Steam System Modeling Tool

Overview and Tour



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 <u>table of contents</u> 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 a the bottom of every page (*internet connection required*)







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





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Introduction to SSMT

General Layout

Customizing Units and Language

Steam Properties and Calculators

Equipment Calculators [description structure]:

- Boiler:	<u>Overview</u>	<u>Inputs</u>	Calculation	<u>Results</u>
- Heat Loss:	<u>Overview</u>	<u>Inputs</u>	Calculation	<u>Results</u>
– Flash Tank:	<u>Overview</u>	<u>Inputs</u>	Calculation	<u>Results</u>
- PRV :	<u>Overview</u>	<u>Inputs</u>	Calculation	<u>Results</u>
- Header:	<u>Overview</u>	<u>Inputs</u>	Calculation	<u>Results</u>
- Deaerator:	<u>Overview</u>	<u>Inputs</u>	Calculation	<u>Results</u>
– Steam Turbine:	Overview	Inputs	Calculation	Results

ENERGY Steam Calculators formitten Disees. Steam Calculators 2 Steam Picaerty Calculator
 7 Steam Elacycrowel Calculation
 Statem Steam Minister Description (Properties Calculators Inten Property Recommend Early Refer Magnicese Treat Tank Flash Lash Determines the mass flows and projection of any EXAMPLE The second seco to a limited Description the siggined some and steals from he Store, labine Calculates the energy gener Stears Senters Modeler Stram Settern Bodelar Crafter a basic Mann system model with up to 3 different proc Carta DE, Troit MB, Poloter I U.B, Daparthari all'Enarge i USA gen-Verman el 8.142 - Rait Sare USDOS Main Entry Page of SSMT

Steam System Modeler:

-SEE FOLLOWING PAGE



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:GeneralUnit CostsSteam DemandBoilerSteam TurbinesCondensateHeat Loss

Comparing the Models

Reloading and Savings: Download Spreadsheet Reloading a Model

Export to AMO eCenter

Tips and Tricks



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





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*.





General Calculator Layout



Examples

for a few common configurations with random data

Assumptions specific to the calculation

GO TO SSMT ONLINE



Diagram of Equipment

with Complete **Steam Property** Details

Calculation **Details** populated with data from current calculation



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 No -

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Glossary					
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Steam Properties					
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Header	Vacuum Pressure	psia	bara	bara	psi (absolute) 💌
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Steam Turbine	Specific Entropy	btu/lbm/R	kJ/kg/K	kJ/kg/K	btu/lbm/R -
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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.

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Steam Calcu	ulators								
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Main About Preferences Olossary	Preference Set preferred unit	S t systems, sh ▼	individ	ual units, a	ind languages.				
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Header	Vacuum Pressure	psia	bara	bara	psi (absolute)				
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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.

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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, <u>www.iapws.org</u>

Calculated properties include*:

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

13

Specific Volume

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





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

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

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Energy Efficiency & Renewable Energy

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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

GO TO SSMT ONLINE

 This calculator can evaluate: sub-cooled liquid, saturated liquid, saturated mixture, saturated gas, superheated gas, and supercritical properties

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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

<u>INPUTS</u>

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

<u>RESULTS</u>

Listing of all calculations results provided by the calculator





SSMT EQUIPMENT Boiler Calculator OVERVIEW

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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SSMT EQUIPMENT Boiler Calculator

INPUTS

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

eaerator Pressure* 35.2 psig

boiler operational characteristics.

Boiler Calculator

Deaerator Pressure*	35.Z	psig
Combustion Efficiency*	79.9	%
Blowdown Rate*	3.7	%
Stea	m	
Pressure*	853.4	psig
Saturated Quality - *	1]
Steam Mass Flow *	85.1	klb/hr
* Required	Enter	[reset]

Determines the amount of fuel energy required to



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SSMT EQUIPMENT Boiler Calculator CALCULATION

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.**





Boiler Calculator

RESULTS

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

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

	Stea	am			Mas	s Flow	85.1 klb/hr
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	Temp	erature	527.8	°F	Sp.	Entropy	1.407 btu/lbm/F
	Satur	ated	1.00		Ene	rgy Flow	101.9 MMBtu/hr
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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

