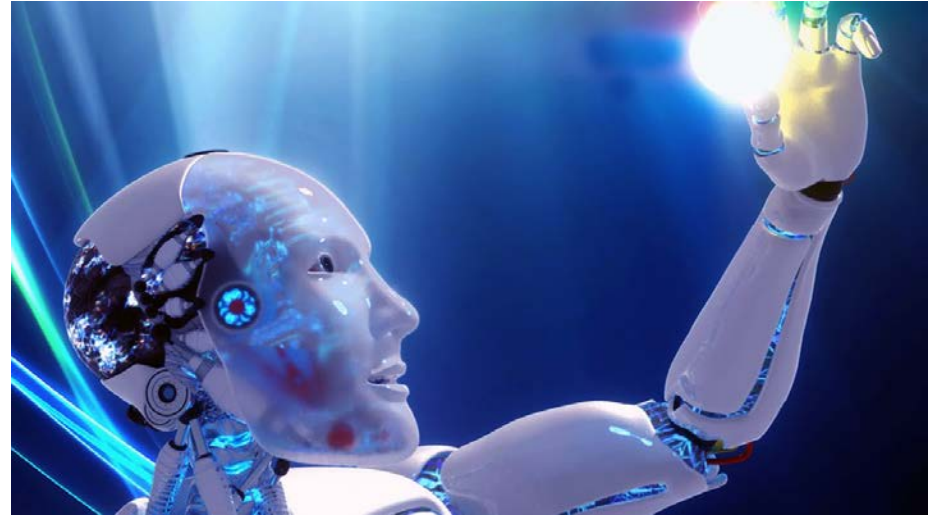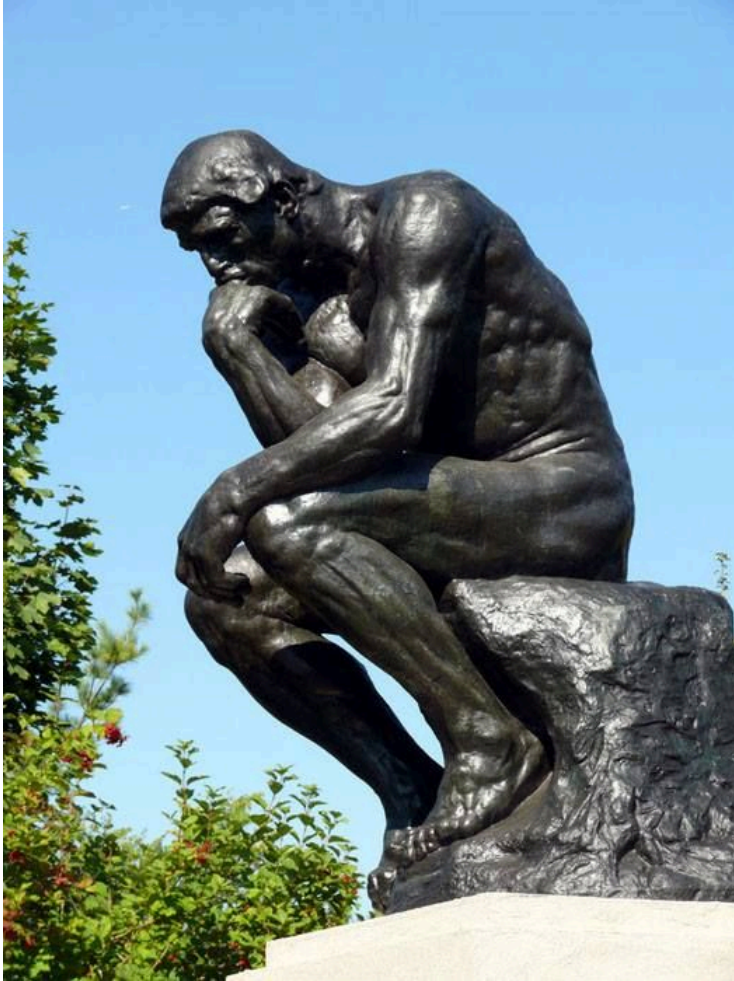# 7B
Optimization of Microgrid Assets Using Artificial Intelligence

Presented by Terence Waldron, PE

First Principles

Wisdom - Ability to think and act using knowledge, experience, understanding, common sense, and insight.

