



# **Data and Analytics Driven Operational Excellence**

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## **Background**

- July 16, 1798 Marine Hospital Service Est.
  - Pres. J. Adam signs First Federal Public Health Law
  - Treated sick & disabled men in the U.S. Navy
  - Seamen paid \$ .20/ mo. to cover expenses
- 1870's Discovery microscopic organisms causes of several infectious diseases
- 1878 Congress appropriated funds
  - "for investigating the origin and causes of epidemic diseases, especially yellow fever and cholera."
- 1904 Moved to Washington, DC
  - \$35,000 for research laboratory on 5 acres
- August 10, 1935 Moved to Bethesda, MD
  - Mr. and Mrs. Luke I. Wilson made a gift of 45 acres of their estate "Tree Tops"
  - Mrs. Wilson donated additional 47 acres



Aerial view of the NIH campus in 1940



#### Today

- 75 buildings over 300 acres
- Total area~12 million sqft, many state-ofthe-art biomedical research facilities
- World-class research hospital
  - 240-bed capacity
- \$37 billion annually in medical research
  - Helping people live longer, healthier lives
  - \$69 billion to our GDP and 7 million jobs
- Leading Biomedical research center



Aerial view of the NIH campus in 2003



## Central Utility Plant (CUP) Overview

- One of the largest CUPs under one roof in the USA
- Provides campus with chilled water, steam, electricity, and compressed air
- CUP Components

Twelve 5,000 Ton capacity chillers

Five gas/ diesel dual fuel fired boilers 800 KPPH, 980 KPPH w/Cogen

#### **Cogeneration Power Plant**

One of the largest US government Cogen plants
One the cleanest Cogen plants in the world
23 MW, 180KPPH steam (40% of campus demand)





#### Capital Projects Under Construction:





Industrial Water System (IWS)
5 Million Gallons

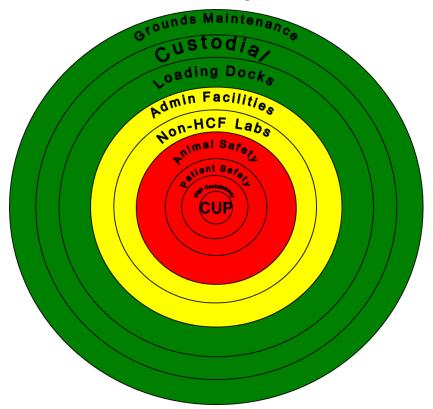
Thermal Energy Storage System (TESS) 7.9 Million Gallons



## What Makes Operation of NIH CUP So Special?

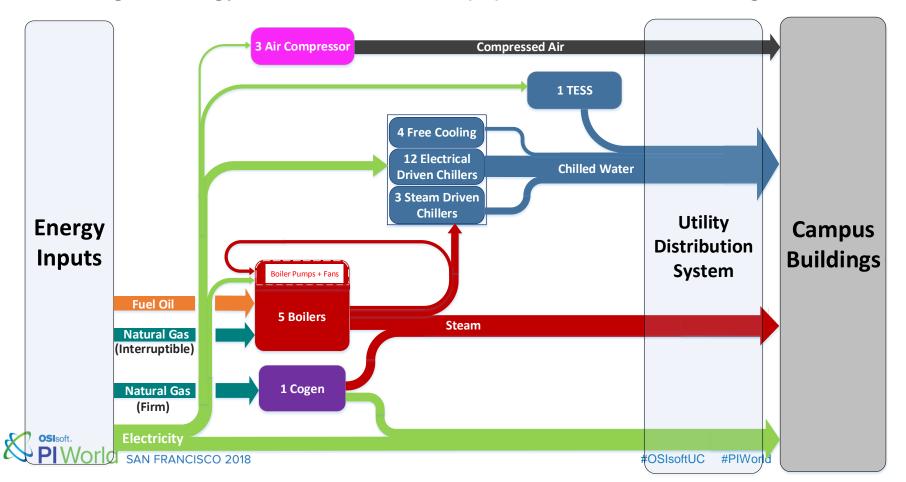
- Reliability is crucial for the <u>mission</u> <u>critical spaces</u> served
  - High containment facilities
  - Research labs
  - Animal facilities
  - World renowned research hospital