EERE + Advanced Manufactur	ing Office + Steam Calculators	Heat Loss	Calculator				Printable Version	D
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	Step 1: Determine Intel Ung the Steam Prope Specific Einhalpy, Spec • Pressure = 928 0 no • Isteam Property Cal • Isteam Property Cal • Isteam Property Cal • Isteam Energy Frow = 3 [Intel Energy Frow = 3 [Intel Energy Frow = 3 [Outlet Energy Frow = 3 [Intel	Properti ty Calculation ty Calculation () () () () () () () () () ()	es for, properties a y, or Quality). Th specific tothalp elay * Mass Flow effor * 420 4 brain Flow after Hee y flow * (1 - Hea hardy = 9.9 MAR) ties entrained from en	re determined using is specific Enthalpy i y = 420.4 blut/bm , bm * 23.6 klb/br] tLoss (%)] ub/r * (1 - 0.0795)] ergy and mass flows:	nlet Pressuré s then multipli	and the selected ad by the Mass i	second parameter (Te	mpera y Flow
	Step 1: Determine Intel Using the Steam Proper Specific Einstapy, Specific Einstapy, Specific Einstapy, Specific Einstapy, Steam Property Cala Steam Property Cala Intel Einstey Prom 3: E Intel Einstey Prom 3: EInste 2: Determine Out Outlet Einstey Prom Step 3: Determine Out Outlet Einstey Prom Step 3: Determine Out Outlet Einstey Prom Dutter Einstey Prom	Propertia try Calculation find Entrop "7" culator[====================================	es Rot, properties a y, or Quality). Th specific Enthalp alpy * Mass Flow drv = 420.4 bruil Flow after Hee y Flow * (1 - Hea hubbr = 9.9 MMB lifes entrined from en taw a Flow * Outlet Si Emergy Flow / Hu Doublow = 9.1	<pre>te determined using b est Specific Enthalpy i y = 420.4 btu/tom , m* 23.6 ktto/br] fLoss fLoss(%) } ergy and mass flows: pecific Enthalpy at Mass Tiow MURUUM / 23.6 ktto/br)</pre>	tlet Pressure , a then multiple	and the selected of by the Mass I	second parameter (Te	mpera y Flow
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	Step 1: Determine Inde Ung the Steam Prope Specific Enthalpy, Specific Enthalpy, 1990 - 1990 - 1990 - 1990 - Steam Propenty Cali I Steam Propenty Cali I Step 2: Determine Outh - Outlet Energy Flow = 1 - Specific Energy Flow	Properti- try Calculation file Entering """ seculatori == seculatori ==	IS Specific properties a concentration of the second seco	re determined uning b e Specific Enthalpy i y = 420.4 blueform , bm * 23.6 Albe/re] Albess (1.0.000795.)] mity and mass flows: section Enthalpy at Mass Thow MMMLahr / (2.5.6 Kib/r re determined uning F 410.3 '/F	niet Pressure a then multipli tressure and S	and the exelected ed by the Mass I ipecific Enthalpy	second parameter (Te	mper y Flov



OVERVIEW

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

Inle	t
ressure*	929 psig
emperature 🔹 *	440.9 °F
ass Flow *	23.6 klb/hr
rcent Heat Loss *	7.95 %
Required	Enter [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.







Heat Loss Calculator

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

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

ATORS

inlet Steam			Mass	Flow	23.6 klb/hr
Pressure	929.0 psig	g	Sp. Er	nthalpy	420.4 btu/lbm
Temperature	440.9 °F		Sp. Er	ntropy	0.615 btu/lbm/R
Phase	Liquid		Energ	y Flow	9.9 MMBtu/hr
		Loat			-
		nea	LOSS	0.8 MMBt	u/hr
Outlet Stea	m	nea	Mass	0.8 MMBta	23.6 klb/hr
Outlet Stea	m 929.0 psi <u>c</u>		Mass Sp. Er	0.8 MMBt	23.6 klb/hr 387.0 btu/lbm
Outlet Stea Pressure Temperature	m 929.0 psi <u>c</u> 410.3 °F	ŋ	Mass Sp. Er Sp. Er	Flow Thalpy	23.6 klb/hr 387.0 btu/lbm 0.578 btu/lbm/R



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.





OVERVIEW

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

INPUTS

Determines the mass flows and properties of ar

Inle	t
Pressure*	622 psig
Saturated Quality - *	0.01
Mass Flow *	47.3 klb/hr
Tank Pressure *	393.1 psig
* Required	Enter [reset]





SSMT EQUIPMENT Flash Tank Calculator CALCULATION

GO TO Table of Contents

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.





Flash Tank Calculator CALCULATORS

The Flash Tank Calculator provides the following results:

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

Inlet Wa	ater		Mass Flow		47.3 klb/hr		
Pressure	ssure 622.0 psig			Sp. Enthalpy		bm	
Temperatu	ire	492.7 °F	PF Sp. Entropy 0.688 btu/h			bm/R	
Saturated		0.01	Energy Flow	N	23.0 MMBtu	ı/hr	
₽↓							
	Out	tlet Gas		Mas	s Flow	3.7 klb/h	r
	Pressure 33 Temperature 44		393.1 psig	93.1 psig Sp. Enthalpy 46.5 °F Sp. Entropy		1,205.1 <i>btu/lbm</i> 1.483 <i>btu/lbm/R</i>	
			446.5 °F				
	Saturated		1.00	Energy Flow		4.4 MMBtu/hr	
L				Fla	ash Tanl	ĸ	
			–	F .			
	Out	tlet Liqui	d 🗬	Mas	s Flow	43.6 klb/	hr
	Out Pres	tl et Liqui sure	d 393.1 <i>psig</i>	Mas Sp. 1	s Flow Enthalpy	43.6 klb/ 426.3 bt/	hr J/Ibm
	Out Pres	tl et Liqui sure perature	d 393.1 <i>psig</i> 446.5 ° <i>F</i>	Mas Sp. Sp.	ss Flow Enthalpy Entropy	43.6 klb/ 426.3 btt 0.624 btt	hr J/Ibm J/Ibm/R



GO TO



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.

