



# Welcome!

## Webinar #29:

# Inlet Chilling Systems & Chilled Water Storage in GTPM

24 Jul 2018

### Agenda:

- \* Introduction
- \* Inlet Air Cooling Systems in GTPM
- \* Chiller types & design in GT Pro
- \* Chiller Operation in GT Master
- \* Chilled Water Storage 24-hr Model
- \* Q & A Session

# Thermoflow Training and Support

- Standard Training
- On-site training course
- User's Meetings / Advanced Workshops
- Webinars when new version is released
- Help, Tutorials, PPT, Videos
- Technical Support

**→ Feature Awareness Webinars**

# Feature Awareness Webinars

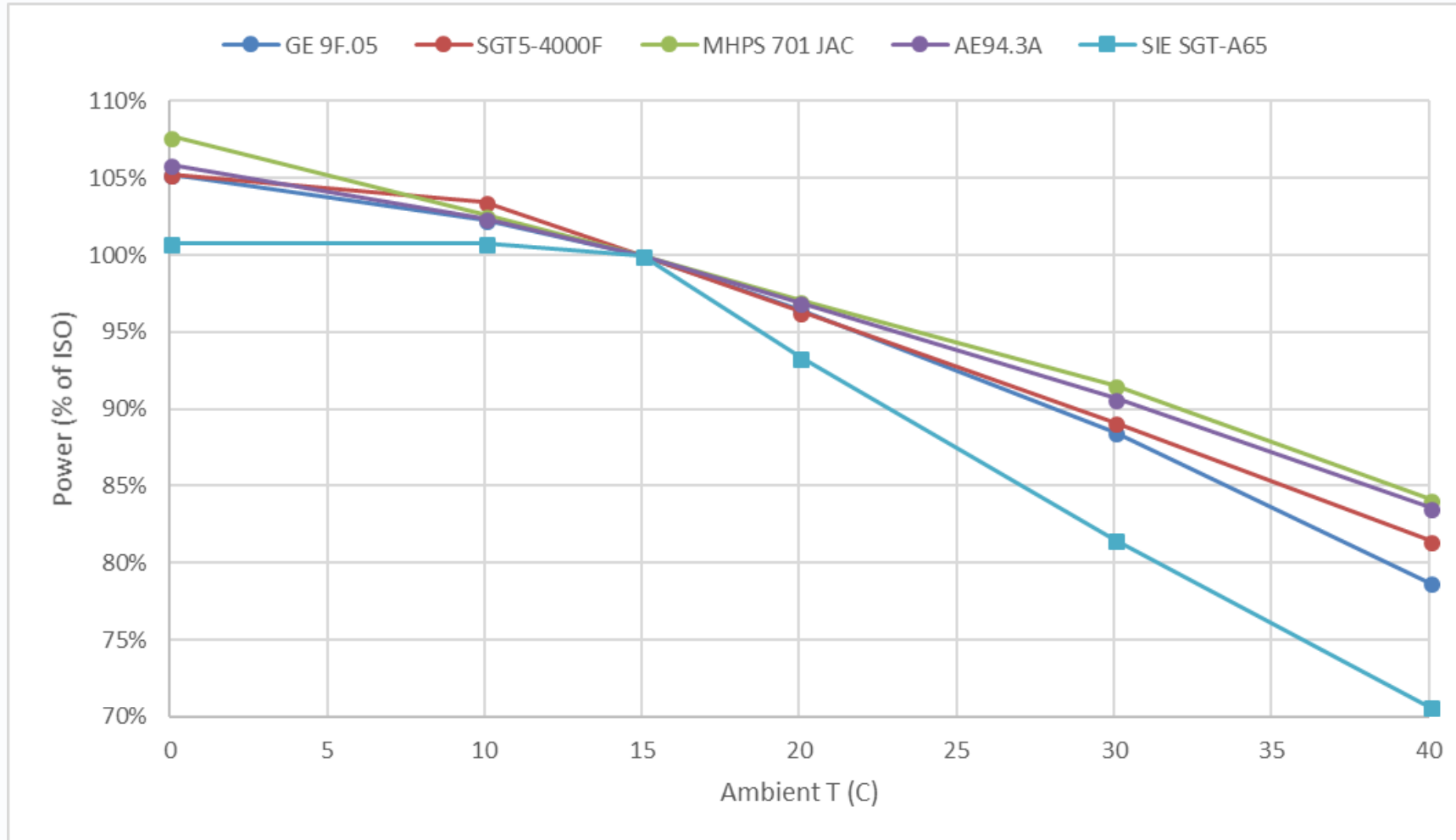
- 1- Assemblies in TFX, June 2016
- 2- Scripts in Thermoflow programs, GTP-GTM-TFX
- 3- Multi Point Design in GTP-GTM
- 4- Reciprocating Engines in TFX
- 5- TIME in GTM
- 6- Matching ST Performance in STP
- 7- Modeling Solar Systems in TFX
- 8- Combining THERMOFLEX & Application-Specific Programs
- 9- Methods & Methodology in GT PRO & STEAM PRO
- 10- Supplementary Firing & Control Loops in GT PRO & GT MASTER
- 11- The Wind Turbine Feature in Thermoflex
- 12- Modelling GT's in Thermoflow program-1
- 13- Thermoflex for on line and off line performance monitoring
- 14- Tflow 27, what's new
- 15- Modelling GT's in Thermoflow program-2
- 16- Multi Point Design in GTP-GTM
- 17- Total Plant Cost in TFX
- 18- Steam Turbine Tuning
- 19- User Defined Components in TFX
- 20- Cooling System Optimization

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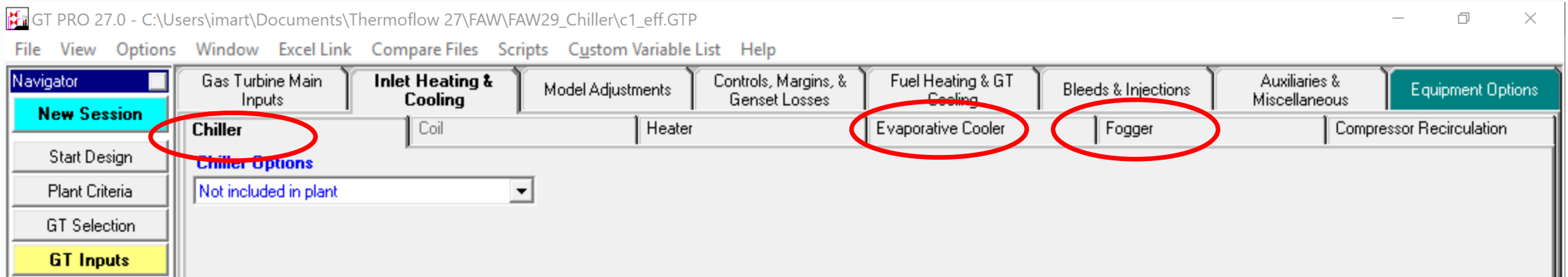
## **29- Inlet Chilling Systems in GTPM**

# Effect of Ambient T on GT Performance



# Inlet Air Cooling Systems in GTPM

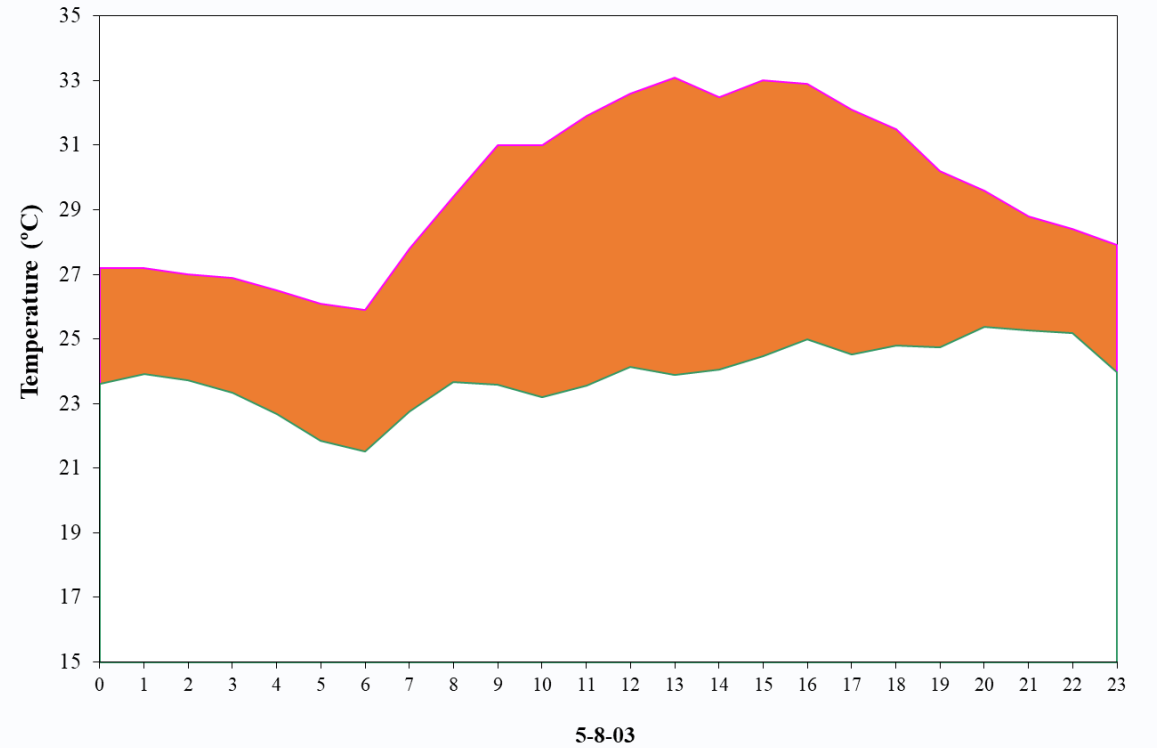
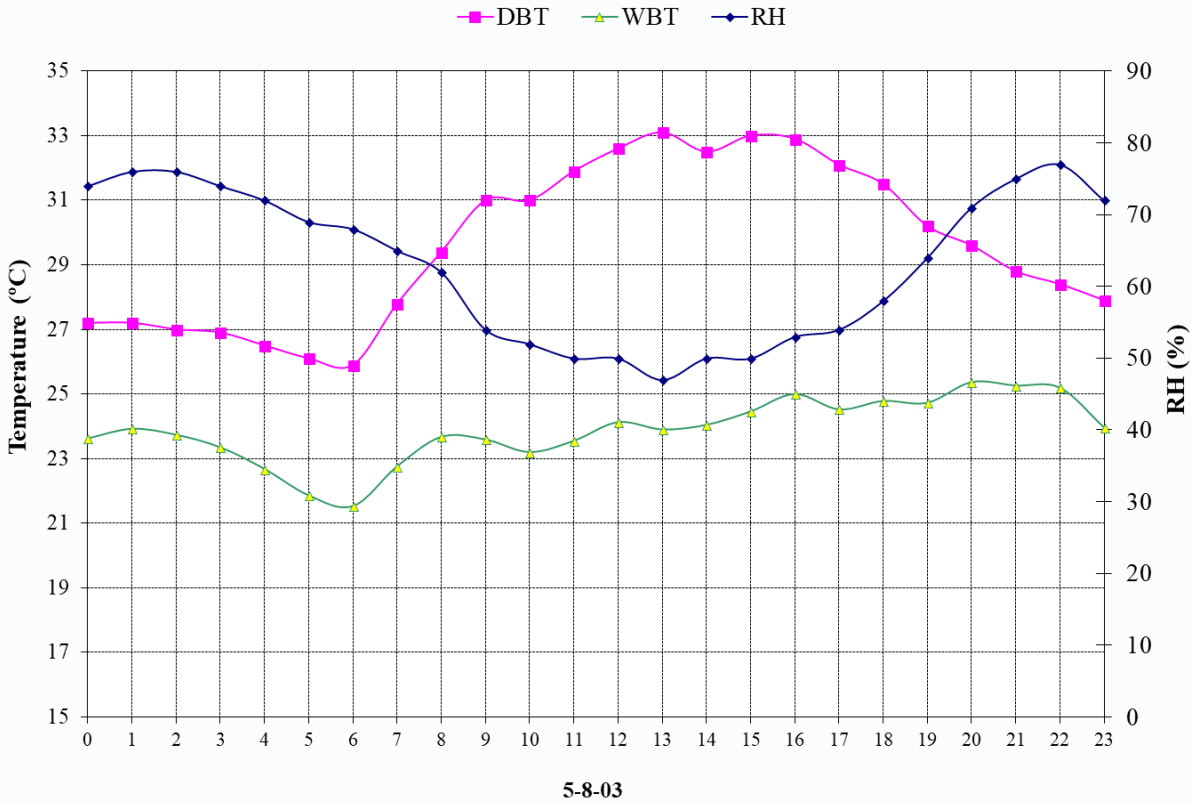
- Chillers
  - Electric
  - Absorption
  - External
- Evaporative Cooling
  - Evap Cooler “Media” type
  - Fogger