NO CUP = NO FUNCTIONING NIH





#### Challenge: Energy Sources & CUP Equipment Portfolio Management



# Data Platform Creates Operational Paradigm Shift

Collect Over 34 Million Data Point per Day

#### Sufficient & reliable data support decision making

Live dashboard reporting; automatic fault detection → High Reliability

Predictive maintenance
Staff training
Fully documented Operational /Maintenance SOPs
Load forecasting and optimization program

Data platform provides us a solid foundation to run the plant safely, reliably, energy efficiently and cost effectively.

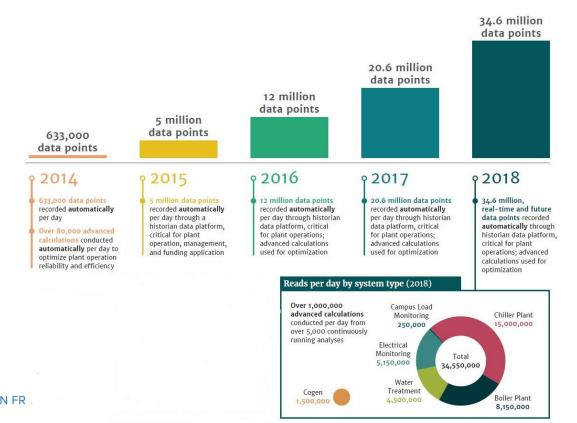
#### You can't manage what you can't measure!

"Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it."

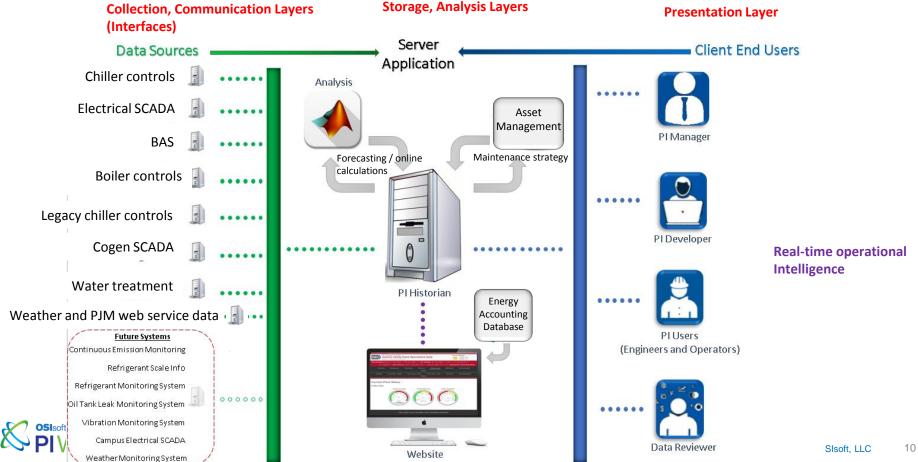
— H. James Harrington

# CUP from a Data Analytics Perspective

• Data Management Platform is at the heart of actionable operational intelligence.

