Better Plants
U.S. DEPARTMENT OF ENERGY

Industrial Process Cooling (Chilled Water) Systems

Virtual INPLT Training & Assessment

Session 4

Thursday – August 6, 2026

2:00 pm – 4:30 pm ET

U.S. DEPARTMENT OF ENERGY

Welcome

- Welcome to the 4th Chilled Water Systems Virtual INPLT training series
- Eight, 2-1/2 hour webinars, focused on Industrial Process Cooling (Chilled Water) Systems Energy Assessment and Optimization
- These webinars will help you gain a significant understanding of your industrial process cooling system, undertake an energy assessment using a systems approach, evaluate and quantify energy and cost-saving opportunities using MEASUR and other US DOE tools and resources
- Thank you for your interest!

Process Cooling (Chilled Water Systems) Virtual INPLT Facilitators

Riyaz Papar, PE, CEM, Fellow – ASME, ASHRAE

Industrial Technologies Advisor
Oak Ridge National Laboratory

paparra@ornl.gov
(346) 610 8787

Ghanshyam (Shyam) Gaudani, PE

Principal
Green System Consulting LLC

g@greensystemio.com
(401) 636 5846

Process Cooling Virtual INPLT Agenda (2026)

- Session 1 (July 16) – Industrial Chilled Water Systems Fundamentals
- Session 2 (July 23) – Review of Chilled Water System Scoping Tool; Efficiency Metrics & Calculations
- Session 3 (July 30) – Introduction to Process Cooling Assessment (using MEASUR)
- **Session 4 (August 6) – Using MEASUR to Quantify Energy Efficiency Opportunities – Part 1**
- **Session 5 (August 13) – Using MEASUR to Quantify Energy Efficiency Opportunities – Part 2**
- **Session 6 (August 20) – US DOE MEASUR other modules, 3EPlus, etc.; Assessment & Reporting**
- **Session 7 (August 26) – Case Studies; Refrigerants – Past, Present & Future; Reclamation and O&M**
- **Session 8 (September 3) – Industrial Process Cooling System VINPLT Wrap-up Presentations**

Agenda – Session 4

- Welcome and Introductions
- Safety and Housekeeping
- Today's Content:
  - Example Chilled Water Plant
  - Modeling in MEASUR Process Cooling Module – Base Model
- Kahoot Quiz Game
- Q&A

Safety and Housekeeping

- Safety Moment
  - Chillers have oil sumps, filters, etc. – be careful when walking around a chiller – oil may be leaking on the floor or there may be a puddle making the floor extremely slippery – exercise caution, wear proper safety shoes to avoid slipping
- You are welcome to ask questions at any time during the webinar
- When you are not asking a question, please MUTE your mic and this will provide the best sound quality for all participants
- We will be recording all these webinars and by staying on-line and attending the meeting you are giving your consent to be recorded
  - A link to the recorded webinars will be provided, afterwards

Comments on Homework

Modeling the Example Chilled Water System in MEASUR

U.S. DEPARTMENT OF ENERGY

Aim of Student Exercise

- Provide an understanding of an actual industrial chilled water system
- Hands-on exercise to demonstrate operation and functionality of MEASUR Process Cooling Module in a real-life scenario
- Start from the basics and get into details and build a “Baseline Model” for a central chilled water system
- Students will learn to model their own chilled water plant and develop a baseline for the energy consumption and the breakdown of energy consumed by the individual sub-systems

Start MEASUR

- Either of the following links can be used for access, both are not required.
  - For Online Use, visit following link and click process cooling
    - https://measur.ornl.gov/
  - For Offline Use, after installation on your PC, click the shortcut Icon or access from your programs

  - Both will land you to the home screen shown.

Facility Description

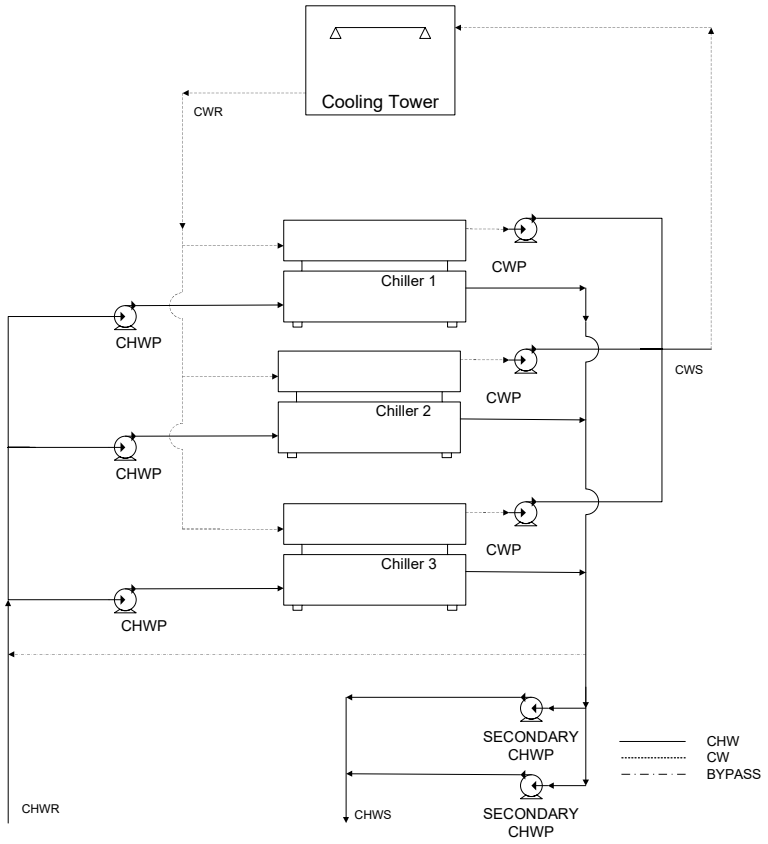
- The plant / facility is a large Food & Beverages plant located in the St. Louis, MO area
- The system selected for the energy assessment provides chilled water for process, packaging, air-conditioning plant areas and warehouse storage
- The plant operates a 3-shift per day operation, 8-hour per shift and runs all year round
- Possible shut-downs are planned for periodic maintenance activities

Description of Chilled Water System

Chilled Water System:

- Water-cooled
- 10 years old
- 3 Chillers
- 2 cell 1-speed Tower (1)
- Primary / Secondary Chilled Water Distribution System

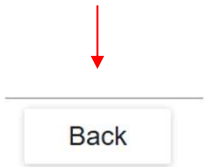
High-level System Schematic



MEASUR Process Cooling INPUT Screenshots

- Geographic location
- System description
- Heat rejection setup
- Pump setups
  - Chilled water
  - Condenser water (if applicable)
- Chiller setup
  - Default
  - Custom
- Utility Cost
- Operation Schedule & Load Profile

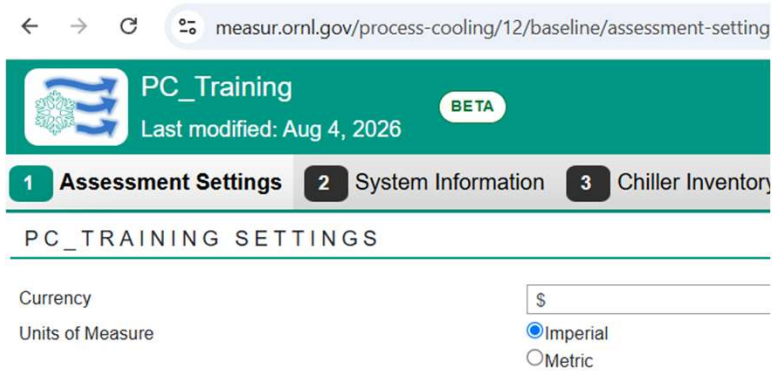
Click the “Back” to go back to previous screen