Artificial Intelligence – Capacity of a computer to perform operations analogous to learning and decision making in humans
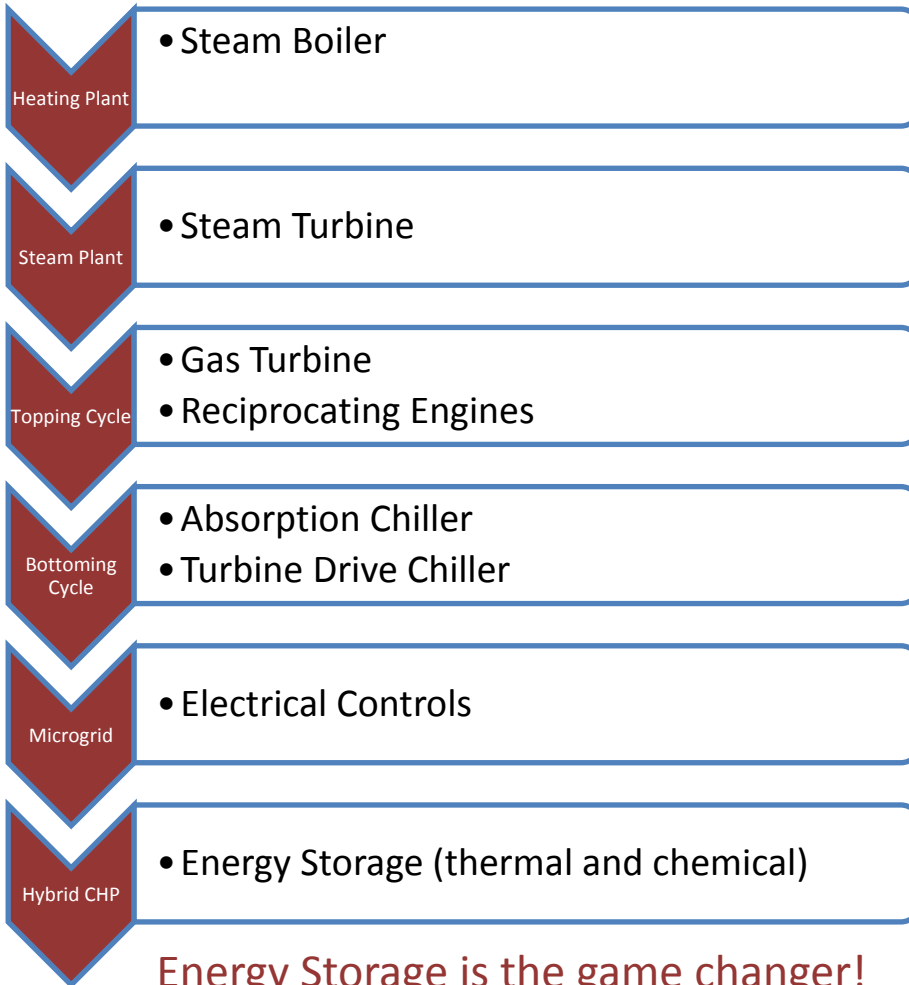
Live in the Moment

- Typical Central Energy plant makes utility products to serve the immediate need.

- Decisions in control systems are typically based on response to input for safe operations.

- Control system optimization to serve the loads before it.

