estimate = Mass Flow
- Future Mass Flow = $\$1,000 \times 1.00 = \$1,000 \times 1.10 = \$1,100$

Step 4: Estimation Future Energy

- Net Energy = Future Mass Flow ▪ Available Energy Flow ▪ Available Energy Flow
- Net Energy Flow = $\$1,000 \times 1.00 = \$1,000 \times 1.10 = \$1,100$ ▪ Available Energy Flow = $\$1,000 \times 1.00 = \$1,000$

Step 5: Estimation Future Cash Flow

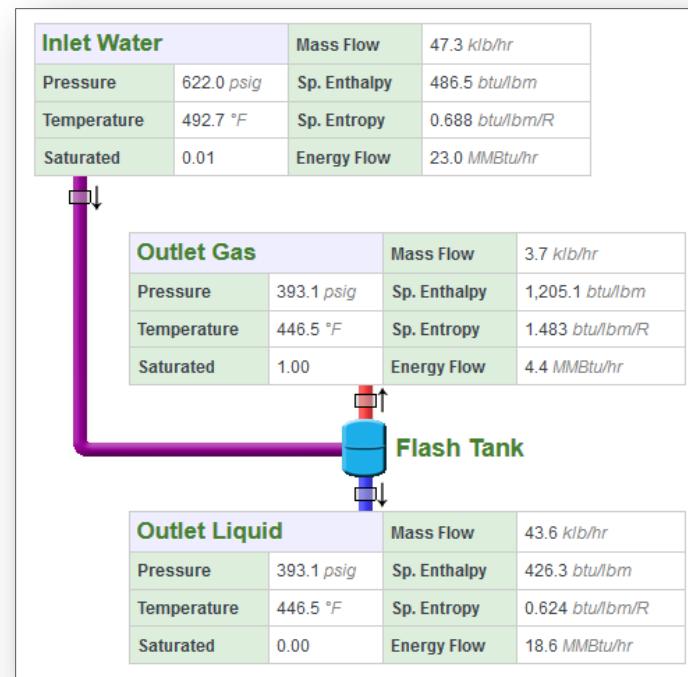
- Net Energy = Future Energy ▪ Generation Planning
- Net Energy Flow = $\$1,000 \times 1.00 = \$1,000$ ▪ Generation Planning = $\$1,000 \times 1.00 = \$1,000$

Assumptions

- Current projects indicate that the bidding temperature is the maximum at operating premium (historical input).
- These rates are historical Project rates as of year t .
- Current rates = historical Project rates as of year t . The directly related to the historical and ring-offshore for $t+1$ cost.
- Direct rates = the rate of energy premium based on the historical bid comparison at historical t operating premium.
- Using historical rates, we can calculate the historical rates.
- These are the rates used in the model.

The Flash Tank Calculator provides the following results:

- Properties and Mass Flows for:
 - Inlet High Pressure Water
 - Outlet Gas
 - Outlet Liquid



The Pressure Reducing Valve (PRV) Calculator determines the properties of steam after a pressure drop with optional desuperheating.

PRVs reduce the pressure of steam without adding or removing energy. This is known as an isenthalpic process.

In some cases, outlet steam needs to be reduced to a set temperature. To do this, PRVs can be configured to desuperheat the outlet steam by injecting water into the steam.

Steam Calculators

PRV w/ Desuperheating Calculator

Calculates the properties of steam after a pressure drop with optional desuperheating.

Inlet	Mass Flow
Pressure: 226 psig	60.3 lb/hr
Temperature: 554.4 °F	
Mass Flow: 60.3 lb/hr	

Outlet	Mass Flow
Pressure: 156.6 psig	63.3 lb/hr
Temperature: 455 °F	
Phase: Gas	

Feedwater	Mass Flow
Pressure: 79.1 psig	3.0 lb/hr
Temperature: 323.2 °F	
Saturated: 0.00	

Calculation Details

Step 1: Determine Inlet Steam Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality):

- Pressure = 226.0 psig
- Temperature = 554.4 °F
- [Steam Property Calculator] => Specific Enthalpy = 1.294.8 btu/lbm

Step 2: If NO Desuperheating: Determine Outlet Steam Properties
A PRV is an isenthalpic process, meaning the inlet enthalpy is equal to the outlet enthalpy. The outlet properties are determined using the inlet enthalpy and outlet pressure.

Step 2 If Desuperheating: Determine Cooling Water Properties
Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality):

- Pressure = 156.6 psig
- Quality = 0.00
- [Steam Property Calculator] => Specific Enthalpy = 293.8 btu/lbm

Step 3: Determine Desuperheated Outlet Steam Properties
Using the Steam Property Calculator, properties are determined using Outlet Pressure and Desuperheating Temperature:

- Pressure = 156.6 psig
- Temperature = 455 °F
- [Steam Property Calculator] => Specific Enthalpy = 1.247.6 btu/lbm

Step 4: Determine Feedwater and Outlet Mass Flows
If the desuperheated outlet specific enthalpy is less than the Feedwater specific enthalpy or greater than the Inlet Steam specific enthalpy, the PRV outlet cannot be desuperheated to the set temperature and desuperheating is canceled.

Flows are determined using mass and energy balance equations:

- Mass Flow = MF
- Specific Enthalpy = SE
- Entropy = ENT
- Outlet Steam MF * Inlet Steam MF + Feedwater MF
- [Outlet Steam MF * Outlet Steam SE] = [Inlet Steam MF * Inlet Steam SE] + [Feedwater MF * Feedwater SE]
- [Inlet Steam MF * Feedwater MF] * [Outlet Steam SE] = [Inlet Steam MF * Inlet Steam SE] + [Feedwater MF * Feedwater SE]
- [Inlet Steam MF * Outlet Steam SE] + [Feedwater MF * Outlet Steam SE] = [Inlet Steam MF * Inlet Steam SE] + [Feedwater MF * Feedwater SE]
- [Feedwater MF * Outlet Steam SE] - [Feedwater SE] = [Inlet Steam MF * Inlet Steam SE] - [Inlet Steam SE - Outlet Steam SE]
- Feedwater MF = [Inlet Steam MF * (Inlet Steam SE - Outlet Steam SE)] / (Inlet Steam SE - Feedwater SE)
- Feedwater MF = 3.0 lb/hr = 60.3 lb/hr * (1.294.8 btu/lbm - 1.247.6 btu/lbm) / (1.247.6 btu/lbm - 293.8 btu/lbm)
- Feedwater MF = 60.3 lb/hr + Feedwater MF
- Outlet Steam MF = 63.3 lb/hr = 60.3 lb/hr - 3.0 lb/hr

Inlet - Pressure [pressure]:

Inlet steam pressure

Inlet - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Inlet - Mass Flow [mass flow]:

Mass flow of the inlet

Outlet Pressure [pressure]:

Outlet steam pressure

If Desuperheating:**Feedwater - Pressure [pressure]:**

Feedwater pressure

Feedwater - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the feedwater

Desuperheating Temperature [temperature]:

Target temperature for desuperheating

PRV w/ Desuperheating Calc

Calculates the properties of steam after a pressurizer valve.

Inlet	
Pressure*	226 psig
Temperature *	554.4 °F
Mass Flow *	60.3 lb/hr
Outlet Pressure *	156.6 psig
Desuperheating	
Pressure*	79.1 psig
Saturated Quality *	0
Desuperheating Temperature *	455 °F
* Required	<input type="button" value="Enter"/> <input type="button" value="reset"/>

Step 1: Determine Inlet Steam Properties

Inlet steam properties are determined using the **Pressure, Secondary Steam Property, and Mass Flow**.

Step 2: 'If NO Desuperheating': Determine Outlet Steam Properties

Outlet steam properties are determined using the **Outlet Pressure** and inlet steam specific enthalpy. [**'NO Desuperheating' CALCULATION COMPLETE**]

'If Desuperheating': Determine Cooling Water Properties

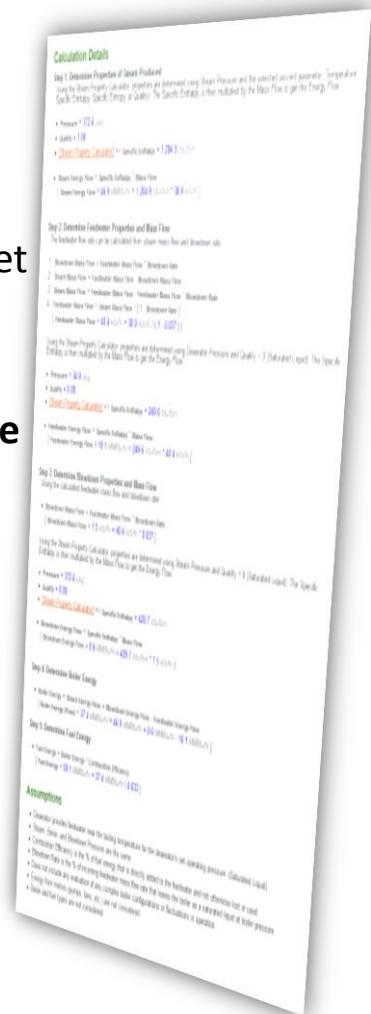
Feedwater steam properties are determined using the **Feedwater-Pressure** and **Feedwater-Secondary Steam Property**.

Step 3: Determine Desuperheated Outlet Steam Properties

Desuperheated outlet steam properties are determined using **Desuperheating Temperature** and **Outlet Pressure**.

Step 4: Determine Feedwater and Outlet Mass Flows

A mass and energy balance is used to determine the ratio of steam and feedwater required to product steam at the desuperheated temperature.



The **PRV Calculator** provides the following results:

- Inlet Steam Properties
- Outlet Steam Properties

If desuperheating:

- Feedwater Properties and Mass Flows
- Total Outlet Steam Mass Flow

Inlet		Mass Flow	60.3 <i>kib/hr</i>
Pressure	226.0 <i>psig</i>	Sp. Enthalpy	1,294.8 <i>btu/lbm</i>
Temperature	554.4 °F	Sp. Entropy	1.631 <i>btu/lbm/R</i>
Phase	Gas	Energy Flow	78.1 <i>MMBtu/hr</i>
Outlet		Mass Flow	63.3 <i>kib/hr</i>
Pressure	156.6 <i>psig</i>	Sp. Enthalpy	1,247.6 <i>btu/lbm</i>
Temperature	455.0 °F	Sp. Entropy	1.618 <i>btu/lbm/R</i>
Phase	Gas	Energy Flow	79.0 <i>MMBtu/hr</i>
Feedwater		Mass Flow	3.0 <i>kib/hr</i>
Pressure	79.1 <i>psig</i>	Sp. Enthalpy	293.8 <i>btu/lbm</i>
Temperature	323.2 °F	Sp. Entropy	0.468 <i>btu/lbm/R</i>
Saturated	0.00	Energy Flow	0.9 <i>MMBtu/hr</i>

The Header Calculator determines the combined steam properties of multiple steam inlets.

