ALBANY 2019
STRIVING FOR SYNERGIES
SUNY/PPAA NYAPPA

# Using Big Data Analytics to Drive Processes

WM Group
Smart solutions that work.


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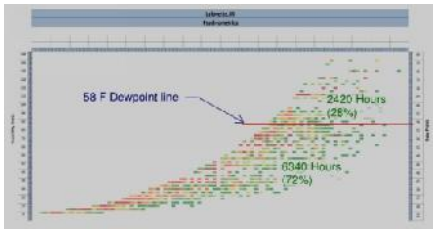
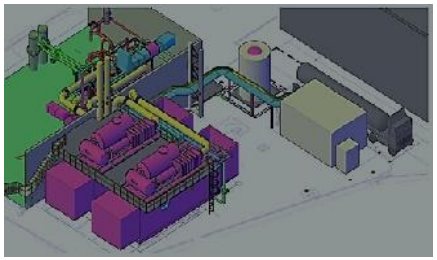
# Our Industry

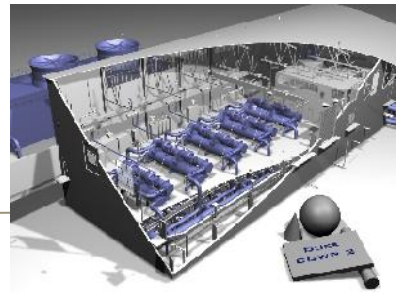
- Recent changes in Energy industry allowed us to invest in M&V.
- We generate a lot of energy data but manage it poorly. Many systems have no actionable logic associated with the data.
- We consume 400% more energy than our European counter part.
- Value of energy is dynamic and relationship with meeting the campus energy needs will also be dynamic.
- Operator training on a regular basis is essential to operate system in a safe, reliable, sustainable, and cost effective way.

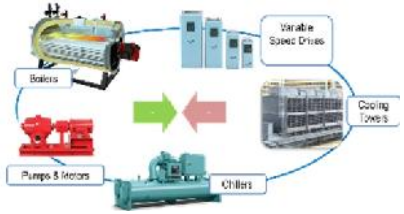


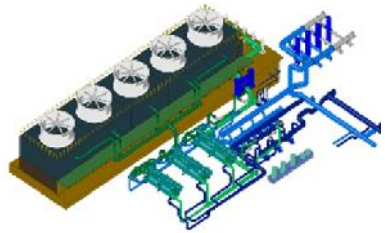



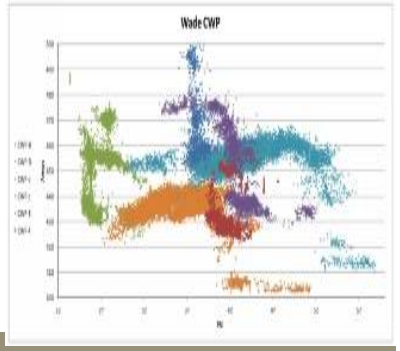
# Big Data Use

- Optimization of processes, components and systems
- Real-time monitoring of KPIs by building live benchmarking tools
- Advanced Analytics for complex system modeling (Cogen, Renewable Energy – value and operational costs)
- Fault detection
- Historical troubleshooting (most of our clients use it for)
- Machine learning