Today me will live in the moment,
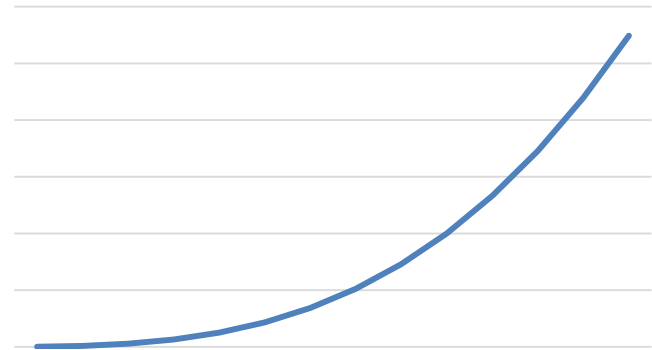unless it's unpleasant,
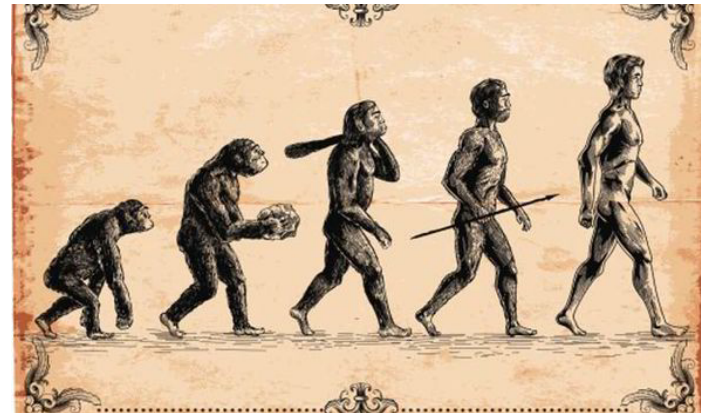in which case me will eat a cookie.

• Cookie Monster

Evolution of Plants

Heating Plant	• Steam Boiler
Steam Plant	• Steam Turbine
Topping Cycle	• Gas Turbine • Reciprocating Engines
Bottoming Cycle	• Absorption Chiller • Turbine Drive Chiller
Microgrid	• Electrical Controls
Hybrid CHP	• Energy Storage (thermal and chemical)

Energy Storage is the game changer!
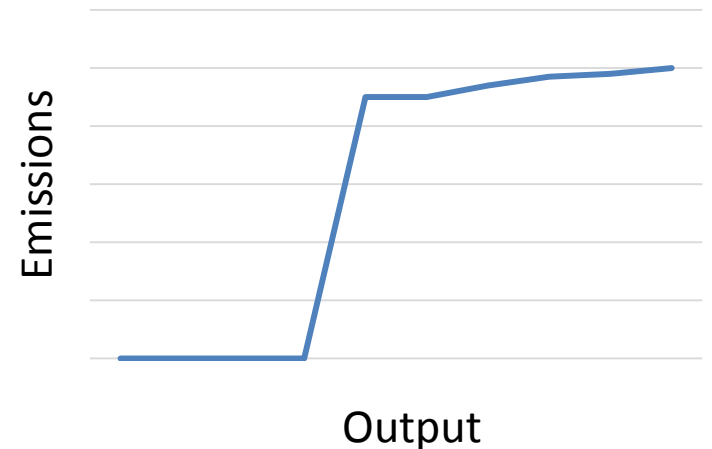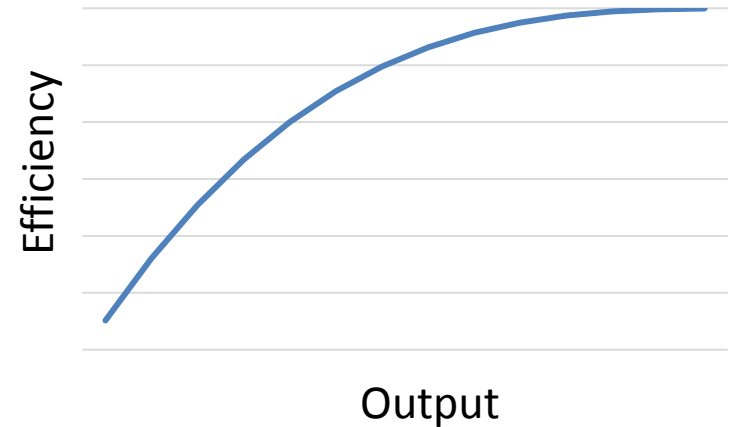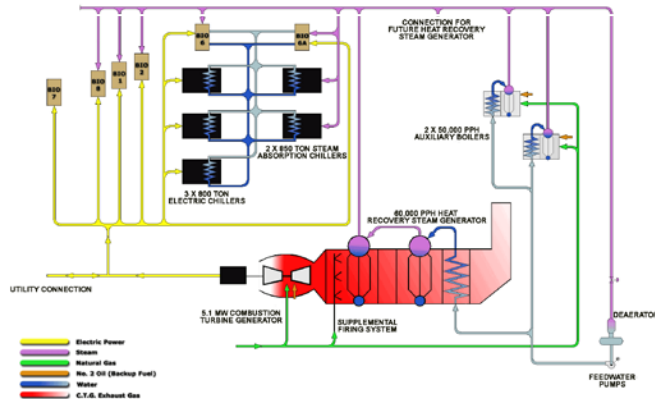
Complexity vs. Degrees of Freedom