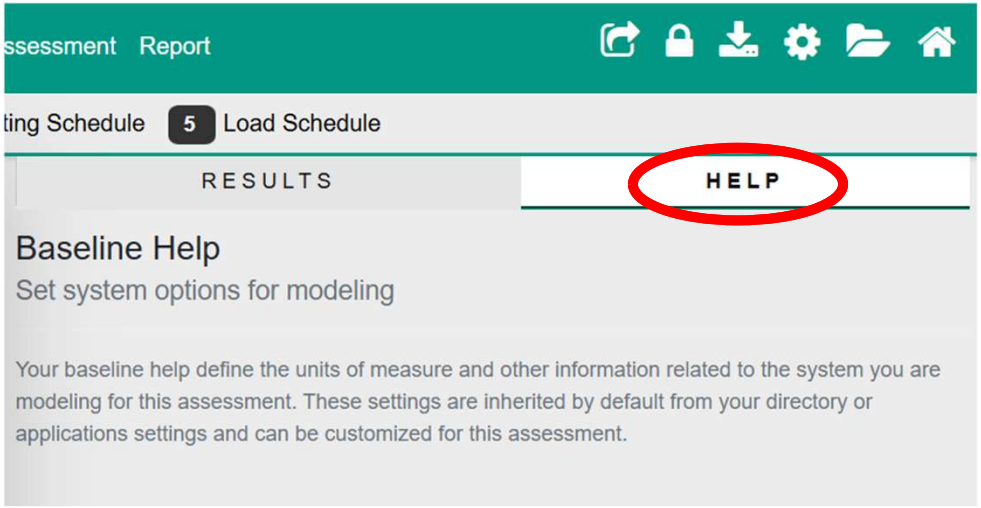


Click the “Next” Button to proceed to the next Input screen

Input Units and use of HELP

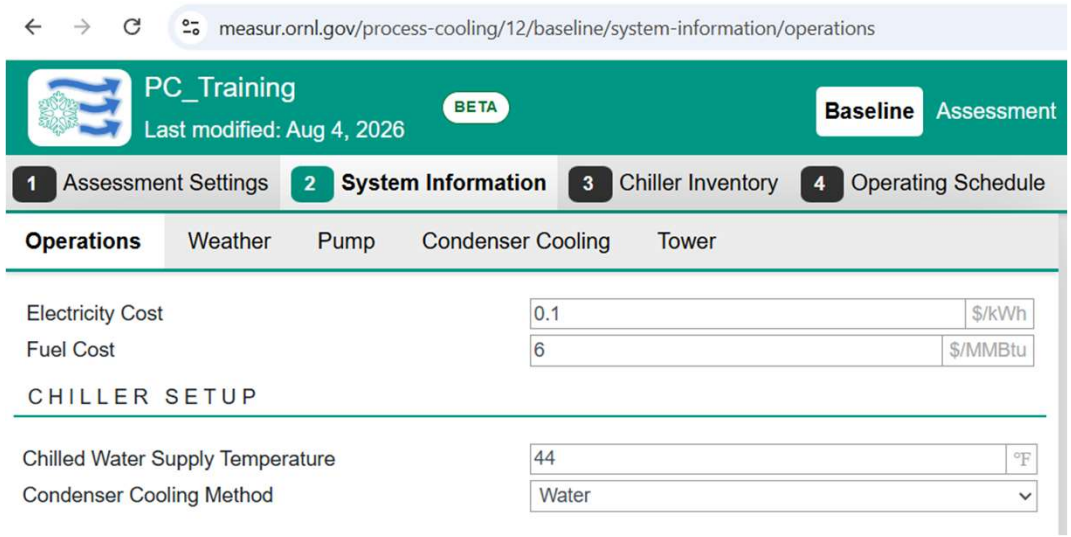
- Select Units if applicable, default “Imperial”, Use Contextual HELP where needed.





System Information - Operations

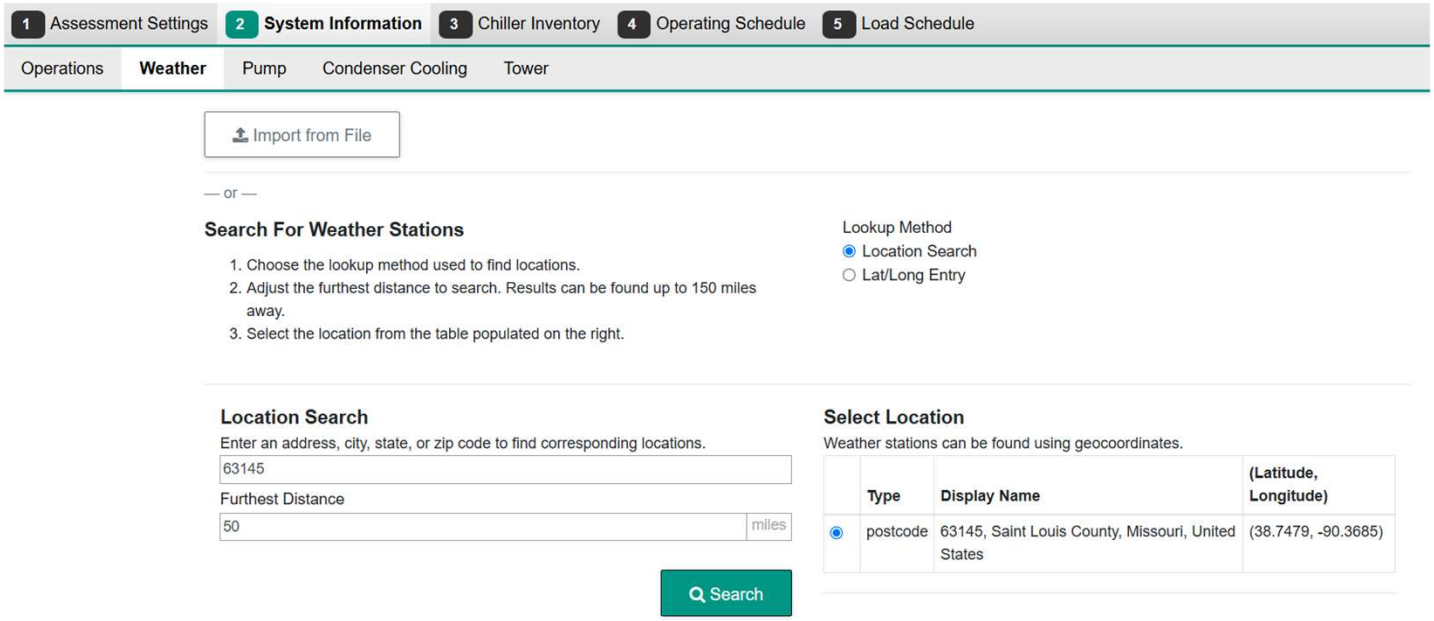
- Electricity Cost : $ 0.1/kWh
  - The electricity utility rate is a very important number
  - For MEASUR – a bundled cost (annual average) should be used
  - For more detailed analysis, multiple bin models can be developed
  - Natural gas cost can be ignored



- Chilled Water Setpoint: 44°F
- Water-Cooled Condensers

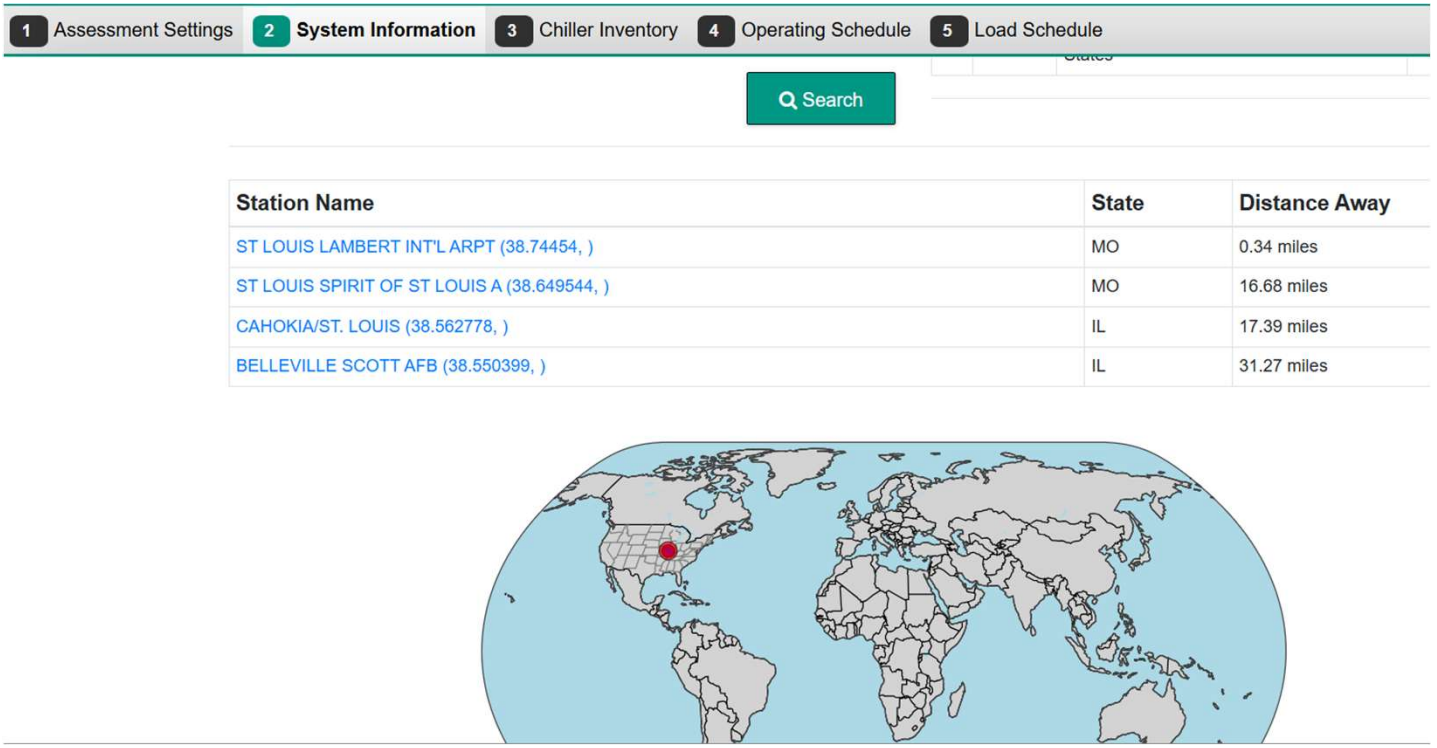
System Information - Geographic Location