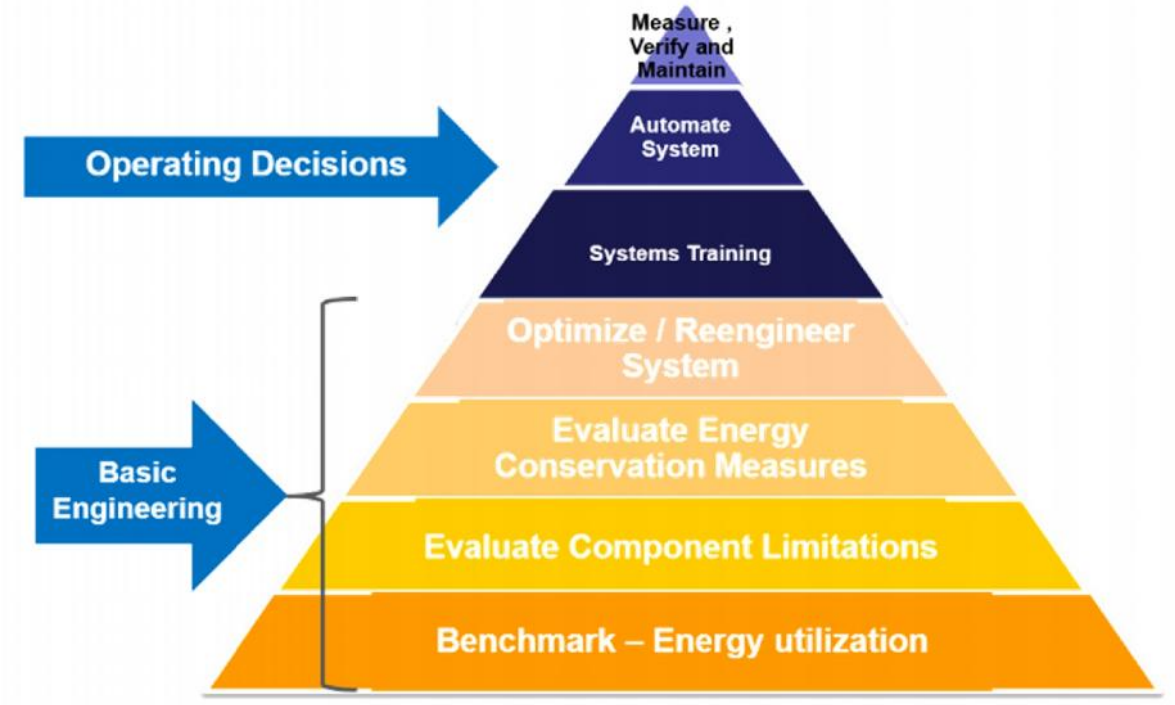
# Campus Industry

- Our fuel and power costs millions per campus
- 10 to 15% savings with less than two years payback is quite feasible.
- There are three components of energy system
  - Generation
  - Distribution
  - Utilization
- It is imperative that all three components are analyzed together to optimize over all system

# Optimization – A Streamlined Process

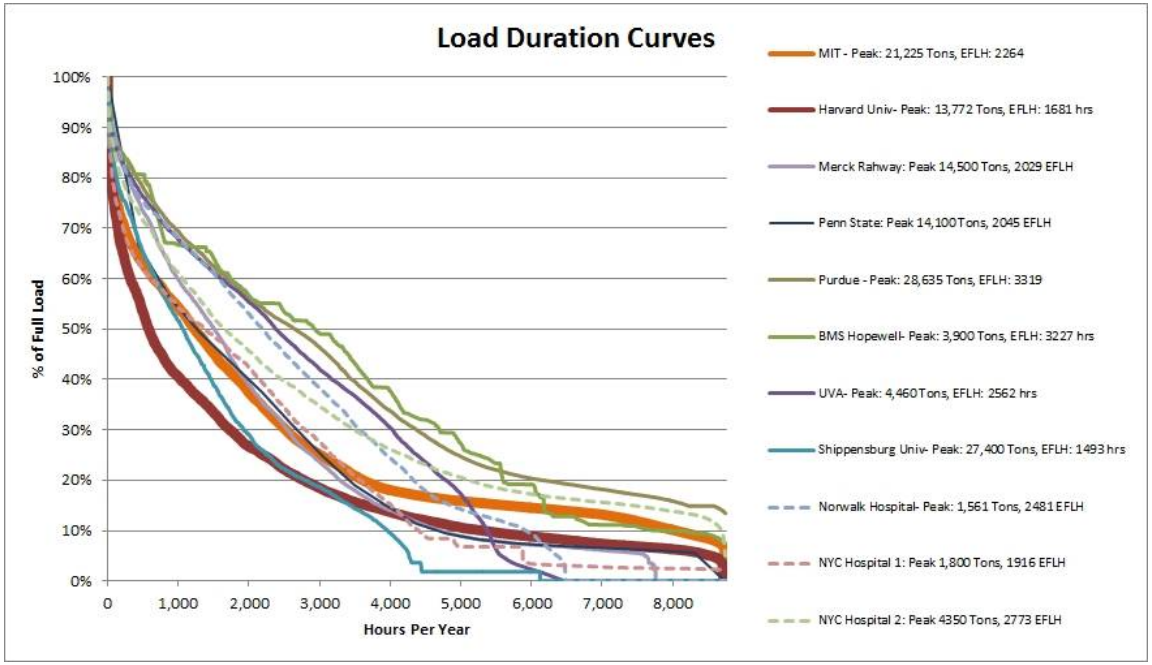
- Our industry is plagued with inefficient systems.
- We still follow designs that were developed in 1970s and fail to capture advanced capabilities of new technologies.
- Component efficiencies have little impact on overall system efficiency.
- Innovations in optimization and big data analytics provide immense opportunities for substantial energy reduction with minimal investment

- Smart Solutions look at basic system with simple but substantial energy savings.
- Solutions include Air Side optimization and water side optimization