Technical Limitations

- Part Load Operation
  - Efficiency
  - Ramp Rates
  - Emissions
- Capacity vs. Temperature
  - Chiller Output vs. Condenser Water
  - Gas Turbine Output vs. Inlet Temp
- Start-Stop Capabilities
  - Purge Cycles
  - Minimum Run Time
- Battery Storage

Economic Paradigm

- Electric Rate Structures
    - Time of Day Rates
    - Demand Charge Ratchets
    - Standby Charges
    - Hourly Energy Rates

- Demand Response Program
- ISO Capacity Payments
- Fuel Availability
- Fuel Arbitrage
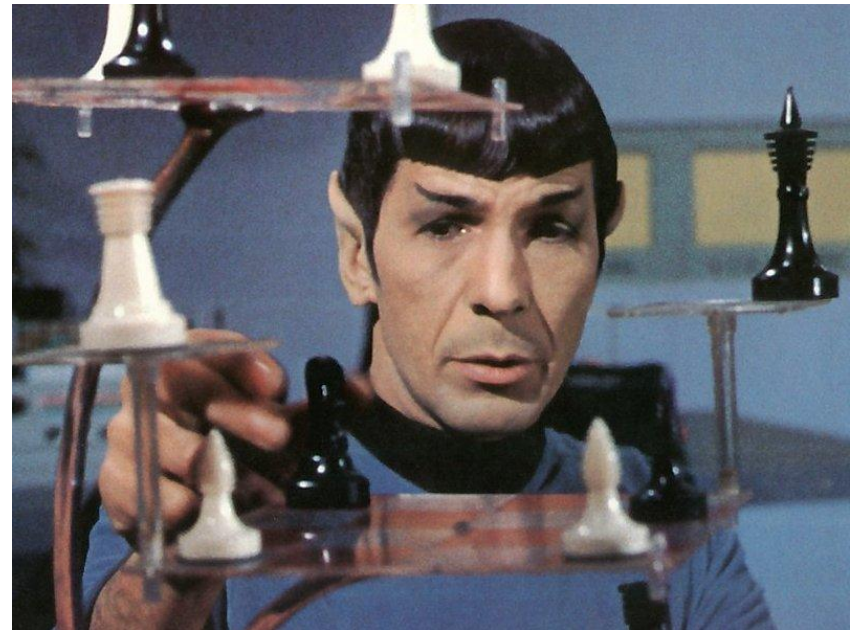
How to Instill Wisdom to Chaos