- Weather Location zip: 63145



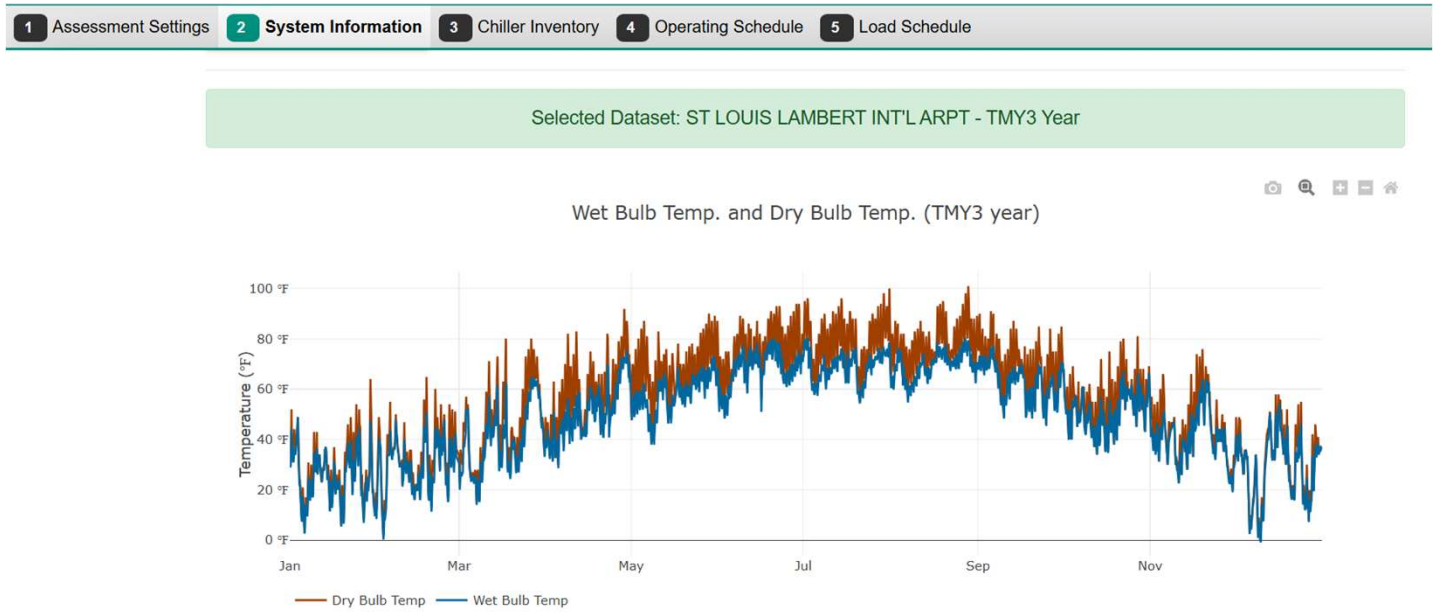
System Information - Geographic Location

- Weather Location : St. Louis Lambert International Airport



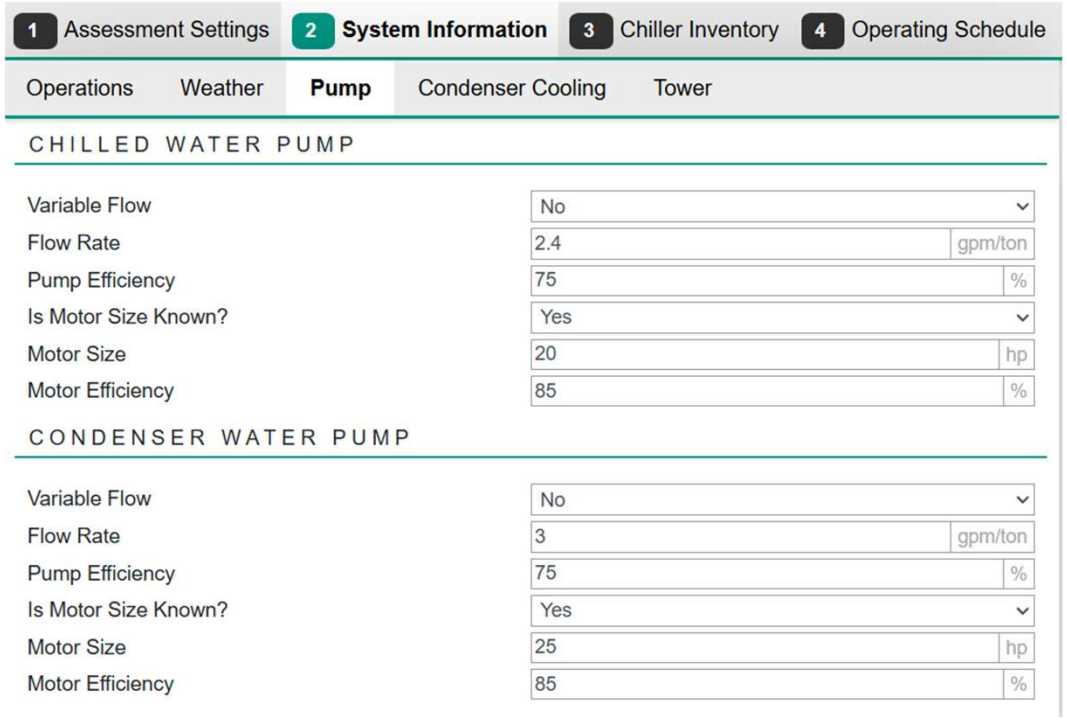
System Information - Geographic Location

- Annual DB and WB plot display



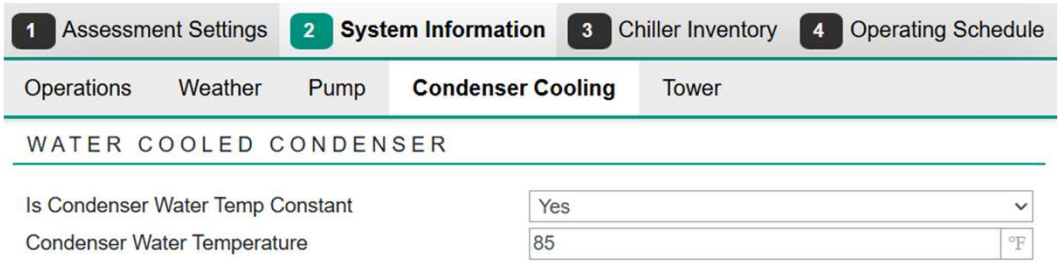
System Information – Pump(s)

- Chilled Water Pumps
  - Primary
    - 2 x 10 hp Constant Speed
    - Flow rate based on 2.40 gpm/RT
  - Secondary
    - 2 x 20 hp Variable Speed
- Condenser Water Pumps
  - 2 x 12.5 hp Constant Speed
  - Flow rate based on 3.0 gpm/RT



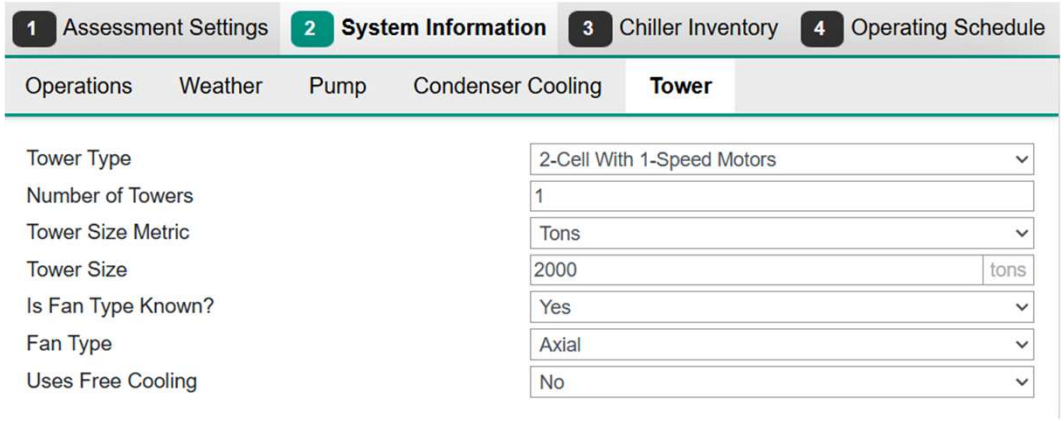
System Information – Condenser Cooling

- Cooling Water Supply Temperature is CONSTANT
- Cooling Water Supply Setpoint: 85°F
- Water-Cooled Condensers



System Information – Tower

- One tower with 2-cells and 1-speed motor
- Tower rated capacity – 2,000 RT
- Axial
- No Free Cooling