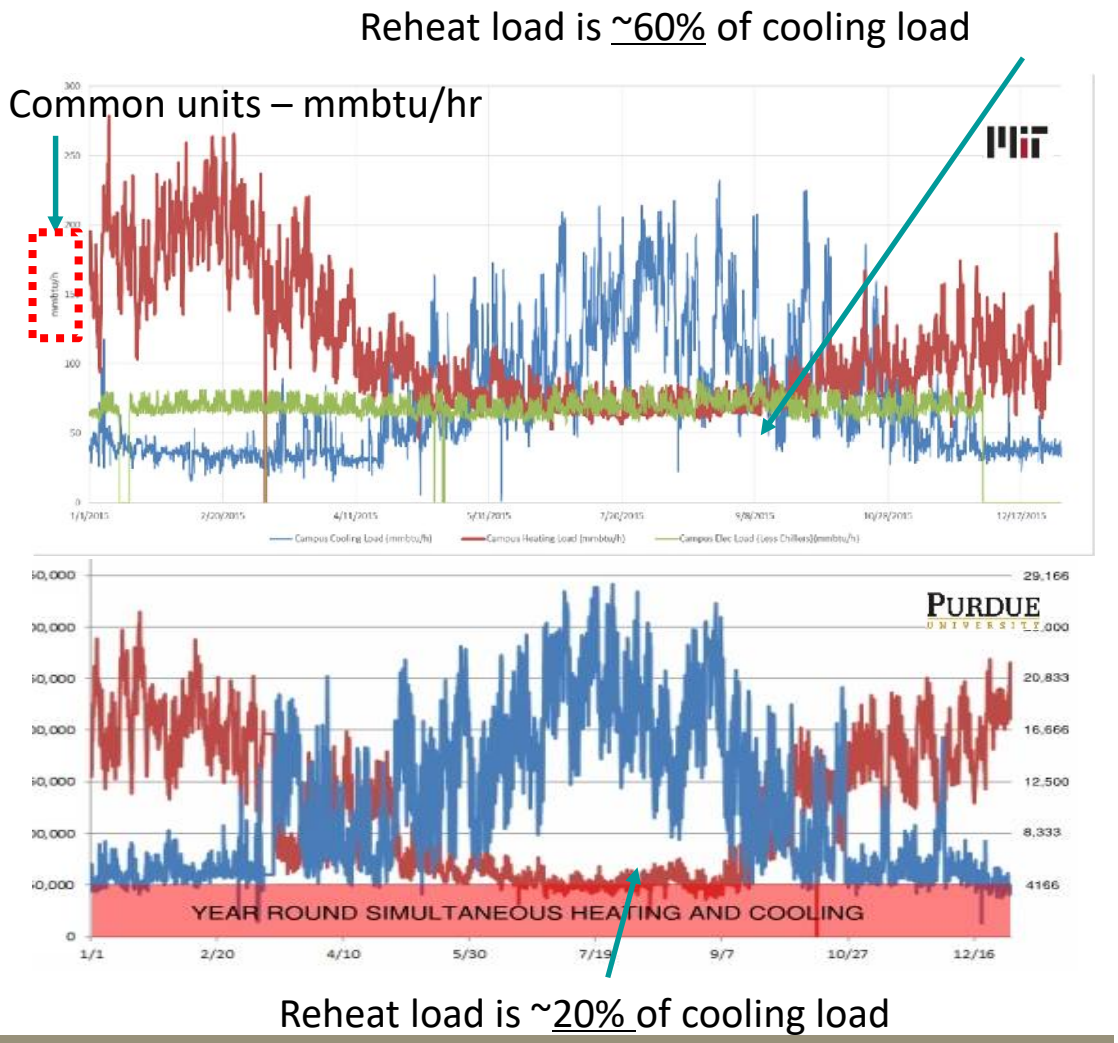
# Data Drives Processes

- Start with understanding of campus energy needs.
  - Campus kBtu/Sqft
  - Effective Full Load Hours (EFLH)
  - Benchmarking