- Live in the Moment

- Complex Plant Configurations

- Technical Limitations

- Economic Factors

We have dealt with these four to varying degrees
Energy Storage is the game changer!
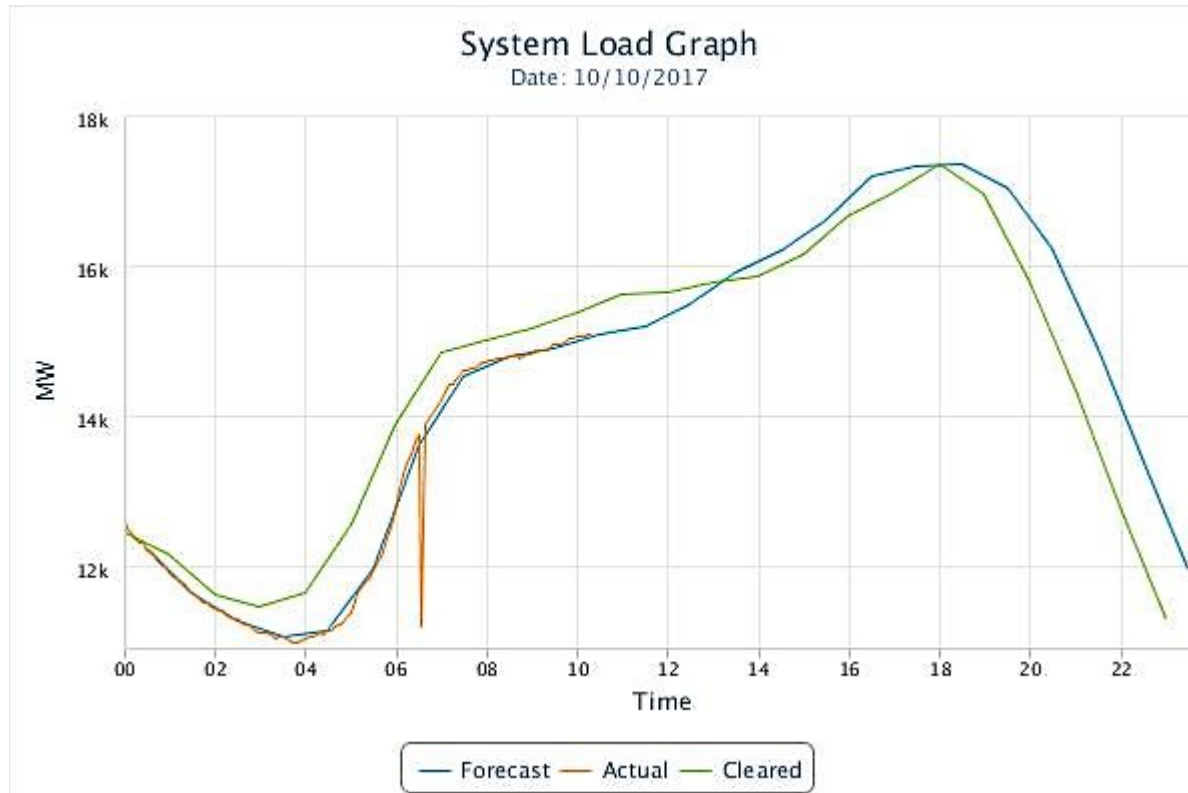Energy Storage allows you to solve the Paradigm using "Wisdom" (AI)

Simple Terms

In the Morning you view the weather and decide if
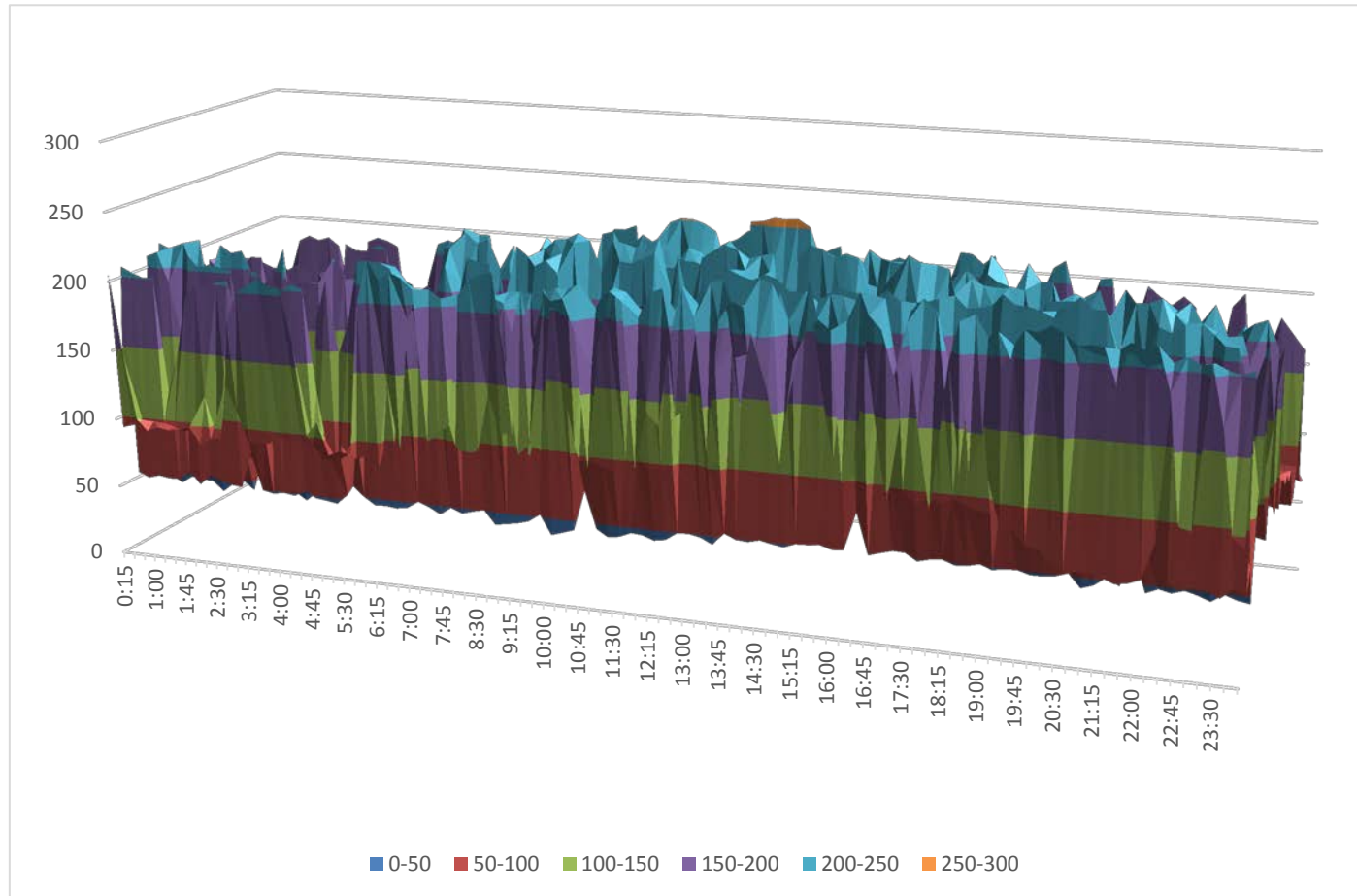you need to bring an Umbrella