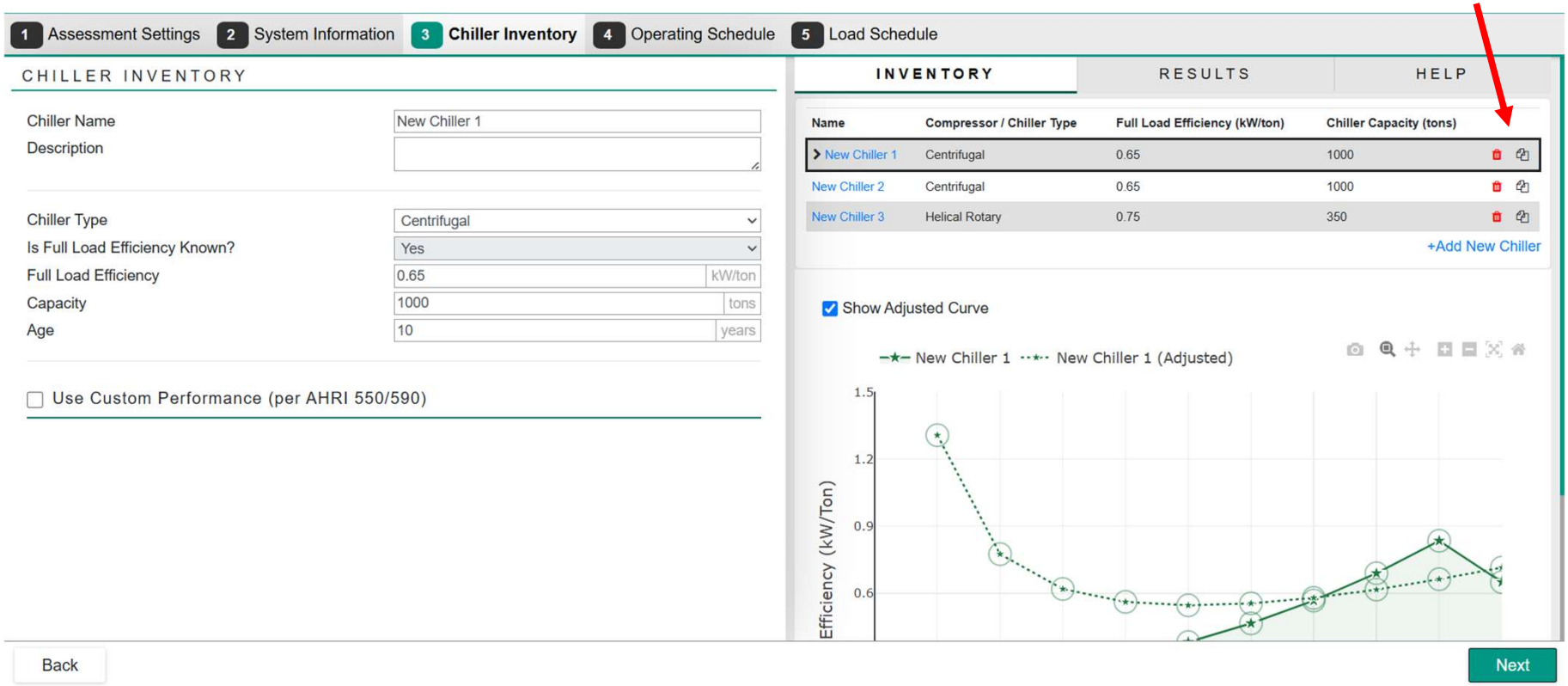


System Information – Chiller Inventory

- Chillers:
  - 2 Centrifugals and 1 Screw machine (constant speed)
    - Centrifugals - 1,000 RT each
    - Screw - 350 RT
  - Rated Full Load Efficiency (kW/RT)
    - Centrifugals – 0.65
    - Screw – 0.75
  - Age: 10 years
  - Chilled Water Setpoint – 44°F
  - Condenser Water Supply Temperature – 85°F

System Information – Chiller Inventory

Delete / Copy / Add - Chiller



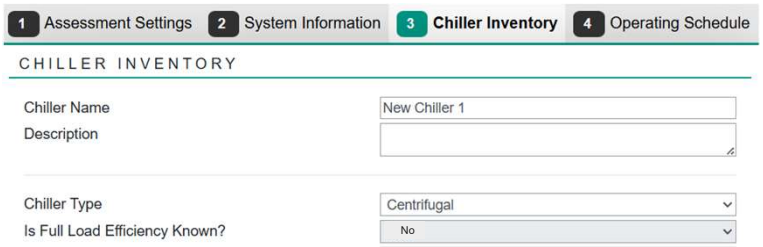
System Information – Chiller Inventory

- There are 3 methods to specify chillers in MEASUR,
  - Method 1 : Full Load Efficiency Known = No, (planned to be implemented in future)
  - Method 2 : Full Load Efficiency Known = Yes
  - Method 3 : Custom performance, AHRI 550/590 performance test data available
- Each chiller is specified independently and can be done in either of the 3 ways
- How you specify a chiller depends on how much information you have on the chiller
- MEASUR is built w/default information

Chiller Specification Methodology – Method 1

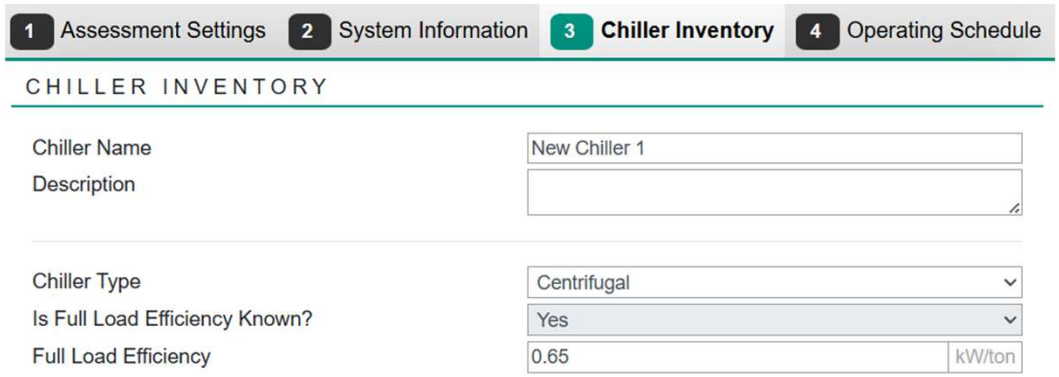
- No information about performance is known

- Following information is enough to use the default performance curves within MEASUR
  - Compressor type – Centrifugal, Screw (helical rotary), Reciprocating
  - Chiller Design Capacity (RT)
  - Age of chiller (years)



Chiller Specification Methodology – Method 2

- Full Load performance (kW/Ton) is known but part-load information is not available
- Following information is enough to use the default performance curves within MEASUR
  - Compressor type – Centrifugal, Screw (helical rotary), Reciprocating
  - Chiller Design Capacity (Tons)
  - Full Load Efficiency (kW/Ton)
  - Age of chiller (years)



Chiller Specification Methodology – Method 3

- Full Load performance (kW/Ton) is known
- Part-load information is also available
- The following information is used to build a performance curve for the specific chiller in MEASUR
  - Compressor type – Centrifugal, Screw (helical rotary), Reciprocating
  - Chiller Design Capacity (Tons)
  - Efficiency (kW/Ton) at the following load conditions
    - 25% load
    - 50% load
    - 75% load
    - 100% load

Chiller Specification Methodology – Method 3

1 Assessment Settings | 2 System Information | 3 **Chiller Inventory** | 4 Operating Schedule | 5 Load Schedule

CHILLER INVENTORY

Chiller Name	New Chiller 1
Description	
Chiller Type	Centrifugal
Is Full Load Efficiency Known?	Yes
Full Load Efficiency	0.65 kW/ton
Capacity	1000 tons
Age	10 years

☑ Use Custom Performance (per AHRI 550/590)

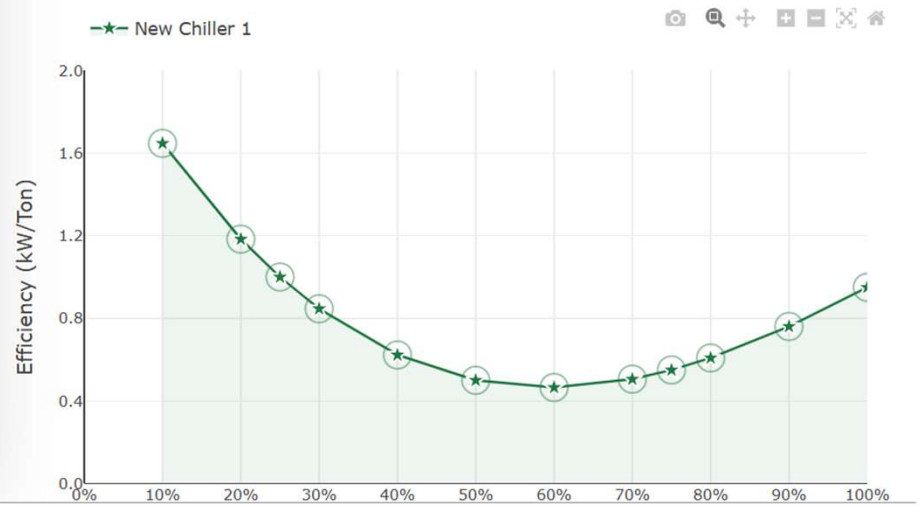
Specify efficiency values (kW/Ton) at 25%, 50%, 75% and 100% loadings as per AHRI 550/590 Specification