	floiency &					ЕЕЛЕ	Home Programs 8	& Offices Co	naumer Information
NERGT Renewal	are Energy								
Steam Calc	ulators								
RE » Advanced Manufactur	ring Office = Steam Calculators =	PRV Calcula	itor				Printab	le Version	C SHARE
tain	PRV w/ Desun	erheati	ing Calcul	ator					
About	Calculates the propertie	is of steam	after a pressure	drop with opt	ional desuper	heating.			
Preferences	Inte	t			nlet		Maco Flow	60.3 Mb	for .
Glossary	Pressure*	226	asia		Prossuro	226.0 psig	So Fotbalov	1 204 8	htvähm
Resources	Temperature *	554.4	+6		Temperature		Sp. Entropy	1.631.01	withmiR
perbes Calculators: Saturated Properties	Mare Elser *	60.3	kibbr		hase	Gas	Energy Flow	78.1 MM	Bluhr
Steam Properties	ING STRONG	00.0	Riterio		_ 1				
ipment Calculators:	Outlet Pressure *	156.6	paig		1				
ceer	Desuperhea	ting +			PRV				
Tash Tark	Feedw	ater			_				
RV w/ Desuperheating	Pressure*	79.1	paig	- I	1 1				
feader	Saturated Quality - *	0		4	Dutlet		Mass Flow	63.3 k/b	/hr
Deaerator	Decuperheating	455	1.0		Pressure	156.6 psig	Sp. Enthalpy	1,247.6	blullbm
Steam Turbine	Temperature *	400			emperature	455.0 °F	Sp. Entropy	1.618 bi	w/bm/R
eam System Modeler	* Required	Enter	Ireset		hase	Gas	Energy Flow	79.0 MM	Stuthr
	"Evamola: Dandom - Wit	h Desunarh	eating	1					
	Example: Handom - Hin	n Desapern	earry	Feedwate	ər	Mass Flow	3.0 kib/hr		
	Examples: Mouse Over	Pressure	79.1 paig	Sp. Enthalpy 293.8 bit		vibm			
	Calculation Details and	Temperature	Ale 323.2 °F Sp. Entropy		0.468 btul	0.468 btuilbm/R			
	Pressure = 226 0.00 Immeriate = 226 0.00 Immeriate = 554.4 Islaam Property Cala Step 2 * 10 Desuperhead ArPV is an isentiality Ind entiality and culter Islam Proper Specific Entiality. Spec Pressure = 731 1.00 Islam Property Cala Step 3. Determine Desu Ung the Steam Prope Understander = 156 0.00 Islam Property	"/F ading': Det process, m pressure: g': Determ ty Calculati (calculation) => 1 perheated ty Calculation Typerheated ty Calculation Typerheated ty Calculation Typerheated ty	specific Enthalpy = armine Outlet S earning the infet e line Cooling Wa yr, properties are (of Quality): specific Enthalpy = Outlet Steam P or, properties are (1.294.8 btwfbm team Propertie nthalpy is equal ter Properties fetermined using 293.8 btwfbm roperties fetermined using	s to the outlet e g Iniet Pressure g Outlet Pressu	nthalpy. The out a and the select are and Desupe	llet properties a led second para rheating Tempe	re determi imeter (Ter rature:	ned using the mperature,
	Temperature = 455.0 [Steam Property Calc Step 4: Determine Feed If the Desurremented of	vater and	outlet Mass Flo	1,247.6 bfu/lbm	ter specific eri	thalmy or preate	r than the inlet	Steam on	acific anthalme
	the PRV outlet cannot b Flows are determined us	e desuperh	eated to the set to and energy balance	emperature and e equations:	desuperheating	is canceled.		oveani ap	circ unitary,
	Mass Flow = WF Specific Inhibity = 25 Specific Inhibity = 25 Duttet Staum MF = Inh Specific Steam MF = 0.0 (Qalet Steam MF = 0.0 (Qalet Steam MF = 0.0 (Datet Steam MF = 0.0) [reedwater MF = 0.0] Feedwater MF = 0.0 [reedwater MF = 0.0] (Duttet Steam MF = 0.0] [reedwater MF = 0.0]	t Steam MF liet Steam St dwater MF) it Steam SE it Steam SE iteam MF * (Ib/hr = 60, it Steam MF	+ Feedwater INF E] = [Iniet Steam NE * Outlet Steam SE + [Feedwater MF - [Feedwater MF - [Feedwater SE] Niet Steam SE - 0 3 klb/hr * (1,294.1 + Feedwater INF 0.3 klb/hr * 2.0	IF * Inlet Steam S = [Inlet Steam N * Outlet Steam S] Feedwater SE] = = [Inlet Steam M] utlet Steam SE] / S bfurfbm - 1,24) utlet deam	8] + [Feedwate IF * Iniet Steam 8] = [Iniet Steam M * iniet Steam M (Outlet Steam) (Outlet Steam) / (r MF * Feedwate SE] + [Feedwate n MF * Inlet Stea F * Inlet Stears : SE - Outlet Stears : E - Feedwater 5 1,247.6 bitwithm	er St] er MF [®] Feedwat MS [‡] feedw kt] - [intet Stear MSE)] kt] a - 293.8 blwfbr	ter SE] atter MF * F MF * Outb m]]	eedwater SE] et Steam SE]



SSMT EQUIPMENT PRV Calculator INPUTS

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

Inl	et	
Pressure*	226	psig
Temperature 👻 *	554.4	°F
Mass Flow *	60.3	klb/hr
Outlet Pressure *	156.6	psig
Desuperhe	ating 👻	
Feedv	vater	
Pressure*	79.1	psig
Saturated Quality - *	0	
Desuperheating Temperature *	455	°F
* Required	Enter	[rese



SSMT EQUIPMENT PRV Calculator CALCULATION

GO TO Table of Contents

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.





