



IDEA2021

Powering the Future: District Energy/CHP/Microgrids
Sept. 27-29 | Austin Convention Center | Austin, Texas



How Digital Twin Will Transform Chilled Water Systems

a case study on how good is getting in the way of great

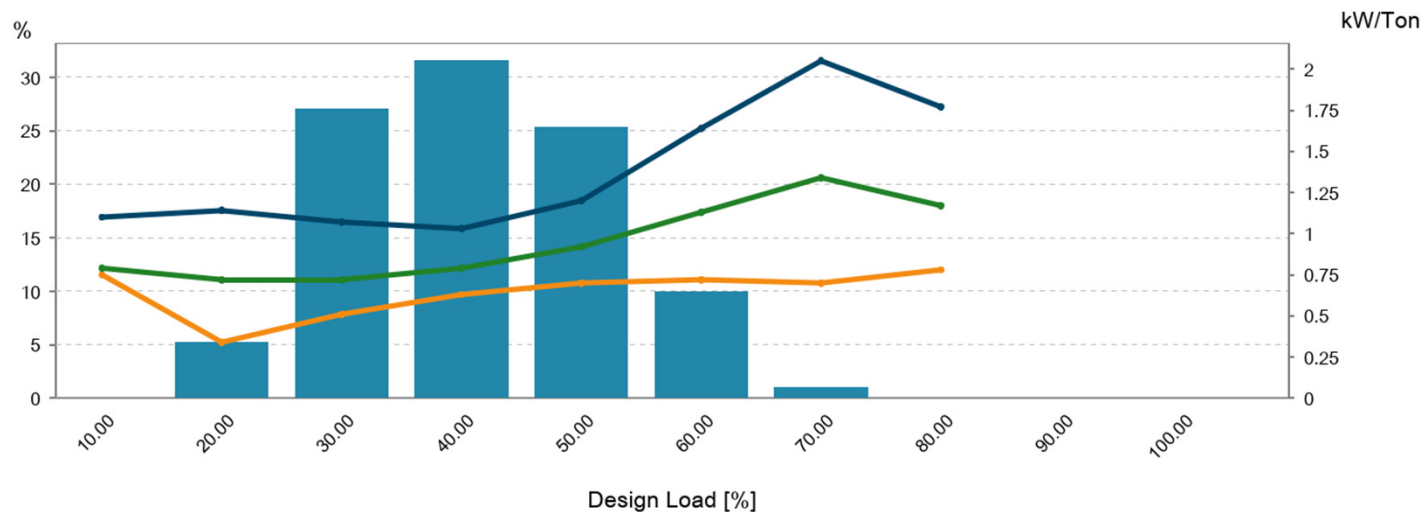
Vanessa Freidberg, PE, CEM, LEED

Siemens Smart Infrastructure



Background

Chilled Water System Optimization Success



Customer

- **Type:** Industrial Manufacturing
- **Location:** New Orleans, LA
- **Capacity:** 3,425 Tons
- **Load:** 9,100,000 Ton-Hours