This simulates situations commonly found in steam systems where multiple sources of steam, with varying pressures and temperatures, are combined into a single steam distribution line, referred to as a steam header.

Steam Calculators

Header Calculator

Calculates the combined steam properties of multiple steam inlets.

Combined Header		Mass Flow
Pressure	388.4 psig	133.5 lb/inhr
Temperature	445.4 °F	747.1 btu/lbm
Sp. Enthalpy		0.979 btu/lbm°F
Sp. Entropy		
Saturated	0.41	Energy Flow 99.7 MBtu/hr

Inlet 1		Mass Flow
Pressure	553.2 psig	52.9 lb/inhr
Temperature	246.8 °F	216.5 btu/lbm
Phase	Liquid	Sp. Enthalpy 0.962 btu/lbm°F
Sp. Entropy		

Inlet 2		Mass Flow
Pressure	496.5 psig	15.2 lb/inhr
Temperature	117.1 °F	80.4 btu/lbm
Phase	Liquid	Sp. Enthalpy 0.919 btu/lbm°F
Sp. Entropy		

Inlet 3		Mass Flow
Pressure	427.8 psig	65.4 lb/inhr
Temperature	645.6 °F	1,329.9 btu/lbm
Phase	Gas	Sp. Enthalpy 1,600 btu/lbm°F
Sp. Entropy		
Energy Flow	11.5 MBtu/hr * 216.5 lb/inhr * 52.9 lb/inhr	87.0 MBtu/hr

Calculation Details and Assumptions below

Calculation Details

Step 1: Determine the properties and energy flows for the inlets

Using the Steam Property Calculator, properties are determined using Inlet Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

Inlet1

- Pressure = 553.2 psig
- Temperature = 246.8 °F
- [Steam Property Calculator] => Specific Enthalpy = 216.5 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
[Inlet Energy Flow = 11.5 MBtu/hr * 216.5 lb/inhr * 52.9 lb/inhr]

Inlet2

- Pressure = 496.5 psig
- Temperature = 117.1 °F
- [Steam Property Calculator] => Specific Enthalpy = 80.4 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
[Inlet Energy Flow = 13.0 MBtu/hr * 80.4 btu/lbm * 15.2 lb/inhr]

Inlet3

- Pressure = 427.8 psig
- Temperature = 645.6 °F
- [Steam Property Calculator] => Specific Enthalpy = 1,329.9 btu/lbm
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
[Inlet Energy Flow = 87.0 MBtu/hr * 1,329.9 btu/lbm * 65.4 lb/inhr]

Step 2: Determine the Header Specific Enthalpy

The header specific enthalpy can be calculated by dividing the Total Inlet Energy Flows by the Total Inlet Mass Flows.

- Total Inlet Energy Flow = 99.7 MBtu/hr + 13.0 MBtu/hr + 87.0 MBtu/hr
- Total Inlet Mass Flow = 133.5 lb/inhr + 52.9 lb/inhr + 15.2 lb/inhr + 65.4 lb/inhr
- Header Specific Enthalpy = Total Energy Flow / Total Mass Flow
[Header Specific Enthalpy = 99.7 MBtu/hr / 133.5 lb/inhr]

Step 3: Determine Header Properties

Using the Steam Property Calculator, properties are determined using Header Pressure and the Header Specific Enthalpy.

- Pressure = 388.4 psig
- Specific Enthalpy = 747.1 btu/lbm
- [Steam Property Calculator] => Temperature = 445.4 °F

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Number of Inlets [#]:

Specifies the number of steam inlets that are used in the calculation

Header Pressure [pressure]:

The final of the combined steam inlets

For Each Steam Inlet:**Pressure [pressure]:**

Inlet steam pressure

Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Mass Flow [mass flow]:

Mass flow of the inlet

Header Calculator
Calculates the combined steam properties of multiple steam inlets.

Number of Inlets	3
Header Pressure *	388.4 psig
Inlet 1	
Pressure*	553.2 psig
Temperature *	246.8 °F
Mass Flow *	52.9 klb/hr
Inlet 2	
Pressure*	496.5 psig
Temperature *	117.1 °F
Mass Flow *	15.2 klb/hr
Inlet 3	
Pressure*	427.8 psig
Temperature *	645.6 °F
Mass Flow *	65.4 klb/hr
* Required	
<input type="button" value="Enter"/> <input type="button" value="Reset"/>	

Step 1: Determine the properties and energy flows for the inlets

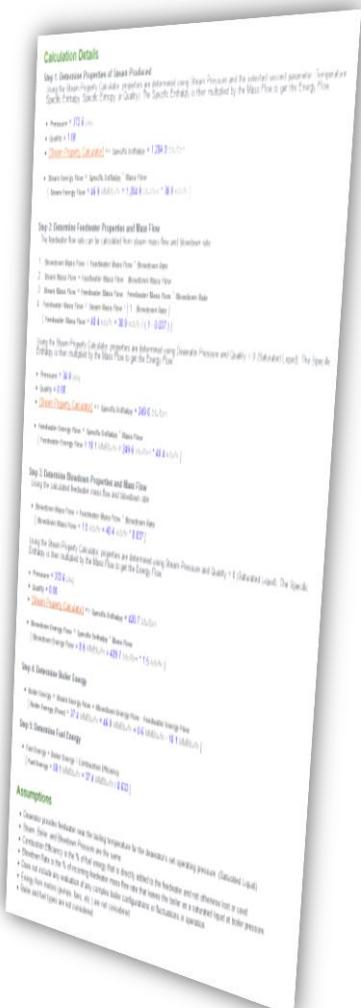
Steam properties for each inlet are determined using the associated **Pressure**, **Secondary Steam Property**, and **Steam Mass Flow**.

Step 2: Determine the Header Specific Enthalpy

The header specific enthalpy is calculated by dividing the total inlet energy flows by the total inlet mass flows.

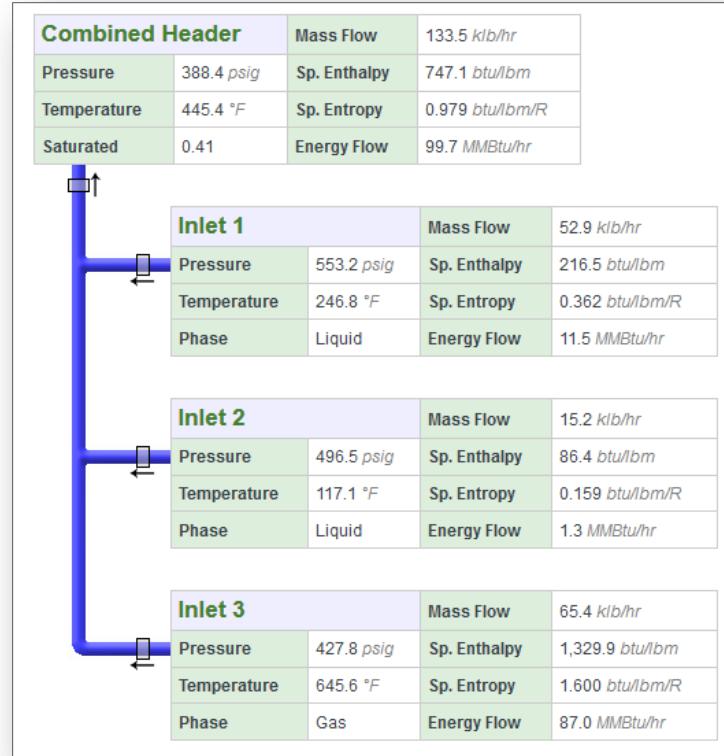
Step 3: Determine Header Properties

The header properties are determined using **Header Pressure** and the header specific enthalpy.



The Header Calculator provides the following results:

- Properties and Mass Flows for each Inlet
- The Combined Header Properties and Mass Flow



The Deaerator Calculator determines the required water and steam flows for a given feedwater mass flow.

- A *deaerator* is a tank used to remove dissolved gases from the feedwater before being sent to the boiler
- The solubility of gases in water is reduced as the water temperature increases. Therefore deaerators increase feedwater to near boiling temperature to remove as much gas as possible.
- The small amount of steam is vented in the process of venting the gases
- Steam is commonly used as the heat source for the deaerator

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Steam Calculators

[EERE](#) > Advanced Manufacturing Office > Steam Calculators > Deaerator Calculator

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Main	Deaerator Calculator
About	Determines the required water and steam flows for a required feedwater mass flow.
Preferences	
Glossary	
Resources	
Properties Calculators:	
Saturated Properties	
Steam Properties	
Equipment Calculators:	
Boiler	Deaerator Pressure * 30.6 psig
Heat Loss	Vent Rate * 0.4 %
Flash Tank	Feedwater Mass Flow * 45.7 lb/hr
PRV w/ Desuperheating	Water
Heater	Pressure* 2.6 psig
Deaerator	Temperature * 61.8 °F
Steam Turbine	Steam
Steam System Modeler	Pressure* 57.9 psig
	Temperature * 1258.7 °F
	* Required <input type="button" value="Enter"/> <input type="button" value="Reset"/>
*Example: Random	
Example Mouse Over	
Calculation Details and Assumptions below	

The diagram illustrates the deaeration process. Feedwater enters the deaerator from the bottom left. It is heated by inlet steam entering from the top right. The treated water exits the deaerator at the top left. A small amount of steam is vented off at the top right.

Feedwater	Mass Flow 45.7 lb/hr
Pressure 30.6 psig	Sp. Enthalpy 243.9 btu/lbm
Temperature 274.8 °F	Sp. Entropy 0.403 btu/lbm°F
Saturated 0.00	Energy Flow 11.1 MBtu/hr

Vented Steam	Mass Flow 0.2 lb/hr
Pressure 30.6 psig	Sp. Enthalpy 1,172.3 btu/lbm
Temperature 274.8 °F	Sp. Entropy 1.667 btu/lbm°F
Saturated 1.00	Energy Flow 0.2 MBtu/hr

Inlet Water	Mass Flow 39.8 lb/hr
Pressure 2.6 psig	Sp. Enthalpy 29.9 btu/lbm
Temperature 61.8 °F	Sp. Entropy 0.059 btu/lbm°F
Phase Liquid	Energy Flow 1.2 MBtu/hr

Inlet Steam	Mass Flow 6.1 lb/hr
Pressure 57.9 psig	Sp. Enthalpy 1,670.2 btu/lbm
Temperature 1,258.7 °F	Sp. Entropy 2.043 btu/lbm°F
Phase Gas	Energy Flow 10.2 MBtu/hr

Calculation Details

Step 1: Determine Inlet Water Properties
Using the Steam Property Calculator, properties are determined using Inlet Water Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality).