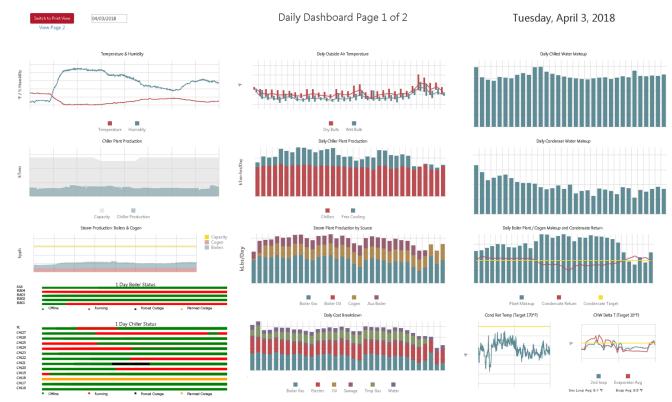


# Enterprise-level Cross Platform Data Integration



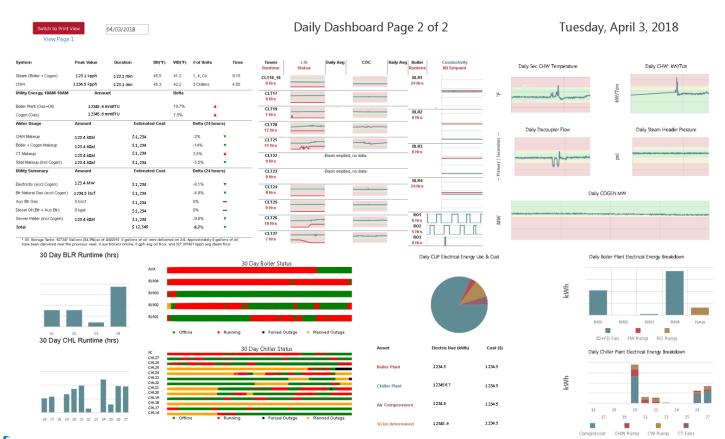
## Web-based Executive Level Summaries and Reporting

High level, executive daily performance data accessible with 1 click



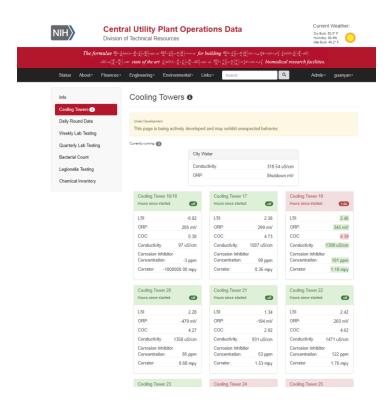
<sup>\*</sup>Not the actual data

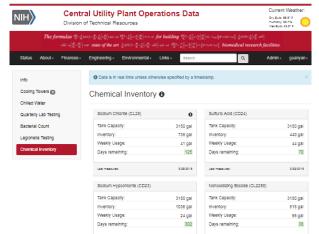
## Web-based Executive Level Summaries and Reporting



<sup>\*</sup>Not the actual data

## Chemical, Environmental & Compliance Dashboard





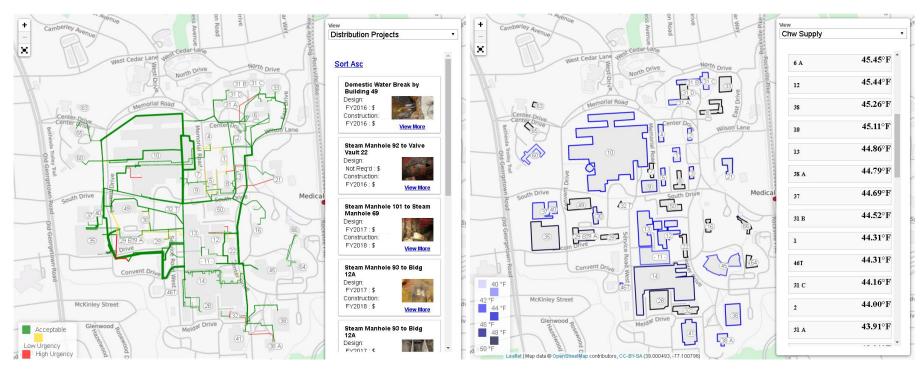
#### Water, air and fuel permit compliance info



\*Not the actual data

## **GIS Visualizing Campus BAS Data**

Integrate real-time data with open-source GIS to visualize real-time BAS and utility distribution info





\*Not the actual data

# Data Platform Powering the CUP Control Room





# Descriptive Analytics Typical Real-time Web-based Control Room Dashboards

Plant Key Performance Indicators (KPI)