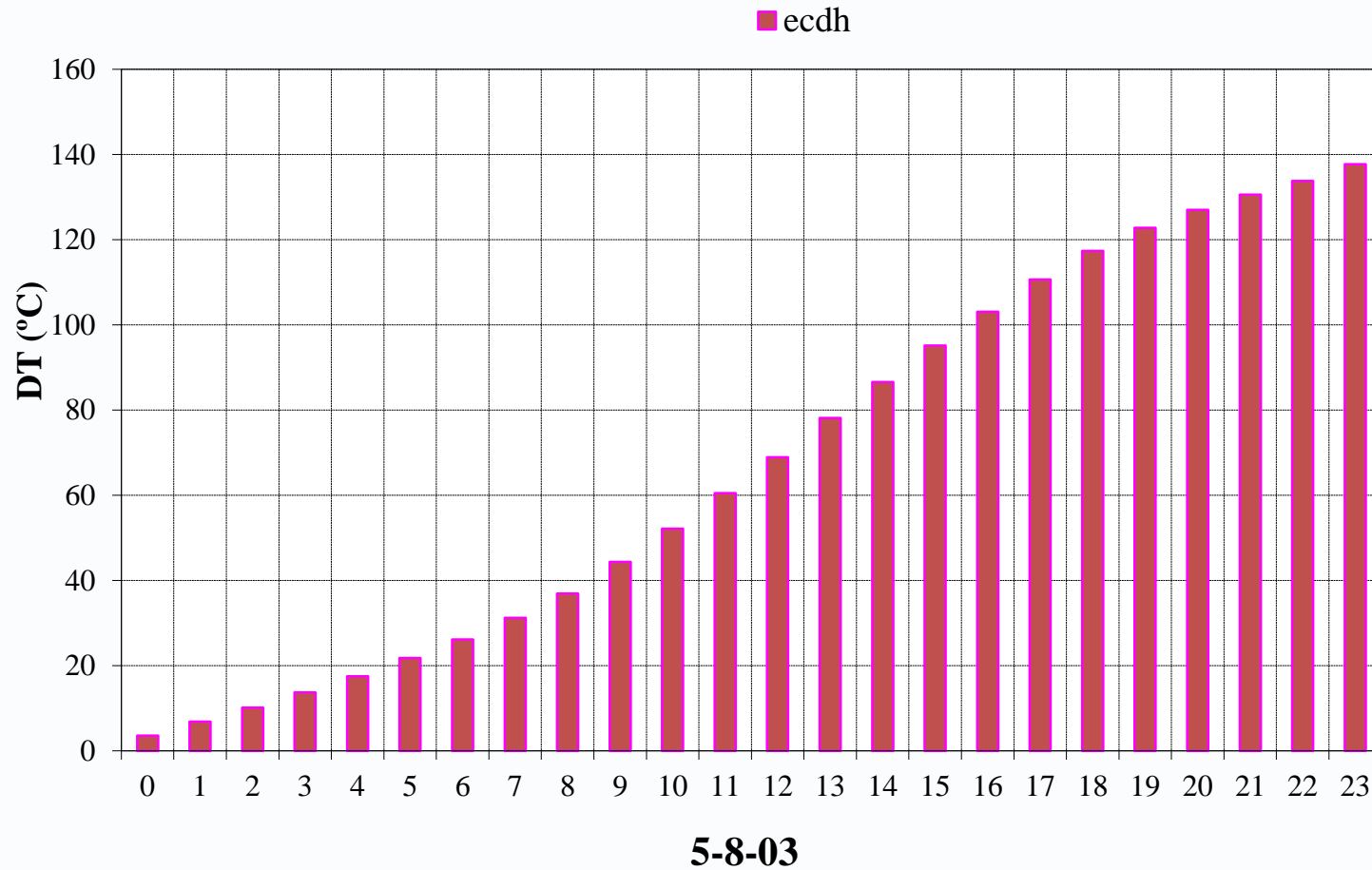
## Evaporative Cooling → Definitions

- *Wet Bulb Depression*:  $WBD = DBT - WBT \rightarrow$  Potential of Cooling
- *Efectiveness*  $\rightarrow \frac{DBT - T \text{ after cooling}}{DBT - WBT}$
- *ECDH* = Equivalent Cooling Degree Hours (per year) =  $\sum_{i=1}^{8760} (DBTi - WBTi)$

# Evaporative Cooling → Potential of Cooling



# Evaporative Cooling → Potential of Cooling



Calculate hour by hour, 8760 hours → ECDH or potential of cooling in a year



## Design in GTP: **Evaporative Cooler**

- Effectiveness
- Air Pressure Drop
- Cycles of Concentration
- Sizing Criteria
  - Use current HB data
  - UD Sizing: Water Flow % of Air Flow

**Include evaporative cooler**

**Current Heat Balance**

Effectiveness  %

Air pressure drop  millibar

Cycles of concentration

**Sizing Criteria**

Use current heat balance data

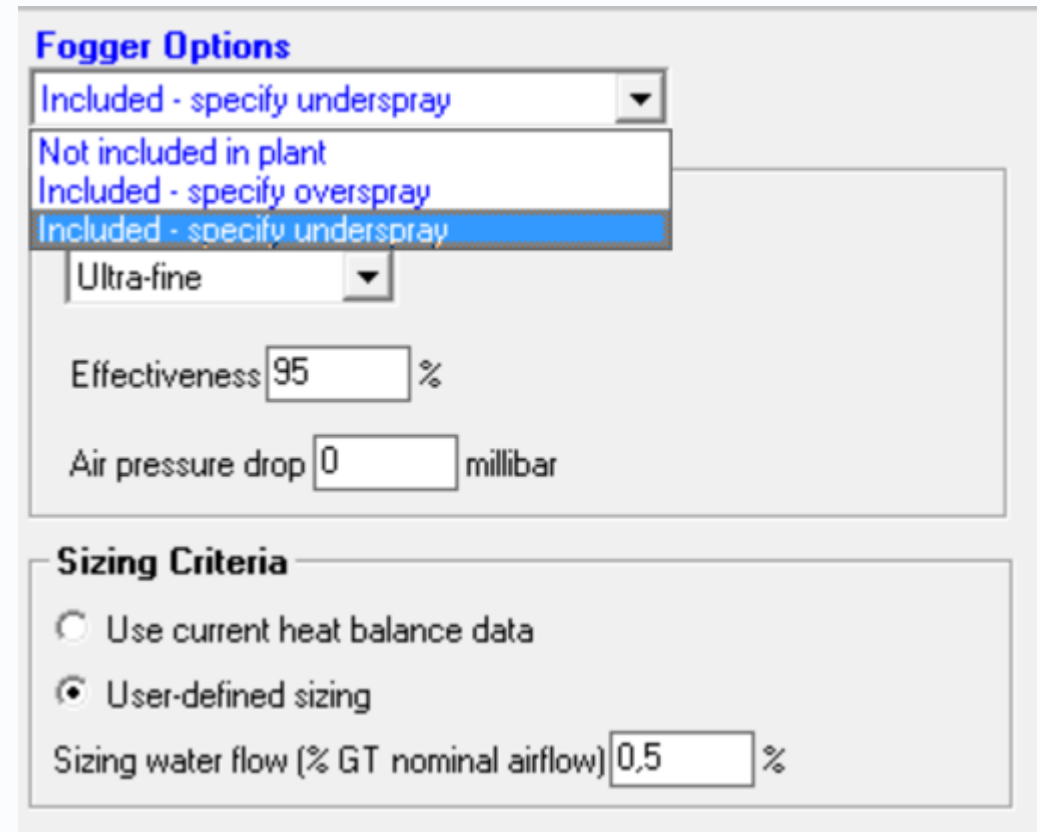
User-defined sizing

Sizing water flow (% GT nominal airflow)  %

## Design in GTP: Fogger

- Fogger specification
  - Underspray → Effectiveness
  - Overspray → % OS
- Mean Droplet Size
- Air Pressure Drop
- Sizing Criteria
  - Use current HB data
  - UD Sizing: Water Flow % of Air Flow

Caution: Certain GT engines are unsuited to overspray fogging. Some vendors do not allow overspray for engines under warranty.



**Fogger Options**

Included - specify underspray

Not included in plant  
Included - specify overspray  
Included - specify underspray

Ultra-fine

Effectiveness 95 %

Air pressure drop 0 millibar

**Sizing Criteria**

Use current heat balance data

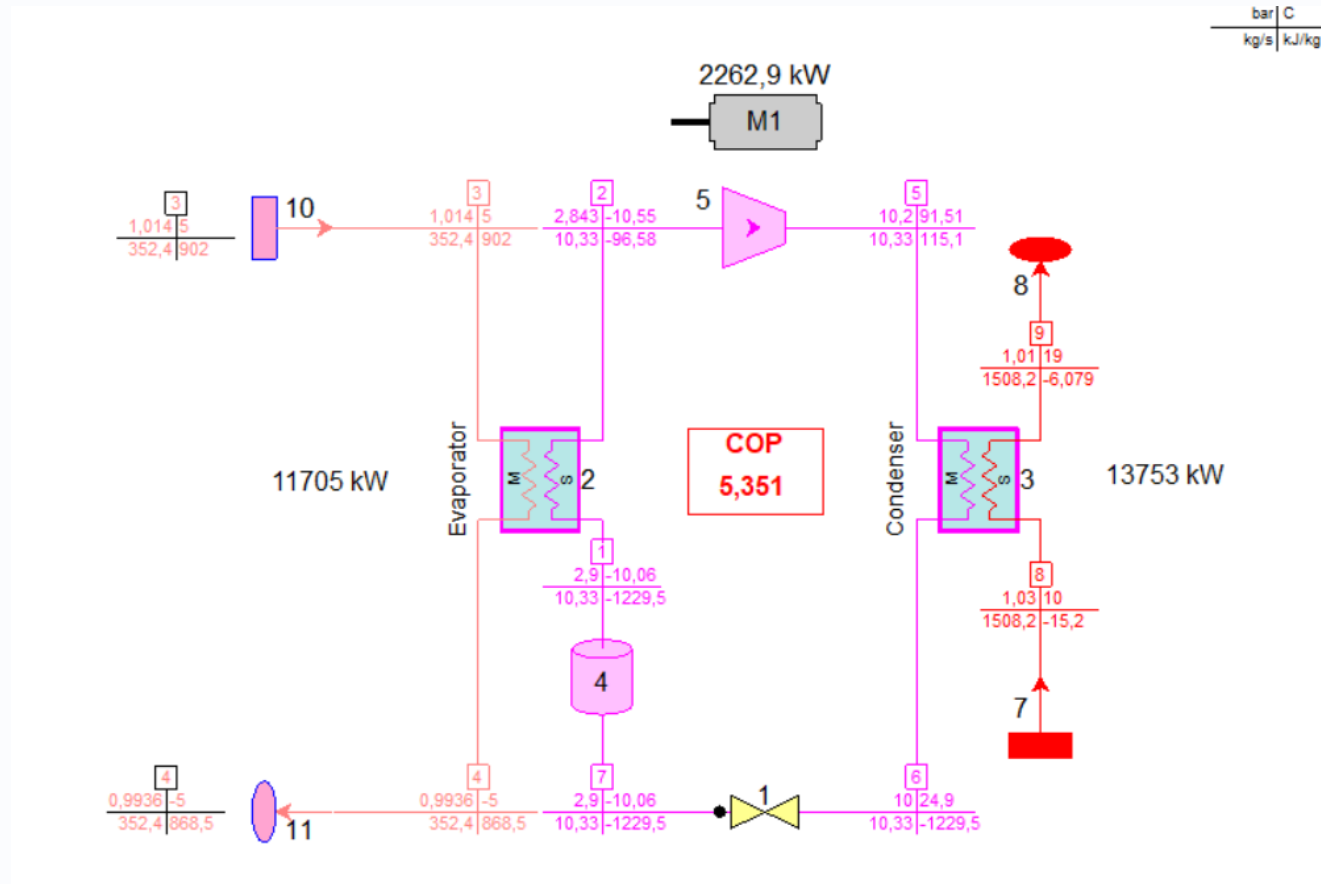
User-defined sizing

Sizing water flow (% GT nominal airflow) 0,5 %

## Inlet Air Cooling Systems in GTP: **Chillers**

- Electric Chillers
  - Water Cooled
  - Air Cooled
- Absorption Chillers
  - Water
  - Steam, low Pressure, 1 stage
  - Steam, medium Pressure, 2 stages
  - Exhaust Gas or Direct Fired → *only TFX*
- External

# Chillers → Definitions



# Chillers → Definitions

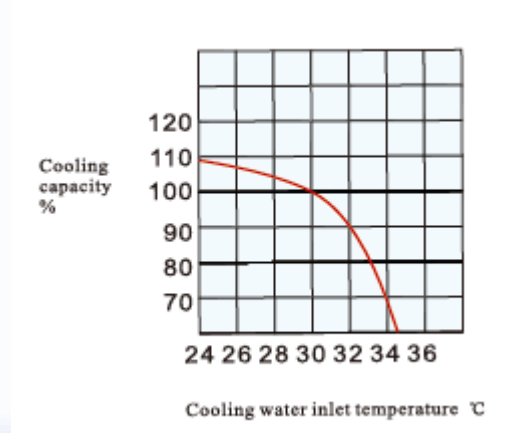
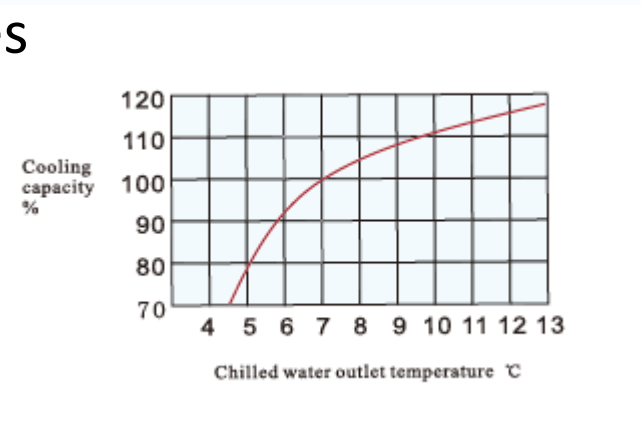
- *Coeficient Of Performance* → 
$$COP = \frac{\text{Cooling Effect}}{\text{Energy Input}}$$

- Energy Input + Cooling Effect = Heat Rejection

- Chiller Nameplate Performance @ Standard Conditions:

- 85 °F (29.4 °C) chiller coolant supply temperature
- 44 °F (6.67 °C) chilled water temperature
- Steam source pressure for absorbtion chillers of 20 psia (1.4 bar) 1 stage - 130 psia (9 bar) 2 stage

- Correction Curves



**Typical COP values**

Absorption		
Hot Water	1 stage	0,6
Low P Steam	1 stage	0,7
Med P Steam	2 stage	1,1
Electric		
Water Cooled		5,25
Air Cooled		3,5

# Design in GTP: Chiller

**Chiller Options**

Water-cooled electric chiller

Not included in plant

**Water-cooled electric chiller**

Air-cooled electric chiller

Single stage water-cooled absorption chiller

Two stage water-cooled absorption chiller

External chilled water

Chiller off. Coil chilled water from storage

**Sizing Criteria**

Use current heat balance data

User-defined sizing

Chiller nameplate capacity relative to nominal GT airflow

10,77 kW / t/h

Minimum number of operating chillers per GT

Maximum chiller unit nameplate capacity  kW

Number of spare chillers per GT

**Cooling Configuration**

Auxiliary cooling tower

Plant cooling tower

**Auxiliary cooling tower**

Dedicated fin fan cooler

Excluded

**Chiller Specification**

Nameplate COP

Water-cooled electric chiller   kW/ton

Air-cooled electric chiller   kW/ton

Single stage water-cooled absorption chiller

Two stage water-cooled absorption chiller

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Chilled water supply pressure  bar

Chilled water supply temperature  C

Chilled water range  C

Cooling water approach to wet bulb  C

Coil water-side DP @ design flow  bar

Chilled water piping DP @ design flow  bar

Cooling water DT / Condenser CW DT

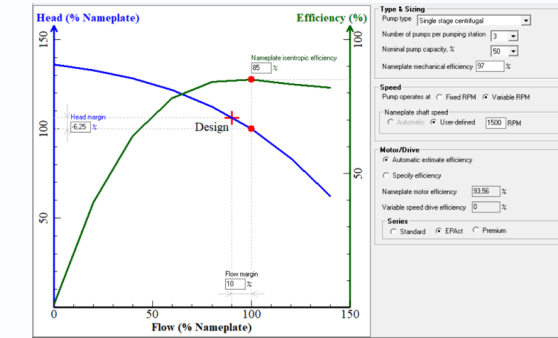
**Chilled Water Storage**

Include chilled water storage

Chilled water storage capacity  hours

Chilled water storage margin  %

**Chilled Water Pump Details**



## Absorption Chillers only

**Steam source**

Main LPT bleed

1st HP substream

2nd HP substream

**Main LPT bleed**

1st LPT substream

2nd LPT substream

Main HPT bleed

1st HPT substream

2nd HPT substream

**Steam from source**

all goes to chiller/ heater

also feeds process

**all goes to chiller/ heater**

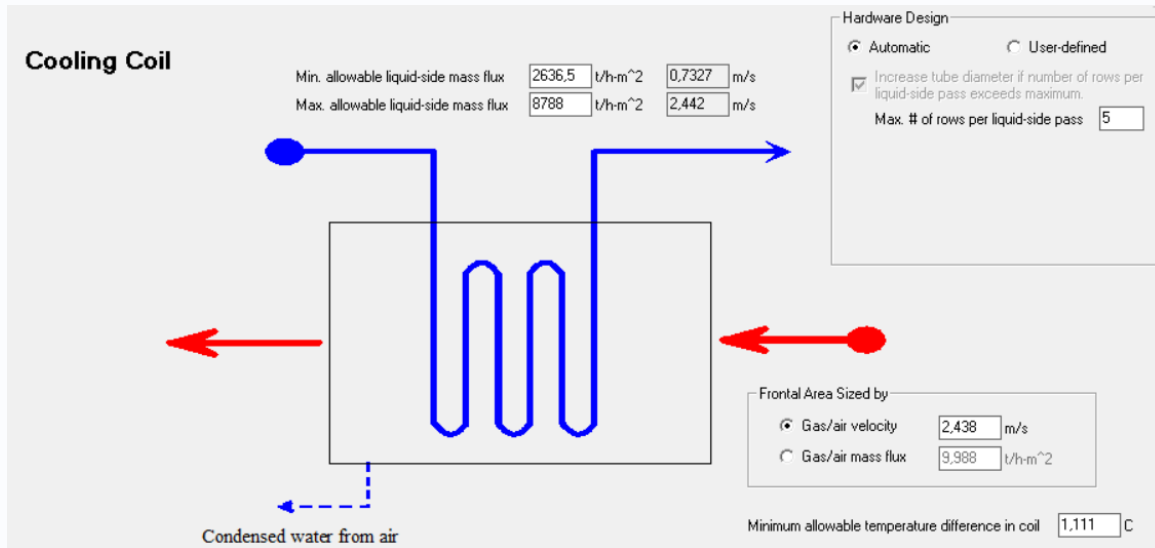
# Design in GTP: Chiller

**Coil Model**

Hardware

Simplified

Hardware



Main Inputs    Hardware    Other Inputs

Fin-tube type: Plate fins    Tube arrangement: Staggered    Fin material: Aluminum, #20    Tube material: Copper, #24     Use different material for fins and tubes

Longitudinal row pitch, Pl: 41,28 mm

Transverse tube pitch, Pt: 38,1 mm

Tube length/HX width (0 = auto): 0,8

Pl = 41,28 mm

Pt = 38,1 mm

Gas

For illustration only. Actual number of tubes and number of rows to be calculated.

0 80 mm

0 30 mm

Tube outer diameter: 15,88 mm

Tube wall thickness: 0,889 mm

Fin thickness: 0,2794 mm

Fin spacing: 3,167 mm

# of fins: 290,2 per meter

Fin height: 14,45 mm

Segment width: 3,967 mm

# of segments: 0

Un-cut height/fin height: 0,2

# Design in GTP: Chiller

**Chiller Performance Corrections**

Automatic  
 **User-defined** Edit Data

Reset all using default chiller corrections

Reset all to unity (no corrections)

**Capacity Correction Factors** | COP Correction Factors

Correction for temperatures     Correction for pressure

**Chilled water exit temperature, C**

Capacity CF	15	20	25	29,44	30	35
0	0,7467	0,8159	0,838	0,8182	0,8131	0,7413
5	0,9096	0,9702	0,9838	0,9564	0,9503	0,8699
6,667	0,9615	1,019	1,03	1	0,9936	0,9103
10	1,062	1,114	1,119	1,084	1,077	0,9877
15	1,203	1,246	1,243	1,2	1,192	1,095
20	1,333	1,368	1,356	1,306	1,297	1,191

**Capacity Correction Factors** | **COP Correction Factors**

Correction for temperatures     Correction for pressure     Correction for part load

**Chilled water exit temperature, C**

COP CF	15	20	25	29,44	30	35
0	0,9264	0,8499	0,7704	0,701	0,6926	0,6196
5	1,235	1,141	1,033	0,9353	0,9232	0,8178
6,667	1,299	1,21	1,102	1	0,9873	0,8753
10	1,307	1,247	1,16	1,068	1,056	0,9463
15	1,058	1,051	1,018	0,9715	0,9647	0,8964
20	0,7403	0,7539	0,7539	0,7425	0,7403	0,7146

**Capacity Correction Factors** | **COP Correction Factors**

Correction for temperatures     Correction for pressure     **Correction for part load**

**Chiller load, %**    **COP Correction Factor**

20	0,99
40	1,03
50	1,05
60	1,04
80	1,02
100	1



## Design in GTP: **Select the appropriate Design Point**

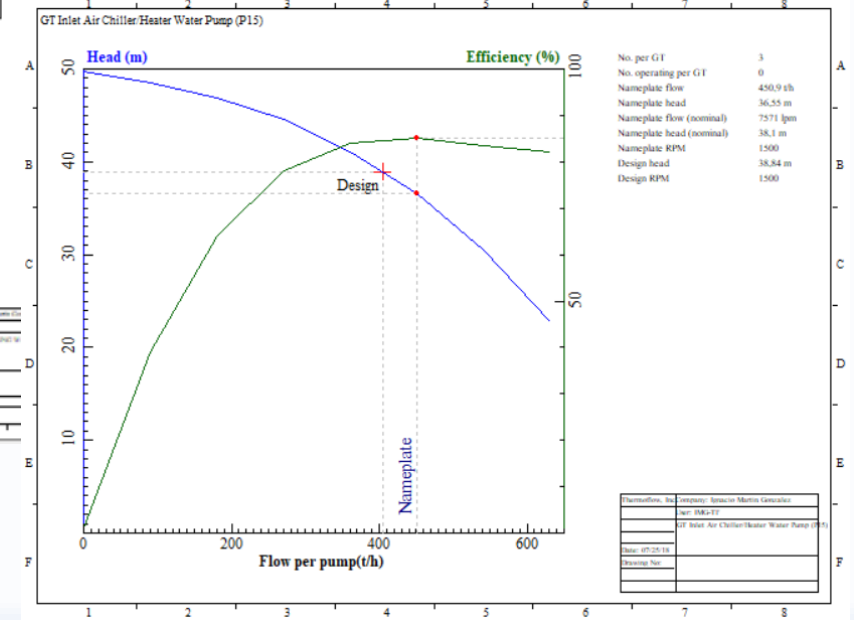
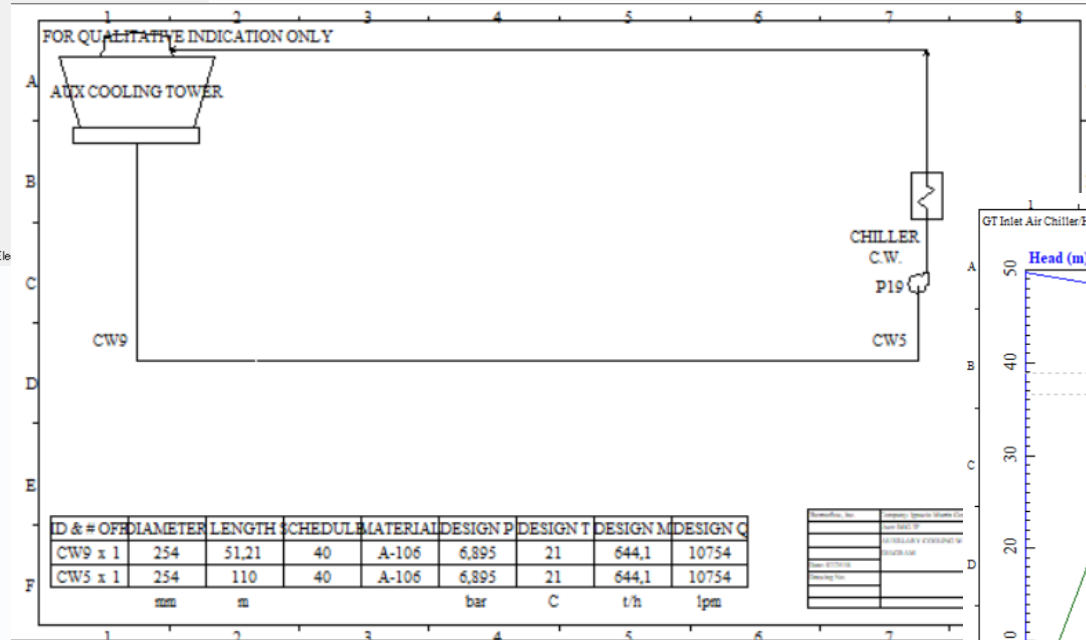
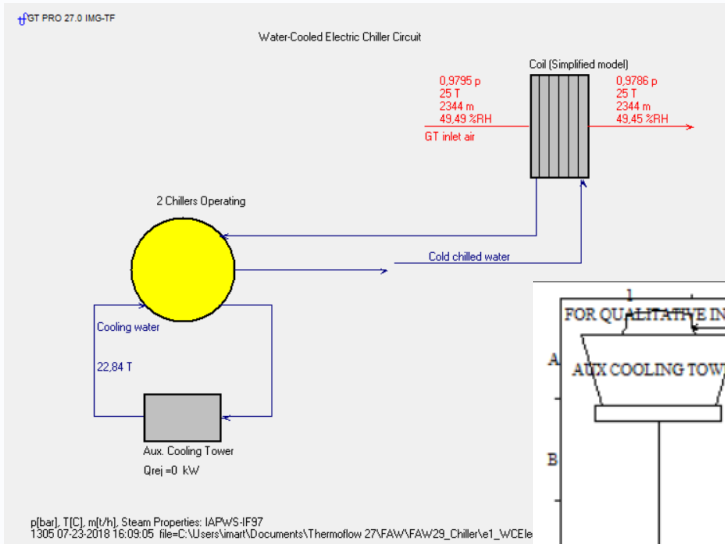
- If you want to design the Cooling System at the same conditions as the design point then select → *Use current Heat Balance data*
- If you want to design the Cooling System at different conditions than the design point then select → *User defined sizing* and enter the sizing criteria:
  - Chillers: *(kW of refrigeration) per (t/h of air)*
  - Evaporative Coolers / Foggers: *water mass flow / nominal air flow (%)*
- Please notice that the design conditions / sizing criteria will affect the equipment design and thus the off design performance
- You can resize the Cooling System:
  - In the conversion process GTP to GTM, *Multi Point Design* option
  - In GT Master directly, by manually manipulating the inputs

# Inlet Air Cooling Systems in GTP: **Outputs (Chiller)**

Estimated Chiller System Data		
<b>1. GT Inlet Chiller</b>		
	Reference data	
Type	Water cooled electric chiller	
Chiller cooling system	Auxiliary cooling tower	
Chiller nominal heat rejection to plant cooling tower	N/A	%
Nameplate cooling capacity @ standard conditions (each)	4719	kW
Chiller compressor motor power rating	895	kW
Length	5,4	m
Width	2,6	m
Weight	20.590	kg
Plant total number of chillers	2	
Reference chiller cost	777.300	USD
Reference coil cost	857.000	USD
Reference material cost	53.600	USD
Reference labor cost	77.950	USD
Reference Equipment+Material+Labor cost	1.766.000	USD
<b>2. Auxiliary Cooling Tower - per plant</b>		
Cell count	2	
Reference equipment cost	195.600	USD
Reference material cost	1.730	USD
Reference labor cost	9.700	USD
Reference Equipment+Material+Labor cost	207.000	USD
<b>3. Fin-fan Cooler - per plant</b>		
Cell count		
Reference equipment cost		
Reference material cost		
Reference labor cost		
Reference Equipment+Material+Labor cost		

<b>4. Chilled Water and Chiller Cooling Pumps - per plant</b>		
Reference equipment cost	159.250	USD
Reference material cost	2.800	USD
Reference labor cost	22.340	USD
Reference Equipment+Material+Labor cost	184.400	USD
<b>5. Chilled Water and Chiller Cooling Pipes - per plant</b>		
Reference material cost	302.600	USD
Reference labor cost	211.650	USD
Reference Material+Labor cost	514.300	USD
<b>6. Chilled Water Storage - per plant</b>		
Reference equipment cost		
Reference material cost		
Reference labor cost		
Reference Equipment+Material+Labor cost		
<b>7. Totals for Costs Included on this Report</b>		
Reference equipment cost	1.989.000	USD
Reference material cost	360.750	USD
Reference labor cost	321.650	USD
Reference Equipment+Material+Labor cost*	2.671.000	USD
*This cost summary is per plant, but does not include indirect costs from increases in site plan area, electrical, controls, engineering, soft costs, etc. to accommodate the chilling system. These indirect costs may be 50% to 70% of the above cost.		