- Pressure = 2.6 psig
- Temperature = 61.8 °F
- [Steam Property Calculator] => Specific Enthalpy = 29.9 btu/lbm

Step 2: Determine Inlet Steam Properties
Using the Steam Property Calculator, properties are determined using Inlet Steam Pressure and the selected second parameter (Temperature, Specific Enthalpy, Specific Entropy, or Quality).

- Pressure = 57.9 psig
- Temperature = 1,258.7 °F
- [Steam Property Calculator] => Specific Enthalpy = 1,670.2 btu/lbm

Step 3: Determine Feedwater and Vented Steam Properties

- Pressure = 30.6 psig
- [Saturated Properties Calculator] =>
 - Saturated Liquid Specific Enthalpy = 243.9 btu/lbm
 - Saturated Gas Specific Enthalpy = 1,172.3 btu/lbm

Step 4: Determine Feedwater and Vented Mass Flows and Total Outlet Energy Flows

- Vented Steam Mass Flow = Vent Rate * Feedwater Mass Flow
[Vented Steam Mass Flow = 0.2 lb/hr = 0.4 * 45.7 lb/hr]
- Total DA Mass Flow = Vented Steam Mass Flow + Feedwater Mass Flow
[Total DA Mass Flow = 45.9 lb/hr = 0.2 lb/hr + 45.7 lb/hr]
- Total Outlet Energy Flow = [Feedwater Specific Enthalpy * Feedwater Mass Flow] + [Vented Steam Specific Enthalpy * Vented Steam Mass Flow]
[Total Outlet Energy Flow = 11.1 MBtu/hr = 243.9 btu/lbm * 45.7 lb/hr + 1,172.3 btu/lbm * 0.2 lb/hr]

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Deaerator Pressure [pressure]:

Operating pressure of the deaerator

Vent Rate [%]:

Deaerator vent rate as a % of feedwater mass flow

Feedwater Mass Flow [mass flow]:

Mass flow of the feedwater sent to the boiler

Water - Pressure [pressure]:

Inlet water pressure

Water - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet water

Steam - Pressure [pressure]:

Inlet steam pressure

Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Deaerator Calculator
Determines the required water and steam flows

Deaerator Pressure *	30.6	psig
Vent Rate *	0.4	%
Feedwater Mass Flow *	45.7	klb/hr
Water		
Pressure*	2.6	psig
Temperature ▾ *	61.8	°F
Steam		
Pressure*	57.9	psig
Temperature ▾ *	1258.7	°F
* Required	<input type="button" value="Enter"/>	<input type="button" value="reset"/>

Step 1: Determine Inlet Water Properties

Inlet water properties are determined using the associated **Pressure** and **Secondary Property**.

Step 2: Determine Inlet Steam Properties

Inlet steam properties are determined using the associated **Steam Pressure** and **Secondary Steam Property**.

Step 3: Determine Feedwater and Vented Steam Properties

The saturated steam properties are calculated for the **Deaerator Pressure**. Feedwater properties set to that of the saturated liquid and the vented steam is set to that of the saturated gas/vapor.

Step 4: Determine Feedwater and Vented Mass Flows and Total Outlet Energy Flows

The vented steam mass flow is determined using the Feedwater Mass Flow and Vent Rate. The energy flow of the vented steam and feedwater is then totaled.

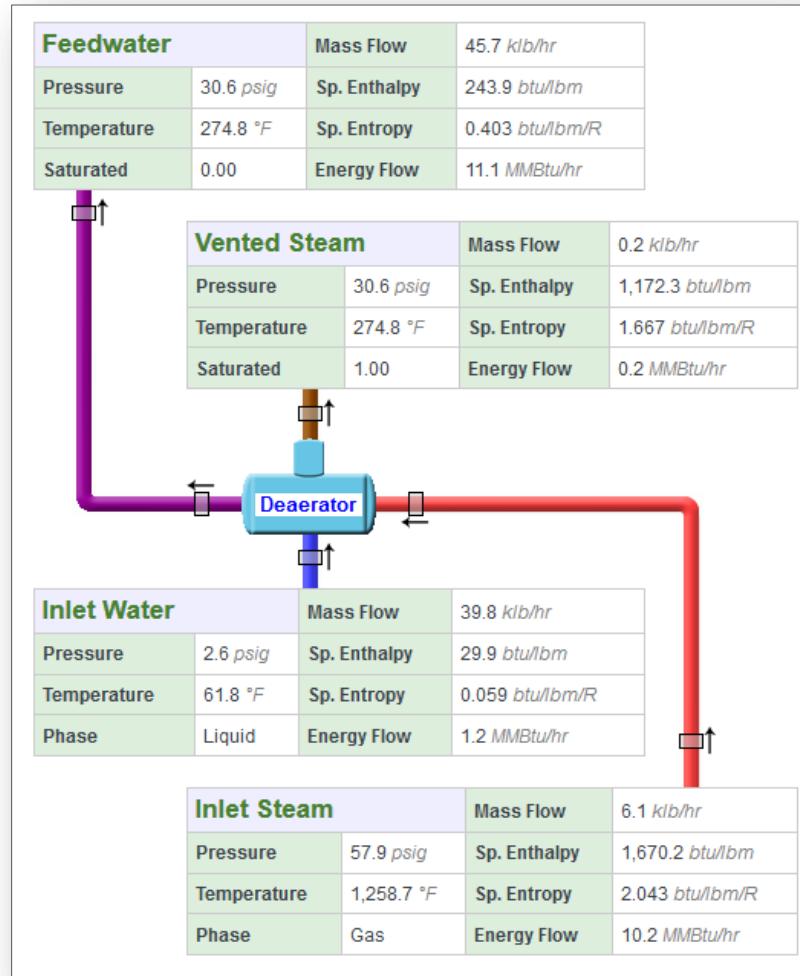
Step 5: Determine Inlet Water and Steam Mass Flows

A mass and energy balance is used to determine the ratio of inlet water and inlet steam required to match the outlet mass and energy flows.



The Deaerator Calculator provides the following results:

- Properties and Mass Flows for:
 - Inlet Water
 - Inlet Steam
 - Feedwater
 - Vented Steam



The Steam Turbine Calculator generates a basic steam turbine model, solving for either:

- Outlet Steam Conditions** – given inlet steam conditions and isentropic efficiency
- Isentropic Efficiency** – given inlet and outlet steam conditions

Users also have the option to enter either the steam mass flow or power generated and the calculator determines the value of the other

The screenshot shows the EERE Steam Turbine Calculator interface. It has two main sections: "Inlet Steam" and "Outlet Steam".

Inlet Steam Properties:

- Pressure: 565.4 psig
- Temperature: 1,064.3 °F
- Phase: Gas
- Mass Flow: 39.3 lb/hr
- Sp. Entropy: 1,553.8 ft-lb/lb
- Sp. Enthalpy: 1,744 ft-lb/lb
- Energy Flow: 611.1 MBtu/hr
- Isentropic Efficiency: 75.7 %
- Energy Out: 3.3 MBtu/hr
- Generator Efficiency: 96.2 %
- Power Out: 926.4 kW

Outlet Steam Properties:

- Pressure: 266.1 psig
- Temperature: 891.7 °F
- Phase: Gas
- Mass Flow: 39.3 lb/hr
- Sp. Entropy: 1,470.1 ft-lb/lb
- Sp. Enthalpy: 1,764 ft-lb/lb
- Energy Flow: 57.8 MBtu/hr

Calculation Details and Assumptions:

Step 1: Determine Inlet Properties
Using the Steam Property Calculator, properties are determined using inlet Pressure and the selected isentropic parameter (Temperature, Specific Entropy, or Specific Enthalpy). The Specific Enthalpy is then multiplied by the Mass Flow to get the Energy Flow.

- Pressure = 565.4 psig
- Temperature = 1,064.3 °F
- [Steam Property Calculator](#) => Specific Enthalpy = 1,553.8 ft-lb/lb
- Inlet Energy Flow = Specific Enthalpy * Mass Flow
[Inlet Energy Flow = 611.1 MBtu/hr * 1,553.8 ft-lb/lb * 39.3 lb/hr]

Step 2: Calculate Ideal Outlet Properties (Inlet Entropy equals Outlet Entropy)

- Pressure = 266.1 psig
- Specific Entropy = 1,744 ft-lb/lb
- [Steam Property Calculator](#) => Specific Enthalpy = 1,443.3 ft-lb/lb

Step 3: If solve for 'Isentropic Efficiency', Determine Outlet Properties
Using the outlet specific enthalpy, calculate the isentropic efficiency.

- Isentropic Efficiency = (Inlet Specific Enthalpy - Outlet Specific Enthalpy) / (Inlet Specific Enthalpy - IDEAL Outlet Specific Enthalpy)
- If solve for 'Outlet Properties', Determine Outlet Specific Entropy

Using the outlet specific enthalpy, calculate the outlet properties:

- Pressure = 266.1 psig
- Specific Entropy = 1,470.1 ft-lb/lb
- [Steam Property Calculator](#) => Temperature = 891.7 °F

Step 4: Calculate Steam Turbine Energy Out and Generation (Power Out)

- Energy Out = (Ideal Specific Enthalpy - Outlet Specific Enthalpy) * Mass Flow
[Energy Out = 3.3 MBtu/hr * (1,553.8 ft-lb/lb - 1,470.1 ft-lb/lb) * 39.3 lb/hr]
- Power Out = Energy Out / Generator Efficiency
[Power Out = 926.4 kW * 3.3 MBtu/hr * 96.2 %]

Assumptions:

- Inlet Mass Flows equal Outlet Mass Flow

-SOLVING FOR Outlet Properties-

Inlet Steam - Pressure [pressure]:

Pressure of inlet steam

Inlet Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Isentropic Efficiency [%]:

The energy actually removed as a percent (%) of the energy removed if the turbine were an isentropic process.

Generator Efficiency [%]:

The percent of the energy extracted by the turbine that is converted to power

Either Mass Flow or Power Out:

Mass Flow [mass flow]:

Mass flow of steam

Power Out [power]:

Mass flow of the feedwater sent to the boiler

Outlet Steam - Pressure [pressure]:

Outlet water pressure

Steam Turbine Calculator
Calculates the energy generated or steam outlet properties.

Solve for:	
Outlet Properties	
Inlet Steam	
Pressure*	565.4 psig
Temperature *	1064.3 °F
Turbine Properties	
Selected Turbine Property	Mass Flow
Mass Flow *	39.3 lb/hr
Isentropic Efficiency *	75.7 %
Generator Efficiency *	96.2 %
Outlet Steam	
Pressure*	266.1 psig
* Required	
<input type="button" value="Enter"/> <input type="button" value="reset"/>	

-SOLVING FOR Isentropic Efficiency-

Inlet Steam - Pressure [pressure]:

Pressure of inlet steam

Inlet Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the inlet steam

Generator Efficiency [%]:

The percent of the energy extracted by the turbine that is converted to power

Either Mass Flow or Power Out:

Mass Flow [mass flow]:

Mass flow of steam

Power Out [power]:

Mass flow of the feedwater sent to the boiler

Outlet Steam - Pressure [pressure]:

Outlet water pressure

Outlet Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality]

Second steam property associated with the outlet steam

Steam Turbine Calculator
Calculates the energy generated or steam output.