Plant Level Dashboard



Chiller Plant Dashboard



Cooling Tower Chemical Dashboard



Chiller Plant Detailed Drill Downs



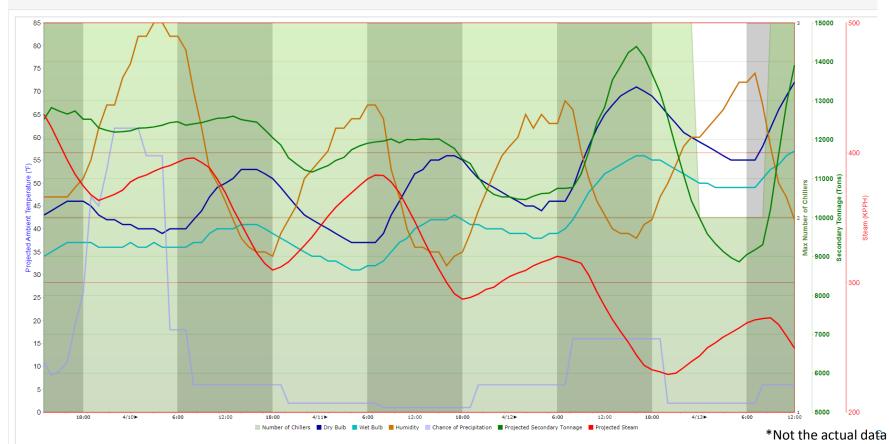
Natural Gas Consumption Dashboard





#### Predictive Analytics – Artificial Neural Network (ANN) based Load Forecaster

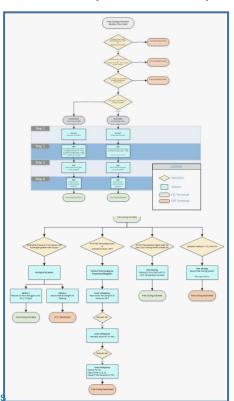
96-hour Forecast Data



## **Assisting Plant Operations – Free Cooling**

- · Weather Forecaster model gives Plant Operator a 12-hour advanced notice when to start free cooling
- The control logic will help the operator to decide how to run free cooling based on ambient weather conditions, CHW flow, and CHW temperature
- Notifies operator when Heat Exchangers need cleaning, should be secured due to low efficiency conditions, or should be aware of potential ice-buildup

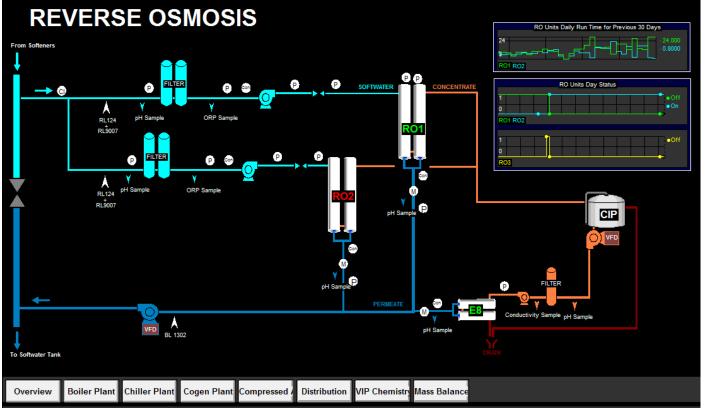




## **Assisting Plant Operations – Reverse Osmosis**

Tracks the run-time (hours) and usage for each RO membrane unit – ensuring the units alternate and do not remain in an idle condition for the extended

periods of time



### **Assisting Plant Operations – Steam Turbine Driven Chiller**

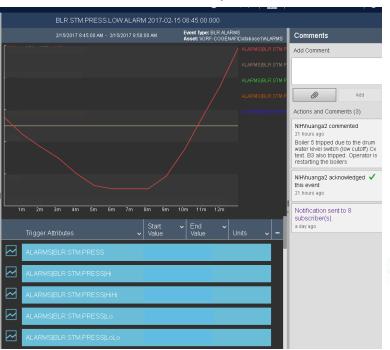
- Data analyses recommend Operators when to run a Chiller on Steam over Electricity
- Data analysis combined with NIH Load Forecaster provides Operator with a 3-hour advanced notice of when to turn on a steam turbine