# Inlet Air Cooling Systems in GTP: **Outputs (Chiller)**



# Inlet Air Cooling Systems Comparison @ Design Point

		No Cooling	Electric WC	Electric AC	Absorption 1st	Absorption 2st	Evap Cooling	Fog Underspray	Fog OS-1%
<b>OUTPUT VARIABLE DESCRIPTION</b>	<b>Units</b>								
Plant gross output	kW	438.475	437.980	437.980	437.980	437.952	437.949	438.475	438.475
Plant net output	kW	428.698	428.209	428.209	428.209	428.181	428.172	428.688	428.645
Plant net elec eff	%	58,1	58,1	58,1	58,1	58,1	58,1	58,1	58,1
GT gross power	kW	289.776	289.357	289.357	289.357	289.357	289.330	289.776	289.776
GT gross LHV eff	%	39,3	39,3	39,3	39,3	39,3	39,3	39,3	39,3
Gas turbine exhaust mass flow	t/h	2.399,3	2.397,0	2.397,0	2.397,0	2.397,0	2.396,8	2.399,3	2.399,3
Gas turbine exhaust temperature	C	615,3	615,5	615,5	615,5	615,5	615,5	615,3	615,3
ST gross power (plant total)	kW	148.699	148.623	148.623	148.623	148.595	148.619	148.699	148.699
Specific Investment	USD/kW	700	716	717	723	727	705	704	710
<b>COP</b>			5,25	3,5	0,67	1,1			
<b>Efectiveness</b>	%						85%	95%	
<b>OS</b>	%								1%
<b>DP</b>	mbar		0,94	0,94	0,94	0,94	1	0	0
<b>Sizing</b>			3,7	3,7	3,7	3,7	0,4	0,5	1,5
<b>Delta Cost</b>	USD/kW		16	16	23	27	5	4	10
	%		2,3%	2,4%	3,2%	3,8%	0,7%	0,6%	1,4%
	MUSD		6,7	6,7	9,3	11,1	1,6	1,7	4,1
<b>Equipment Cost</b>	USD		1.716.000	1.881.000	2.263.000	2.393.000	725.600	310.000	537.000

## Inlet Air Cooling Systems in **GTM**

- Equipment Need to be included in GT Pro
- Chillers
  - Electric
  - Absorption
  - External
- Evaporative Cooling
  - Evap Cooler “Media” type
  - Fogger
- Chilled Water Storage

## Operate in GTM: **Evaporative Cooler**

- Effectiveness
- Min operating Amb T
- Air Pressure Drop CF
- Cycles of Concentration
- Size: Water Flow Capacity

Include evaporative cooler

**Current Heat Balance**

Effectiveness	<input type="text" value="85"/>	%
Minimum operating ambient temperature	<input type="text" value="5"/>	C
Air pressure drop correction factor	<input type="text" value="1"/>	
Cycles of concentration	<input type="text" value="5"/>	

**Capacity**

Water flow capacity	<input type="text" value="10,2"/>	t/h
---------------------	-----------------------------------	-----

## Operate in GTM: Fogger

- Fogger specification
  - Underspray → Effectiveness
  - Overspray → % OS
- Mean Droplet Size
- Air Pressure Drop CF
- Min operating Amb T
- Capacity

**Fogger options**

Included - specify underspray

Included - specify overspray

Included - specify underspray

Included - specify percent load

**Current Heat Balance**

Mean droplet size

Ultra-fine

Overspray as percent of saturated air flow 0 %

Minimum operating ambient temperature 5 C

Air pressure drop correction factor 0

**Capacity**

Water flow capacity 12,75 t/h

# Operate in GTM: Chiller

Chiller
Coil
Heater
Evaporative Cooler

**Chiller Options**

Water-cooled electric chiller

**Coil Model**

Simplified

Chilled Water Pump Details

[Click here to edit chiller system pipe and tank details on the 'Pipes' and 'Tanks' tab of the 'Pipes, Pumps, etc.' PEACE ONLY topic.](#)

**Electric Chiller & Coil Operation Mode**

1) Direct Chilling

Chilled Water Storage 24-hr Model

**Current Heat Balance**

Specify chilled air temperature drop (DT) DT = 0 C

Air-side pressure drop correction factor 1

Number units running per GT 2

Minimum coil operating ambient temperature 5 C

Reduce chiller load when GT reaches power limit

**Unit Capacity**

Nameplate capacity @ standard conditions (each) 4719 kW

Number of chillers per GT 2

**Decoupled Operation Inputs**

Average chilled water temperature @ storage tank 7 C

Warm chilled water temperature 17 C

Chiller load percent 100 %

Maximum coil effectiveness 0

Minimum coil pinch temperature difference 1,111 C

Chilled water temperature rise from chiller exit to storage tank 0,5556 C

Chilled water temperature rise from storage tank to coil 0,5556 C

**Chiller Specification**

Nameplate COP		
Water-cooled electric chiller	5,25	0,6698 kW/ton
Air-cooled electric chiller	3,5	1,005 kW/ton
Single stage absorption chiller	0,67	
Two stage absorption chiller	1,1	

**User-defined chilled water flow**

Chilled water supply pressure	3,447 bar
Chilled water supply temperature	7 C
Nominal chilled water flow (per chiller)	405,8 t/h
Chilled water flow as % of nominal flow	100 %
Water pipe resistance coeff.	0,8784 m <sup>-4</sup>
Coil water-side resistance coeff.	0,732 m <sup>-4</sup>
Cooling water flow (per chiller)	467,9 t/h

Electric chiller power correction factor 1

Chilled water pump power correction factor 1

**Cooling Configuration**

Auxiliary cooling tower

**Chiller Performance Corrections**

Automatic

User-defined Edit Data

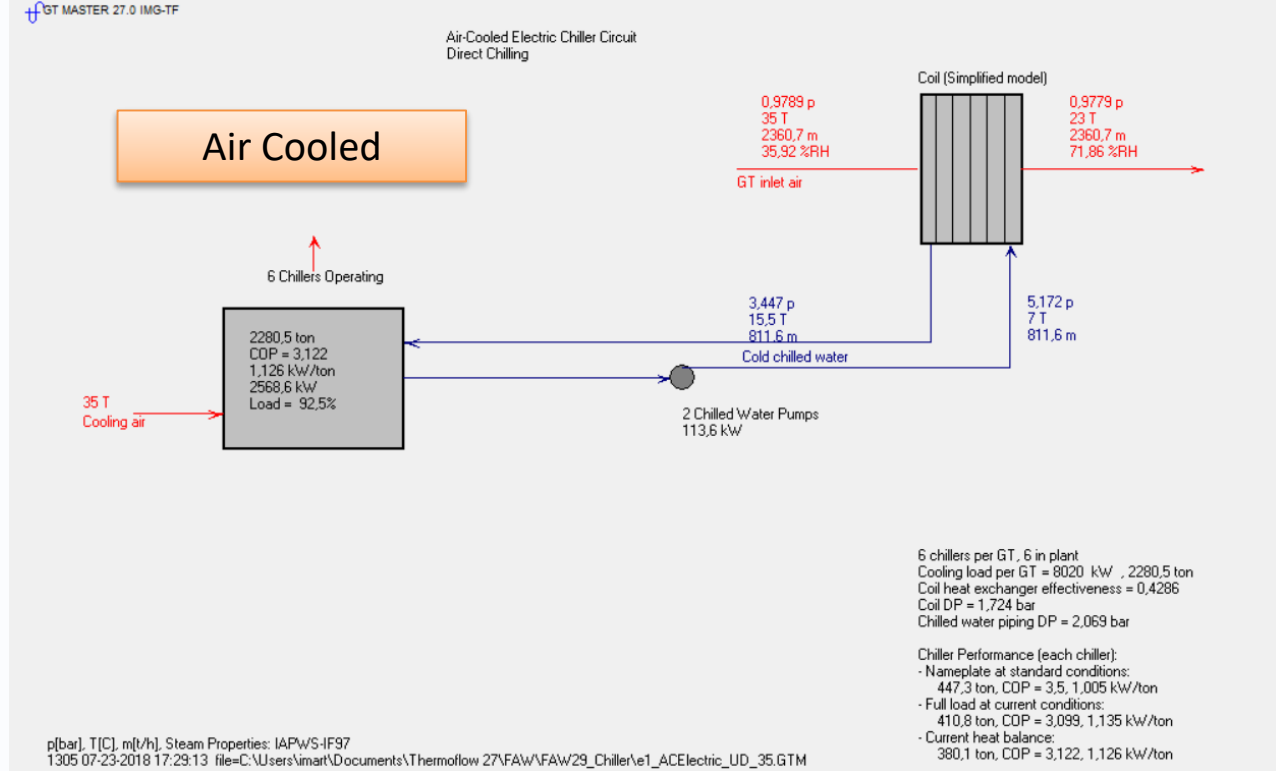
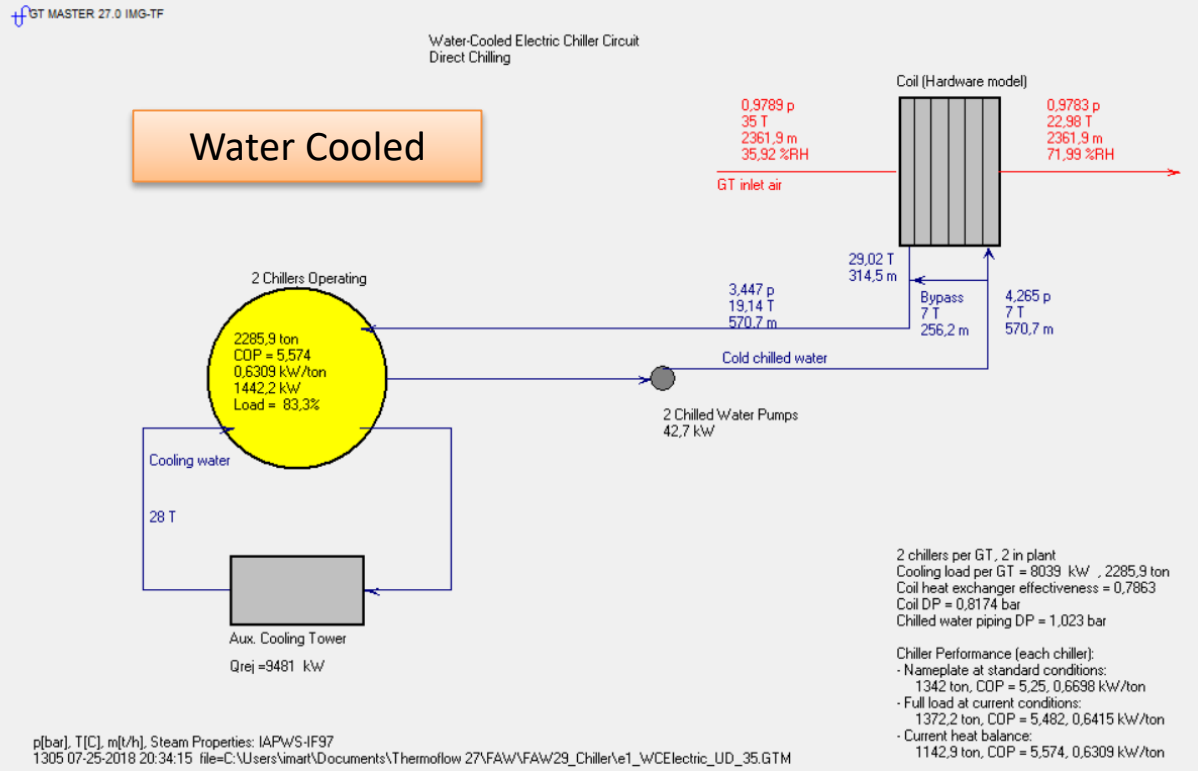