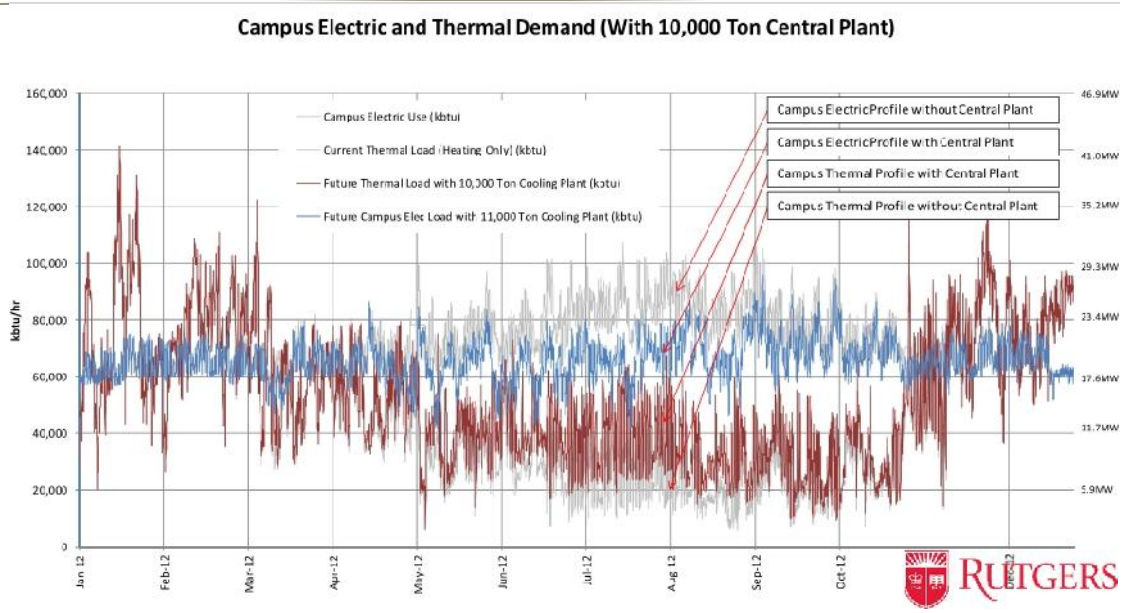
# Big Data – Energy Stream Relationship

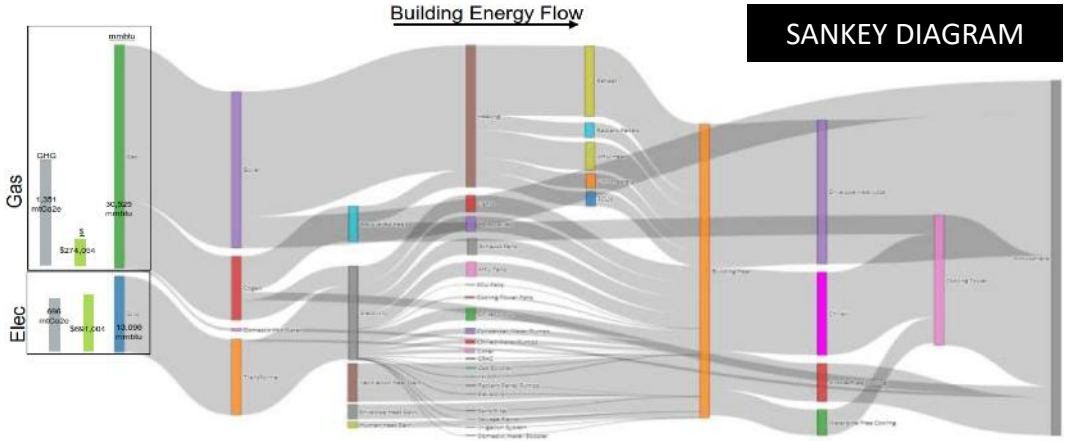
- Develop annual loads and relationship of energy streams
- Energy flow on common unit basis
- Allows understanding of interplay of various energy uses



# Big Data – Energy Stream Relationship

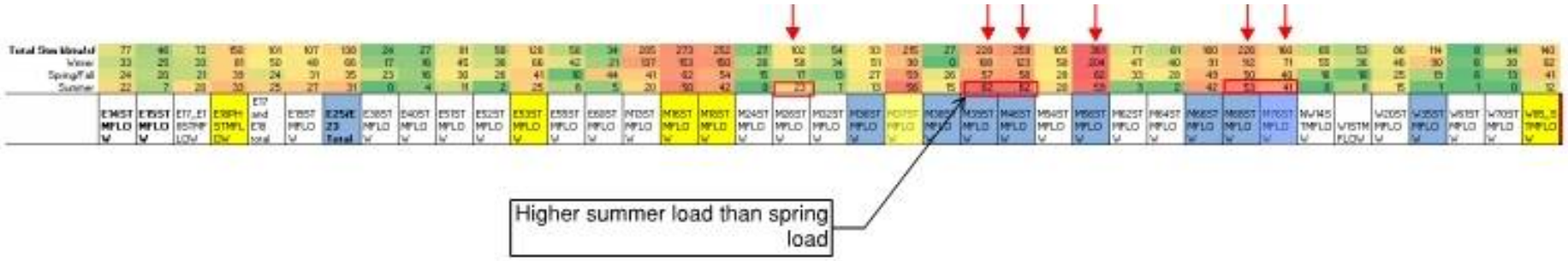
- Analysis for 8,760 hours to understand interplay of loads
- Factor in variations in utility rate structure
- Utility sensitivity analysis
- Resiliency requirements
- Component efficiency in different seasons



# Big Data – Seasonal Benchmarking

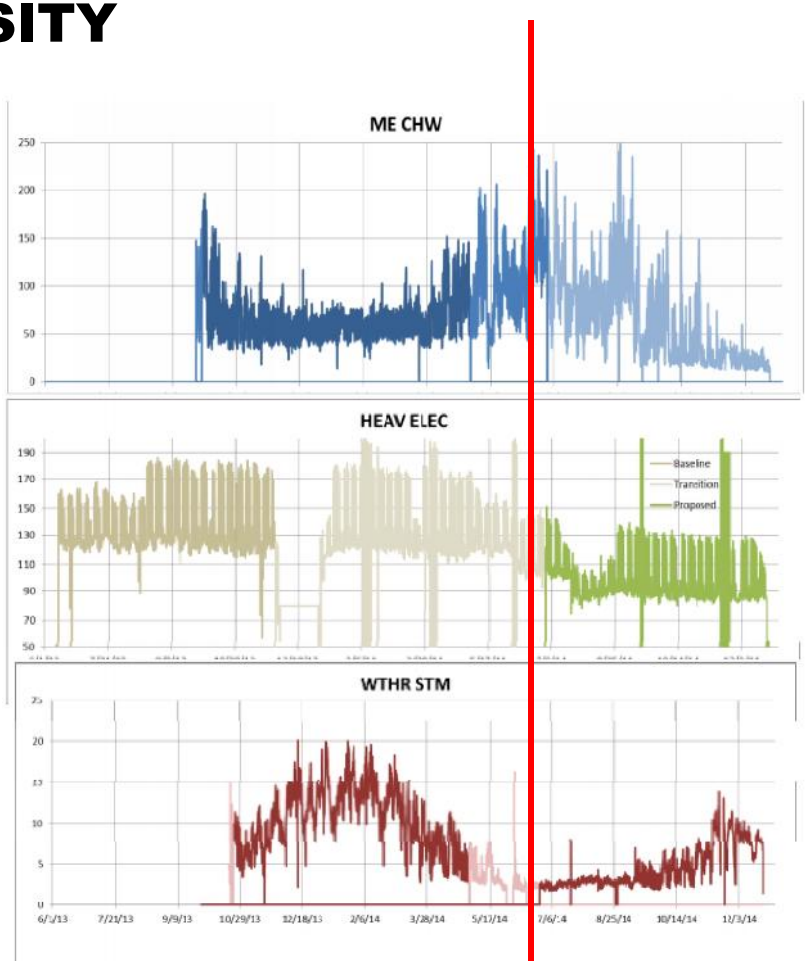
- Realizing unnecessary consumption can often be seen by comparing seasonal relationships of buildings