25% Load	1 kW/Ton
50% Load	0.5 kW/Ton
75% Load	0.55 kW/Ton
100% Load	0.95 kW/Ton

New Chiller 2	Centrifugal	0.65	1000	
New Chiller 3	Helical Rotary	0.75	350	

+Add New Chiller

☐ Show Adjusted Curve



Better Plants U.S. DEPARTMENT OF ENERGY

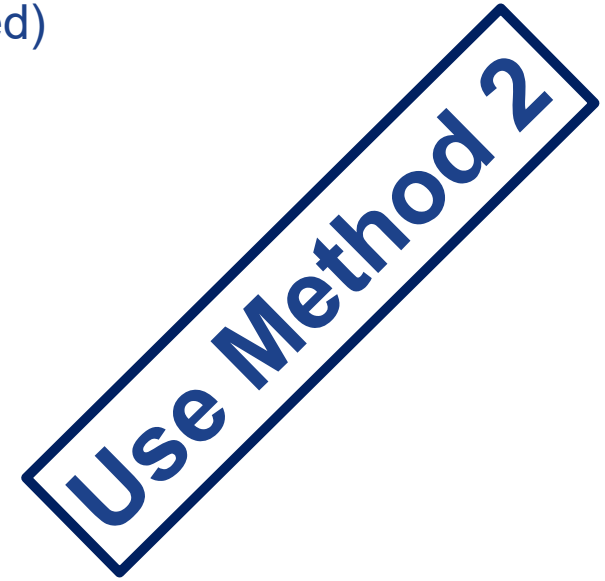
U.S. DEPARTMENT OF ENERGY

Chiller Specification Methodology

- Method 3 is the ideal way to specify chillers in MEASUR
- It will require some due diligence and information gathering but to build confidence in the assessment and results thereafter, it is well worth the extra effort
- Nevertheless, it should not be a show-stopper and if getting the information is delayed, use Method 2 – FLE required
- Method 1 should NOT be used for assessments and quantifying energy efficiency opportunities but can be used for scoping purposes

System Information

- Chillers:
  - 2 Centrifugals and 1 Screw machine (constant speed)
    - Centrifugals - 1,000 RT each
    - Screw - 350 RT
  - Rated Full Load Efficiency (kW/RT)
    - Centrifugals – 0.65
    - Screw – 0.75
  - Age: 10 years
  - Chilled Water Setpoint – 44°F
  - Condenser Water Supply Temperature – 85°F



System Information – Chiller Inventory

1 Assessment Settings | 2 System Information | 3 **Chiller Inventory** | 4 Operating Schedule | 5 Load Schedule

CHILLER INVENTORY

Chiller Name: New Chiller 1
Description:

Chiller Type: Centrifugal
Is Full Load Efficiency Known?: Yes
Full Load Efficiency: 0.65 kW/ton
Capacity: 1000 tons
Age: 10 years

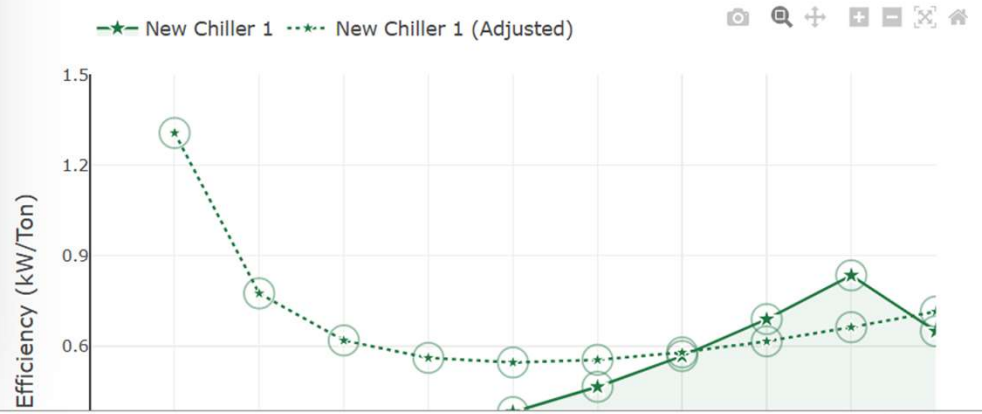
☐ Use Custom Performance (per AHRI 550/590)

INVENTORY | RESULTS | HELP

Name	Compressor / Chiller Type	Full Load Efficiency (kW/ton)	Chiller Capacity (tons)
New Chiller 1	Centrifugal	0.65	1000
New Chiller 2	Centrifugal	0.65	1000
New Chiller 3	Helical Rotary	0.75	350

+Add New Chiller

☑ Show Adjusted Curve



Back | Next

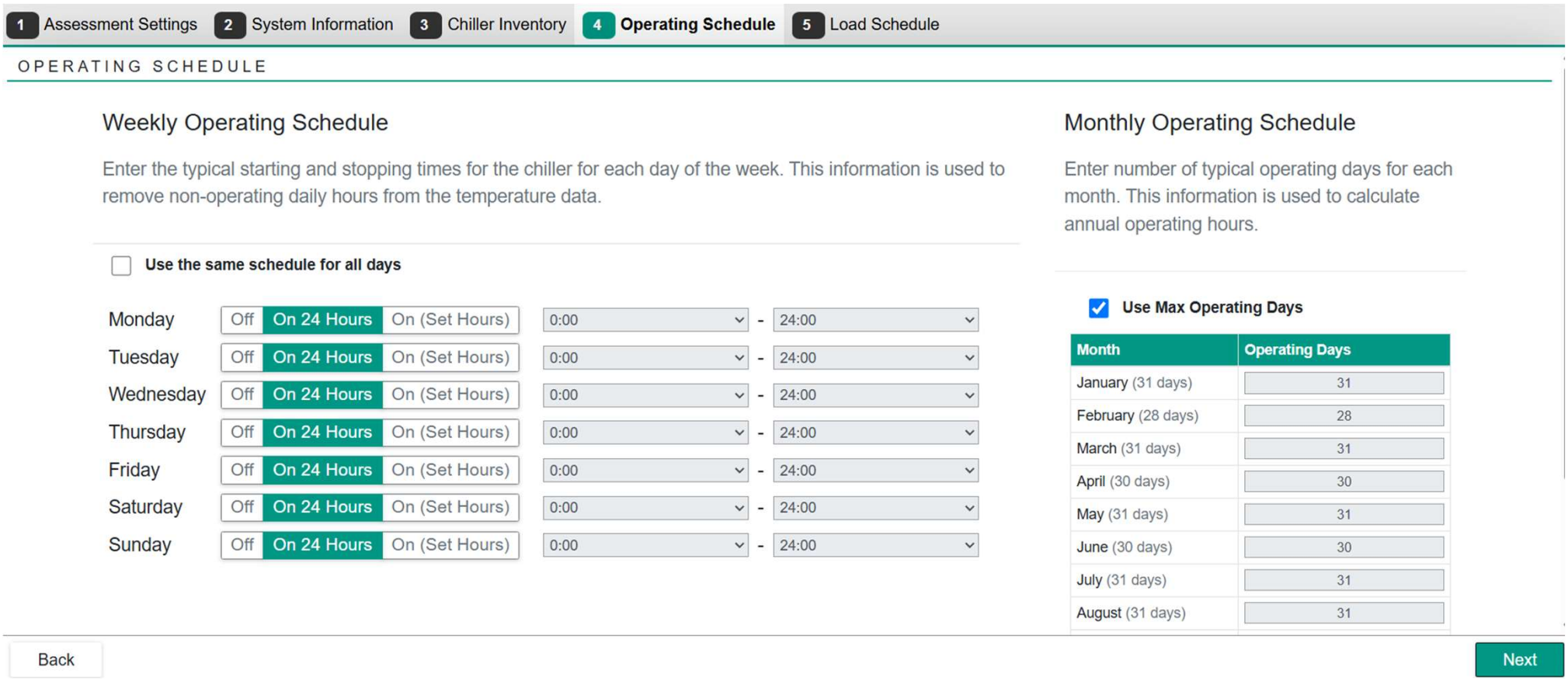
Better Plants U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY

Operating Schedule Information

- Operating Schedule provides information on when the chilled water plant is ON or OFF.
- Simplest option – plant is ON all year round (24x7) – 8,760 hours
- ONLY if the chilled water plant is turned OFF manually or if it is on an automatic ON/OFF schedule based on day of the week, shift schedule, etc. should this operating schedule screen be used for details
- If a chiller turns OFF automatically because the chilled water system load is met, that information is captured on the load profile

Operating Schedule Information



Better Plants U.S. DEPARTMENT OF ENERGY

U.S. DEPARTMENT OF ENERGY

Individual Chiller Load Profile

- The geographic location's weather data, load profile along with the operating schedule allows the MEASUR to allocate actual cooling load (Tons) for each hour of operation to each chiller
- MEASUR does a very detailed chilled water system analysis – 8,760 individual runs representing each specific hour of the year
- MEASUR has an algorithm to match every hour of the year with the actual operating load and corresponding efficiency based on the system