## Operate in GTM: **Chiller**

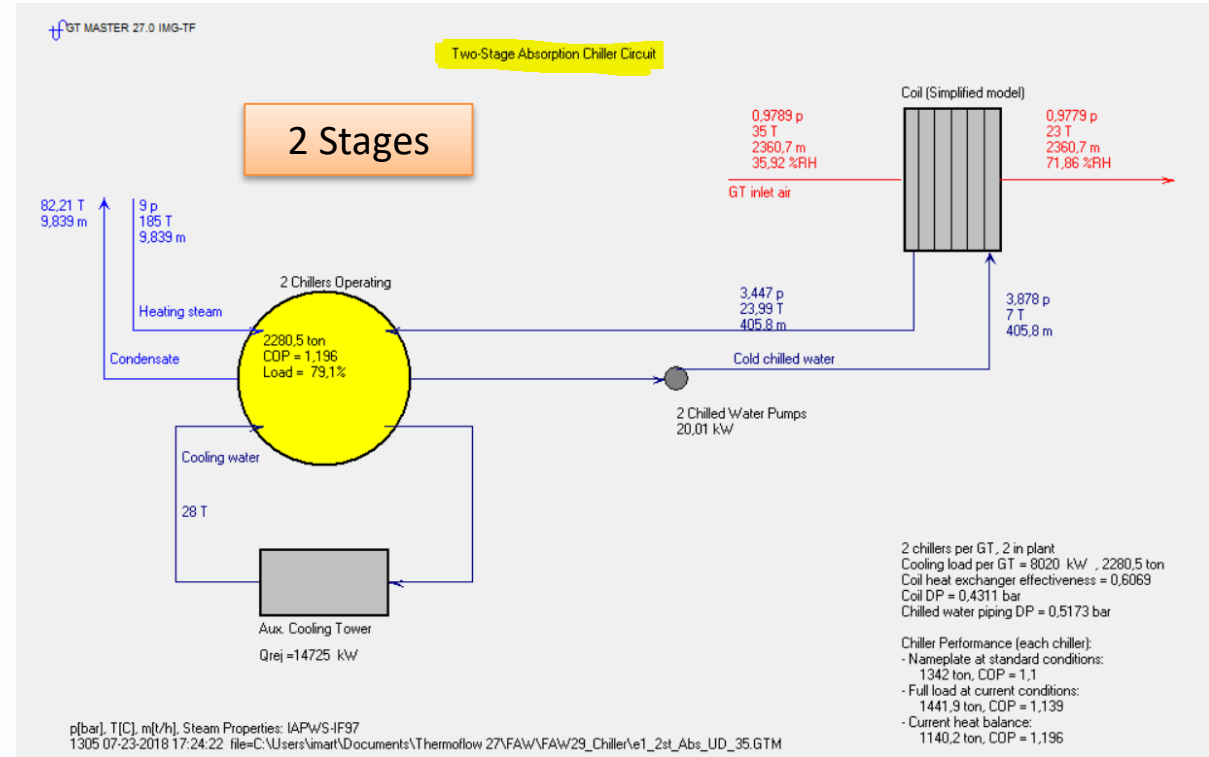
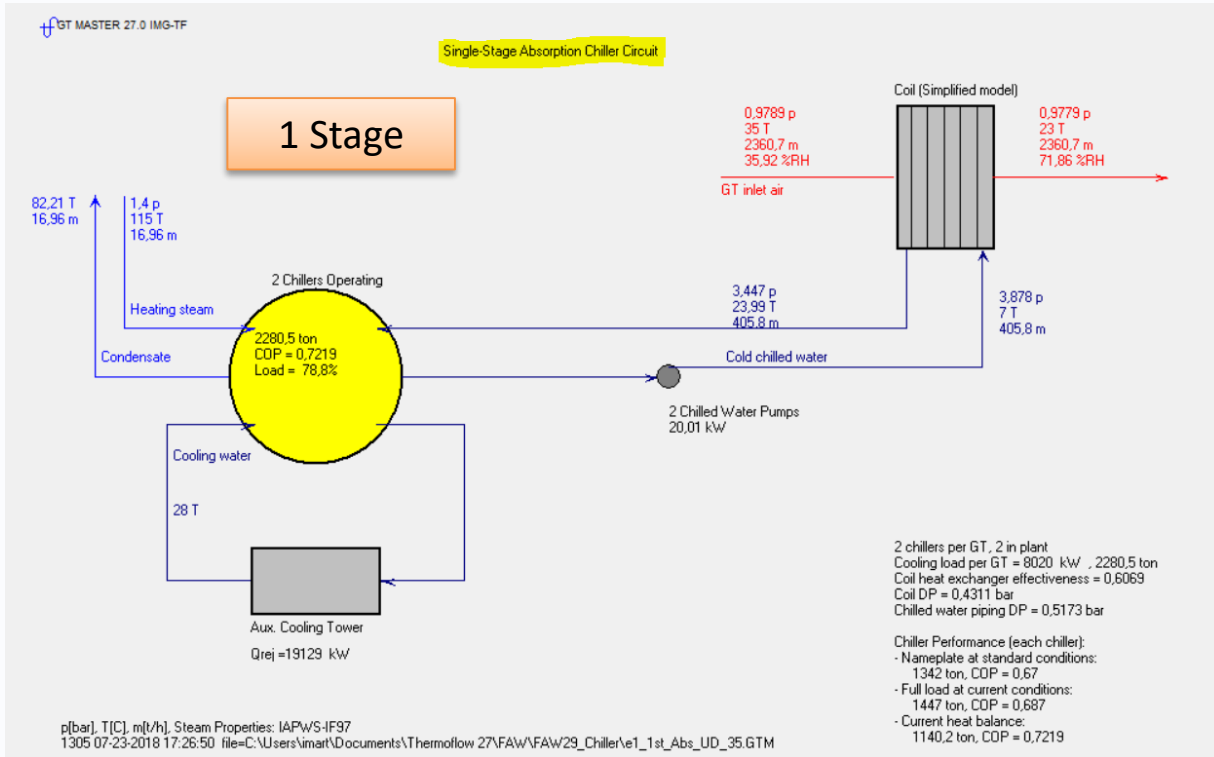
### Operation Parameters (no storage)

- Specify Air DT or exit T
- Number of Units running per GT
- Minimum Coil operating T
- Reduce Chiller load when GT reaches power limit
- Chilled water Flow: UD or calculated from resistance
- Performance Corrections
- Correction Factors (Air DP, Electric Power, ...)

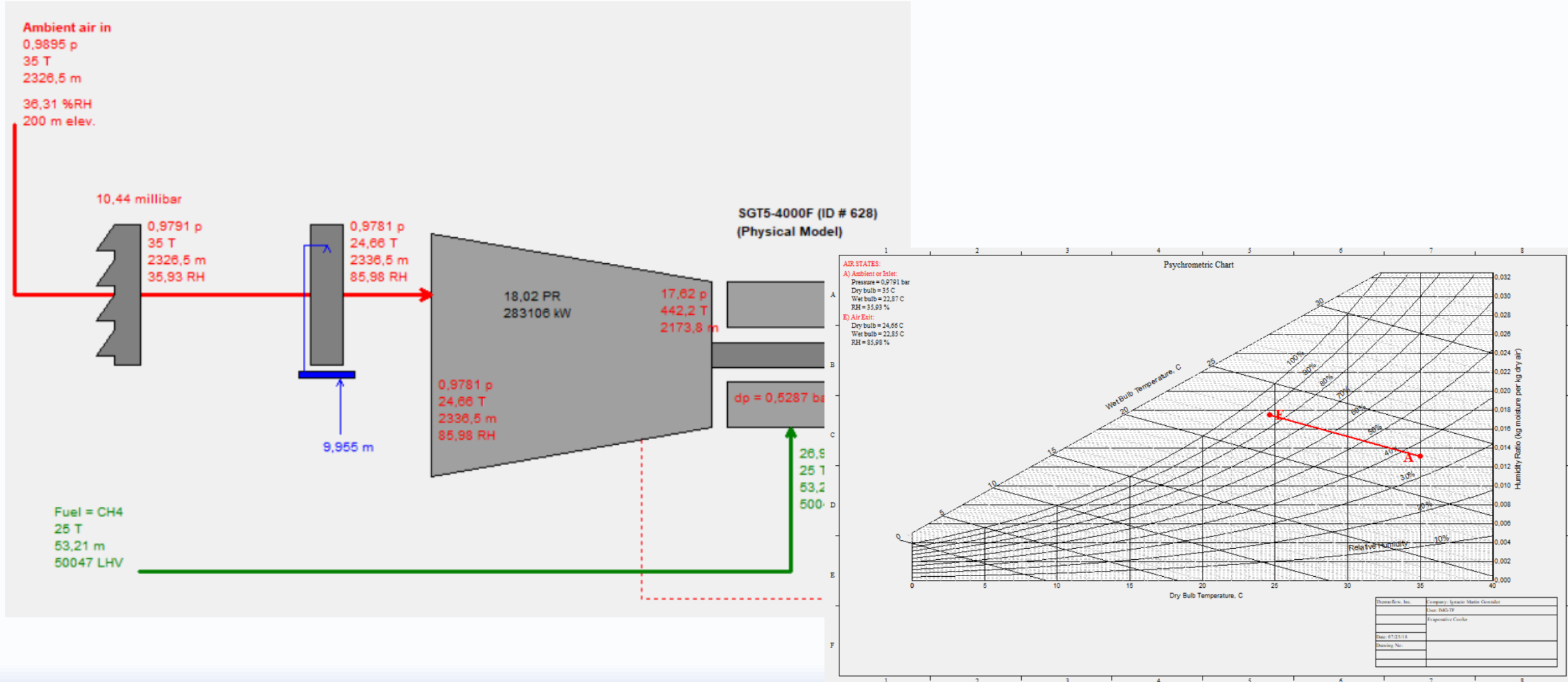
# Operate in GTM: Outputs (Electric Chiller)



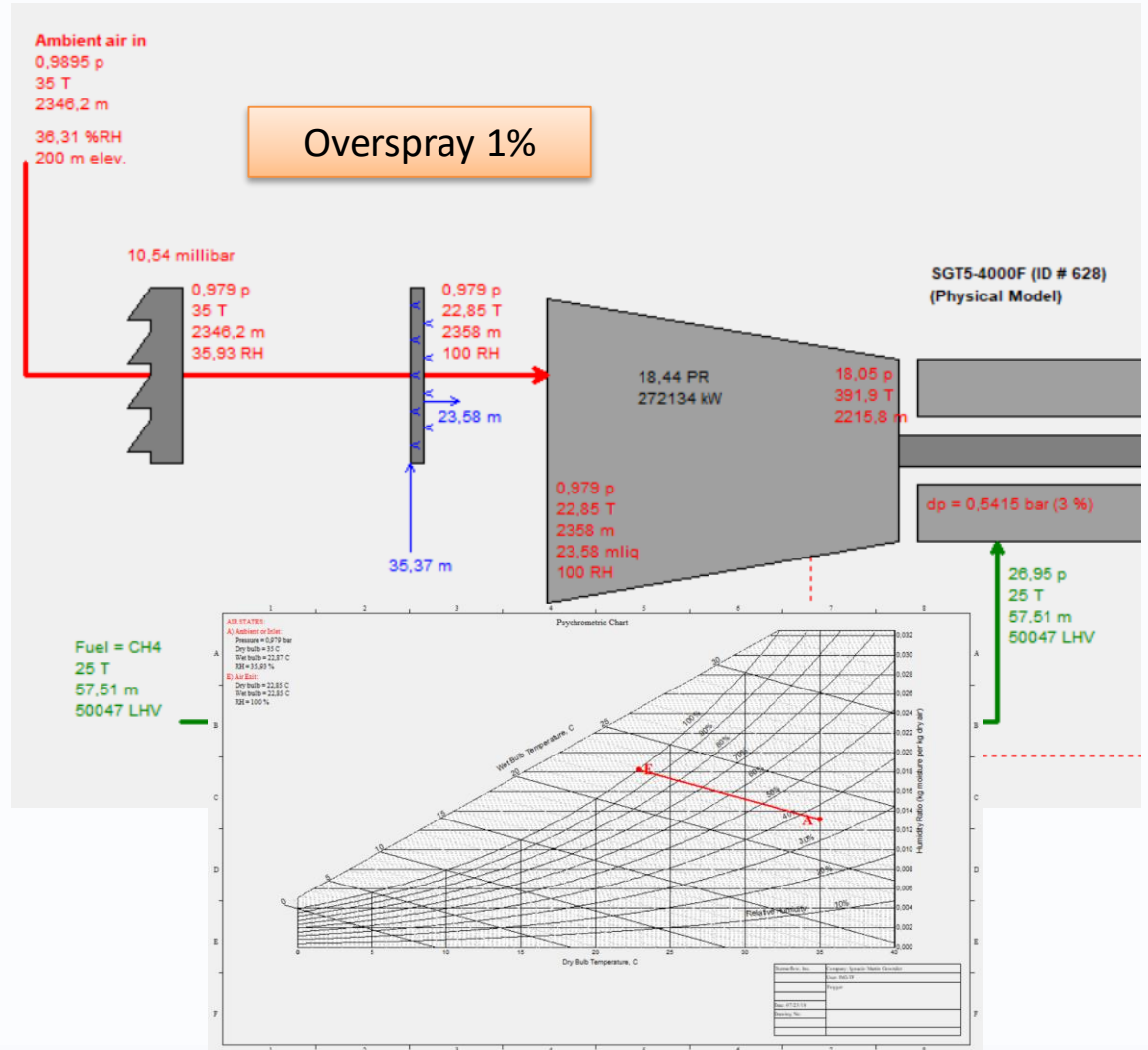
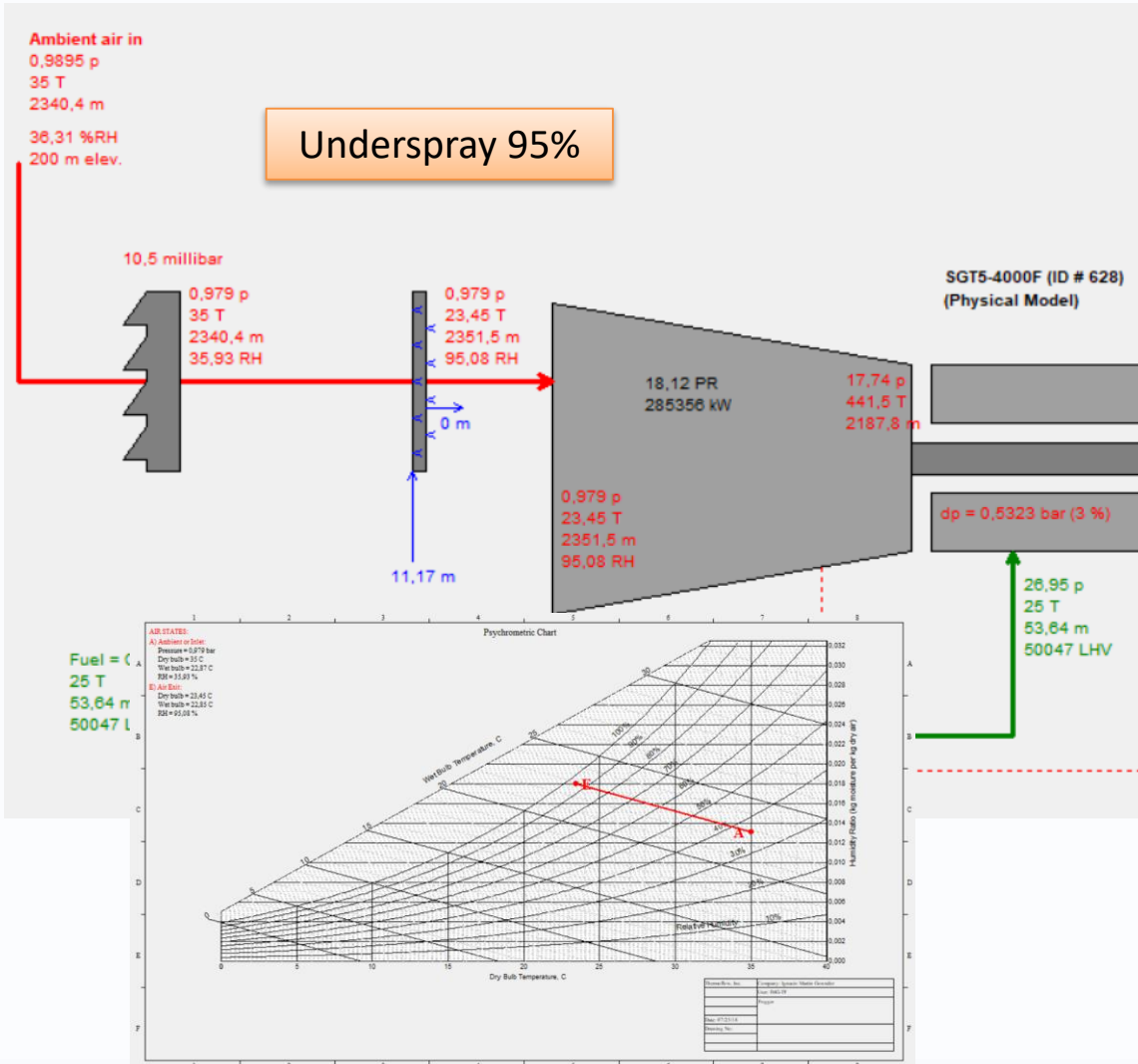
# Operate in GTM: Outputs (Absorption Chiller)