Results

- **Actual vs Predicted:** 19.96%
- **Total Savings:** 47.19%

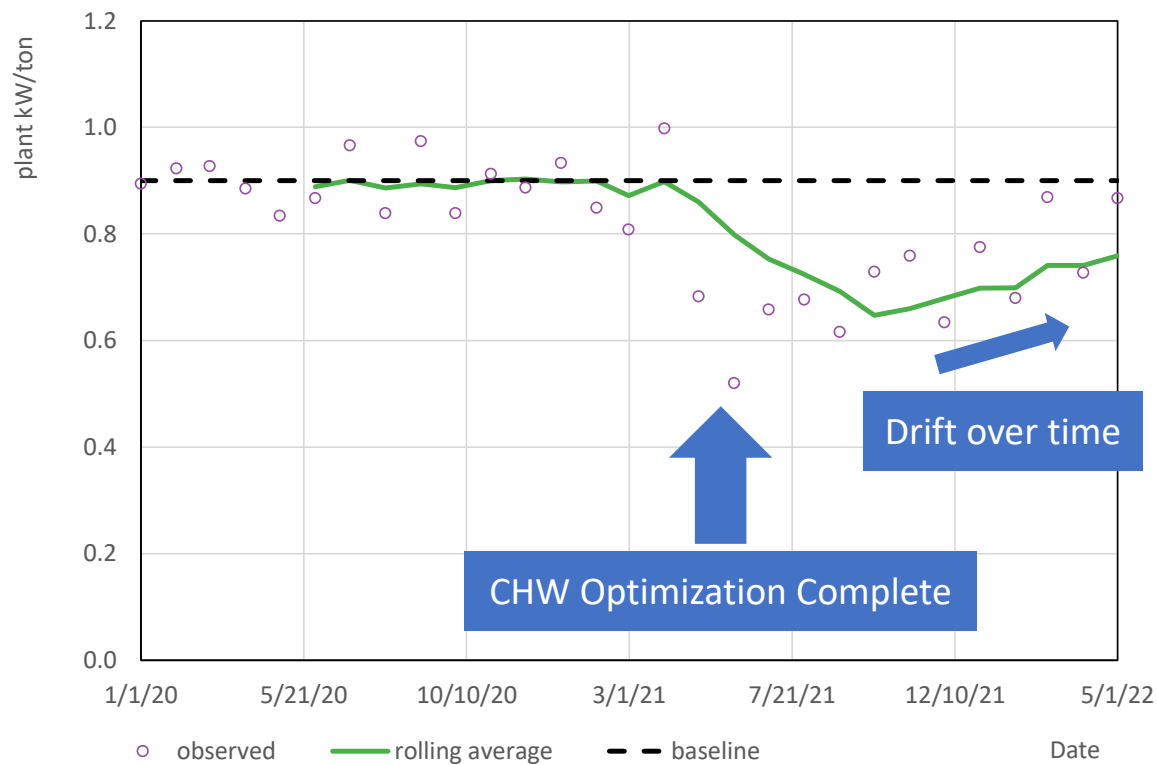


Problem

Performance Long-term?

- Critical systems are complex and dynamic, always changing
 - Equipment changes and degradation
 - Operator interventions and staff turnover
 - Load and occupancy changes
 - Environmental condition shift between seasons
- Commissioning is a snapshot in time
- Re-commissioning is manual and expensive

Best Operators Experience Drift



Without monitoring, performance drifts back towards baseline



Solution

Protect & Improve on Investment

Analytics – Fault Detection & Diagnostics

- 1 chiller plant
- 5 chillers
- 5 cooling towers
- 5 primary chilled water pumps
- 5 secondary chilled water pumps
- 7 condenser water pumps
- Total: 190 actively monitored rules
- Quarterly review and remediation of faults

ALARM

Alarms are immediate issues, found by comparing a single monitored value to a predefined limit.



FAULT

Faults define “off-normal” conditions, continuously comparing building or equipment data to an advanced set of analytics/rules that consider multiple interdependent factors.