JIPMENT PRV Calculator RESULTS

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

	Inle	t			Mas	s Flow	60.3 klb/	'nr
	Pres	sure	2	26.0 psig	Sp.	Enthalpy	1,294.8	otu/lbm
	Temp	erature	5	i54.4 °F	Sp.	Entropy	1.631 bt	u/lbm/R
	Phas	е	Ģ	Gas	Ene	rgy Flow	78.1 MM	Btu/hr
٢	đ	PRV			Mar	an Flaur	62.2 Mb	
	Jui	ICL			Mas	STIOW	03.3 KID	rir
	Pres	sure	1	56.6 psig	Sp.	Enthalpy	1,247.6	ptu/lbm
	Temp	erature	4	55.0 °F	Sp.	Entropy	1.618 bt	u/lbm/R
	Phas	е	G	Gas	Ene	rgy Flow	79.0 MM	Btu/hr
È.								
eedwa	ter			Mass Flow		3.0 klb/hr		
essure		79.1 <i>psig</i>		Sp. Enthalpy		293.8 btu/lb	m	
mperatu	re	323.2 °F		Sp. Entropy		0.468 btu/lbm/R		
turated		0.00		Energy Flow		0.9 MMBtu/br		





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.

Enterior Renewal	Har molet (09)							
Steam Calc	ulators							
ERE = Advanced Manufactur	inu Office + Siteam Calculatora	Header Cal	culator				Printago la Va	nian 🖸 swar
them.	Header Calcul	ator						
Abeul	Calculates the combine	ator	roperties of	multiple steam inlot				
Preferences				Combined	Handas			
Gussay	Number of Inieta 3 +			Combined	rieader	Mann Flow	133.5 ADDAY	
Resources	Header Pressure *	388.4	paig	Pressure	388.4 pag	Sp. Enthalpy	747.1.0526500	
voperties Calculators	Inte	11		Temperature	445.4.2	Sp. Entropy	0.979 (112/10/05	R
Classe Docentice	Pressure*	553.2	ping.	Saturated	0.41	Energy flow	99.7 MMD5244	
quipment Calculatora:	Temperature • *	246.8	40	cent				
Buller	Mass Flow *	52.9	Alber	a second second	inlet 1		Mass Flow	52:9 kilshr
Heat Loss	Inte	12			Pressure	553.2 pmg	Sp. Enthalpy	216.5 blutom
Plash Tank	Pressure	490.5	(cm)u		Temperature	246.8 %	Sp. Entropy	0.362 pluthm
PRV w/ Desigerheating	Temperature	1171	- prog	_	Phase	Liquid	Energy Flow	11.5 MAINUT
Pressler	There is a second second	10.1	han					
Conservator	and bit Flow -	10.2	NUDAX.		Inlet 2		Mass flow	15.2 Mb/hr
Stears Turbie	Inte	497.8			Pressure	496.5.peig	Sp. Enthalpy	80.4 bhz/0m
annan ayatan Monoyr	Presente.	427.0	pdy.		Temperature	117.1 %	Sp. Entropy	0.159 ptulb/n
	Temperature • *	645.6	96		Phase	Liquid	Energy Flow	1.3 /////00/07
	Mass flow *	65.4	Althere .					
	* Required	Enter	treest		Inlet 3		Mass Flow	65.4 N/b/hr
	"Example: Random Inlet				Pressure	427.8 prig	Sp. Enthalpy	1.329.9 (0.40)
	Examples House Corr			-	Temperature	645.6 9	Sp. Entropy	1.600 064000
	EXAMPLES. MOVIE DYN				Phane	Gas	Energy Flow	87.0 LARDAN
	Bigedite: Erithalpy: Boye Iniet1 • Pressure = 56.5.2 pm • Temperature = 24.6 big • Direct Direct Case • Direct Direct Case • Pressure = 40.6 pm • Temperature = 107.6 • Direct Direct Case • Direct Direct Case • Direct Case	9 7/ 2014001 =>> excite Enthal 11.6 AMADna 9 7/ 2014001 =>> yeothe Enthal 1.3 AMADnaf 9 7/ 2014001 =>> yeothe Enthal	er Guality) Specific Enthal by * Mass Fis for = 216.5 bi Specific Enthal by * Mass Fis w = 06.4 bitul	The Specific Enthalpy wy = 216.5 bit/fbm w widdem * 52.9 kit/sfr] try = 89.4 bit/fbm w * 15.2 kit/sfr]	is then multiple	ed by the Mass	Flow to get the D	nergy Flaw.
	Steph Property Case Iniet Energy Flow = 5(Iniet Energy Flow = 1) Iniet Energy Flow = 1 The header specific ent Total letet Energy Flow	Header Spe halpy can b r = 99.7 MM	toroni Unha try * Mass Ro Ar = 1,329.9 solfic Enthal e calculated I Elludr = 11.5	w = 1,229 9 stortom w boultern * 65.4 kotome py ny dividing the Total Ini JANEDhame = 1,3 ARARE) et Energy Flow (why + 67.0 Mil	s by the Total In	et Mass Flows	
	Total Inlet Mass Flow Beader Specific Enthal	= 133.5 Alla	dv = 52.9 kib sergy Now / 1	vity + 15.2 kits/ly + 65 otal Mass Flow	4 Addutha			
	I Header Specific Enth	atpy = 747.1	Difutition = 9	9.7 MMBN//fr/133.5	(may) I			
	Step 3: Determine Hear	get Probel	10.0					