Solve for:	
Outlet Properties	
Inlet Steam	Properties
Pressure*	565.4 psig
Temperature *	1064.3 °F
Turbine Properties	
Selected Turbine Property	Mass Flow
Mass Flow *	39.3 lb/hr
Isentropic Efficiency *	75.7 %
Generator Efficiency *	96.2 %
Outlet Steam	
Pressure*	266.1 psig
* Required	<input type="button" value="Enter"/> <input type="button" value="Reset"/>

Step 1: Determine Inlet Properties

Inlet steam properties are determined using the **Pressure** and **Secondary Property**.

Step 2: Calculate Ideal Outlet Properties (Inlet Entropy equals Outlet Entropy)

Ideal outlet steam properties are determined using the associated **Outlet Steam Pressure** and inlet specific entropy. The ideal case assumes that no entropy is created in the turbine.

Step 3: If solving for 'Isentropic Efficiency', Determine Outlet Properties

Outlet steam properties are determined using the **Outlet Steam Pressure** and **Outlet Secondary Steam Property**.

Step 3: If solving for 'Outlet Properties', Determine Outlet Specific Enthalpy

The outlet specific enthalpy is calculated using the **Isentropic Efficiency**, inlet specific enthalpy, and ideal outlet specific enthalpy. The outlet specific enthalpy and outlet pressure are used to determine the outlet properties.

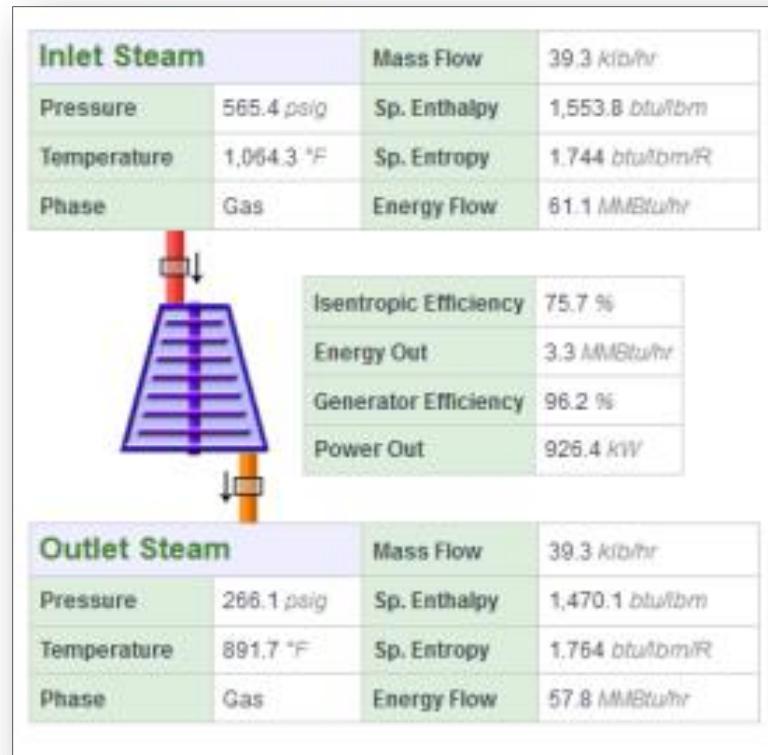
Step 4: Calculate Steam Turbine Energy Out and Generation (Power Out)

The difference between the outlet and inlet steam energy flows are used to determine the energy extracted from the steam (Energy Out). The **Generation Efficiency** is then used to determine the power generated (Power Out).



The Steam Turbine Calculator provides the following results:

- Inlet Steam Properties
- Outlet Steam Properties
- Isentropic Efficiency
- Energy Out (*energy extracted*)
- Power Out (*power generated*)

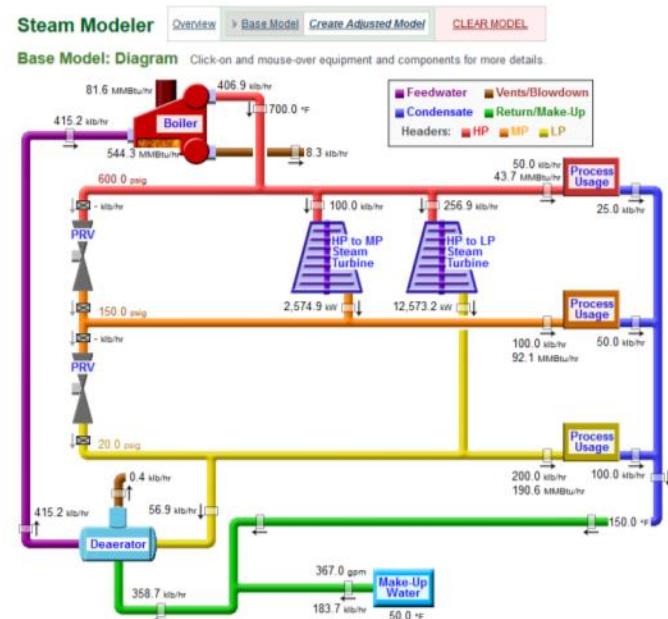


Steam System Modeler

A 1-3 header steam system model can be generated with the associated PRVs, steam turbines, flash tanks, heat losses, and condensate return conditions. Users can then evaluate the impact of a significant number of adjustments to the model.

SSMT is capable of creating a basic ***steam system model*** that can be used to better understand the current operating conditions of a system and evaluate the impacts of numerous adjustments. Steam models include the following components:

- Boiler
- Deaerator
- 1 to 3 Steam Pressure Headers
- Backpressure Steam Turbines
- Condensing Steam Turbine
- Flash Tanks
- Pressure Reducing Values (PRVs)
- Blowdown Heat Exchanger



Models are NOT saved online and must be
manually downloaded and reload in later sessions.

Base Model

The initial steam system model created by the user.

Adjusted Model

The model generated by applying all selected adjustments to the base model.

SSAT

The Steam System Assessment Tool which was the previous steam system modeler. The modeler is able to load examples based on the default models used by SSAT.

HP, MP, and LP

High Pressure, Medium Pressure, and Low Pressure. These terms are just relative to each other and do not have further meaning.

The basic steps for using the Steam System Modeler are as follows:

Step 1: Generate a Base Model

There are 3 ways to generate a Base Model:

- Manually enter specific steam system details
- Load an example
- Reload a previously downloaded model

Step 2: Generate an Adjusted Model

- A series of projects and system adjustments may be selected and combined with the Base Model to generate an Adjusted Model.

Step 3: Compare Base Model to Adjusted Model

- A summary of Base Model vs Adjusted Model metrics will be generated once both a Base Model and Adjusted Model have been created.
- A generated model may also be downloaded as an excel file and re-uploaded later.

The initial generation of a base model only requires the successful submission on 1 form which is broken into 4 sections (*additional details on the following pages*):

Boiler Details

Boiler and deaerator related information

General Details

Unit costs, operating hours, make-up water, and electricity

Header Details

Pressures, steam usage, and other related data

Steam Turbine Details

Operating conditions for the various possible steam turbines configuration

Steam Modeler [Overview](#) [Create Base Model](#) [Reload Model](#)

Boiler Details

Boiler Combustion Efficiency*	85	%
Fuel Type*	Natural Gas	
Blowdown Rate*	2	%
Is the blowdown flashed?*	No	
Preheat Make-Up Water with Blowdown*	No	
Steam Temperature*	°F	
Degaerator Vent Rate*	0.1	%
Degaerator Pressure*	psig	

General Details

Site Power Import*	kW	
Electricity Unit Cost*	\$ / kWh	
Yearly Operating Hours*	hrs	
Make-Up Water Unit Cost*	\$ / gal	
Make-Up Water Temperature*	50	°F
Fuel Unit Cost*	\$ / MMbtu	

Header Details

Number of Headers	3 - Header			
HEADERS	HP	MP	LP	
Pressure*				psig
Process Steam Usage*				Kilobtuhr
Condensate Recovery*				%
Flash Condensate into Header	No	No		
Condensate Return Temperature*	150	°F		
Flash Condensate Return*	No			
Heat Loss*	0.1	0.1	0.1	%
Desuperheat Steam into MP*	No	370	°F	
Desuperheat Steam into LP*	No	270	°F	

Steam Turbine Details

Condensing Turbine	<input type="checkbox"/> On/Off
HP to LP Turbine	<input type="checkbox"/> On/Off
HP to MP Turbine	<input type="checkbox"/> On/Off
MP to LP Turbine	<input type="checkbox"/> On/Off

GENERATE BASE MODEL

Boiler Combustion Efficiency [%]:

% of the fuel energy that is transferred to the boiler water and steam

Fuel Type [fuel type]:

Primary fuel for the boiler

Blowdown Rate [%]:

% of feedwater being drained from the boiler as a saturated liquid to reduce dissolved solids concentration

Is the blowdown flashed? [yes/no]:

Indicate if model should include flashing of blowdown

Preheat Make-Up Water with Blowdown [yes/no | temperature]:

Indicate if mode should preheat make-up water with blowdown. If 'Yes', an approach temperature can also be set

Steam Temperature [temperature]:

Temperature of the generated steam which must be equal to or greater than the boiling temperature

Deaerator Vent Rate[%]:

Vent rate as a % of feedwater mass flow

Deaerator Pressure [pressure]:

Operating pressure of the deaerator

Boiler Details

Boiler Combustion Efficiency*	<input type="text" value="85"/> %
Fuel Type*	Natural Gas
Blowdown Rate*	<input type="text" value="2"/> %
Is the blowdown flashed?*	No
Preheat Make-Up Water with Blowdown*	No
Steam Temperature*	<input type="text"/> °F
Deaerator Vent Rate*	<input type="text" value="0.1"/> %
Deaerator Pressure*	<input type="text"/> psig

Site Power Import [power]:

The average power import rate of electricity for the site which is primarily used to evaluate the potential of steam turbine generation

Electricity Unit Cost [\$/electricity]:

The unit cost associated with electricity

Yearly Operating Hours [hours]:

Total hours of operation for the steam system

Make-Up Water Unit Cost [\$/volume]:

The unit cost associated with make-up water

Make-Up Water Temperature [temperature]:

The average temperature of the make-up water

Fuel Unit Cost [\$/energy]:

The unit cost associated with the fuel

General Details

Site Power Import*	<input type="text"/> kW
Electricity Unit Cost*	<input type="text"/> \$ / kWh
Yearly Operating Hours*	<input type="text"/> hrs
Make-Up Water Unit Cost*	<input type="text"/> \$ / gal
Make-Up Water Temperature*	<input type="text"/> 50 °F
Fuel Unit Cost*	<input type="text"/> \$ / MMBtu