## Assisting Alarm Notification and Mobility

Notifications via emails, and SMS text messages allow us fully aware of the plant operational issues





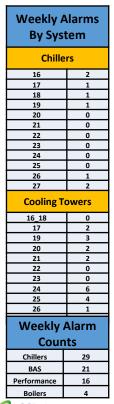


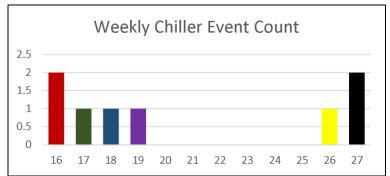
## **Assisting Reliability Centered Maintenance Program**

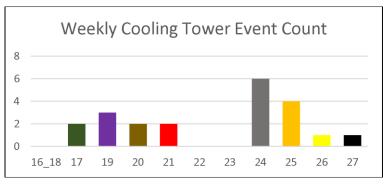


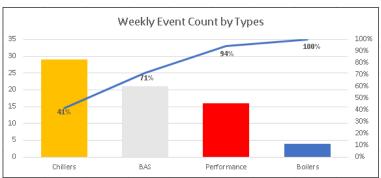
# Dynamic Alarm Management Analysis and Reporting

Reports the event counts, frequency per system, or per time period









#### Daily weekly / monthly Alarm History

Past Alerts (24h):

Current Alerts:

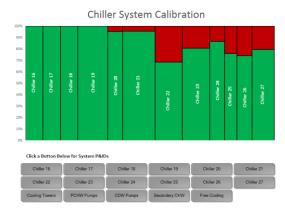


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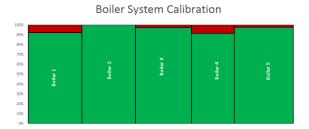
Showing 8 of 8 records

#### **Assisting Calibration Program**

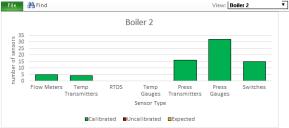
- To avoid GIGO, calibration and online cross platform validation improve the data quality
- Allows for visual reporting and status checks on calibration program
- Strides are being made on error propagation and more rigorous metrological standards





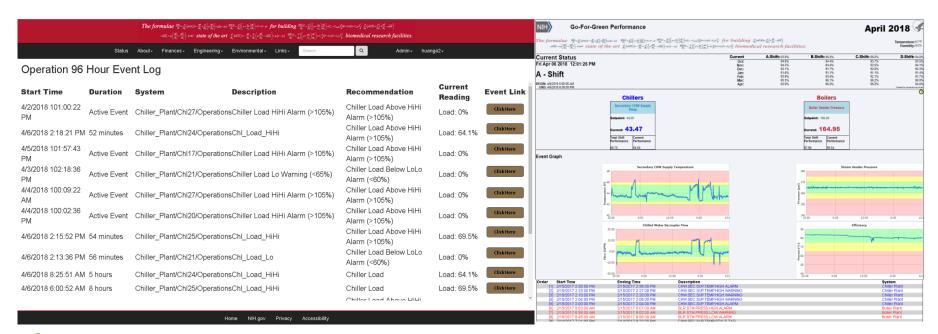






#### **Providing Actionable Operational Intelligence & Fault Detection**

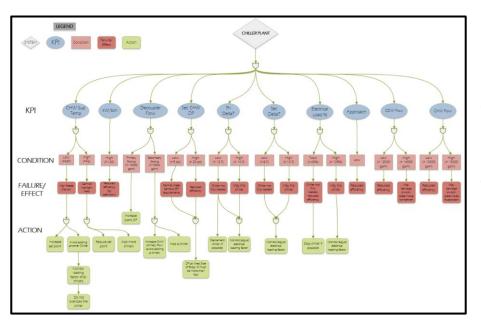
Data Platform provides operators with actionable intelligence, in-time RCA, Auto Fault Detection, and review operators' performance