What Does the ISO Do?

System Load Graph
Date: 10/10/2017

Mine the Data to Predict the Next Day Load Shape.

Optimize Assets to Meet the Load

We Have The Data

③ $\int_0^1 \frac{1-x}{x+3} dx$

④ $\int \frac{\csc x \cot x}{\csc^2 x} - \frac{1}{\cos(2x)} dx$

Calendar Day + Weather + Data Base = Load Profile

Equipment Status + Technical Limitations = Availability

Fuel Cost + Rate Structures + Influencing Economics = Unit Costs

Load Profile + Availability + Unit Cost = Optimal Economics

$\left[4\ln|u| - u \right]_3^4$

$(4\ln|4| - 4) - (4\ln|3| - 3)$

$\boxed{4\ln 4 - 4\ln 3 - 1}$

$-\int 5u^{-2} du - \frac{1}{2}\ln|\sec u + \tan u| + c$

$-1 \cdot \frac{u^{-1}}{-1} + c \quad -\frac{1}{2}\ln|\sec 2x + \tan 2x| + c$

$\boxed{\frac{1}{\csc x} - \frac{1}{2}\ln|\sec 2x + \tan 2x| + c}$

$\boxed{\sin x - \ln\sqrt{\sec 2x + \tan 2x} + c}$

Its just an Algorithm

The Future is Here

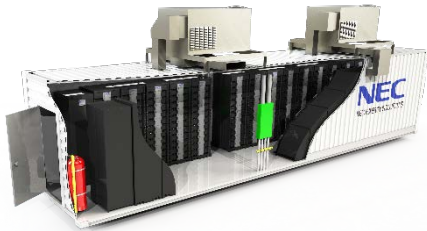# TWA Flight Center Hotel - Hybrid CHP Plant

3   CHP Engines
2   Hot Water Boilers
3   Engine driven Chillers
1   Electric Centrifugal Chiller
1   Battery Storage System
1   Standby Generator

- Without an AI Based Control System This Plant Would Never Meet The Owners:
  - Economic
  - Reliability or;
  - Sustainability Requirements

- The Control System Will Automatically Dispatch Equipment Based on an Algorithm, AI.