Number of Headers [#]:

The total number of steam headers (1-3)

For each Header:

Pressure [pressure]:

Operating pressure of the header

Process Steam Usage[mass flow]:

The amount of header steam used for processes

Condensate Recovery [%]:

% of process steam recovered as condensate

Flash Condensate into Header [yes/no]:

Indicate if model should flash condensate into the lower pressure header (for 3 headers: HP into MP, MP to LP)

Condensate Return Temperature [temperature]:

Average temperature of the returned combined condensate

Flash Condensate Return [yes/no]:

Indicate if model should flash returned condensate into the lowest pressure header

Heat Loss [%]:

% heat loss for each header adjusting for numerous sources of heat loss in a header

Desuperheat Steam into MP/LP [yes/no | temperature]:

Indicate if PRV is also desuperheating and set the target temperature

Header Details

Number of Headers

HEADERS	HP	MP	LP	
Pressure*				psig
Process Steam Usage*				klb/hr
Condensate Recovery*				%
Flash Condensate into Header	No ▾	No ▾		
Condensate Return Temperature*	150	°F		
Flash Condensate Return*	No ▾			
Heat Loss*	0.1	0.1	0.1	%
Desuperheat Steam into MP*	No ▾	370	°F	
Desuperheat Steam into LP*	No ▾	270	°F	

Each Steam Turbine can be turned ON/OFF and the following operational conditions can be set:

Isentropic Efficiency [%]:

The energy actually removed as a percent (%) of the energy removed if the turbine were an isentropic process (*entropy in = entropy out*)

Generator Efficiency [%]:

The percent of the energy extracted by the turbine that is converted to electricity (*power*)

Condenser Pressure [vacuum pressure] (condensing turbine only):

The vacuum pressure at the exit of the turbine

Operation Type (condensing turbine can only use Steam Flow and Power Gen):

Balance Header

Allows enough steam flow to balance lower pressure header

Steam Flow [mass flow]:

Operates at this specific steam mass flow

Flow Range [mass flow]:

Sets minimum and maximum flow based on balancing requirements

Power Generation [power]:

Operates at this specific power generation

Power Range [power]:

Sets minimum and maximum power generation based on balancing requirements

Steam Turbine Details

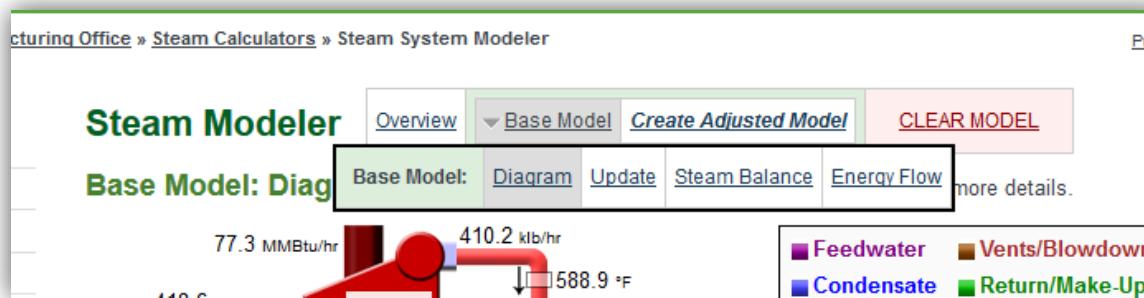
Condensing Turbine	<input checked="" type="checkbox"/> On/Off
Isentropic Efficiency*	65 %
Generation Efficiency*	98 %
Condenser Pressure*	725.2 psia
Operation Type*	Steam Flow ▾
Fixed Flow*	100 klb/hr

HP to LP Turbine	<input checked="" type="checkbox"/> On/Off
Isentropic Efficiency*	65 %
Generation Efficiency*	98 %
Operation Type*	Flow Range ▾
Minimum Flow*	Balance Header
Maximum Flow*	Steam Flow
HP to MP Turbine	Flow Range
	Power Generation
	Power Range
MP to LP Turbine	<input type="checkbox"/> On/Off

Once the base model has successfully been generated, user may:

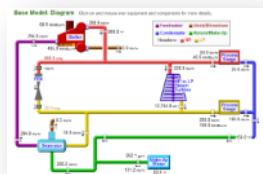
- View a **Diagram** of the Base Model
- **Update** the Base Model by modifying the initial base model form
- View a **Steam Balance** of the Base Model
- View a Sankey diagram of the base model **Energy Flow**
- And create an Adjusted version of the base model

*Moving the mouse over “Base Model”
will open the menu of viewing options*

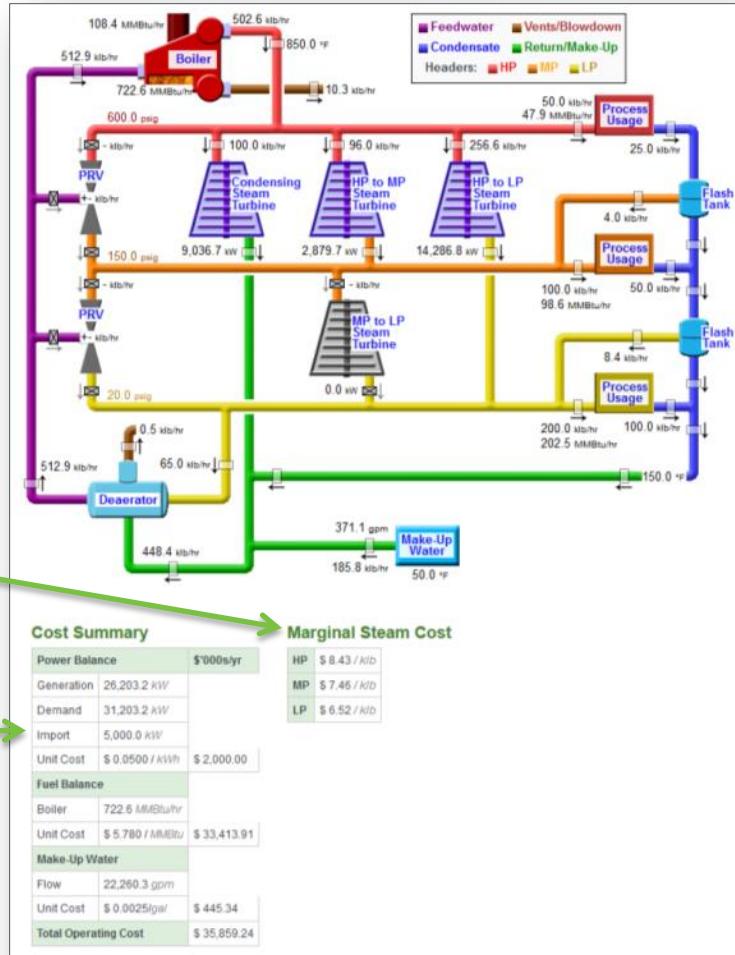


The Steam System Modeler Diagram includes:

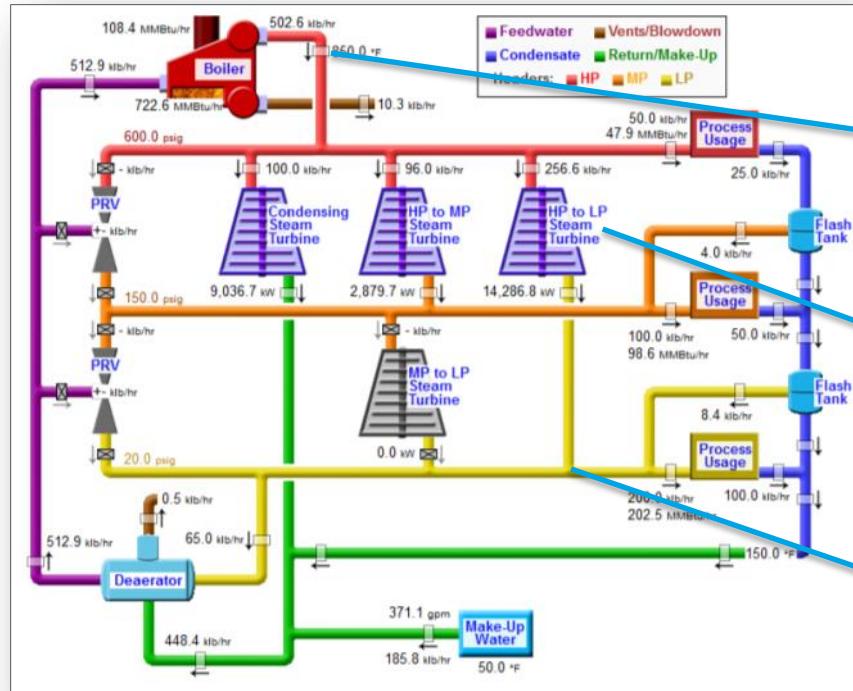
- A customized layout of equipment and headers dependent on the specific model
- Example:



- Marginal Steam Costs by Header
 - these are marginal costs associated with a small increase or decrease in steam usage
- Power, Fuel, and Water Cost Summary
- Moving the mouse over each piece of equipment and steam point provides additional information
- Clicking on a specific piece of equipment provides even more detail (cont.)