Fault Distribution

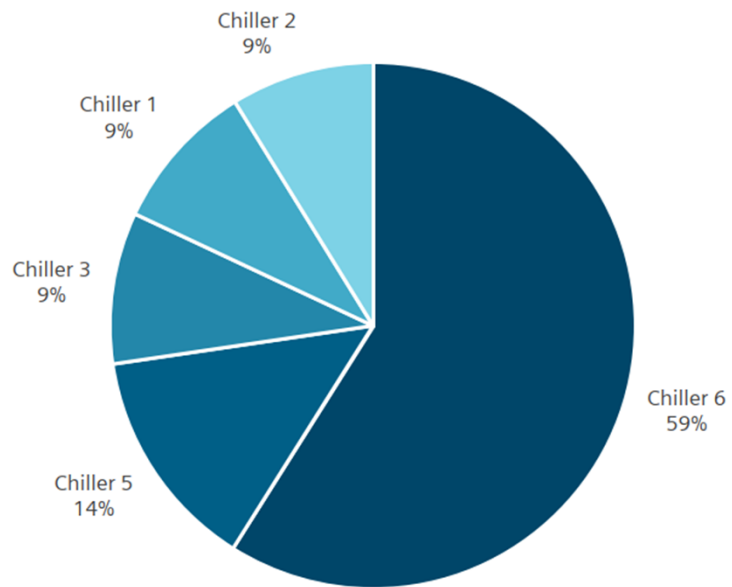


Figure 1: P2 Chiller Fault Distribution

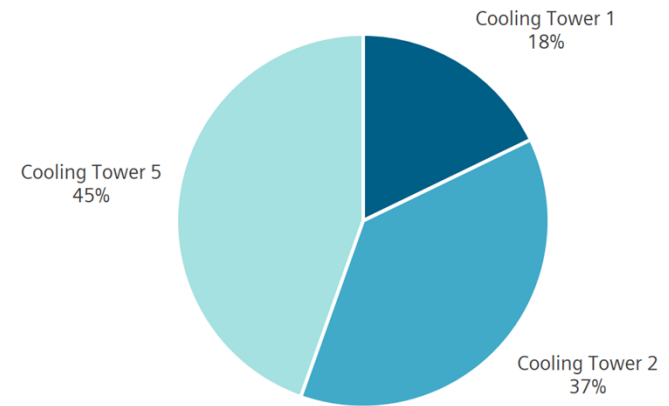


Figure 2: P2 Cooling Towers Fault Distribution

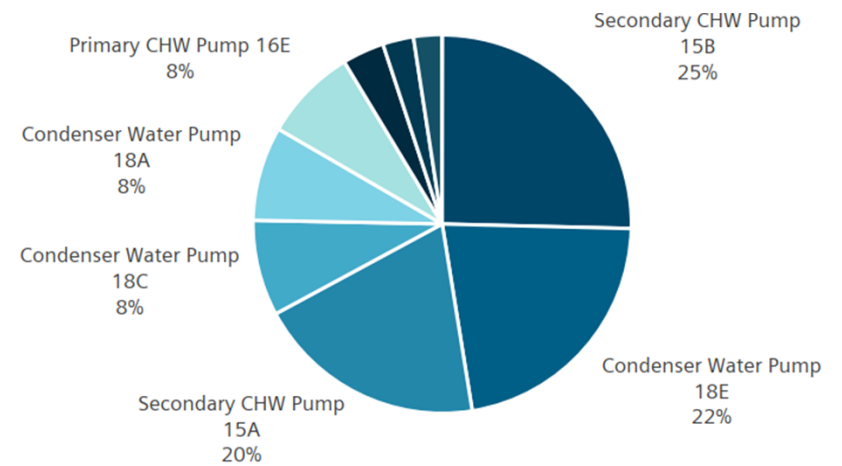


Figure 3: Pump Fault Distribution

Customer Fault Example A – CW Flow



Customer Fault Example A – CW Flow

Fault ID	Fault	Equipment	Description	Branch/Owner Feedback
A	Chillers_Condenser Flow Not at Setpoint	Chiller 1 Chiller 2 Chiller 3 Chiller 5 Chiller 6	Each chiller has experienced instances of condenser flow not at setpoint within the past 30 days. Investigate condenser flow loop and verify whether this can be adjusted. Deviation has averaged as: Chiller 1 - 523 GPM Above Setpoint (63 hours) Chiller 2 - 721 GPM Above Setpoint (23 hours) Chiller 3 - 265 GPM Above Setpoint (18 hours) Chiller 5 - 182 GPM Above Setpoint (109 hours) Chiller 6 - 323 GPM Below Setpoint (158 hours)	The CW isolation valve minimum positions adjusted to improve operations and increase energy savings going forward.