# Big Data – Seasonal Benchmarking

## CASE STUDY – PURDUE UNIVERSITY

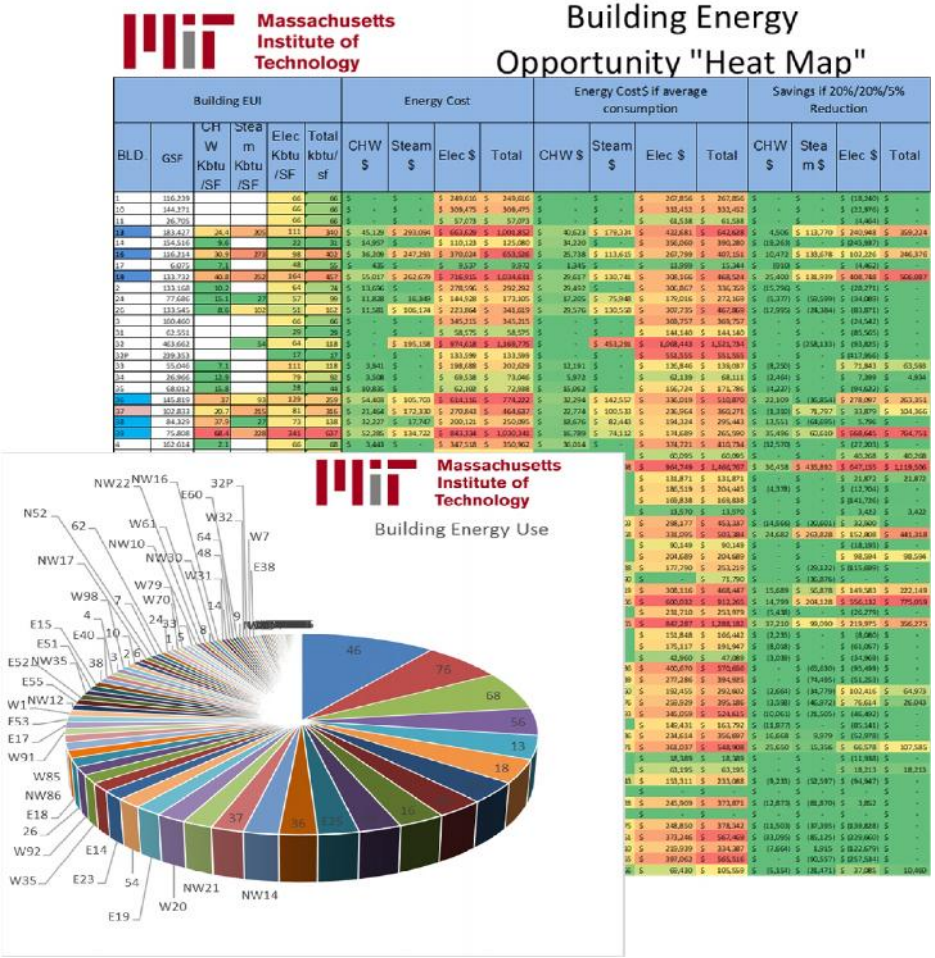
- Data revealed focus on 7 buildings – Energy intensive
- Used trended data
- 35% reduction in Cooling Energy
- 21% reduction in Heating Energy
- 14% reduction in Electrical Energy
- 2 year payback (at $0.04/kwh)
- Projected across campus(at $0.04/kwh)
  - $4m annual savings



# Big Data – Seasonal Benchmarking

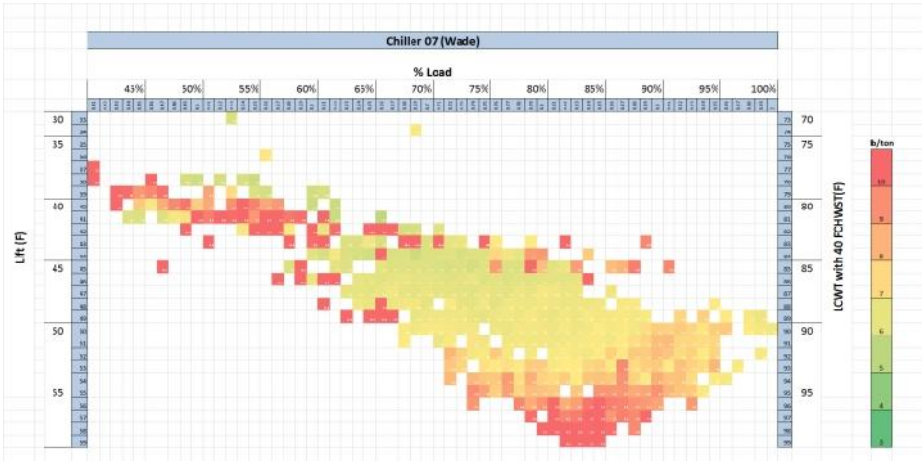
## CASE STUDY – MIT

- 10 biggest building energy users
- These account for about 27% of metered GSF but consume:
  - 47% of metered campus energy
  - 58% of metered CHW
  - 62% of campus steam
  - 37% of campus electricity