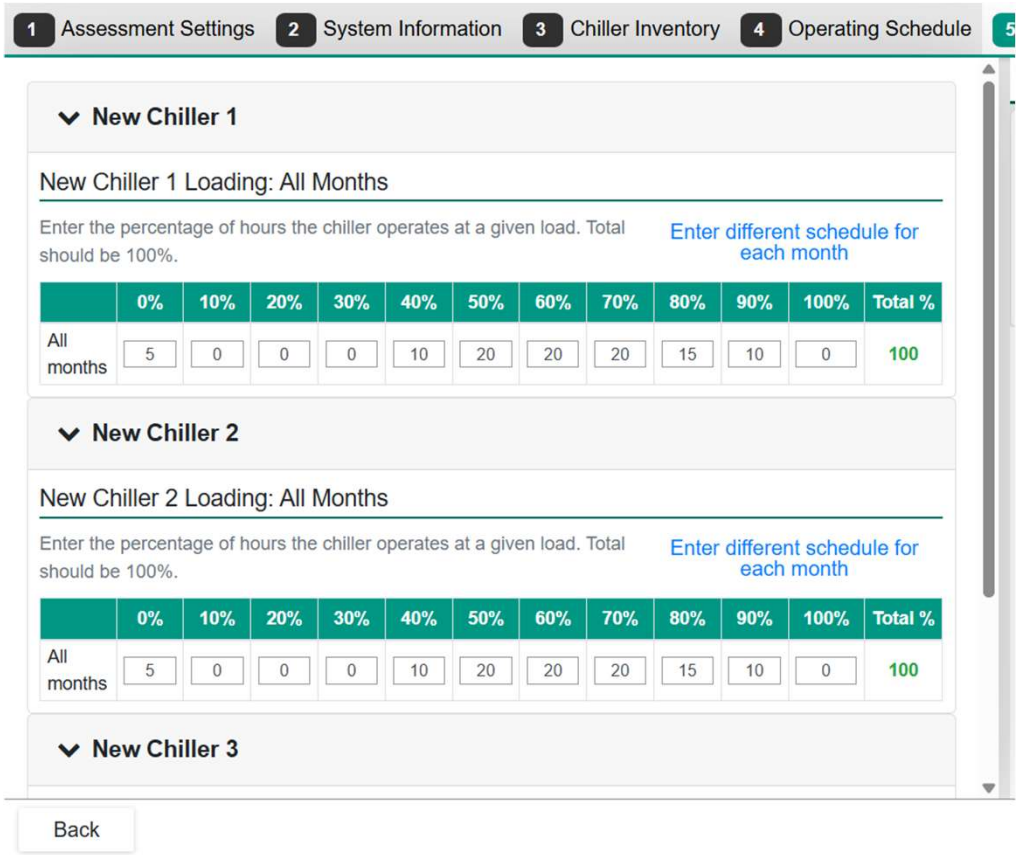
Individual Chiller Load Profile

- AHRI chiller load profile can be used for HVAC loads

- This can be used when
  - The cooling load is purely HVAC (or predominantly HVAC > 90%)
  - Chiller load information is not available yet but it is clear that a major portion of the load (90% or so) is comfort cooling for personnel and environment

Chiller Loading Schedule											
Chiller	0% load	10% Load	20% load	30% load	40% load	50% load	60% load	70% load	80% load	90% load	100% load
ARI	0%	0%	1%	5%	13%	23%	26%	19%	9%	3%	1%

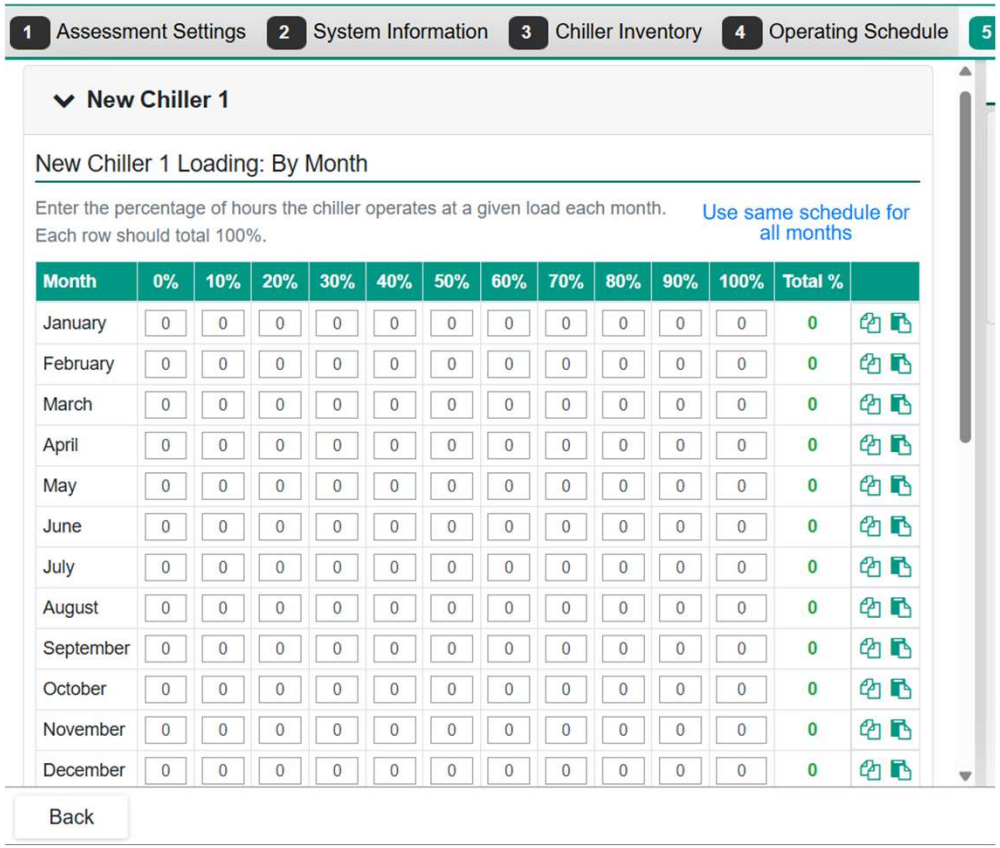
Individual Chiller Load Profile



- Chiller load variation – month to month
- Load variation between chillers

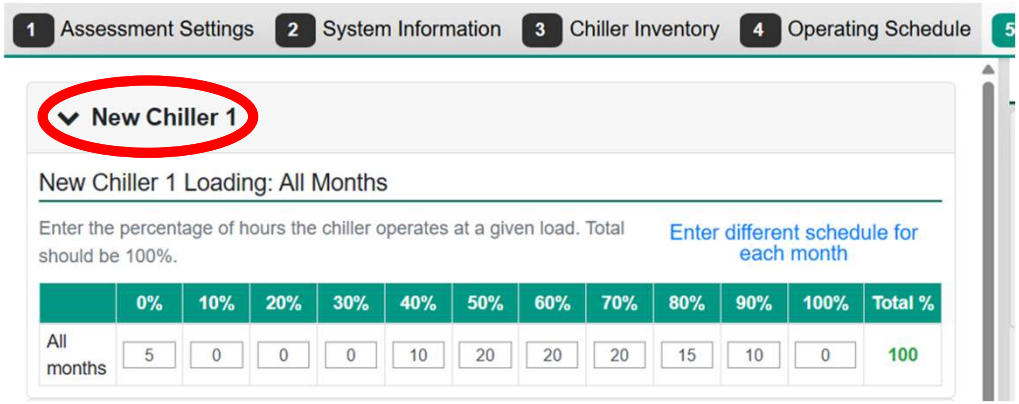
Individual Chiller Load Profile

- Most Complex
- Most Detailed
- Recommended for Assessments
- Can capture seasonality of operations, weather impacts, etc.



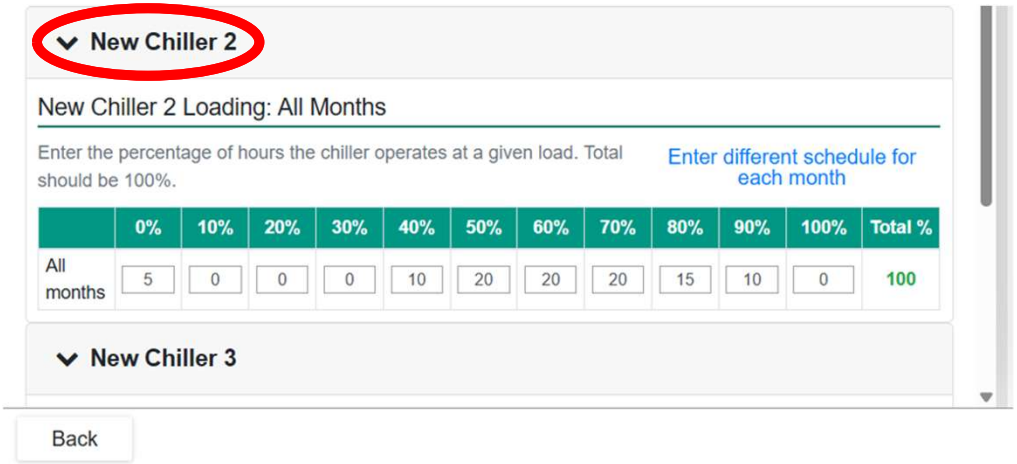
Centrifugal Chillers Load Profile

- There are 2 centrifugal chillers that are operated in a manner such that they are at similar load conditions all the time unless there is maintenance activity on one of them