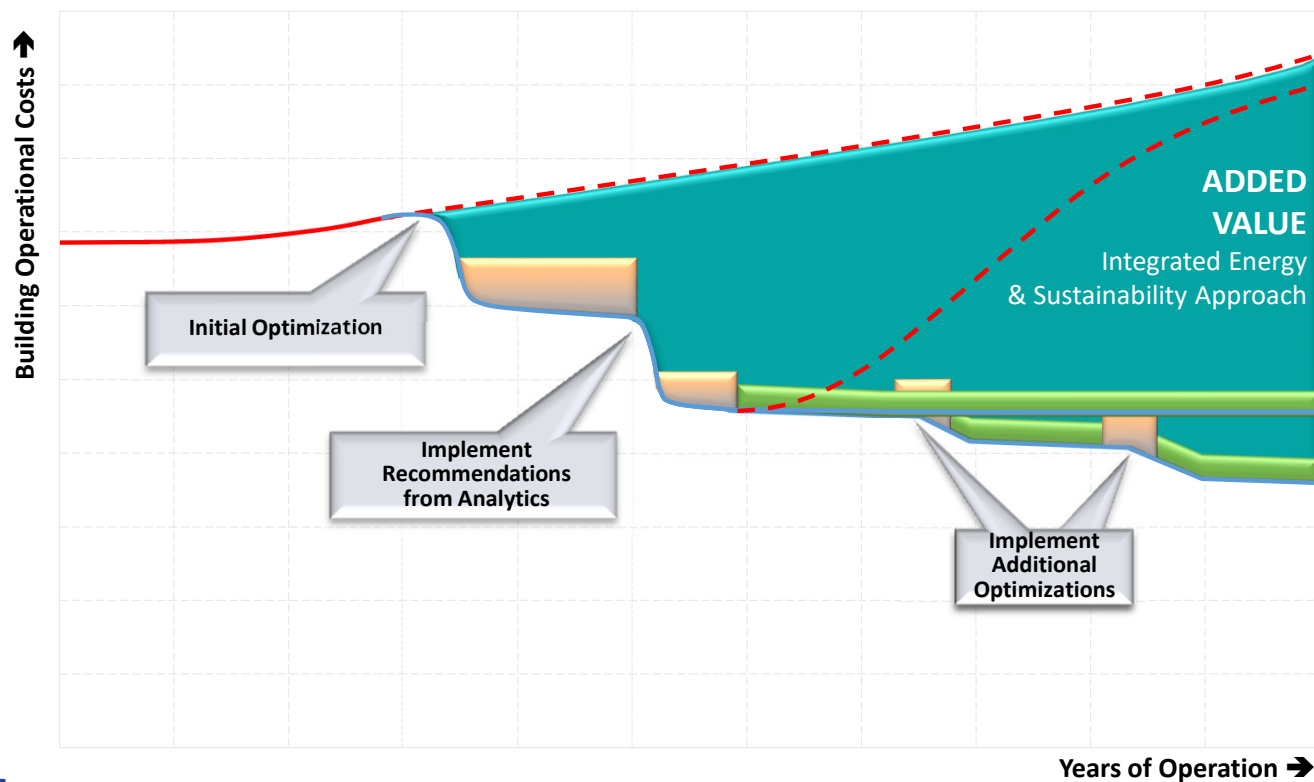
Customer Fault Example B – CHW Pump



Customer Fault Example B – CHW Pump

Fault ID	Fault	Equipment	Description	Branch/Owner Feedback
B	CWP-18E_Pump VFD Remains at 100% Speed	Condenser Water Pump 18E	There have been 1,000+ hours in which condenser water pump 18E has operated above 90% speed. This indicates that the system capacity may not be able to reach the demand with 18E operating alone.	When Chiller 6 runs by itself, it cannot make CW GPM setpoint with only pump 18E running. This could be because of pump size constraints or possible pump mechanical issues. Suggested onsite evaluation to further develop root cause.

Increased Lifecycle Value



Situation

- Operating costs drift
- Analytics increase savings over time
- Cost is a fraction of the value added