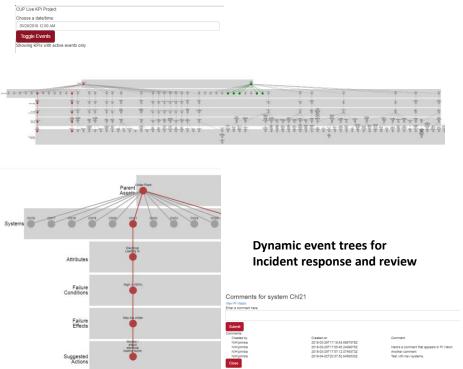




#### **Operation Optimization – Dynamic KPIs & Automatic Early Fault Detection**

• Data should flag the issues out - our website can identify the dynamic events and potential problems for Operators and Engineers to respond and review







# Prescriptive Analytics by Machine Learning Chiller Plant Optimization & Operation Recommendations

**OBJECTIVE:** Minimize (the total equivalent cost)

#### **CONSTRAINTS:**

- Chiller run time and availability
- Limits of the individual chiller /free cooling capacity, flow, temp, etc.
- Load forecasting and energy balance
- Future PJM electricity price

#### **VARIABLES:**

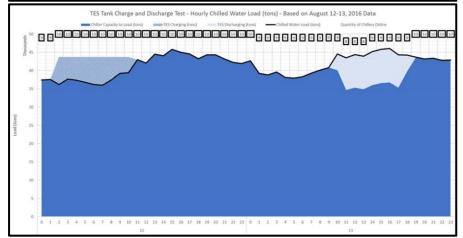
- The chiller condenser evaporator flow, temp
- The load distribution among the chillers

**SOLVER: Spreadsheet Solver optimization add-ins** 

**TYPICAL SUGGESTIONS:** Run minimum number of chillers, shift more load to the more efficient chillers or the steam turbine chiller, run more cooling tower cells to reduce the tower return temp, or increase the CHW supply temp.

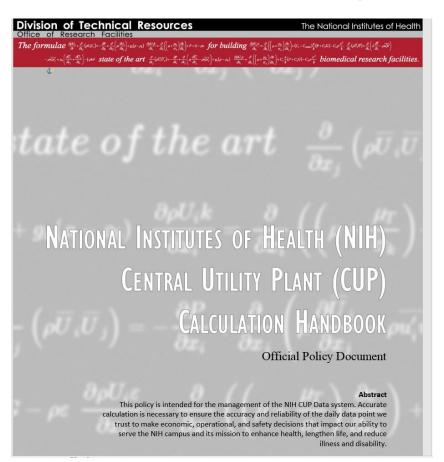




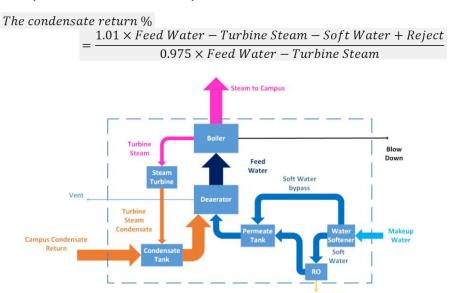


Mutual communication process between the operator and machine

#### Real-time Live Data Management Process & Data Quality Enhancement



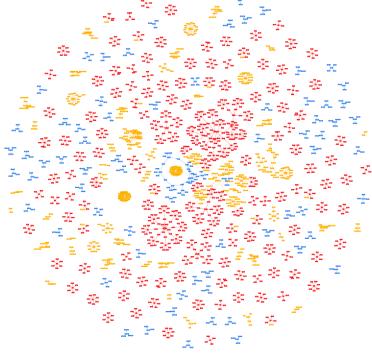
Sample calculation: Campus condensate return%



Calculation Handbook and Change Management SOP
Daily / Monthly Dashboard Review SOPs
Energy / mass/ cost balance and cross disciplinary check
Text message & emails to engineers for calculation errors
#OSIsoftUC #PIWorld ©2018 OSIsoft LLC