OVERVIEW

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CALCULATORS Header Calculator

INPUTS

Number of Inlets [#]:

Specifies the number of steam inlets that the 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

lumber of Inlets	3 •		
Header Pressure '		388.4	psig
	Inle	1	
Pressure*		553.2	psig
Temperature	• *	246.8	*F
Mass Flow *		52.9	klb/hr
	Inlet	12	
Pressure*		496.5	psig
Temperature	••	117.1	*F
Mass Flow *		15.2	kib/hr
	Inlet	13	
Pressure*		427.8	psig
Temperature	• *	645.6	*F
Mass Flow *		65.4	klb/hr
* Required		Enter	Ireset


INPUTS

Header Calculator CALCULATORS

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.





Energy Efficiency & **Renewable Energy**



SSMT EQUIPMENT

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GO TO

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

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

Combined H	Combined Header		133.5 klb/hr	
Pressure	388.4 psig Sp. Enthalpy		747.1 btu/lbm	
Temperature	445.4 ° <i>⊢</i> Sp. Entropy		0.979 btu/lbm/R	
Saturated	0.41	Energy Flow	99.7 MMBtu/hr	
_ 1			-	
	Inlet 1		Mass Flow	52.9 klb/hr
	Pressure	553.2 psig	Sp. Enthalpy	216.5 btu/lbm
-	Temperature	246.8 °F	Sp. Entropy	0.362 btu/lbm/R
	Phase	Liquid	Energy Flow	11.5 MMBtu/hr
	Inlet 2		Mass Flow	15.2 klb/hr
	Pressure	496.5 psig	Sp. Enthalpy	86.4 btu/lbm
	Temperature	117.1 °F	Sp. Entropy	0.159 btu/lbm/R
	Phase	Liquid	Energy Flow	1.3 MMBtu/hr
	Inlet 3		Mass Flow	65.4 klb/hr
┕╴ϼ	Pressure	427.8 psig	Sp. Enthalpy	1,329.9 btu/lbm
· ·	Temperature	645.6 °F	Sp. Entropy	1.600 btu/lbm/R

RESULTS





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 a 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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Pressure 57 θ μου Sp. G Temporature 1.258 7 ½ Sp. G Phase Gas Energy	Flow	6.1 kib/hr
Temporature 1258 7 % Sp. E Phase Gas Energ	thatpy	1.670.2 pr
Phase Gos Energ	tropy	2.043 blut
	y Flow	10.2 MMB
Calculation Details Step 1: Determine Intel Water Properties Using the Steam Property Calculator, progeness are determined using lefet Water Pressure and the selected are (temperature, Specific Enthalpy, Specific Entropy, or Quality) • Pressure = 2.6 arcsit	cond parar	ameter
Temperature = 61.8 ^{sp} (Steam Property Calculated) => Specific Entirety = 29.9 <i>Objective</i>		
Step 2: Determine Indel Steam Properties Using the Steam Properly Calculator, progenies are determined using lotet Steam Pressure and the selected s (Temperature, Specific Enthalpy: Specific Entropy, or Quality)	icond para	ameter
Pressure = 57.9 ptc) Temperature = 1.286.7 1/m IBern Property Calculated => specific Enthalpy = 1.670.2 blueform		
Step 3: Determine Feedwater and Vented Steam Properties		
Pressure = 30.6 poly Estimated Properties Calculated #> Submitted Properties Calculated #> Submitted Calculated Sector Entertainy = 243.9 Diuriform Saturated Case (specific Entertainy = 1,172.3 Diuriform		
Step 4: Determine Feedwater and Vented Mass Flows and Total Outlet Energy Flows		
 Vented Basar Mass Flow = Vent Rate * Feedwater Mass Flow. [Veeted Stearn Mass Flow = 0.2 http://www.com/article/stearney/article/		
• Total DA Mass Row = Venited Steam Mass Row + Feedwater Mass Row [Total DA Mass Row = 45.9 $k(tothr = 0.2 \ k(tothr + 45.7 \ k(tothr)$		

OVERVIEW



Energy Efficiency & Renewable Energy

GO TO SSMT ONLINE

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



Energy Efficiency & Renewable Energy

Deaerator Calculator

INPUTS

Determines the required water and steam flows

Deaerator Pressure *	30.6 psig
Vent Rate *	0.4 %
Feedwater Mass Flow *	45.7 klb/hr
Wat	er
Pressure*	2.6 psig
Temperature •	61.8 °⊱
Stea	m
Pressure*	57.9 psig
Temperature •	1258.7 °F
* Required	Enter [reset]

SSMT EQUIPMENT CALCULATORS Deaerator Calculator

CALCULATION

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.