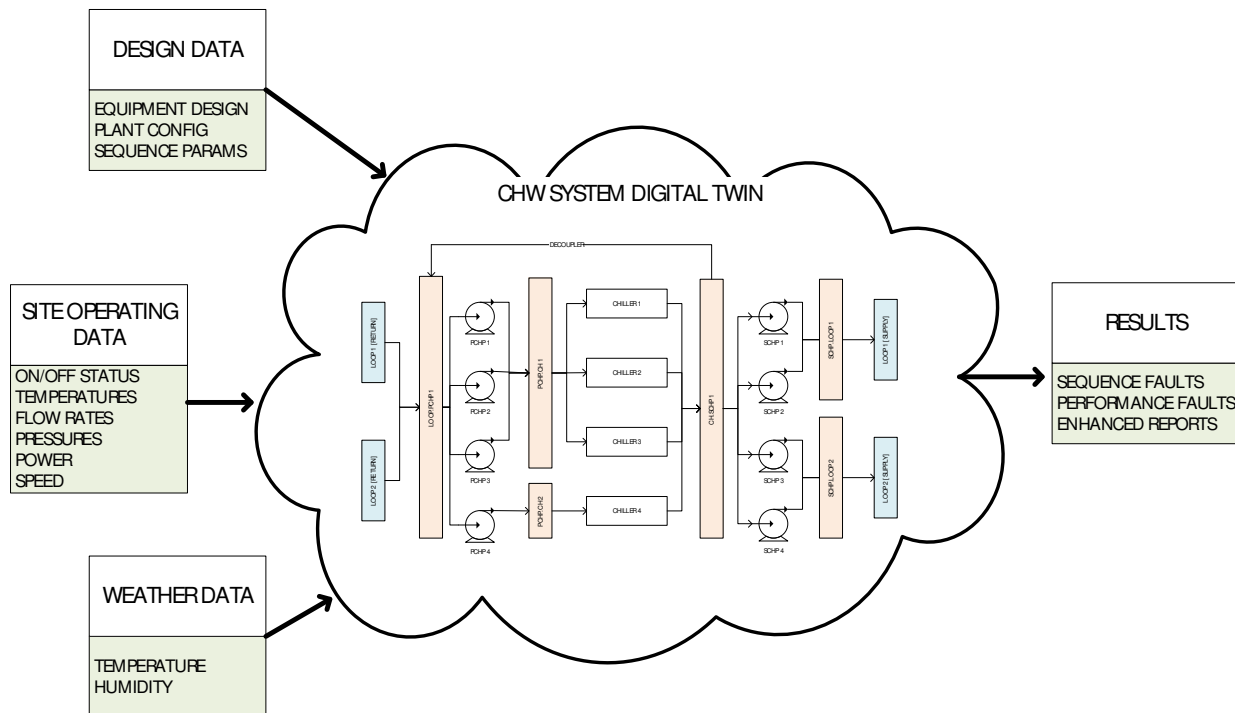
Lessons Learned



What Isn't Great?

- Results were good, everyone was happy
 - So what else?
- Traditional analytics
 - Tell us if equipment is meeting what is expected
- Limitation of analytics
 - Not able to tell us root cause of why
 - Requires manual on-site investigation
- Digital twin
 - Identify and evaluate root cause automatically

What is a Digital Twin?



A Digital Twin is a **model** of your system

When provided with the **same inputs** as your system, it should calculate the **same outputs** as observed

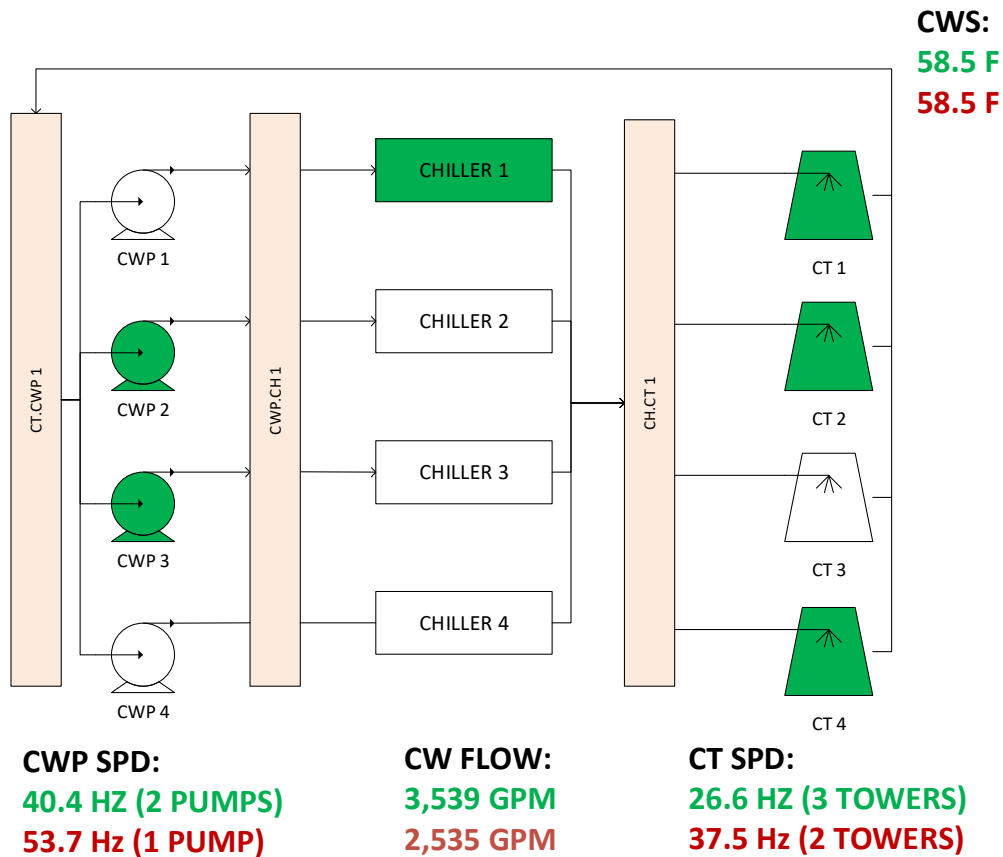
A Digital Twin can be used to **detect**:

- Sequence faults
- Performance faults

A Digital Twin can be used to **evaluate**:

- Operational changes
- Equipment upgrades

Sequence Faults



Sequence fault: when observed parameters deviate from expectations per sequence of operations

Compare **observed values** to **modeled values**

CWS setpoints are the same

This portion of the sequence is operating as intended

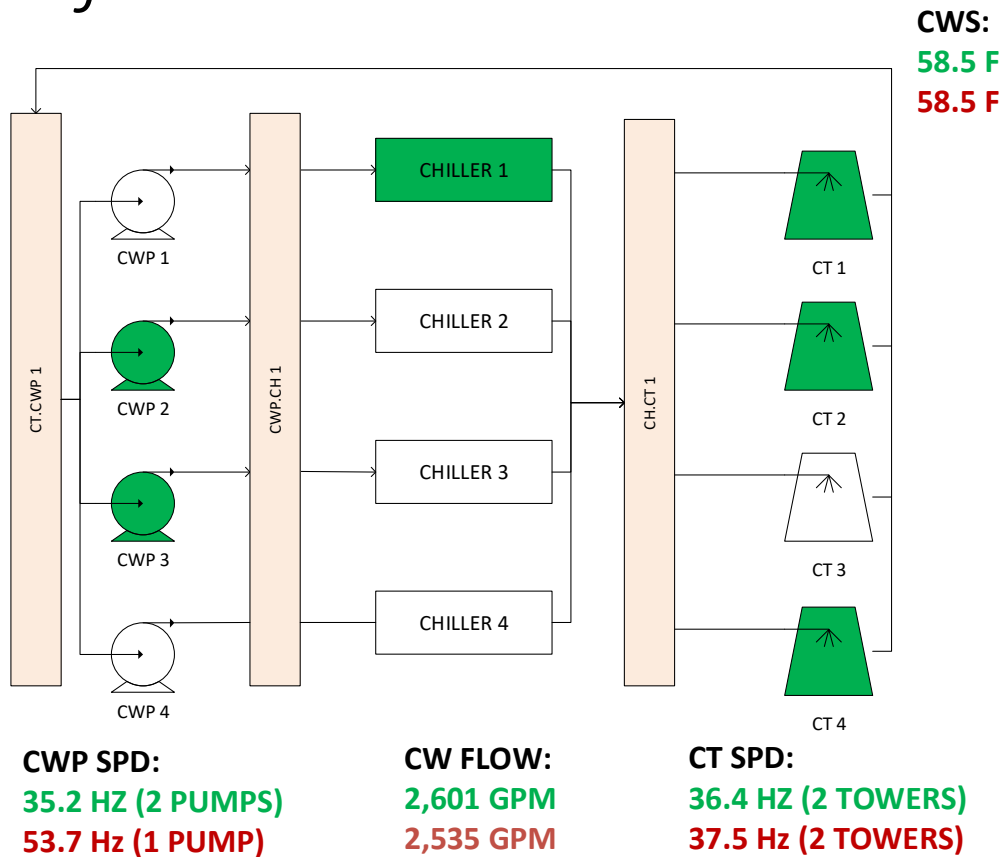
CW flow setpoints are different

A *sequence fault* has occurred

Diagnosing Sequence Faults

Operator Intervention	Commissioning Error	Performance Drift
 Setpoint has been overridden	 Control parameter does not match with Digital Twin	 No actual issue – apparent issue due to error in output measurement
 Speed command has been overridden	 Sensor or device scaling issue	 Tower fill damaged or scaled
 Min/Max limit has been overridden		