All plants of the diagram are interactive and provide additional details when a mouse is moved over it. The diagram below has ***over 50 different components*** that provide specific additional pop-up details:

**Examples:**

Boiler Steam		Mass Flow	403.4 klb/hr
Temperature	850.0 °F	Sp. Enthalpy	1,435.1 btu/lbm
Pressure	600.0 psig	Sp. Entropy	1.653 btu/lbm/R
Phase	Gas		

HP to LP Turbine

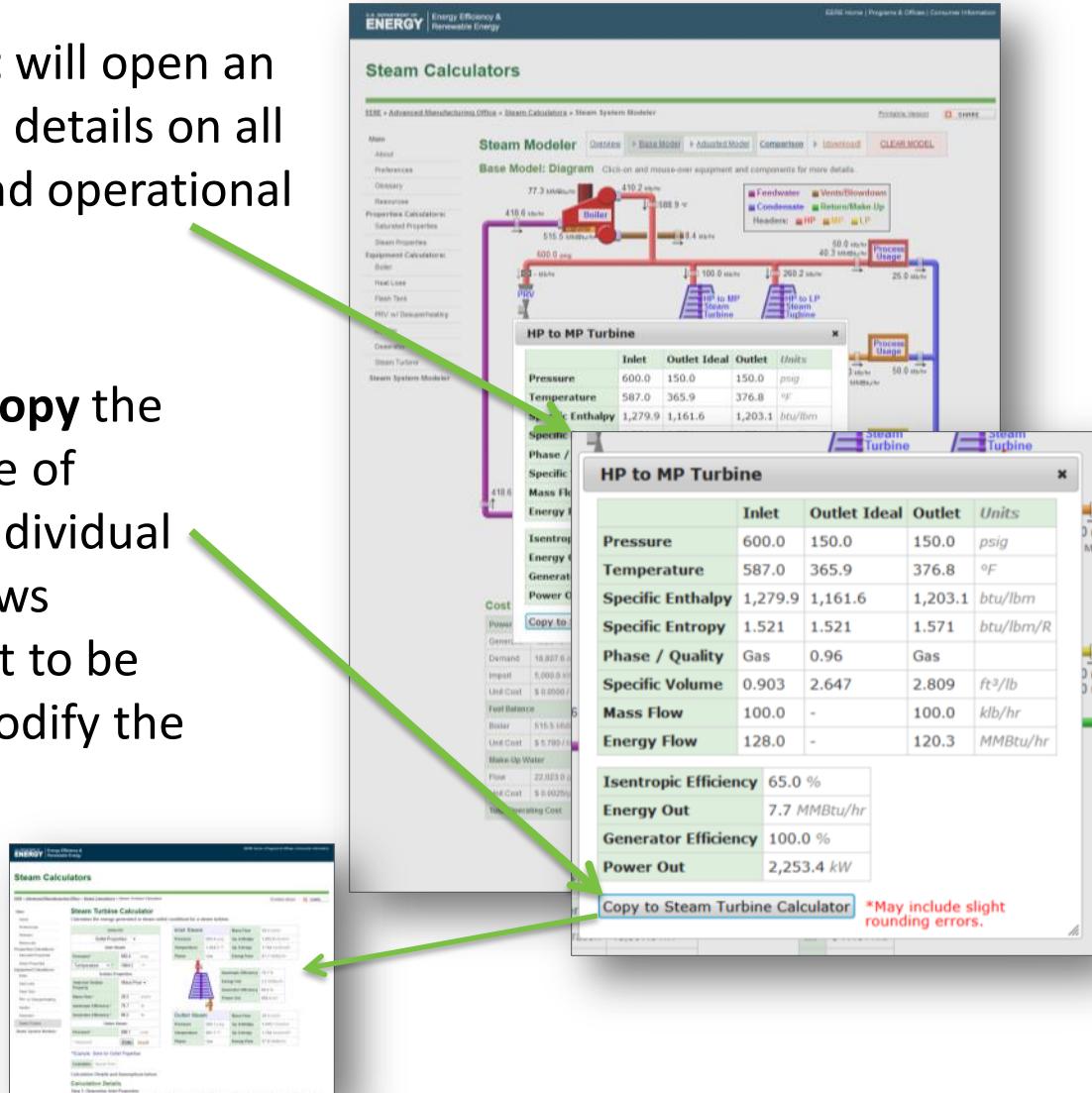
Isentropic Eff	65.0 %	Energy Out	48.1 MMBtu/hr
Generation Eff	100.0 %	Power Out	14,108.9 kW
<i>Click on Turbine for Details</i>			

LP Header Details

Pressure	20.0 psig	Mass Flow	253.4 klb/hr
Energy Loss %	0.10 %	Energy Loss	0.3 MMBtu/hr
Temperature	410.7 °F	Phase	Gas

Clicking on specific equipment will open an in-page window with complete details on all associated steam properties and operational conditions.

Users also have the option to **copy** the properties of the selected piece of equipment to the associated individual equipment calculator. This allows modifications of the equipment to be evaluated without having to modify the entire model.



[GO TO SSMT ONLINE](#)

Users can view a detailed *mass and energy balance* This collectively referred to a “**Steam Balance**” in SSMT.

- Validates that the steam system model has properly converged
- Includes all key sections of the model. For a 3 header steam model the sections include:
 - System Overall
 - HP Header
 - MP Header
 - LP Header
 - Condensate Return
 - Feedwater

Steam Balance

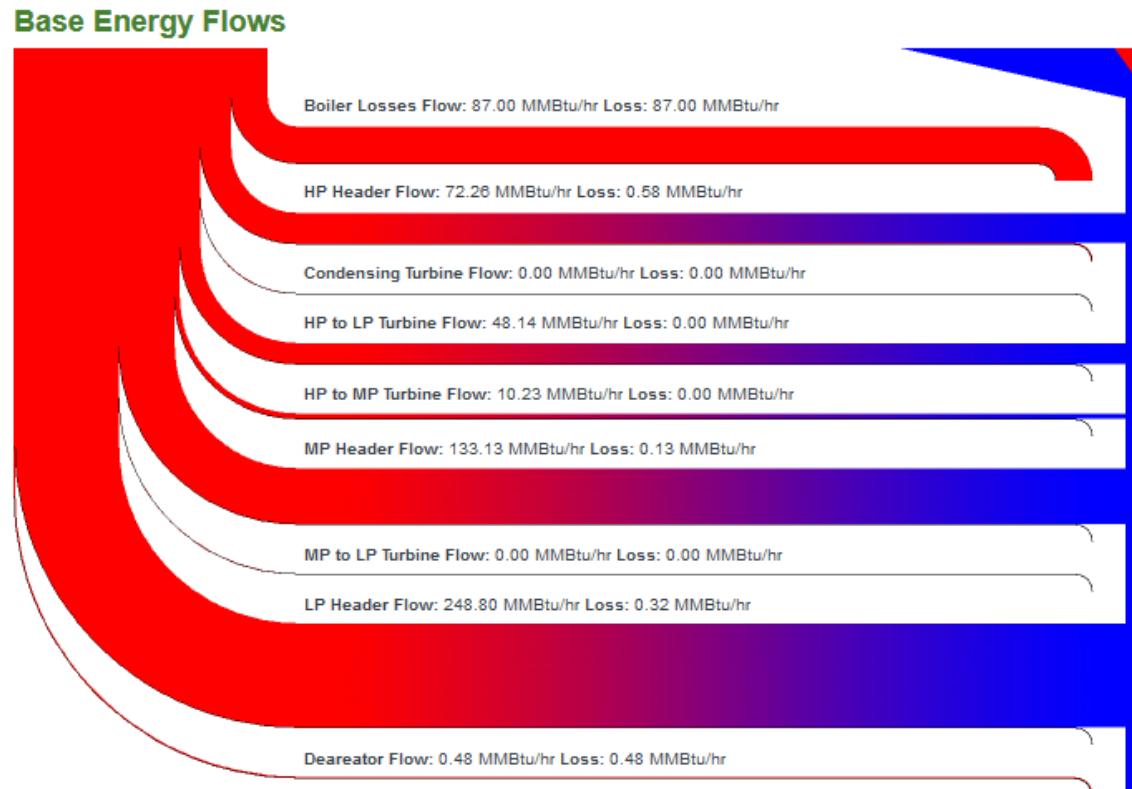
Mass and Energy flows are listed and summed system wide for and the model has correctly converged.

<small>** TOTALs may include a small difference from rounding</small>			
System	Base Model		
	Klb/hr	MMBtu/hr	btu/lbm
Boiler Energy	-	580.0	
Boiler Energy Losses	-	-87.0	
Cond Turbine	-	-	
Cond Turbine Losses	-	-	
HP tp MP Turbine	-	-10.2	
HP to LP Turbine	-	-48.1	
MP to LP Turbine	-	-	
HP Energy Losses	-	-0.6	
HP Process Losses	-25.0	-59.8	
MP Energy Losses	-	-0.1	
MP Condensate Losses	-50.0	-116.1	
LP Energy Losses	-	-0.3	
LP Condensate Losses	-100.0	-225.7	
LP Vented Steam	-	-	
Make Up Water	183.6	3.3	18.1
Blowdown	-8.2	-3.9	474.8
Condensate Flash	-	-	
Condensate Heat Loss	-	-30.9	
Deaerator Steam Vent	-0.4	-0.5	1,163.9
TOTAL:	-	-	

HP Header

	Base Model		
	Klb/hr	MMBtu/hr	btu/lbm
Boiler Steam	403.4	578.9	1,435.1
Condensing Turbine Inlet	-	-	
HP to MP Turbine Inlet	-100.0	-143.4	1,433.7
HP to LP Turbine Inlet	-253.4	-363.3	1,433.7
HP to MP PRV Inlet	-	-	
HP Processes	-50.0	-71.7	1,433.7
HP Energy Losses	-	-0.6	
TOTAL:	-	-	

The energy flows of both the base model and adjusted models can be viewed in **Sankey diagrams** as seen below. Each segment is dynamically adjusted to be proportionate to the associated energy flow.

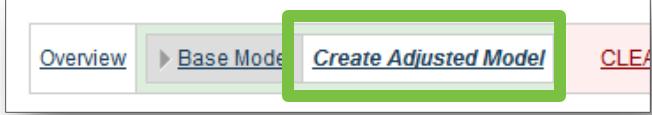


Adjusted Models are created by adding various adjustments, relative to the Base Model, grouped in these major areas:
(additional details on the following pages)

- Adjust General Operation
- Adjust Unit Costs
- Adjust Steam Demand
- Adjust Boiler Operation
- Adjust Steam Turbine Operation
- Adjust Condensate Handling
- Adjust Insulation / Heat Loss

Notes:

- Users must select at least 1 adjustment
- Updates to the base model automatically update the adjusted model
- The adjusted model represents **combined impacts** of all adjustments on the base model



The screenshot shows a software interface for creating an adjusted model. At the top, there are three buttons: 'Overview' (disabled), 'Base Model' (disabled), 'Create Adjusted Model' (highlighted with a green border), and 'CLEAR'. Below this is a section titled 'Select Potential Adjustments/Projects' containing a list of checkboxes for various adjustments. A large blue button at the bottom right is labeled 'GENERATE ADJUSTED MODEL'.

Select Potential Adjustments/Projects

Unless adjusted Steam Demands are set, the Adjusted Model's that all processes will still required the same amount of energy.