- The System will Continuously Learn Based on the Data.
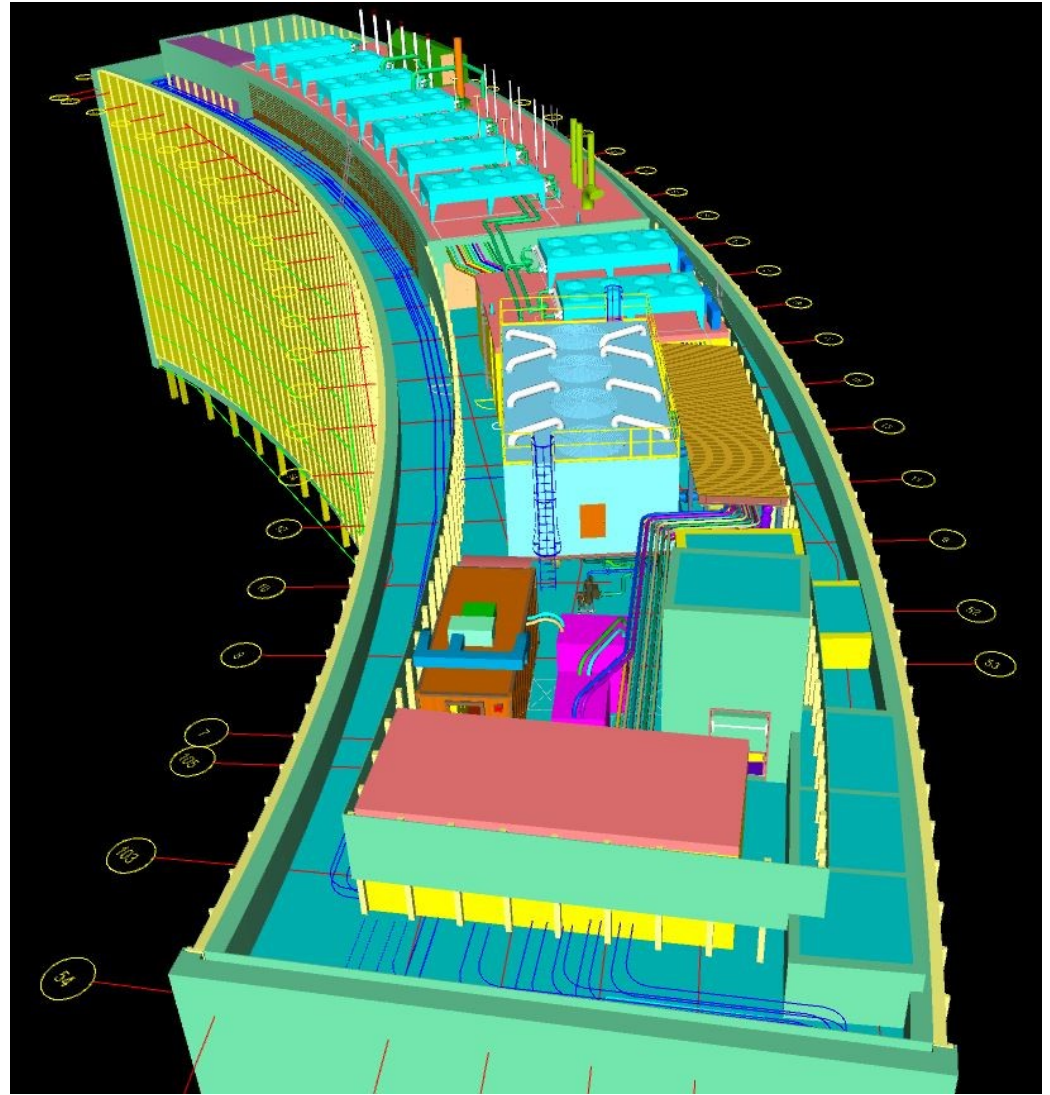
Second Application - Updating the Past

Three CHP Projects Being Upgraded to Hybrid CHP in Massachusetts.

Without the Addition of AI to the Control System, the Battery Storage Systems May Only Have the Value of Paperweights

Takeaway

- Projects are getting more complex due to the emergence of new technology.

- Energy Storage has allowed us to get out of the moment to optimize economics

- We do sophisticated modeling of projects as part of the economic analysis.

- We need a control systems instilled with knowledge of the model, with the wisdom to learn, and the intelligence to make decisions based on that learned knowledge

- This all needs to be part of the plant from day one.

Questions…

WALDRON ENGINEERING & CONSTRUCTION, INC.