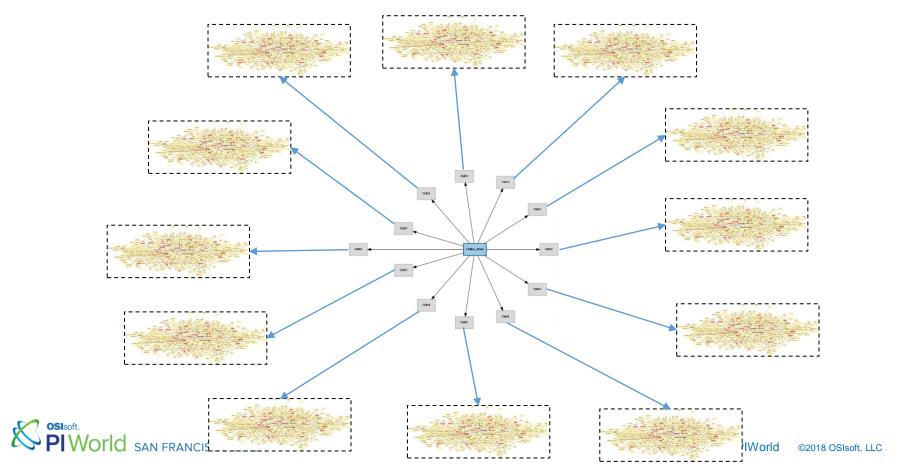
## **CUP Data Universe – Data and Calculation relationship**

This shows the asset-centric models, hierarchies, objects, and equipment. We integrate, contextualize, refine, reference, and further analyze data from multiple sources. Together, these metadata and time series data provide a detailed description of equipment or assets.





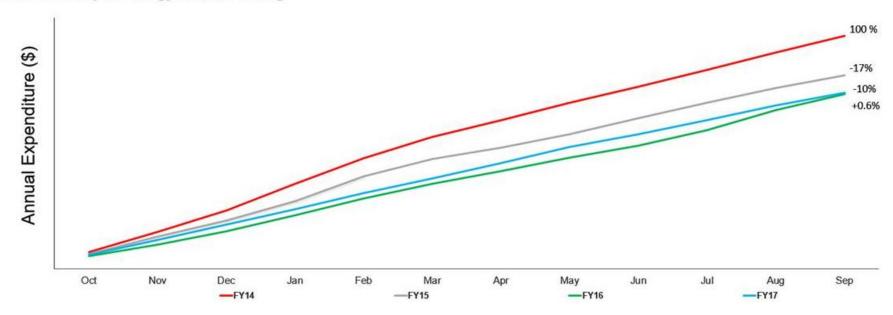
# Chiller Plant Relationships This small snippet shows some of the interdependencies between the references and analyses that are used for the Chiller Plant.



# Tangible Results – Financial

Millions of dollars saved despite increased utility cost & demand!

#### Bethesda Campus Energy & Water Billing



# Summary Slide

#### **COMPANY** and **GOAL**

- 1) NIH operations depend on reliable utility supply.
- 2) Central Plant relies on the leveraging of big data to best serve NIH campus optimally and reliably.







#### **CHALLENGE**

Utilizing millions of data points daily in an intelligent manner such as to ensure the CUP's mission of serving NIH facilities.

- · High quality of data is critical
- Must adhere to the industrial reliability standards due to the unique nature of NIH utility needs.



Leverage data system features to collect, analyze, validate, and deliver data to a broad base of data consumers – all vital to the CUP mission.

- Data historian is crucial to management of over 34 million data points captured daily.
- Data platform is vital for organization and visualization of the data across multiple systems.



Real-time data management platform has led to increased reliability in conjunction with systems optimization and monetary savings, with improvements in all facets expected to continue.

- Significant reliability improvement in terms of equipment failure and reliability since FY13
- Consistent utility saving per year since FY13
- Integration with data-driven optimization technology.



Merci

谢谢

Спасибо

Danke

Gracias

Thank You

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ありがとう

Grazie

Obrigado

Many thanks to NIH Office of Research Facilities Director Mr. Dan Wheeland Division of Technical Resources (DTR) Director Dr. Farhad Memarzadeh, **DTR Deputy Director Mrs. Alamelu Ramesh,** and colleagues in DTR team to make all of these happen!

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