Calculation Datails



EQUIPMENT Deaerator Calculator

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

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

Feedwater Ma		ss Flow	45.7 klb/hi			
Pressure	30.6 psig Sp. Enthalpy		243.9 btu/lbm			
Temperature	274.8 °F	°F Sp. Entropy		0.403 btu/lbm/R		
Saturated	0.00 Energy Flow		11.1 MMBt	11.1 MMBtu/hr		
_ _↑						
	Vented S	tea	m	Mass Flow	/	0.2 klb/hr
	Pressure		30.6 psig	Sp. Enthal	ру	1,172.3 btu/lbm
	Temperature	е	274.8 °F	Sp. Entrop	y	1.667 btu/lbm/R
	Saturated		1.00	Energy Flo	w	0.2 MMBtu/hr
L		erate	or) - L			
Inlet Water		erato Mas	or L	39.8 klb/hr		
Inlet Water Pressure	2.6 psig	erate Mas Sp.	or as Flow Enthalpy	39.8 klb/hr 29.9 btu/lbl	m	
Inlet Water Pressure Temperature	2.6 <i>psig</i> 61.8 ° <i>F</i>	erate Mas Sp. Sp.	es Flow Enthalpy Entropy	39.8 klb/hr 29.9 btu/lbi 0.059 btu/ll	m bm/R	
Inlet Water Pressure Temperature Phase	2.6 psig 61.8 °F Liquid	erate Mas Sp. Sp. Ene	es Flow Enthalpy Entropy rgy Flow	39.8 klb/hr 29.9 btu/lbi 0.059 btu/ll 1.2 MMBtu/l	m bm/R hr	
Inlet Water Pressure Temperature Phase	2.6 psig 61.8 °F Liquid	Mas Sp. Ene	es Flow Enthalpy Entropy rgy Flow	39.8 klb/hr 29.9 btu/lb 0.059 btu/ll 1.2 MMBtu/l	m bm/R hr	
Inlet Water Pressure Temperature Phase	2.6 psig 61.8 °F Liquid	erato Mas Sp. Sp. Ene	es Flow Enthalpy Entropy rgy Flow	39.8 klb/hr 29.9 btu/lbi 0.059 btu/lt 1.2 MMBtu/l	m bm/R hr	6.1 <i>klb/hr</i>
Inlet Water Pressure Temperature Phase	2.6 psig 61.8 °F Liquid Inlet Stea Pressure	erato Mas Sp. Sp. Ene	ss Flow Enthalpy Entropy rgy Flow	39.8 klb/hr 29.9 btu/lb 0.059 btu/lb 1.2 MMBtu/l Mass Flow Sp. Entha	m bm/R hr	6.1 <i>klb/hr</i> 1,670.2 <i>btu/lbm</i>
Inlet Water Pressure Temperature Phase	2.6 <i>psig</i> 61.8 °F Liquid Inlet Stea Pressure Temperature	Mas Sp. Sp. Ene am	ss Flow Enthalpy Entropy rgy Flow 57.9 <i>psig</i> 1,258.7 °F	39.8 klb/hr 29.9 btu/lbi 0.059 btu/lbi 1.2 MMBtu/li Mass Flow Sp. Enthal Sp. Entrop	m bim/R hr N Ipy	6.1 <i>klb/hr</i> 1,670.2 <i>btu/lbm/</i> 2.043 <i>btu/lbm/</i>

RESULTS





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





OVERVIEW

SSMT EQUIPMENT Steam Turbine Calculator INPUTS (1/2)

-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 Calculates the energy g	Calculator enerated or steam outle			
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 klb/hr			
Isentropic Efficiency *	75.7 %			
Generator Efficiency *	96.2 %			
Outlet Steam				
Pressure*	266.1 psig			
* Required	Enter [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

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Outlet Steam - Secondary Steam Property [varies]:

[Either: Temperature, Specific Enthalpy, Specific Entropy, or Quality] Second steam property associated with the outlet steam





INPUTS (2/2)

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

Steam Turbine Calculator

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)

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SSMT EQUIPMENT

CALCULATORS

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CALCULATION

Sainulation Details

1.1001110

The **Steam Turbine Calculator** provides the following results:

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

Inlet Steam		Mass Flow	39.3 klb/hr	
Pressure	565.4 ps/	Sp. Enthalpy	1,553.8 btulbm	
Temperature	1,054.3 *	Sp. Entropy	1.744 btullbm/R	
Phase	Gas	Energy Flow	61.1 MMBluthr	
	L			
		sentropic Efficiency	75.7 %	
	E	Energy Out	3.3 MMBlu/ht	
		Energy Out Generator Efficiency	3.3 MMBluthr 96.2 %	
		Energy Out Generator Efficiency Power Out	3.3 MMBtu/hr 96.2 % 926.4 kW	
		Energy Out Generator Efficiency Power Out	3.3 MMBtu/w 96.2 % 926.4 kW	
Outlet Stea		Energy Out Generator Efficiency Power Out Mass Flow	3.3 MMBtu/hv 96.2 % 926.4 kW 39.3 ktb/hr	
Outlet Stea	266.1 pai	Energy Out Generator Efficiency Power Out Mass Flow Sp. Enthalpy	3.3 MMBtu/hr 96.2 % 926.4 kW 39.3 ktb/hr 1,470.1 btu/lbm	
Outlet Stea Pressure Temperature	266.1 psi 891.7 °F	Energy Out Generator Efficiency Power Out Mass Flow 9 Sp. Enthalpy Sp. Entropy	3.3 MMBlu/hr 96.2 % 926.4 kW 39.3 klb/hr 1,470.1 blu/lbm 1.764 blu/lbm/R	

RESULTS



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.



GO TO Modeler Table of Contents

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

Overview

- 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

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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 reuploaded later.



SSMT STEAM SYSTEM MODELER Initial Generation a Base Model

GO TO Modeler Table of Contents

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





SSMT STEAM SYSTEM MODELER Base Model – Boiler Details

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[%]:

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Vent rate as a % of feedwater mass flow

Deaerator Pressure [pressure]:

Operating pressure of the deaerator

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
Deaerator Vent Rate*	0.1 %
Deaerator Pressure*	psig



SSMT STEAM Base Model – General Details

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*		kW
Electricity Unit Cost*		\$ I kWh
Yearly Operating Hours*		hrs
Make-Up Water Unit Cost*		\$ I gal
Make-Up Water Temperature*	50	°F
Fuel Unit Cost*		\$ / MMBtu



SSMT STEAM SYSTEM MODELER Base Model – Header Details

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



Energy Efficiency &
Renewable Energy

Header Details	•				
Number of Headers	3 - Header	•			
HEADERS		НР	MP	LP	
Pressure*					psig
Process Steam Usag	je*				klb/hr
Condensate Recover	γ*				%
Flash Condensate int	to Header		No 🔻	No 🔻	
Condensate Return 1	femperature*	150	°F		
Flash Condensate Re	eturn*	No 🔻			
Heat Loss*		0.1	0.1	0.1	%
Desuperheat Steam	into MP* No	▼ 370	°F		
Desuperheat Steam	into LP* No	▼ 270	°F		

GO TO SSMT ONLINE

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	On/Off
Isentropic Efficiency*	65 %
Generation Efficiency*	98 %
Condenser Pressure*	725.2 psia
Operation Type*	Steam Flow 🔹
Operation Type* Fixed Flow*	Steam Flow Iloo klb/hr
Operation Type* Fixed Flow*	Steam Flow Iloo klb/hr
Operation Type* Fixed Flow* HP to LP Turbine	Steam Flow Steam Flow On/Off

HP to LP Turbine	I On/Off
Isentropic Efficiency*	65 %
Generation Efficiency*	98 %
Operation Type*	Flow Range
Minimum Flow*	Balance Header Steam Flow
Maximum Flow*	Flow Range Power Generation
	Power Range
HP to MP Turbine	On/Off
MP to LP Turbine	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







SSMT STEAM MODELER MODEL Diagram

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.)





SSMT STEAM MODELER MODELER MODELER MODELER

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:







SSMT STEAM MODELER MODEL Diagram – Equipment Details

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.





SSMT STEAM SYSTEM MODELER STEAM Balance

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

St	03	m	Bal	a	nc	.,
31	ea		Dal	a	III.	1

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

System			
	Base N	lodel	
	klb/hr	MMBtu/hr	btu/lbm
Boiler Energy	-	580.0	
Boiler Energy Losses	*	-87.0	
Cond Turbine		-2	
Cond Turbine Losses	4		
HP tp MP Turbine	×	-10.2	
HP to LP Turbine		-48.1	
MP to LP Turbine	2	-	
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	<u>e</u>	-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:	2	5	

HP Header			
	Base N	lodel	
	klb/hr	MMBtu/hr	btu/lbm
Boiler Steam	403.4	578.9	1,435.1
Condensing Turbine Inlet	-	а. -	
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	-	2	
HP Processes	-50.0	-71.7	1,433.7
HP Energy Losses	-	-0.6	
TOTAL:	-	а С	





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.

Base Energy Flows

Boiler Losses Flow: 87.00 MMBtu/hr Loss: 87.00 MMBtu/hr
HP Header Flow: 72.26 MMBtu/hr Loss: 0.58 MMBtu/hr
Condensing Turbine Flow: 0.00 MMBtu/hr Loss: 0.00 MMBtu/hr
HP to LP Turbine Flow: 48.14 MMBtu/hr Loss: 0.00 MMBtu/hr
HP to MP Turbine Flow: 10.23 MMBtu/hr Loss: 0.00 MMBtu/hr
MP Header Flow: 133.13 MMBtu/hr Loss: 0.13 MMBtu/hr
MP to LP Turbine Flow: 0.00 MMBtu/hr Loss: 0.00 MMBtu/hr
LP Header Flow: 248.80 MMBtu/hr Loss: 0.32 MMBtu/hr
Deareator Flow: 0.48 MMBtu/hr Loss: 0.48 MMBtu/hr