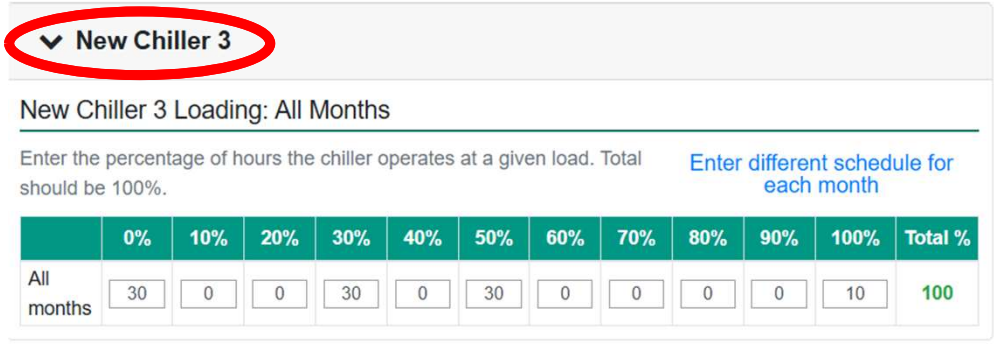
Centrifugal Chillers Load Profile

- There are 2 centrifugal chillers that are operated in a manner such that they are at similar load conditions all the time unless there is maintenance activity on one of them



Screw Chiller Load Profile

- Chiller #3 is a screw chiller that does come ON periodically when loads are high or when one of the centrifugal chillers is down for maintenance



New Chiller 3

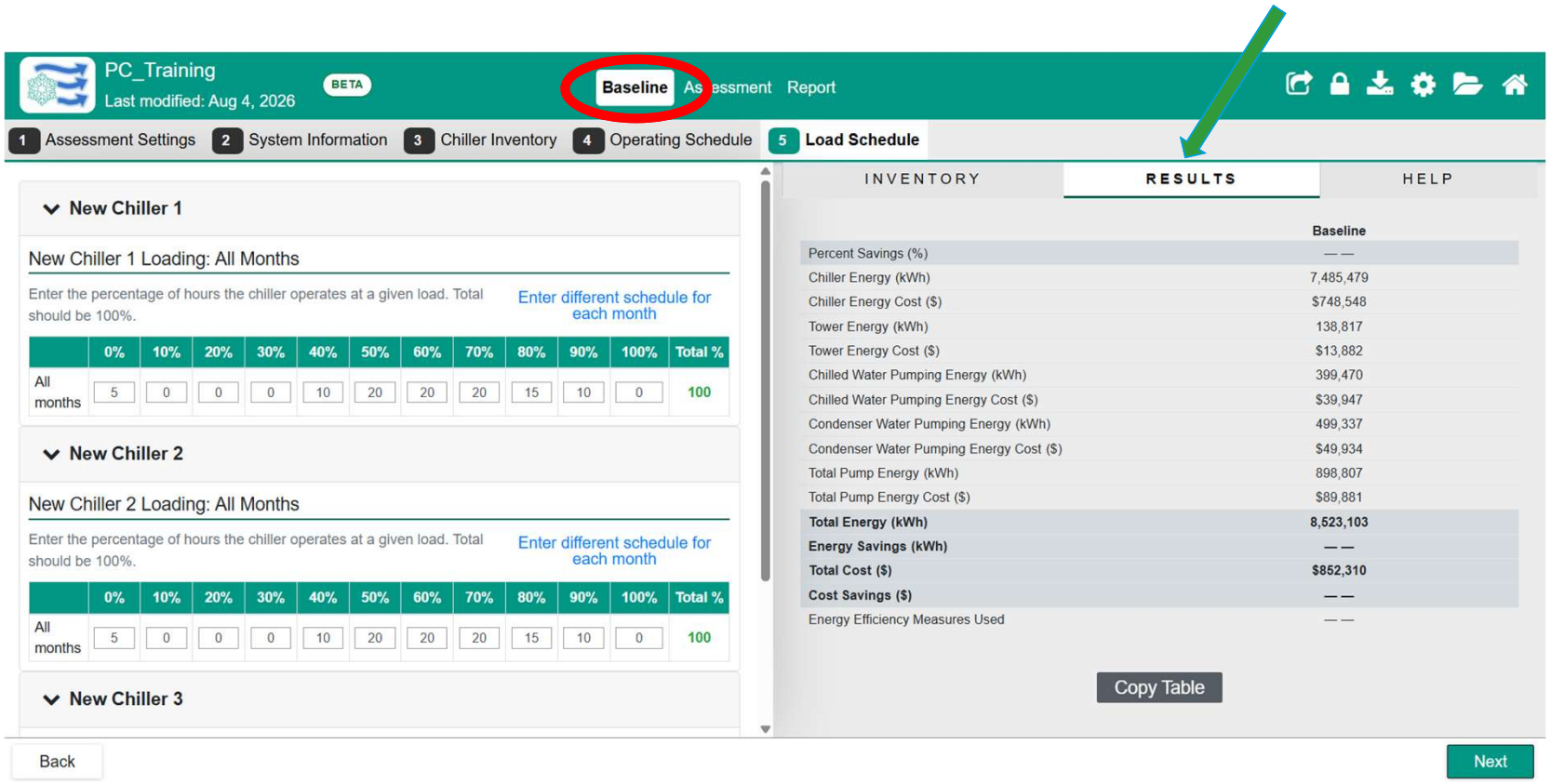
New Chiller 3 Loading: All Months

Enter the percentage of hours the chiller operates at a given load. Total should be 100%.

Enter different schedule for each month

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Total %
All months	30	0	0	30	0	30	0	0	0	0	10	100

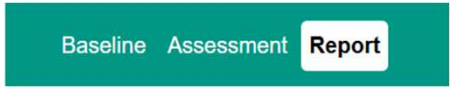
Baseline - Results



All INPUTs are COMPLETE!

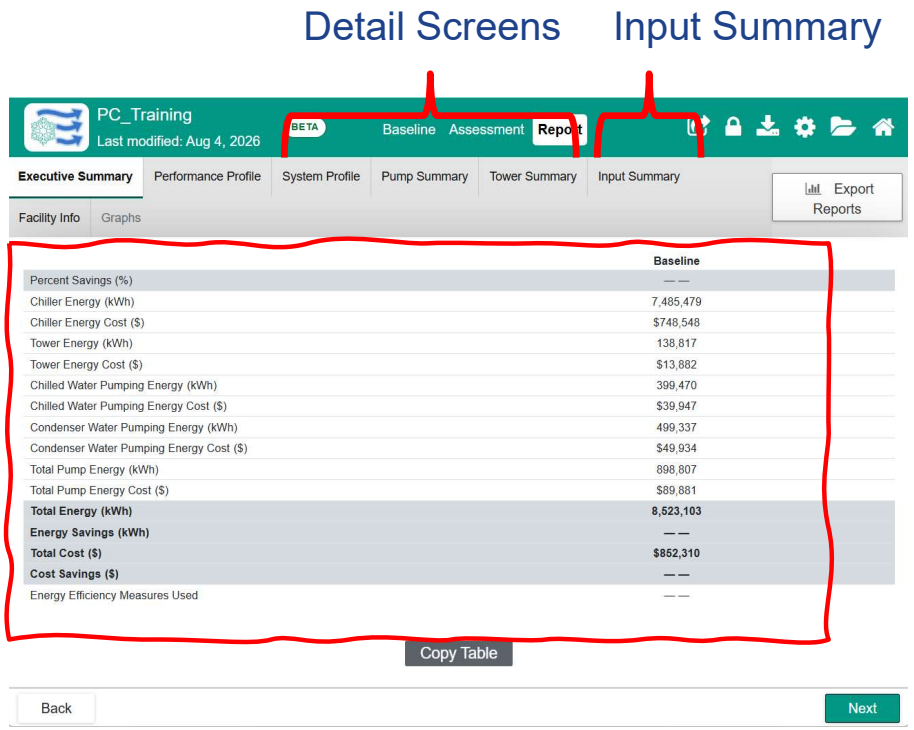
- At this point in MEASUR – all the inputs required for modeling the chilled water system are completed
- The next button will go to “Assessment”

- The “Assessment” Screen is a high-level summary of the overall baseline energy and cost of chilled water plant operations.
- The “Assessment” Screen is where various Opportunities can be explored
- The next button will go to “Report”



Output Screen (Baseline)

- Annual energy consumption (kWh)
- Annual operating cost ($)
- All the Detailed calcs/info are shown here in Detailed Screens
- All the major inputs are shown here in Input Summary



Chiller Operating Details Screen (Baseline)