# Big Data – Benchmarking Component

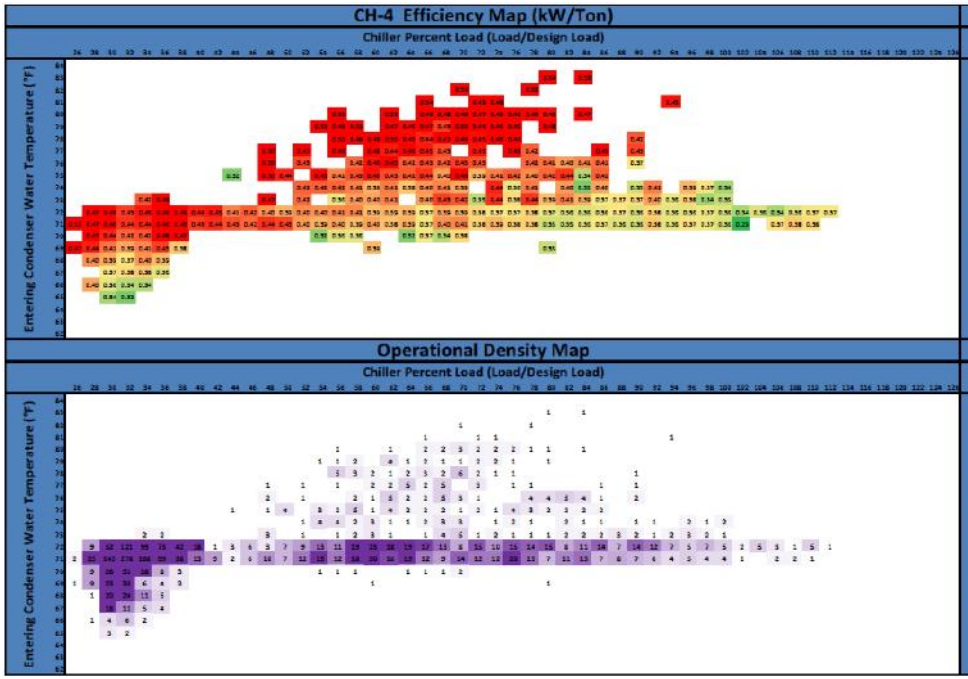
- Identify “sweet spot” for component operation
- Understanding of inter-relationship with ancillary systems
- Each unit has its own efficient operation footprint
- Use data analytics to reveal optimum operating conditions for individual components