SSMT STEAM Creating an Adjusted Model

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





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								
Modify Make-Up Water Temperature								
Initial Make-Up Water Temperature	50.0 °F	NEW Make-Up Water Temperature*	50 °F					



Unit Costs adjustments include:

- Electricity Unit Cost [\$/electricity]
 - Electricity prices are generaly 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

Modify Electricity Unit Cost			
Initial Electricity Unit Cost	\$ 0.0500 / kWh	NEW Electricity Unit Cost*	\$ I kWh
Modify Fuel Unit Cost			
Initial Fuel Unit Cost	\$ 5.7800 / MMBtu	NEW Fuel Unit Cost*	MMBtu \$1
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

Modify Process Steam Dema	nd/Usage					Just onit costs			
Initial HP Steam Usage	50.0 klb/hr	NEW Steam Usage*	50	klb/h	V Ad	just Steam Demand (only	1 may be selec	ted)	
Initial MP Steam Usage	100.0 klb/hr	NEW Steam Usage*	100	klb/h	/h Modify Process Steam Demand/Usage				
Initial LP Steam Usage	200.0 klb/hr	NEW Steam Usage*	200	klb/h		Modify Process Energy Demai	nd		
Modify Process Energy Dema	ind					Initial HP Energy Usage	40.3 MMBtu/hr	NEW Energy Usage*	40.3 MMBt
						Initial MP Energy Usage	86.3 MMBtu/hr	NEW Energy Usage*	86.3 MMBt
						Initial LP Energy Usage	180.0 MMBtu/hr	NEW Energy Usage*	180 MMBt





SSMT STEAM Adjusted Model – Boiler Operation

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

~,	ast boner operation				
1	Change Boiler Combustion Effic	iency			
	Initial Boiler Combustion Efficiency	85.0 %	NEW Combustion Efficiency ⁴	85.0	%
7	Change Fuel Type				
	Initial Fuel Type:	Natural Gas	NEW Fuel Type*	Natura	l Gas 🔹
J	Change Boller Blowdown Rate				
	Initial Boiler Blowdown Rate	2.0 %	NEW Blowdown Rate*	2.0	56
4	Blowdown Flash to LP				
	Flash Blowdown? Base:	No	Adjusted*	No •	
7	Preheat Make-Up Water with Bl	owdown			
	Preheat Make-Up	No	NEW Preheat Make-Up ^z	No +	
	Approach Temperature	20.0 °F	NEW Approach Temperature*	20	1F
4	Change Steam Generation Cond	itions			
	Initial Steam Temperature:	588.9 'F	NEW Steam Temperature*		'F
V	Change DA Operating Condition	5			
	Initial DA Vent Rate	0.1 %	NEW DA Vent Rate*	0.1	1%
	Initial DA Pressure	15.0 psig	NEW DA Pressure*	15	APP



SSMT STEAM Adjusted Model – Steam Turbine

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

1	Modify HP to Condensing Ste	eam Turbine			
	Initial Turbine Status	Off	Adjusted Status*	0n/0	ff
71	Modify HP to LP Steam Turb	ine			
	Initial Turbine Status	On	Adjusted Status*	🗹 0n/0	ff
	Isentropic Efficiency	65.0 %	Isentropic Efficiency*	65	%
	Generation Efficiency	100.0 %	Generation Efficiency*	100	%
	Operation	Balance Header	Operation* Flow	Range	•
			Minimum Flow*	50	klb/hr
			Maximum Flow*	150	klbftr
7	Modify HP to MP Steam Turb	ine			
	Initial Turbine Status	On	Adjusted Status*	🗹 0n/0	ff
	Isentropic Efficiency	65.0 %	Isentropic Efficiency*	65	%
	Generation Efficiency	100.0 %	Generation Efficiency*	100	%
	Operation	Balance Header	Operation [®] Balar	nce Heade	r •
71	Modify MP to LP Steam Turb	ine			



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

1	Condensate Recovery			
	Initial HP Condenstate Return	50.0 %	NEW Condenstate Return*	50.0 %
	Initial MP Condenstate Return	50.0 %	NEW Condenstate Return*	50.0 %
	Initial LP Condenstate Return	50.0 %	NEW Condenstate Return*	50.0 %
7	Condensate Flash to MP			
	Flash Condensate to MP? Base:	No	Adjusted*	No •
7	Condensate Flash to LP		•	
	Flash Condensate to LP? Base:	No	Adjusted*	No 🕶
V	Modify Condensate Return Tempe	rature		
	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%

Adjust Insulation / Heat Loss							
V Adjust Heat Loss Percentage							
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 "<u>Review the Base Model</u>" section for specific details on these

Moving the mouse over "Adjusted Model" will open the menu of viewing options





GO TO SSMT ONLINE

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	Reductio	n
	\$'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			
CO2 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


SSMT STEAM SYSTEM MODELER MODELER MODELER MODELER MODELER <u>GO TO Modeler</u> <u>Table of Contents</u>

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 <u>Reloading Models</u>

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.**





SYSTEM MODELER DOWNLOAD Excel Spreadsheet

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

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Energy Efficiency & Renewable Energy



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





SSMT STEAM DOWNLOAd/Export AMO Tracker

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







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.