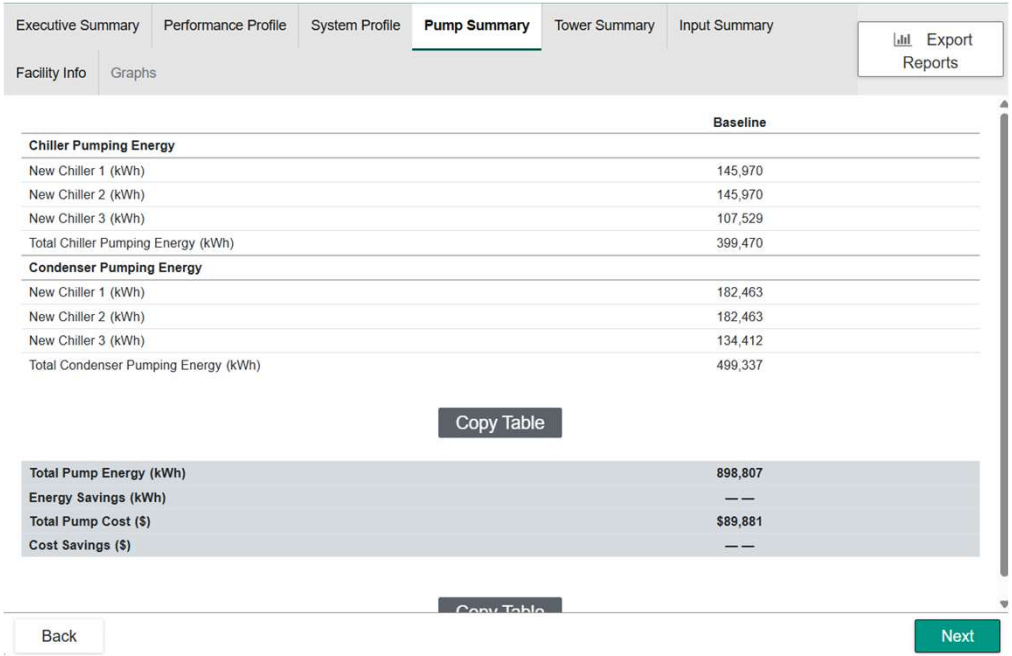
Executive Summary | Performance Profile | **System Profile** | Pump Summary | Tower Summary | Input Summary | Facility Info | Graphs | Export Reports

Baseline

Load %	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Total
New Chiller 1												
Performance (kW/Ton)	-	0	0	0	0.608	0.591	0.592	0.609	0.638	0.675	0	
Hours	444	0	0	0	873	1,754	1,753	1,746	1,317	873	0	8,760
Power (kW)	0	0	0	0	243.1	295.6	355.2	426.4	510.1	607.3	0	
Energy (kWh)	0	0	0	0	212,214	518,479	622,681	744,489	671,849	530,133	0	3,299,844
New Chiller 2												
Performance (kW/Ton)	-	0	0	0	0.608	0.591	0.592	0.609	0.638	0.675	0	
Hours	444	0	0	0	873	1,754	1,753	1,746	1,317	873	0	8,760
Power (kW)	0	0	0	0	243.1	295.6	355.2	426.4	510.1	607.3	0	
Energy (kWh)	0	0	0	0	212,214	518,479	622,681	744,489	671,849	530,133	0	3,299,844
New Chiller 3												
Performance (kW/Ton)	-	0	0	0.932	0	0.82	0	0	0	0	0.825	
Hours	2,634	0	0	2,627	0	2,626	0	0	0	0	873	8,760
Power (kW)	0	0	0	97.8	0	143.4	0	0	0	0	288.8	
Energy (kWh)	0	0	0	257,034	0	376,678	0	0	0	0	252,079	885,790

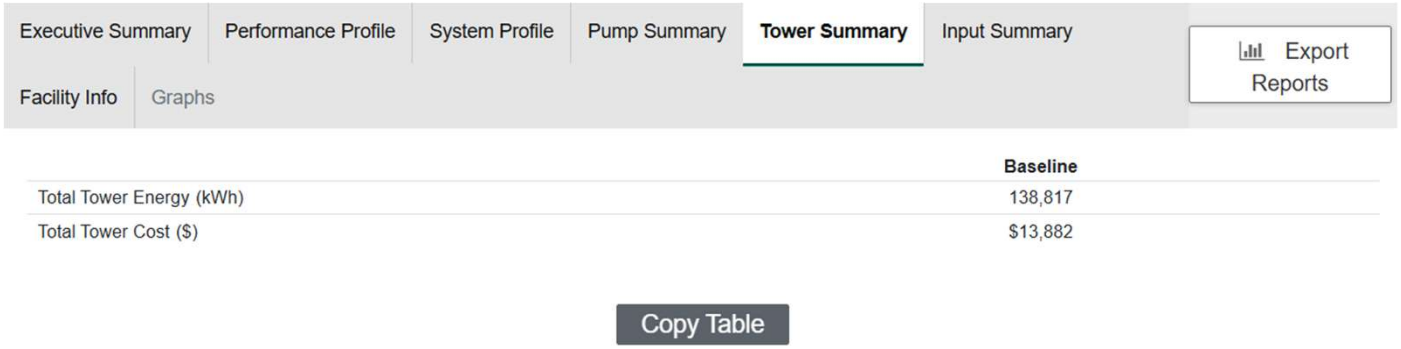
Pumps Operating Details Screen (Baseline)

- Be careful with this output – water flow rate allocation is an issue
- It's a good estimate but actual operation may be different
- Assumes no flow when chiller is OFF
- Primary loop ONLY



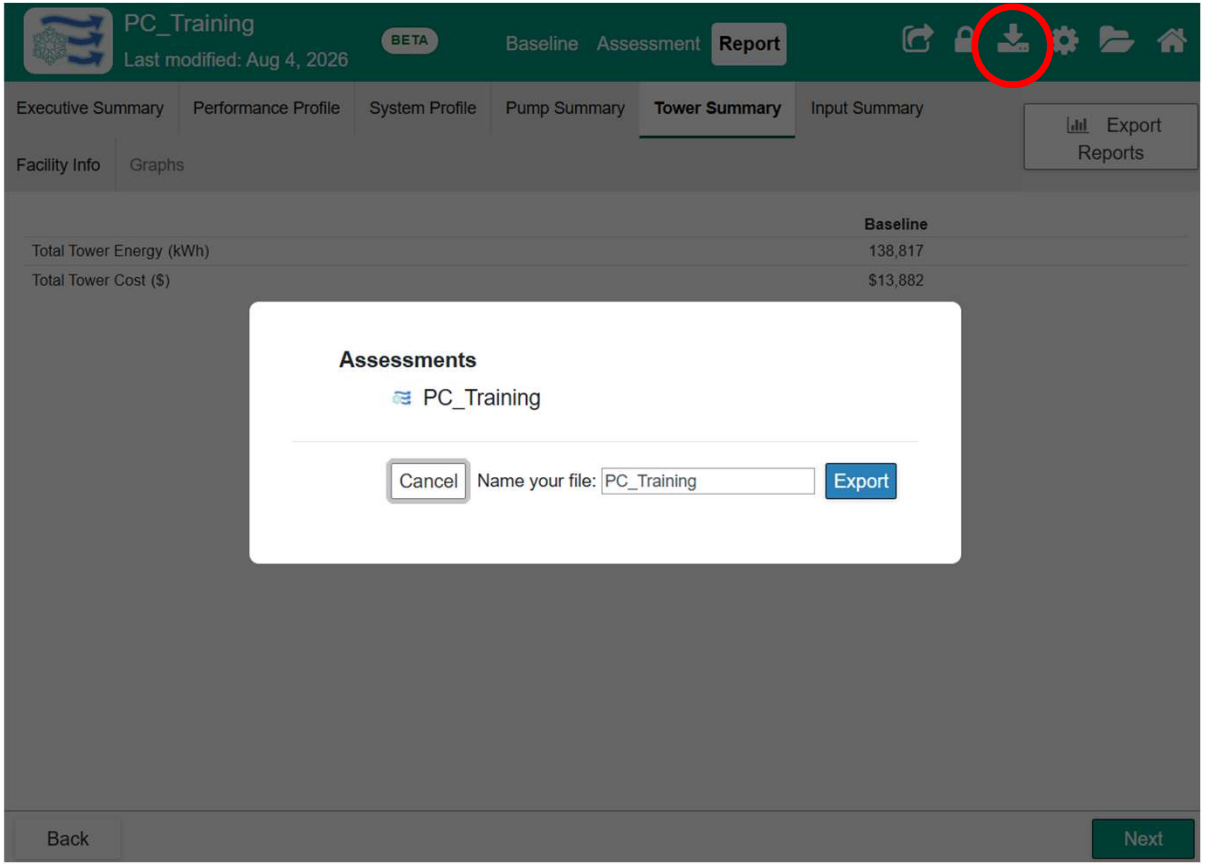
Tower Operating Details Screen (Baseline)

- Model provides good results when the cooling towers are within reasonable design limits
- More details will be added in future releases



Saving the Baseline Model file – MOST IMPORTANT!

- Can be accessed from any screen
- Exported files can be imported in future
- Recommended to export once all baseline inputs are entered



Additional MEASUR Topics

- Your weather location data use
- Input Sensitivity
- Report Print
- Detailed results screens
- Tool Benefits:
  - Energy end-use distribution
  - Identify areas to examine for conservation
  - “What-if” analyses

Key Points / Action Items

1. *A chilled system consists of multiple chillers and NOT all chillers have the same performance curves – full load and part-load*

2. *To do an accurate model, it is important to have the part-load design performance of each chiller and define the chillers in MEASUR*

3. *MEASUR can model a chilled water system and provide significant details to understand overall operations of the plant*

Homework #4

- Attempt to build a chilled water system model in MEASUR of your own chilled water plant
- Use default information of MEASUR wherever your information is not available
- Compare the MEASUR modeled annual energy usage and costs with information that you may have on your plant
- Identify areas that you had difficulty in understanding and modeling
- Identify discrepancies and shortcomings, if any, in the MEASUR software

Thank You all for attending today's webinar.

See you all on Thursday – August 13, 2026 – 2 pm ET

If you have specific questions, please stay online and we will try and answer them.

Alternately, you can email questions to us at paparra@ornl.gov and g@greensystemio.com

U.S. DEPARTMENT OF ENERGY

Kahoot Quiz Time