# Operate in GTM: Outputs (Evaporative Cooler)



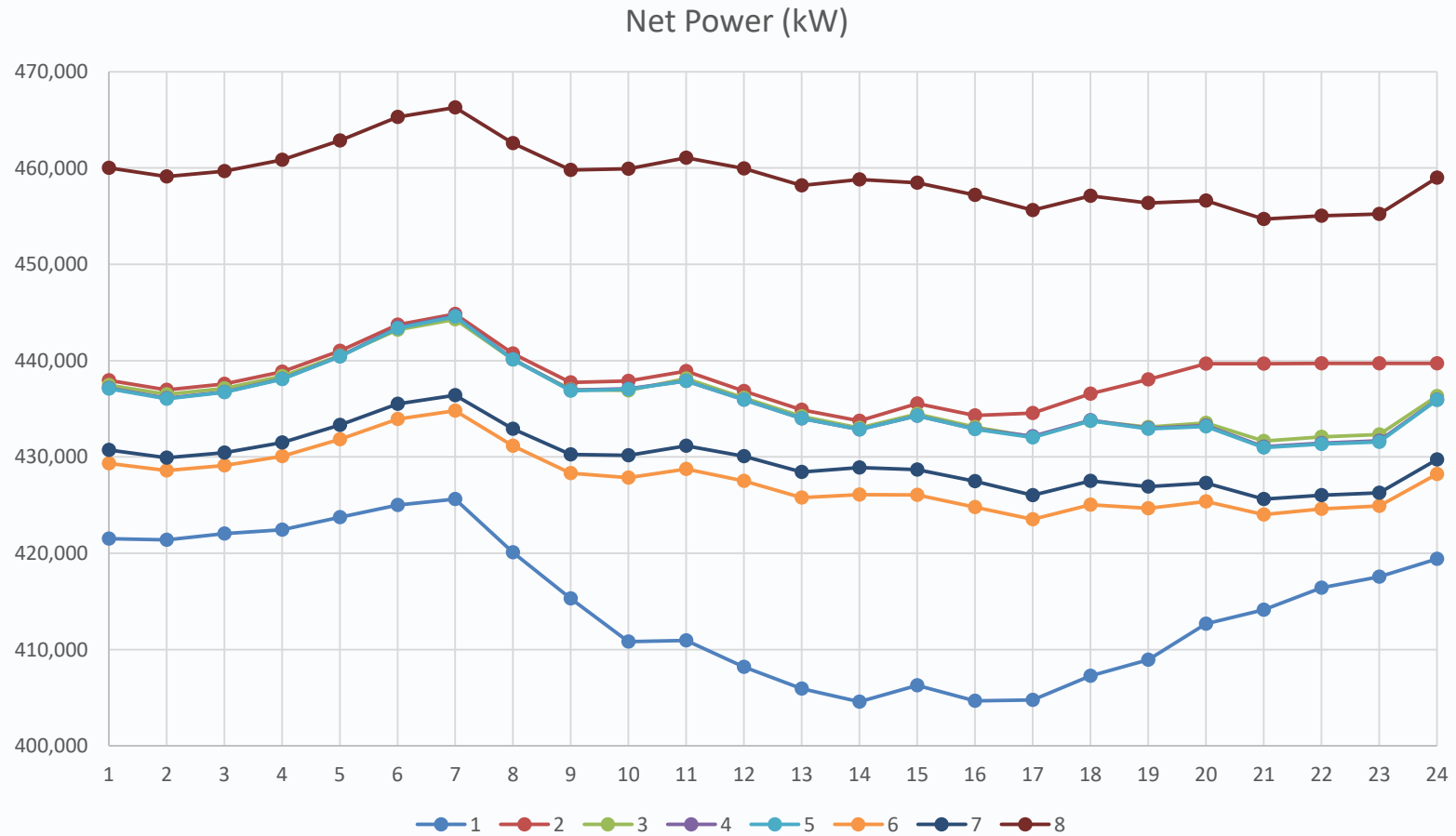
# Operate in GTM: Outputs (Fogger)



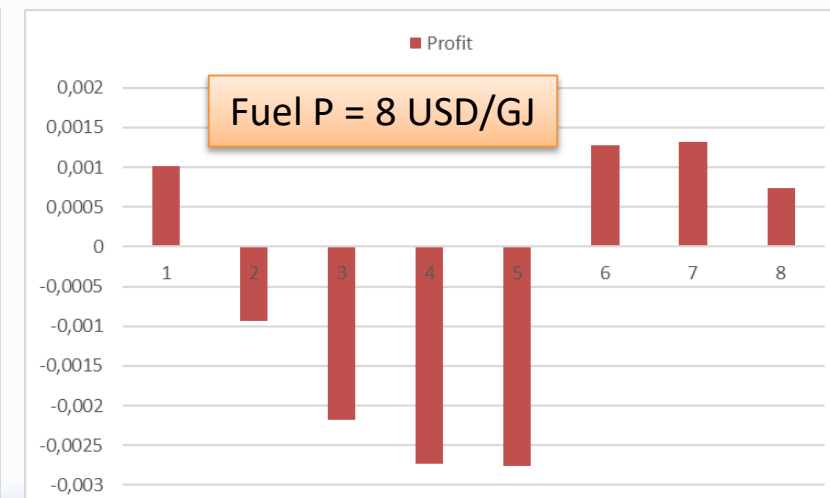
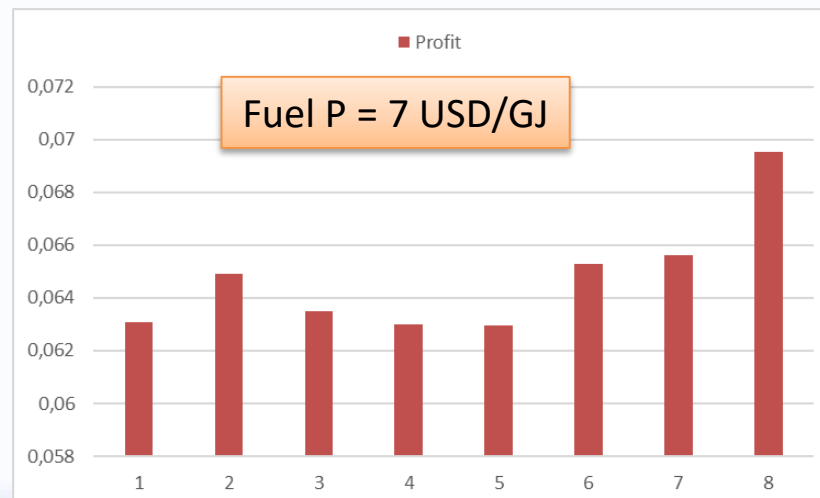
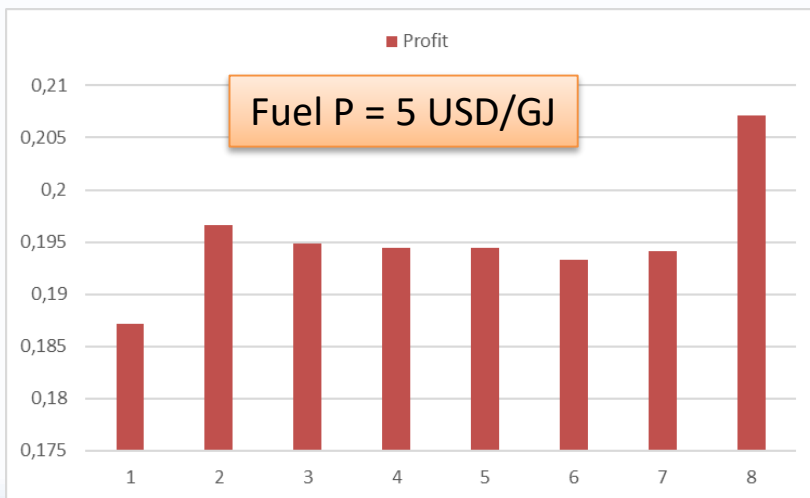
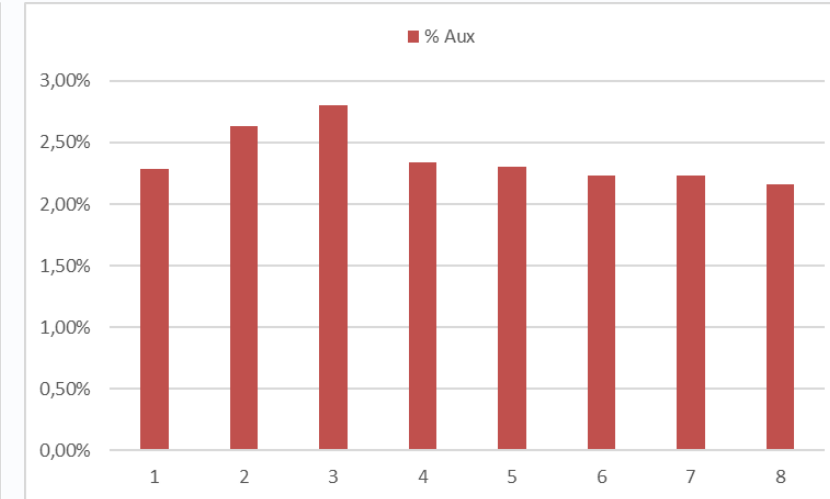
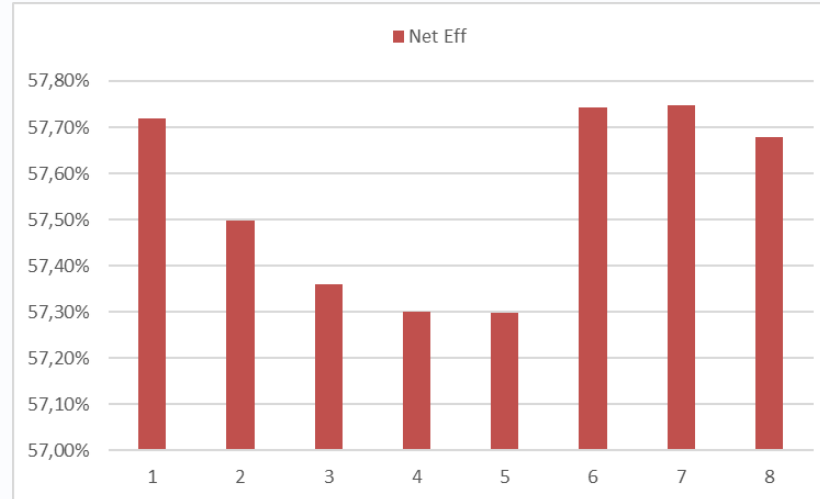
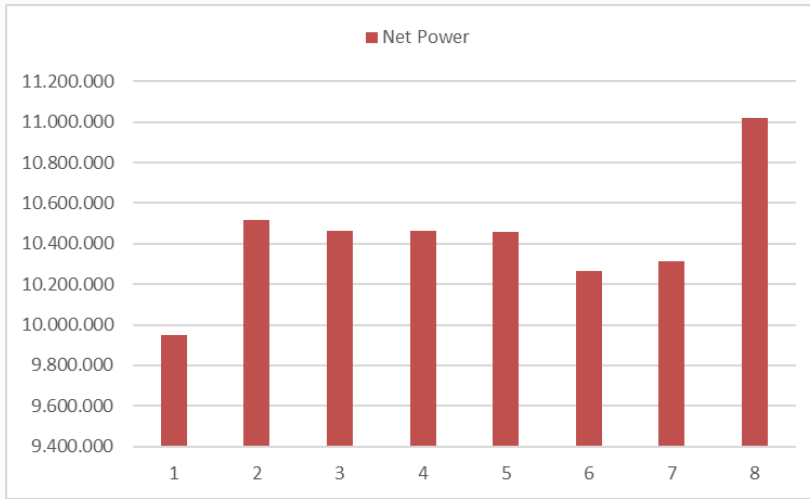
# Inlet Air Cooling Systems Comparison @ Off Design: 35C-36%RH