Performance Faults



Performance fault: when equipment uses more energy than expected to deliver the output

Compare **observed values** to **modeled values**

Setpoints are the same

Sequence faults have been resolved

CT speeds are the same

This equipment is performing as expected

CWP speeds are different

A performance fault has occurred

Diagnosing Performance Faults

Unknown Loads



Balancing valve closed off



Unmetered use of water or CT capacity

Maintenance Issues



Clogged pump strainers



Plugged or fouled chiller tubes



Tower fill damaged or scaled

Sensor Error



No actual issue – apparent issue due to error in output measurement

Digital Twin Example – CHW Pump

Fault ID	Fault	Equipment	Description	Branch/Owner Feedback
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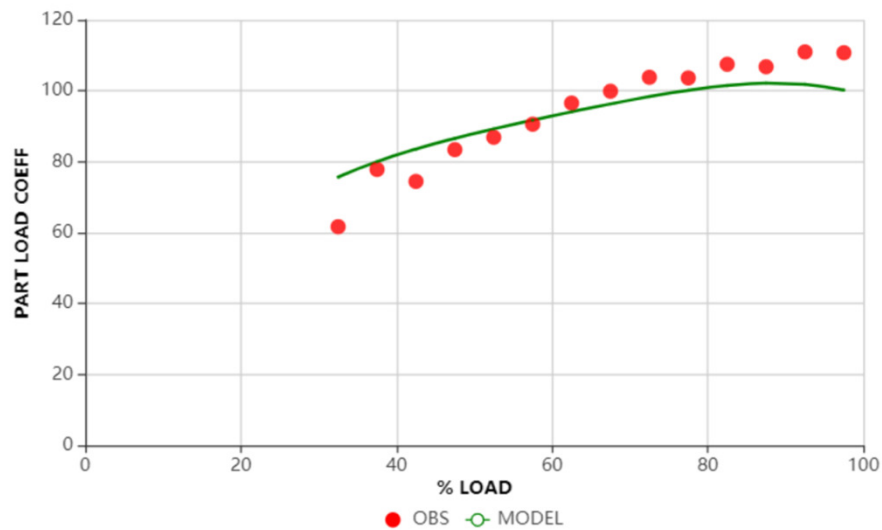
Is the pump
too small?

OR

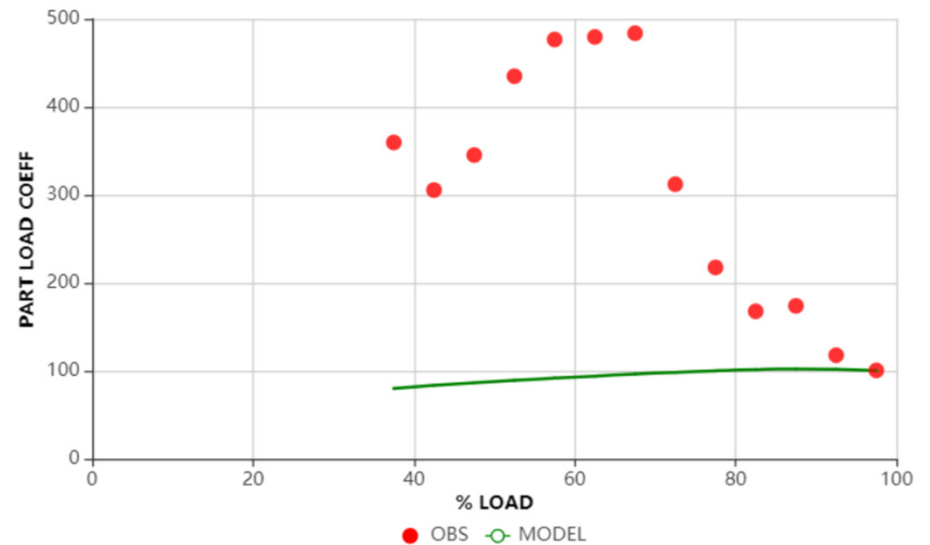
Is the pump
not working?