Adjust General Operation

Adjust Unit Costs

Adjust Steam Demand (only 1 may be selected)

Adjust Boiler Operation

Adjust Steam Turbine Operation

Adjust Condensate Handling

Adjust Insulation / Heat Loss

GENERATE ADJUSTED MODEL

General Operation adjustments include:

- **Operating Hours [hours]**
 - This reflects a potential change in yearly operation of the steam system
- **Average Make-Up Water Temperature [temperature]**
 - By changing sources, average make-up water temperatures may also change

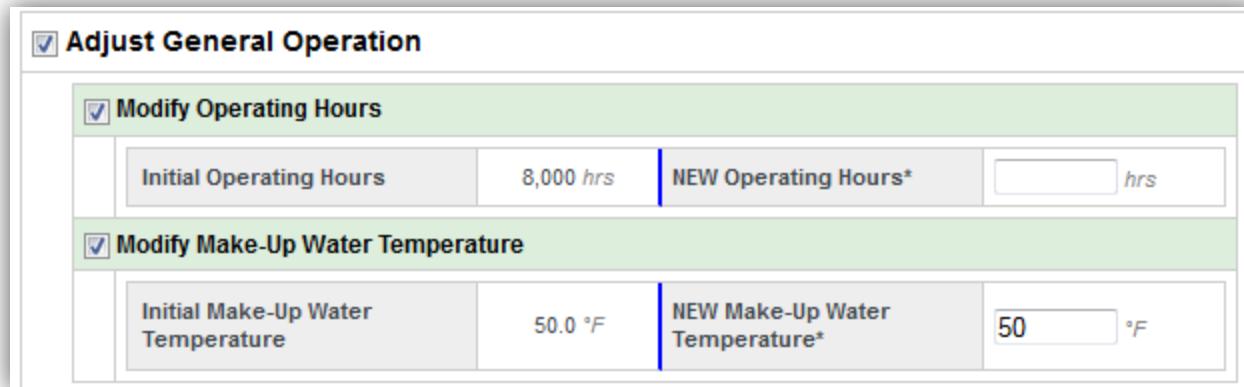
Adjust General Operation

Modify Operating Hours

Initial Operating Hours	8,000 hrs	NEW Operating Hours*	hrs
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Modify Make-Up Water Temperature

Initial Make-Up Water Temperature	50.0 °F	NEW Make-Up Water Temperature*	50 °F
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Unit Costs adjustments include:

- **Electricity Unit Cost [\$/electricity]**
 - Electricity prices are generally always subject to change
- **Fuel Unit Cost [\$/energy]**
 - Normal market fluctuations as well as switching fuels and/or suppliers can adjust cost
- **Make-Up Water Unit Cost [\$/volume]**
 - Changes in water source, supplier, and water treatment can all impact water cost

Adjust Unit Costs

Modify Electricity Unit Cost

Initial Electricity Unit Cost	\$ 0.0500 / kWh	NEW Electricity Unit Cost*	\$ / kWh
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Modify Fuel Unit Cost

Initial Fuel Unit Cost	\$ 5.7800 / MMBtu	NEW Fuel Unit Cost*	\$ / MMBtu
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Modify Make-Up Unit Cost

Initial Make-Up Water Unit Cost	\$ 0.0025 / gal	NEW Make-Up Water Unit Cost*	\$ / gal
---------------------------------	-----------------	------------------------------	----------

Steam Demand adjustments may include only 1 of the 2 subcategories:

Energy Demand – fixes the energy usage levels for each headers process steam usage. Therefore if header steam properties change, the process steam usage will be adjusted to match the energy usage.

Energy Usage (for each header) [energy]

Any change in a systems process steam requirements would change energy usage requirements

Steam Demand/Usage – fixes the steam usage levels for each header's process steam usage regardless of changes in steam properties.

Steam Usage (for each header) [mass flow]

Any change in a systems process steam requirements would change steam usage requirements

The screenshot shows two overlapping dialog boxes from the SSMT Steam System Modeler. Both dialogs have a title bar 'Adjust Unit Costs' and a checked checkbox 'Adjust Steam Demand (only 1 may be selected)'.

Left Dialog (Modify Process Steam Demand/Usage):

Initial HP Steam Usage	50.0 klb/hr	NEW Steam Usage*	50 klb/hr
Initial MP Steam Usage	100.0 klb/hr	NEW Steam Usage*	100 klb/hr
Initial LP Steam Usage	200.0 klb/hr	NEW Steam Usage*	200 klb/hr

Modify Process Energy Demand

Right Dialog (Modify Process Energy Demand):

Initial HP Energy Usage	40.3 MMBtu/hr	NEW Energy Usage*	40.3 MMBtu/hr
Initial MP Energy Usage	86.3 MMBtu/hr	NEW Energy Usage*	86.3 MMBtu/hr
Initial LP Energy Usage	180.0 MMBtu/hr	NEW Energy Usage*	180 MMBtu/hr

Combustion Efficiency [%]:

Various improvements to the boiler can improve combustion efficiency

Fuel Type [fuel type]:

Fuel types may sometimes be switched for a variety of reasons

Blowdown Rate [%]:

Blowdown rates can often be reduced with better controls and water treatment, saving energy and water

Is the blowdown flashed? [yes/no]:

Steam systems may add blowdown flash tanks to improve waste energy and water recovery

Preheat Make-Up Water with Blowdown [yes/no]:

Blowdown water can also be used to preheat make-up water

Steam Temperature [temperature]:

Steam generation temperature may be changed by the adjusting boiler pressure or adding a superheating section

Deaerator Vent Rate[%]:

The deaerator vent rate may be reduced with better controls, reducing associated steam losses

Deaerator Pressure [pressure]:

Operating pressure may be adjusted to match condensate return pressure

Adjust Steam Demand (only 1 may be selected)

Adjust Boiler Operation

<input checked="" type="checkbox"/> Change Boiler Combustion Efficiency	Initial Boiler Combustion Efficiency	85.0 %	NEW Combustion Efficiency*	85.0 %
<input checked="" type="checkbox"/> Change Fuel Type	Initial Fuel Type:	Natural Gas	NEW Fuel Type*	Natural Gas
<input checked="" type="checkbox"/> Change Boiler Blowdown Rate	Initial Boiler Blowdown Rate	2.0 %	NEW Blowdown Rate*	2.0 %
<input checked="" type="checkbox"/> Blowdown Flash to LP	Flash Blowdown? Base:	No	Adjusted*	No
<input checked="" type="checkbox"/> Preheat Make-Up Water with Blowdown	Preheat Make-Up	No	NEW Preheat Make-Up*	No
	Approach Temperature	20.0 °F	NEW Approach Temperature*	20 °F
<input checked="" type="checkbox"/> Change Steam Generation Conditions	Initial Steam Temperature:	500.9 °F	NEW Steam Temperature*	°F
<input checked="" type="checkbox"/> Change DA Operating Conditions	Initial DA Vent Rate	0.1 %	NEW DA Vent Rate*	0.1 %
	Initial DA Pressure	15.0 psig	NEW DA Pressure*	15 psig

The adjustment to the Steam Turbine are the same as the base model. On/Off can be changed to add or remove a steam turbine:

Isentropic Efficiency [%]:

During turbine maintenance and overhauls isentropic efficiency can be changed inadvertently or intentionally

Generator Efficiency [%]:

Upgrading or repairing a generator can improve efficiency

Condenser Pressure [vacuum pressure] (condensing only):

Changes to cooling fluid flow/temperature affect pressure

Operation Type (switching types is an allowed adjustment)

Balance Header

Removes limits and fixed operation

Steam Flow [mass flow]:

Specifically set steam flow

Flow Range [mass flow]:

Flow might be allowed to change when it was previously fixed or unrestricted

Power Generation [power]:

Specifically set power generation

Power Range [power]:

Power generation might be allowed to change when it was previously fixed or unrestricted

Initial Turbine Status	Adjusted Status*	On/Off
Off	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Initial Turbine Status	Adjusted Status*	On/Off	
On	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Isentropic Efficiency	65.0 %	Isentropic Efficiency*	65 %
Generation Efficiency	100.0 %	Generation Efficiency*	100 %
Operation	Balance Header	Operation* Flow Range	<input type="button" value="▼"/>
		Minimum Flow*	50 kib/hr
		Maximum Flow*	150 kib/hr

Initial Turbine Status	Adjusted Status*	On/Off	
On	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	
Isentropic Efficiency	65.0 %	Isentropic Efficiency*	65 %
Generation Efficiency	100.0 %	Generation Efficiency*	100 %
Operation	Balance Header	Operation* Balance Header	<input type="button" value="▼"/>

Initial Turbine Status	Adjusted Status*	On/Off
Off	<input type="checkbox"/>	<input type="checkbox"/>

Condensate adjustments include:

- **Condensate Return Rates [%]**
 - Improvements to the condensate return system can increase the return rate
- **Condensate Flash to Header (MP/LP) [yes/no]**
 - Flash tanks can be added that will flash high pressure condensate, saving energy and water
- **Condensate Return Temperature [temperature]**
 - Improvements to the condensate return system can increase the return temperature

Condensate Recovery			
Initial HP Condensate Return	50.0 %	NEW Condensate Return*	50.0 %
Initial MP Condensate Return	50.0 %	NEW Condensate Return*	50.0 %
Initial LP Condensate Return	50.0 %	NEW Condensate Return*	50.0 %

Condensate Flash to MP			
Flash Condensate to MP? Base:	No	Adjusted*	No ▾

Condensate Flash to LP			
Flash Condensate to LP? Base:	No	Adjusted*	No ▾

Modify Condensate Return Temperature			
Initial Condensate Return Temperature:	150.0 °F	NEW Condensate Return Temperature*	°F

Insulation / Heat Loss adjustments include:

- **Heat Loss for each Header [%]**

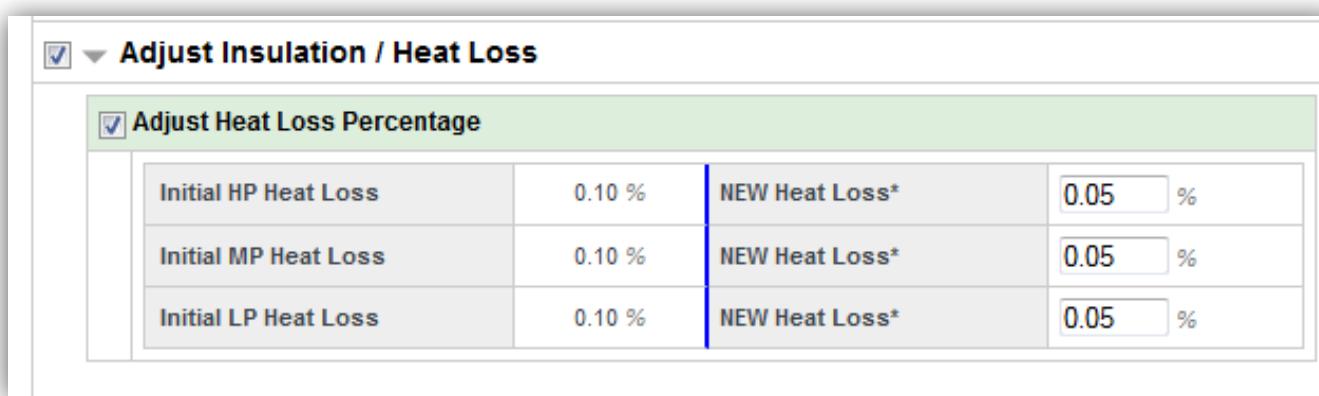
- Improvements in insulation will likely reduce a header's heat loss by a certain %, the heat loss % should similarly be adjusted to reflect this improvement

Example:

Initial Heat Loss: 0.10%

Potential Improvement of Insulation: 50%

NEW Heat Loss: 0.05%



The screenshot shows a software window titled "Adjust Insulation / Heat Loss". Under the "Adjust Heat Loss Percentage" section, there are three rows of data:

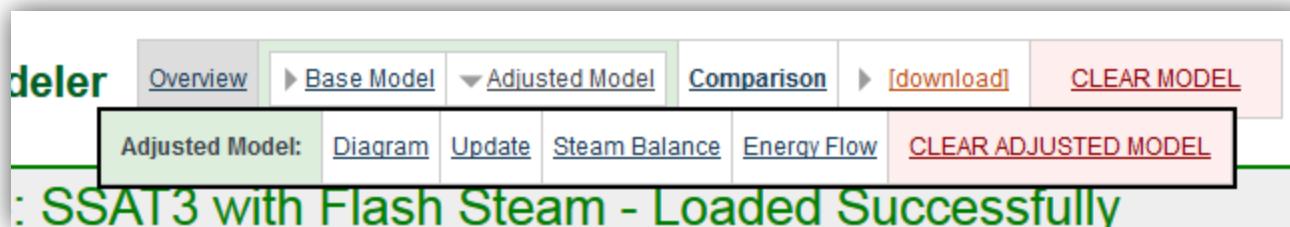
Initial HP Heat Loss	0.10 %	NEW Heat Loss*	0.05 %
Initial MP Heat Loss	0.10 %	NEW Heat Loss*	0.05 %
Initial LP Heat Loss	0.10 %	NEW Heat Loss*	0.05 %

The Adjusted Model can be reviewed in exactly the same way as the Base Model:

- View a **Diagram** of the Adjusted Model
- **Update** the Base Model by modifying the initial base model form
- View a **Steam Balance** of the Base Model
- View a Sankey diagram of the base model **Energy Flow**
- And create an Adjusted version of the base model

*See the “[Review the Base Model](#)” section for specific details on these

*Moving the mouse over “Adjusted Model”
will open the menu of viewing options*



The model **Comparison** page provides a detailed breakdown of the total costs and relative operating conditions. The benefit of these collective adjustments can quickly be evaluated based on the difference between both.

[Green = savings | Red = loss]

Included Tables:

Cost Summary

power, fuel, water, and total cost

Utility Balance

fuel, water, and electricity use

Lists Active Projects/Adjustments

specifically lists the name of each adjustment

Base Model vs Adjusted Model

Cost Summary	Base Model	Adjusted Model	Reduction	
	\$'000s/yr	\$'000s/yr	\$'000s/yr	
Power Cost	\$ 2,000	\$ 2,265	265	-13.3%
Fuel Cost	\$ 23,837	\$ 22,856	-981	-4.1%
Make-Up Water Cost	\$ 441	\$ 434	-6	-1.4%
Total Cost	\$ 26,277	\$ 25,555	-722	-2.7%

Utility Balance	Base	After Projects	Reduction	Units
Power Generation	13,807.6	13,144.3	-663.2	-4.8% kW
Power Import	5,000.0	5,663.2	663.2	13.3% kW
Total Site Demand	18,807.6	18,807.6	0.0	0.0% kW
Boiler Fuel	515.5	494.3	-21.2	-4.1% MMbtu/hr
Fuel Type	Natural Gas	Natural Gas		
CO ₂ Emissions*	218,818	209,815	-9,003	-4.1% tons
Boiler Steam	410.2	393.3	-16.9	-4.1% klb/hr
Make Up Water	367.2	361.9	-5.3	-1.4% gpm

*Source of CO₂ Coefficients: <http://www.eia.gov/oiaf/1605/coefficients.html>

Adjusted Model: Active Projects

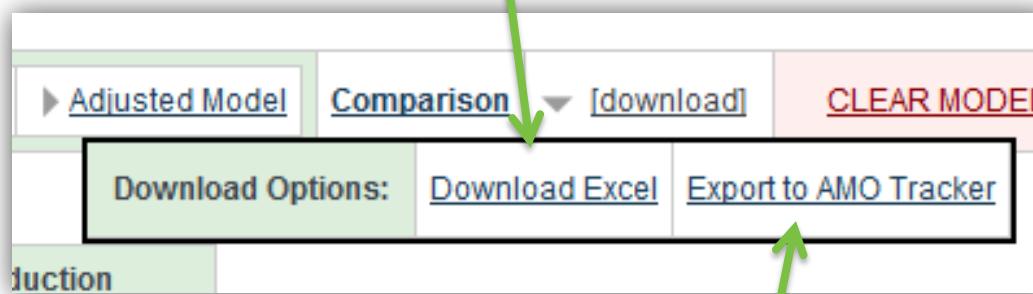
Adjust Boiler Operation
• Blowdown Flash to LP
Adjust Condensate Handling
• Condensate Flash to MP
• Condensate Flash to LP

WARNING:

- STEAM MODELS ARE NOT SAVED ONLINE
- IF THE WEB BROWSER IS CLOSED, THE STEAM MODELS ARE CLEARED

To save for future use, models must be downloaded. Once downloaded, they can easily be reloaded at anytime.

To download, click on the “Download Excel” link in the model navigation menu:



For reload instruction go to [Reloading Models](#)

Models can also be exported to the AMO Opportunity Tracker by clicking on the “Export to AMO Tracker” and following the instructions. **NOTE: The AMO Tracker file cannot be used to reload a model.**

The downloadable spreadsheet has 6 sheets, most of which mirror SSMT's online forms and reports :

- Title Page
- Base Model Details
- Adjusted Model Details
- Steam Balance
- Comparison of Models
- Upload Data – *used to reload model into SSMT*

The screenshot displays the SSMT Steam System Model spreadsheet with multiple tabs:

- [Demo] Steam tool**: A placeholder tab.
- Steam System Model**: The main data entry sheet containing detailed information about the steam system, such as header details, pump details, turbine details, and balance headers.
- Adjusted Model**: Shows the adjusted values for various parameters like Header Operation, Bleeding Flash to LP, and Condensate Handling.
- Cost Summary**: Compares the cost of the base model and the adjusted model across categories like Power Cost, Fuel Cost, and Make-Up Water Cost.
- Base Model vs. Adjusted Model**: Provides a detailed comparison of the two models across numerous parameters.
- Units**: A sheet listing conversion factors for various units used in the model.

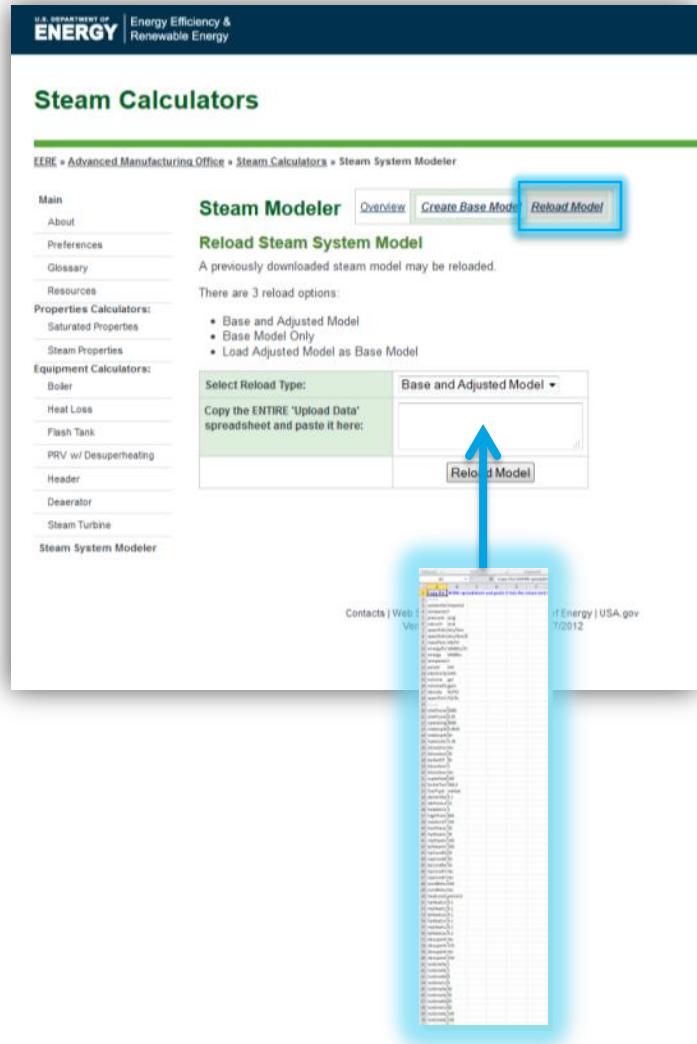
[GO TO SSMT ONLINE](#)

To reload a Model, it must first have been downloaded as a spreadsheet.

To reload a model, copy the **ENTIRE** “Upload Data” spreadsheet and paste it into the steam tool reload/upload field on the “Reload Model” page.

There are 3 reload options:

- **Base and Adjusted Model** - reloads the model just as it was when it was downloaded
- **Base Model Only** - only reloads the base model
- **Load Adjusted Model as Base Model**
- only reloads adjusted model as if it were the base model



The export option is limited to English using imperial units.

Instructions for Export

- Generate downloadable file by hovering your mouse over “[download],” clicking “Export to AMO tracker,” and saving the file on your computer.
- Log on to the eCenter, go to the Project Opportunities Tracker, click “Import”, and choose the file that you just saved
- You will now be able to sort, edit, and save data from the Steam System modeler in the Project Opportunities Tracker



```
<?xml version="1.0" encoding="UTF-8"?>
<Recommendations>
  <Recommendation>
    <Action_ID>1</Action_ID>
    <Action_Title>Adjust Condensate Handling</Action_Title>
    <Action_Description>Condensate Flash to LP (Savings based on individual plant)</Action_Description>
    <Action_Category>Steam Generation</Action_Category>
    <SourceToolID>18</SourceToolID>
    <Notes/>
    <StatusID>1</StatusID>
    <ProjectedCost>0</ProjectedCost>
    <ProjectedSavings>91621.7</ProjectedSavings>
    <Implemented>False</Implemented>
    <ImplementationNotes/>
    <Priority>1</Priority>
    <CustomCategory></CustomCategory>
    <Plant_ID>1</Plant_ID>
    <Deleted>0</Deleted>
    <ProjectedCostSavings>588396</ProjectedCostSavings>
    <ProjectedCO2>0</ProjectedCO2>
    <SourceText/>
  </Recommendation>
</Recommendations>
```

Number of Headers can be changed at any time

Base and adjusted models will automatically update.

Units can be changed at any time

Just go to preferences and change the units at any time. All models and calculations will automatically update.

Adjusted models can be set as a new base model

If modifications have been made an adjustment model can be set as a base model, allowing further adjustments to be modeled.

All Calculations and Models can be Reset and/or Cleared

To do this look for the reset and clear model links. Be careful as resets and clears are permanent.