		No Cooling	Electric WC	Electric AC	Absorption 1st	Absorption 2st	Evap Cooling	Fog Underspray	Fog OS-1%
Ambient temperature	C	35,0	35,0	35,0	35,0	35,0	35,0	35,0	35,0
Ambient relative humidity	%	36,3	36,3	36,3	36,3	36,3	36,3	36,3	36,3
Plant gross output	kW	408.955	440.930	440.930	438.831	438.689	437.342	440.864	471.670
Plant net output	kW	399.370	429.343	428.468	428.458	428.481	427.579	431.012	461.461
Plant net elec eff	%	57,7	57,6	57,4	57,4	57,5	57,8	57,8	57,7
GT Power	kW	266.613	293.516	293.516	293.517	293.521	290.110	293.164	321.849
GT gross LHV eff	%	38,5	39,4	39,4	39,4	39,4	39,2	39,3	40,3
Compressor inlet temperature	C	35,0	23,0	23,0	23,0	23,0	24,7	23,5	22,8
Gas turbine exhaust mass flow	t/h	2.271,5	2.414,3	2.414,3	2.414,3	2.414,3	2.389,7	2.405,2	2.439,1
Gas turbine exhaust temperature	C	624,4	614,1	614,1	614,1	614,1	615,7	614,6	611,5
ST gross output (plant total)	kW	142.342	147.414	147.414	145.313	145.168	147.233	147.701	149.820
Steam cycle gross eff	%	34,1	33,9	33,9	33,4	33,4	34,0	33,9	33,7
Aux Power	kW	9.585	11.587	12.462	10.373	10.208	9.764	9.853	10.208
	%	2,3%	2,6%	2,8%	2,4%	2,3%	2,2%	2,2%	2,2%
Delta Power GT	kW		26.903	26.903	26.904	26.908	23.497	26.550	55.236
Delta Power ST	kW		5.072	5.072	2.972	2.827	4.891	5.359	7.479
Delta Power total, net	kW		29.973	29.097	29.087	29.111	28.208	31.641	62.091
	%		7,5%	7,3%	7,3%	7,3%	7,1%	7,9%	15,5%
Delta Eff GT	%		0,8	0,8	0,8	0,8	0,7	0,8	1,7
Delta Eff Steam Cycle	%		-0,3	-0,3	-0,7	-0,8	-0,2	-0,2	-0,4
Delta Eff total net	%		-0,1	-0,3	-0,3	-0,3	0,1	0,1	0,0
Consumption	kW pumps		188,6	113,6	195,0	130,0		59,6	185,0
	kW elect/ther		1.439	2.569	11.109	6.705			
	t/h				17,0	9,8	10,0	11,2	35,4

# Inlet Air Cooling Systems Comparison @ Off Design: 24 Hours



# Inlet Air Cooling Systems Comparison @ Off Design: 24 Hours





# Inlet Air Cooling Systems Comparison @ Off Design

## Entire Year Simulation

- System Selection & Optimization
- Use TIME
- Use ELink

# Operate in GTM: **Chiller w/ Storage**

## Electric Chiller & Coil Operation Mode

- 1) Direct Chilling
- 1) Direct Chilling
- 2) Decoupled - Chiller On, Coil Off
- 3) Decoupled - Chiller Off, Coil On
- 4) Decoupled - Chiller On, Coil On

## Decoupled Operation Inputs

Average chilled water temperature @ storage tank	<input type="text" value="7"/>	C
Warm chilled water temperature	<input type="text" value="17"/>	C
Chiller load percent	<input type="text" value="100"/>	%
Maximum coil effectiveness	<input type="text" value="0,75"/>	
Minimum coil pinch temperature difference	<input type="text" value="1,111"/>	C
Chilled water temperature rise from chiller exit to storage tank	<input type="text" value="0,5556"/>	C
Chilled water temperature rise from storage tank to coil	<input type="text" value="0,5556"/>	C

Chilled Water Storage 24-hr Model

## Operate in GTM: **Chiller w/ Storage**

- 1) **Direct Chilling**: The chiller and coil are integrated, operating in a closed loop with no chilled water storage involved. The air temperature drop across the coil dictates the load placed upon the chiller, except that it may be limited by the chiller capacity or the coil effectiveness.
- 2) **Decoupled - Chiller On, Coil Off**: The chiller is operating but the coil is not. The chilled water produced by the chiller goes directly to the storage. The air temperature drop across the coil will be zero. The chiller's load is dictated by the Chiller Load Percent entry described below.
- 3) **Decoupled - Chiller Off, Coil On**: The coil is operating but the chiller is not. The coil is supplied with chilled water from the storage. The chiller power consumption will be zero. The coil's cooling load is dictated by the prescribed inlet air temperature drop.
- 4) **Decoupled - Chiller On, Coil On**: Both chiller and coil are operating, but loads are independently set. If the chiller produces more chilled water than requested by the coil, the surplus will go to the storage. On the other hand, if the chiller produces less chilled water than requested by the coil, the deficit will come from the storage

# Operate in GTM: Chiller w/ Storage 24 Hours

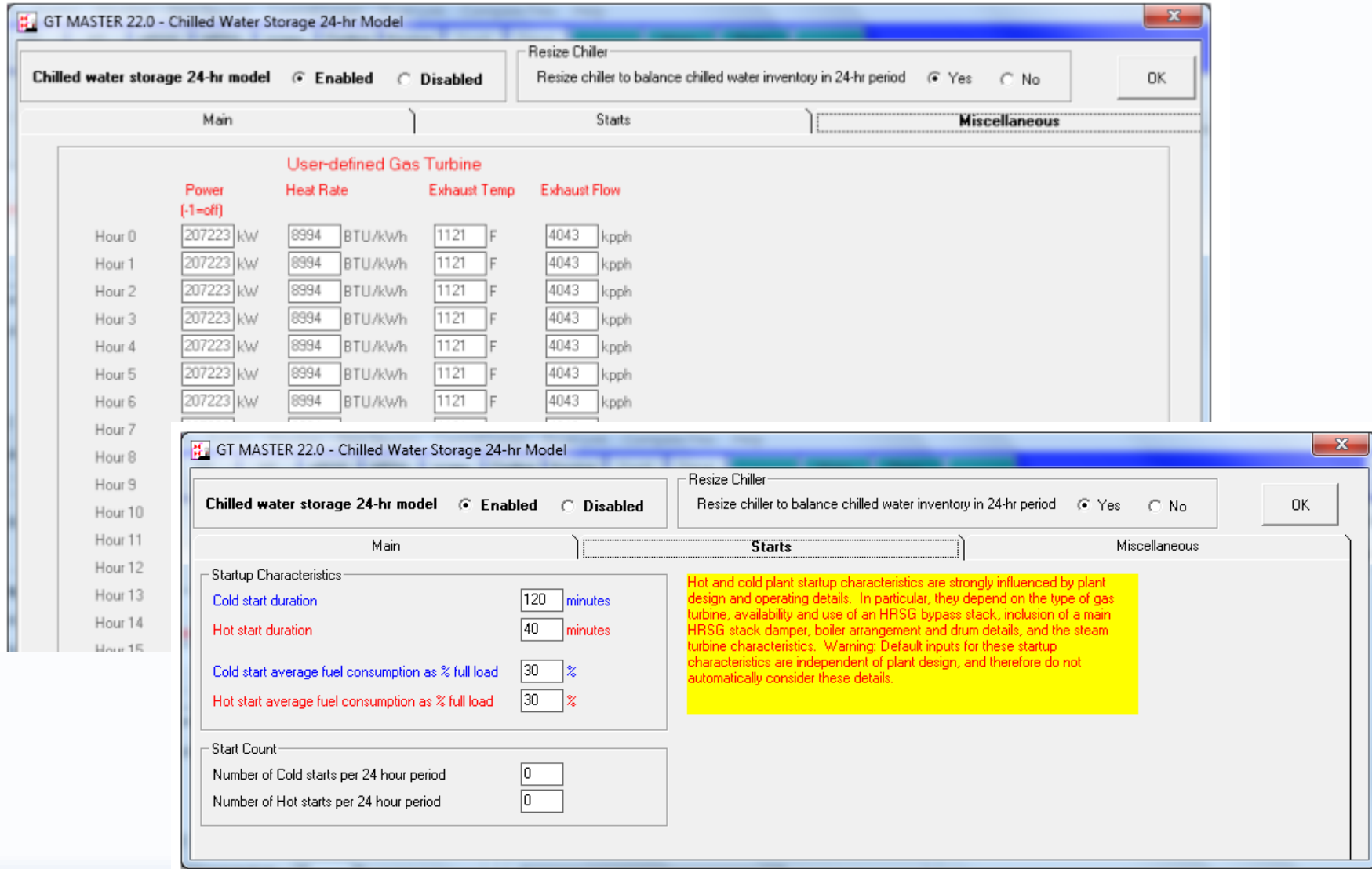
GT MASTER 22.0 - Chilled Water Storage 24-hr Model

Chilled water storage 24-hr model  Enabled  Disabled

Resize Chiller  
 Resize chiller to balance chilled water inventory in 24-hr period  Yes  No OK

24-hr Cycle Parameters	Main			Starts		Miscellaneous				
	Ambient T	Ambient RH	GT Load % or kW (-1=off)	Chiller Status (0=Off, 1=On)	Chiller Load	Coil Status (0=Off, 1=On)	Coil exit air temperature	DB Q/HRSG kBTU/hr	2nd DB Q/HRSG kBTU/hr	Process heat [% nominal]
Hour 0	65 F	70 %	60	1	100 %	0	65 F	0	0	100 %
Hour 1	64 F	70 %	60	1	100 %	0	61 F	0	0	100 %
Hour 2	64 F	70 %	60	1	100 %	0	61 F	0	0	100 %
Hour 3	63 F	70 %	60	1	100 %	0	61 F	0	0	100 %
Hour 4	63 F	70 %	60	1	100 %	0	63 F	0	0	100 %
Hour 5	62 F	70 %	60	1	100 %	0	62 F	0	0	100 %
Hour 6	62 F	70 %	60	1	100 %	0	62 F	0	0	100 %
Hour 7	65 F	70 %	70	1	100 %	0	65 F	0	0	100 %
Hour 8	70 F	65 %	80	1	100 %	1	65 F	0	0	100 %
Hour 9	75 F	65 %	90	1	100 %	1	65 F	0	0	100 %
Hour 10	80 F	60 %	100	1	100 %	1	65 F	0	0	100 %
Hour 11	82 F	60 %	100	0	100 %	1	65 F	0	0	100 %
Hour 12	85 F	55 %	100	0	100 %	1	65 F	0	0	100 %
Hour 13	87 F	55 %	100	0	100 %	1	65 F	0	0	100 %
Hour 14	89 F	55 %	100	0	100 %	1	65 F	0	0	100 %
Hour 15	92 F	50 %	100	0	100 %	1	65 F	0	0	100 %
Hour 16	92 F	50 %	100	0	100 %	1	65 F	0	0	100 %
Hour 17	90 F	55 %	100	0	100 %	1	65 F	0	0	100 %
Hour 18	85 F	55 %	100	1	100 %	1	65 F	0	0	100 %
Hour 19	85 F	55 %	100	1	100 %	1	65 F	0	0	100 %
Hour 20	80 F	60 %	90	1	100 %	0	65 F	0	0	100 %
Hour 21	75 F	65 %	80	1	100 %	0	65 F	0	0	100 %
Hour 22	70 F	65 %	70	1	100 %	0	65 F	0	0	100 %
Hour 23	68 F	70 %	60	1	100 %	0	65 F	0	0	100 %

# Operate in GTM: Chiller w/ Storage 24 Hours



The screenshot displays the 'GT MASTER 22.0 - Chilled Water Storage 24-hr Model' interface. It features a 'Chilled water storage 24-hr model' section with 'Enabled' selected, and a 'Resize Chiller' dialog box with 'Yes' selected. The 'Main' tab is active, showing a table of 'User-defined Gas Turbine' data for hours 0 through 15. The 'Starts' tab is also visible, containing 'Startup Characteristics' and 'Start Count' sections. A yellow warning box is present in the 'Starts' section.