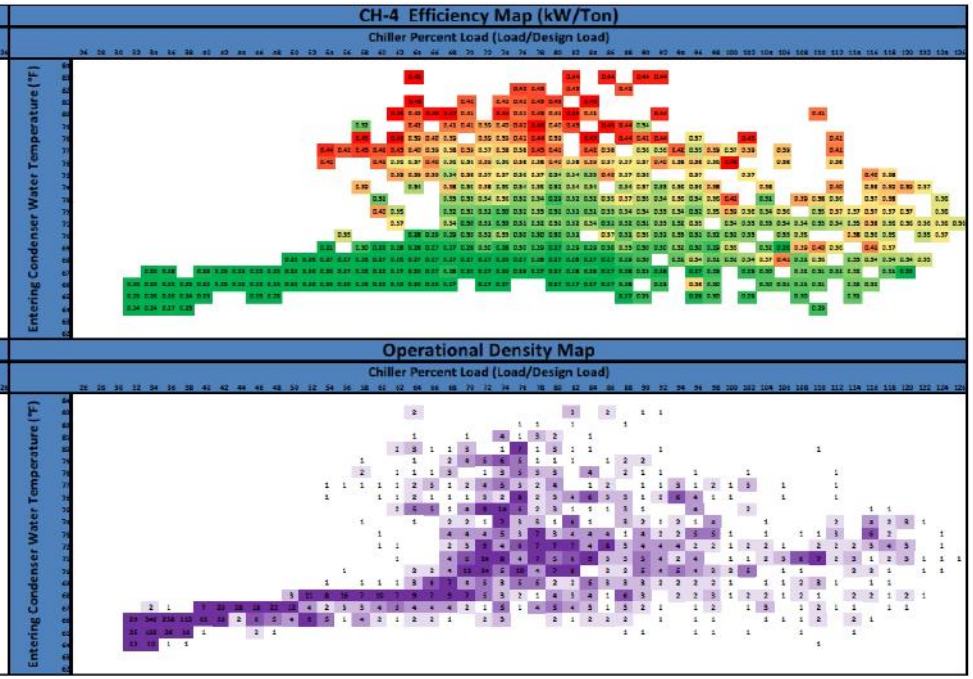
# Big Data –Benchmarking Components

## CASE STUDY – Bristol Myers Squibb

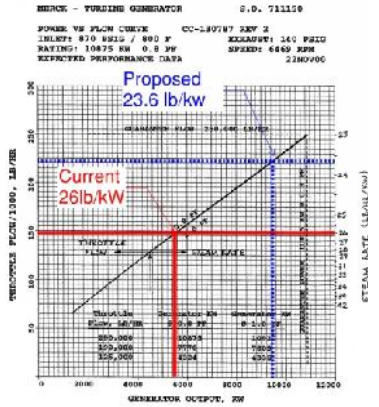
### Pre-Optimization




### Post-Optimization

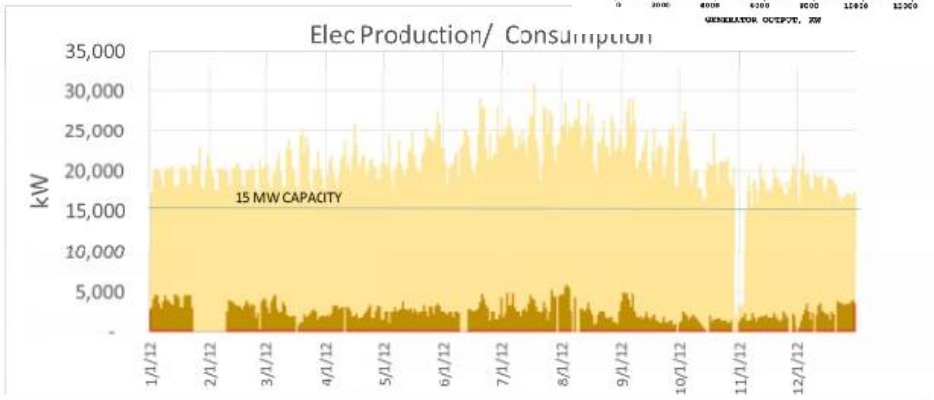


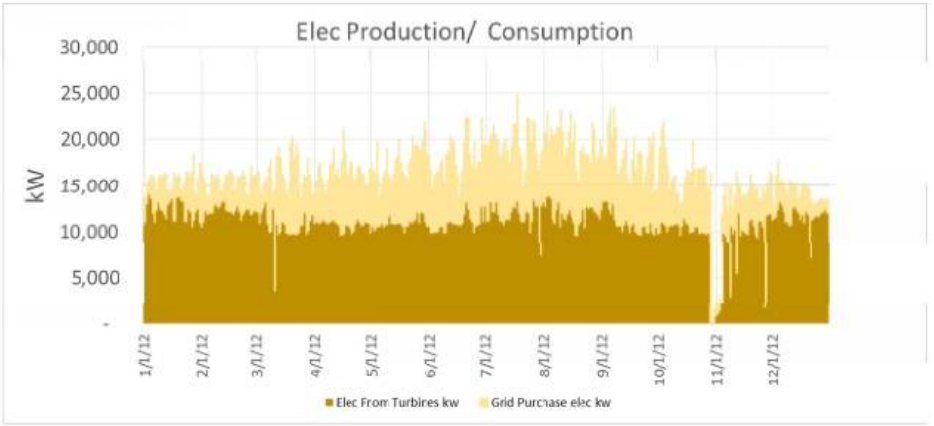
# Big Data – Advanced Analytics




## CASE STUDY – Merck Rahway

- 15MW plant could only make full capacity if it vents steam
- Addition of condensing steam turbine:
  - Recover heat for production of additional power (5MW)
  - Increase power from existing turbines
  - Increase existing turbine efficiency
  - Increase overall plant efficiency from 59% to 67.5%

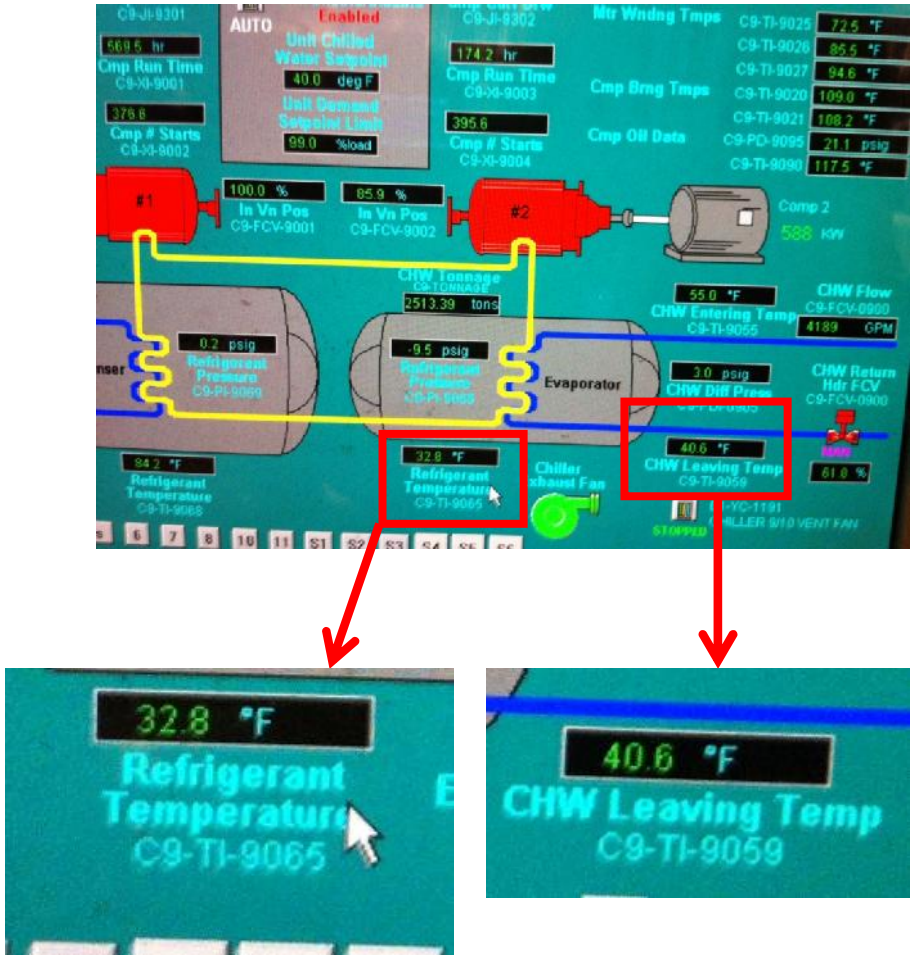



| Utility | Savings | Payback |
|---|---|---|
| Compressed Air System | $271,924 | 1 yr |
| Chilled Water Optimization | $613,200 | 1-2 yrs |
| Steam System Optimization | $372,000 | 1-2 yrs |
| Condensing Steam Turbine | $3,500,000 | 2-4 yrs |
| Flue Gas Heat Recovery | $700,000 | 3-4 yrs |
| Building Recip Cogen Engine | $100,000 | 2-3 yrs |