Digital Twin Example – Chiller kW/ton

observed vs modeled

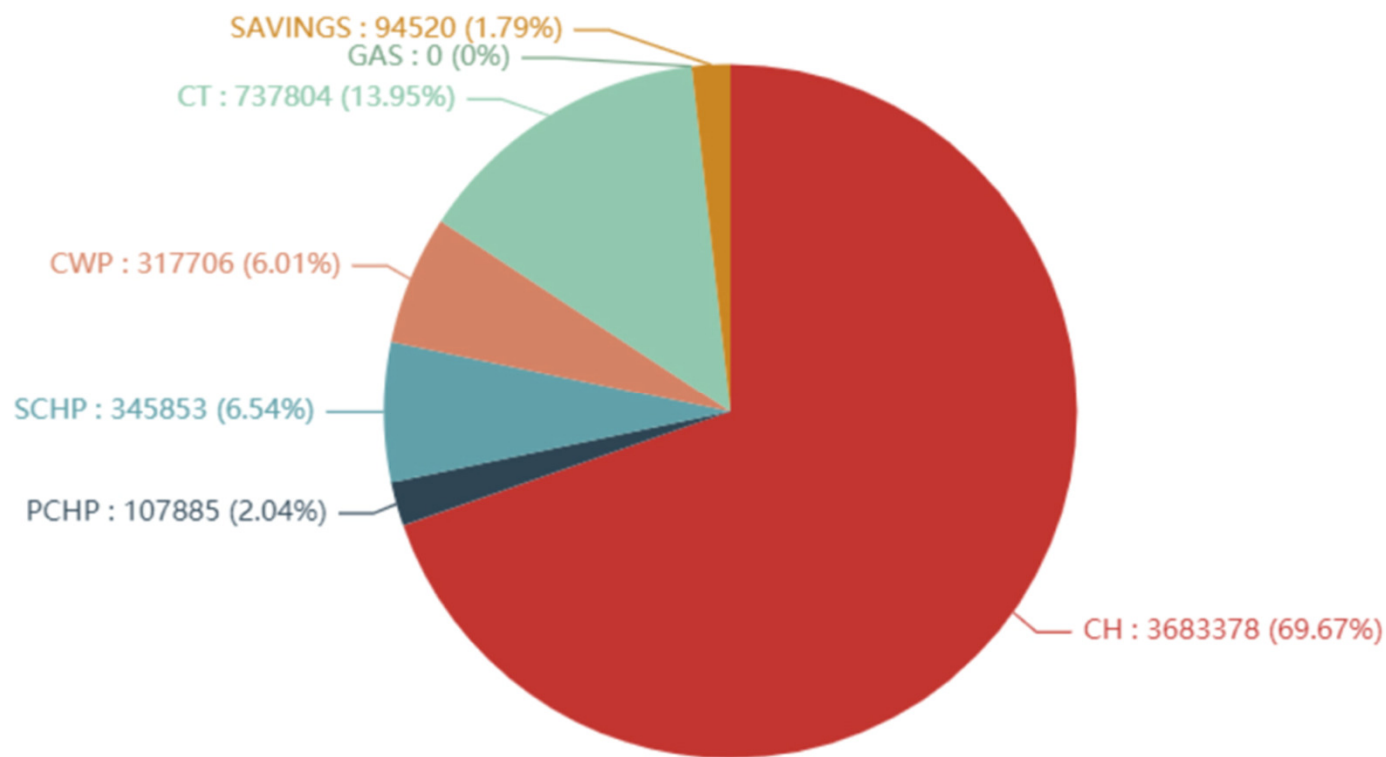


Expected Output



Performance error

Digital Twin Example – Sequence Results





Thank You!



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When: Tuesday, September 28th, 2021

Where: Rules and Regs

(Located on the 7th floor of Fairmont Hotel)

Time: 7:00PM – 9:00PM

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