	Power (-1=off)	Heat Rate	Exhaust Temp	Exhaust Flow
Hour 0	207223 kW	8994 BTU/kWh	1121 F	4043 kpph
Hour 1	207223 kW	8994 BTU/kWh	1121 F	4043 kpph
Hour 2	207223 kW	8994 BTU/kWh	1121 F	4043 kpph
Hour 3	207223 kW	8994 BTU/kWh	1121 F	4043 kpph
Hour 4	207223 kW	8994 BTU/kWh	1121 F	4043 kpph
Hour 5	207223 kW	8994 BTU/kWh	1121 F	4043 kpph
Hour 6	207223 kW	8994 BTU/kWh	1121 F	4043 kpph
Hour 7				
Hour 8				
Hour 9				
Hour 10				
Hour 11				
Hour 12				
Hour 13				
Hour 14				
Hour 15				

**Startup Characteristics:**

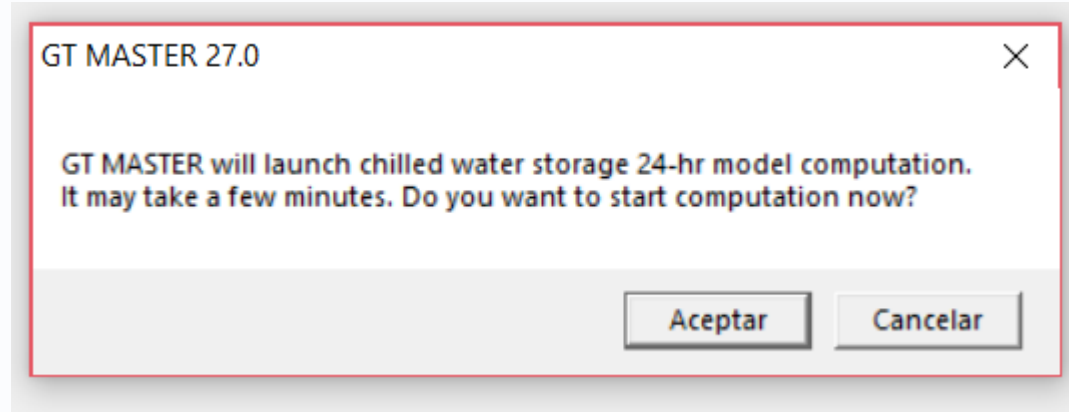
- Cold start duration: 120 minutes
- Hot start duration: 40 minutes
- Cold start average fuel consumption as % full load: 30 %
- Hot start average fuel consumption as % full load: 30 %

**Start Count:**

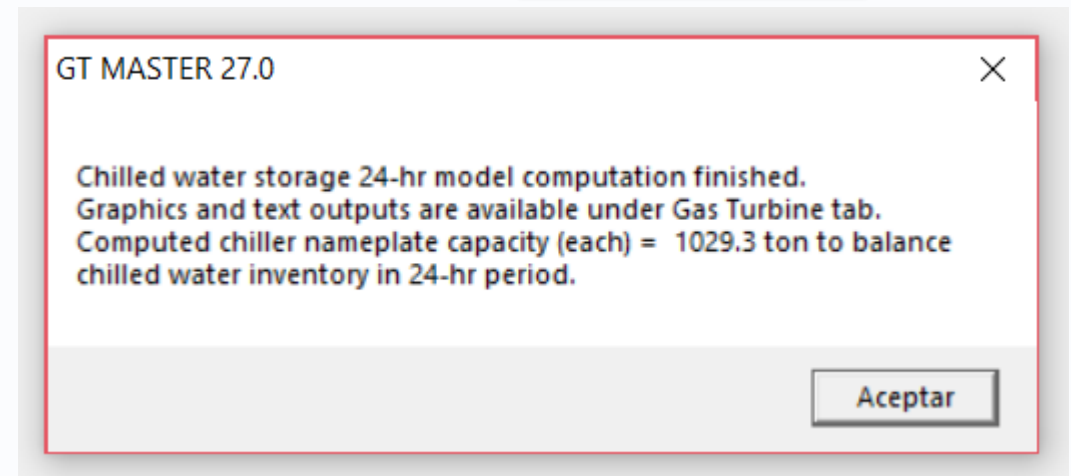
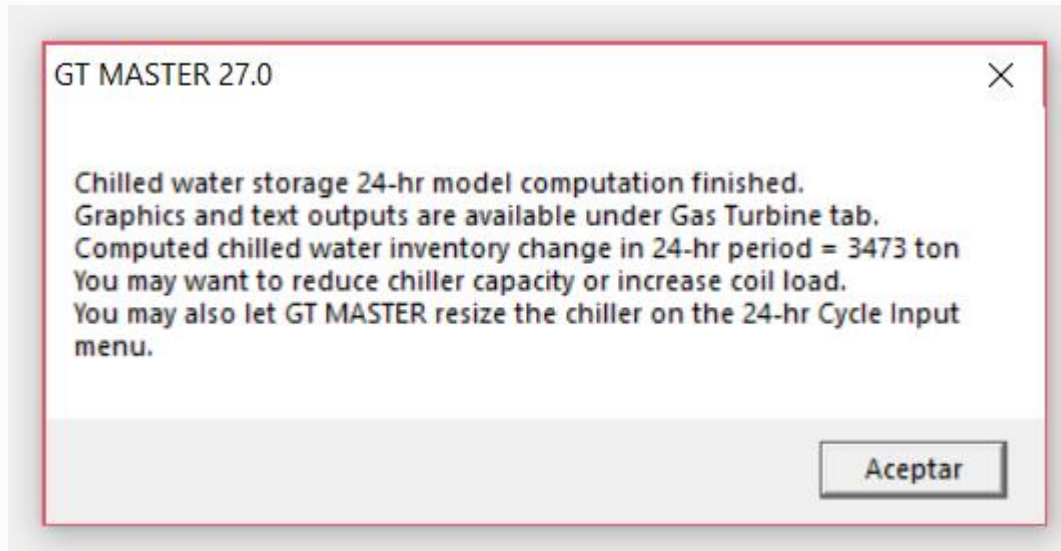
- Number of Cold starts per 24 hour period: 0
- Number of Hot starts per 24 hour period: 0

**Warning:** Hot and cold plant startup characteristics are strongly influenced by plant design and operating details. In particular, they depend on the type of gas turbine, availability and use of an HRSG bypass stack, inclusion of a main HRSG stack damper, boiler arrangement and drum details, and the steam turbine characteristics. Warning: Default inputs for these startup characteristics are independent of plant design, and therefore do not automatically consider these details.

# Operate in GTM: **Chiller w/ Storage 24 Hours**



**Resizing**

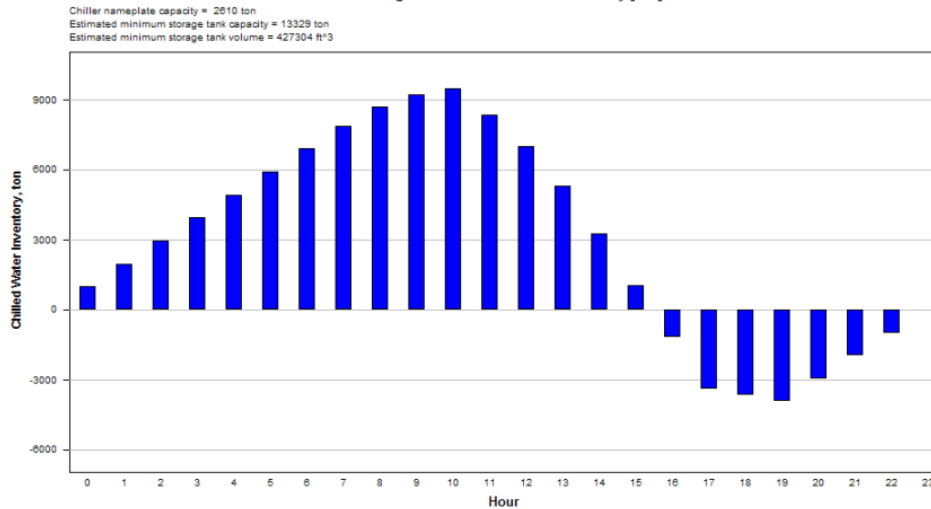


# Operate in GTM: Chiller w/ Storage 24 Hours

CHILLED WATER STORAGE 24-HR MODEL SUMMARY		
Total electricity export	12.6	10 <sup>6</sup> kWh
Total gas turbine fuel LHV import	78.53	GBTU
Total duct burner fuel LHV import	0	GBTU
Total heat export	0	GBTU
Plant average LHV heat rate (excl. starts)	6231	BTU/kWh
Number of cold starts in 24-hr period (user-defined)	0	
Number of hot starts in 24-hr period (user-defined)	0	
Plant average LHV heat rate (incl. starts)	6231	BTU/kWh
<b>Electric chillers</b>		
- Number of chillers in plant	4	
- Chiller nameplate capacity @ standard conditions (each)	652.5	ton (R)
- Chiller nameplate capacity @ standard conditions (plant total)	2610	ton (R)
- Total chiller power consumption in 24-hr period	32124	kWh
<b>Storage tank</b>		
- Estimated minimum storage tank capacity	13329	ton water
- Estimated minimum storage tank volume	427304	ft <sup>3</sup>
- Total chilled water inventory gain in 24-hr period	0.0131	ton

HOURLY REPORT - I										
Hour	Tamb	GT Load % or kW	Chiller			Coil			CW to Storage	CW Inventory
			CW ton	Load %	Capacity ton (R)	CW ton	Air DT F	Tair out F		
0	65	60	983.5	100	3114	0	0	65	983.5	983.5
1	64	60	984	100	3116	0	0	64	984	1967.5
2	64	60	984	100	3116	0	0	64	984	2951.5
3	63	60	984.4	100	3117	0	0	63	984.4	3936
4	63	60	984.4	100	3117	0	0	63	984.4	4920
5	62	60	984.6	100	3118	0	0	62	984.6	5905
6	62	60	984.6	100	3118	0	0	62	984.6	6889
7	65	70	982.9	100	3113	0	0	65	982.9	7872
8	70	80	1162	100	3134	352.1	5	65	809.9	8862
9	75	90	1064.2	100	3104	532.2	10	65	532	9214
10	80	100	1024.9	100	3075	802.8	15	65	222	9436
11	82	100	0	0	0	1129.4	17	65	-1129.4	8307
12	85	100	0	0	0	1333.8	20	65	-1333.8	6973
13	87	100	0	0	0	1681.9	22	65	-1681.9	5291
14	89	100	0	0	0	2044.5	24	65	-2044.5	3247
15	92	100	0	0	0	2209.6	27	65	-2209.6	1037.1
16	92	100	0	0	0	2209.6	27	65	-2209.6	-1172.5
17	90	100	0	0	0	2231.5	25	65	-2231.5	-3404
18	85	100	1015.3	100	3046	1259.7	20	65	-244.4	-3648
19	85	100	1015.3	100	3046	1259.7	20	65	-244.4	-3893
20	80	90	961.5	100	3045	0	0	80	961.5	-2931.2
21	75	80	970.5	100	3073	0	0	75	970.5	-1960.7
22	70	70	979.5	100	3102	0	0	70	979.5	-981.2
23	68	60	981.2	100	3107	0	0	68	981.2	0.0128

Storage Tank Chilled Water Inventory [ton]



HOURLY REPORT - II							
Hour	Plant Net		Gas Turbine Output kW	ST Output kW	Aux. Load kW	Elec. Chiller kW	Fuel Flow kpph
	Output kW	Heat Rate BTU/kWh					
0	420513	6510	252200	183703	15390	1852.2	127.2
1	421199	6509	252793	183799	15393	1847.2	127.4
2	421199	6509	252793	183799	15393	1847.2	127.4
3	421880	6508	253387	183887	15393	1842	127.6
4	421880	6508	253387	183887	15393	1842	127.6
5	422553	6508	253982	183966	15395	1836.8	127.8
6	422553	6508	253982	183966	15395	1836.8	127.8
7	471050	6362	293196	193594	15740	1857.1	139.3
8	519842	6248	333924	202253	16335	1933.3	151
9	567492	6154	374382	209753	16643	1954.4	162.3
10	613780	6073	414439	216269	16928	1967.1	173.2
11	615704	6054	414453	216175	14923	0	173.2
12	615464	6057	414448	215941	14925	0	173.2
13	615037	6061	414445	215517	14925	0	173.2
14	614557	6066	414441	215046	14930	0	173.2
15	614327	6068	414437	214821	14931	0	173.2
16	614327	6068	414437	214821	14931	0	173.2
17	614299	6068	414439	214791	14931	0	173.2
18	613188	6079	414448	215673	16932	1975.8	173.2
19	613188	6079	414448	215673	16932	1975.8	173.2
20	553272	6161	361130	208453	16311	1915	158.4
21	511276	6254	326076	201235	16035	1899.8	148.6
22	467096	6367	289741	193081	15727	1874.8	138.2
23	418401	6513	250429	183359	15386	1867.3	126.7

## Q & A Session

- Please forward your questions on the WebEx Chat
- Further questions by email to: [info@thermoflow.com](mailto:info@thermoflow.com)
  
- PP Presentation will be available on the Website / Tutorials
- Video will be available on the Service Center



# Thank you!

IGNACIO MARTIN - SPAIN    [martin@thermoflow.com](mailto:martin@thermoflow.com)