# Big Data – Faults

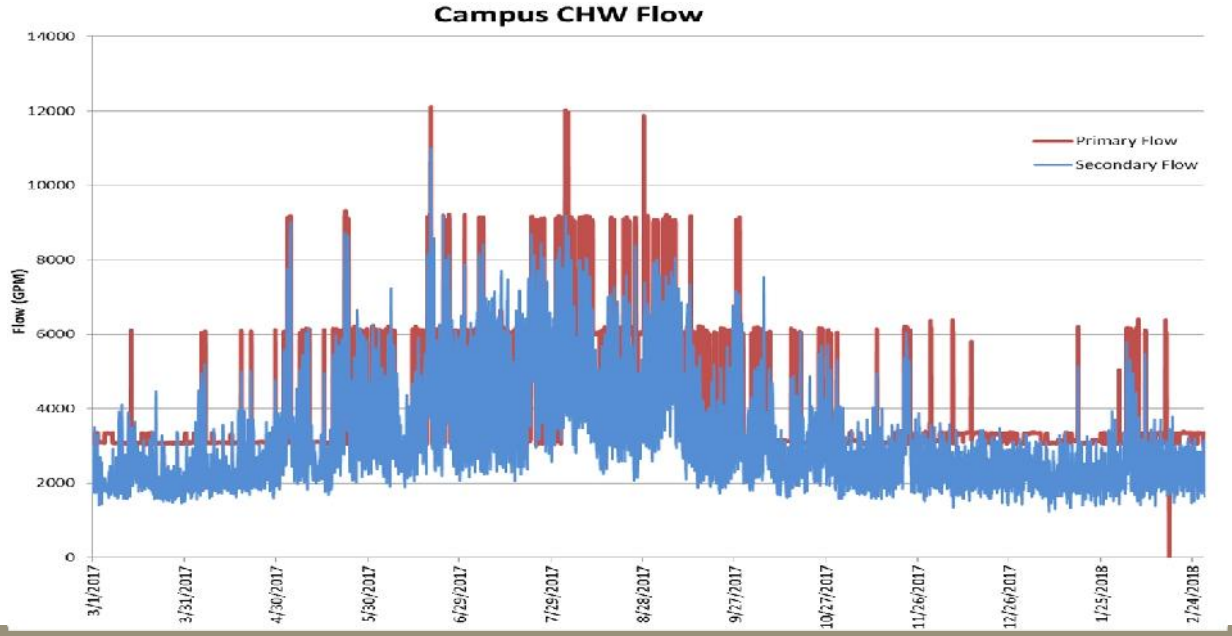
- Provides simple tool to quickly identify system faults
- Big Data helps in revealing many improper control points.
- Systems trending helps in evaluation of improper logic of operation



# Big Data – Fault

## CASE STUDY – University of Oregon

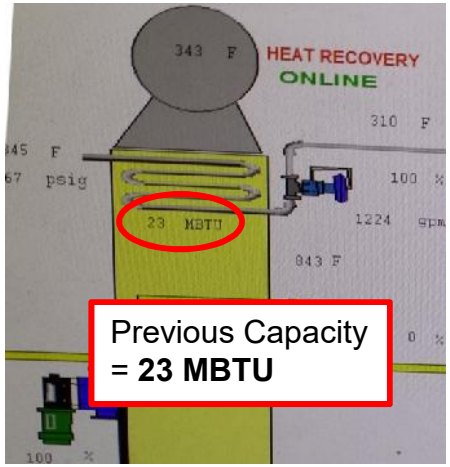
- Primary CHW flow higher than secondary chilled water flow for over 79% of time. Incorrect operation.
- Mixing wastes energy, reduced equipment capacity and campus is unable to maintain space temperatures.

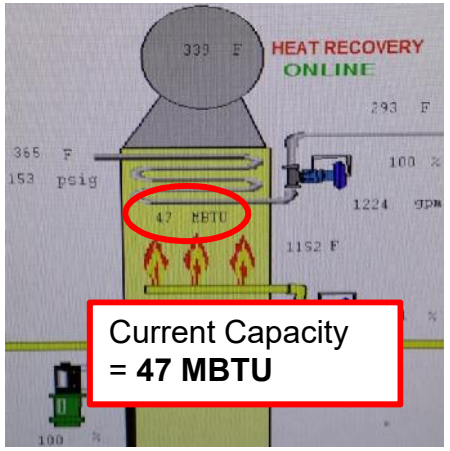


# Big Data – Fault

## CASE STUDY – Rutgers University

- Loss of Capacity - HTHW
- Generating at 360F
- Buildings have excellent DT 110F, but mixing in decoupler causing plant DT to be 40F
- Proper staging and decoupler flow control increased capacity by 35%.



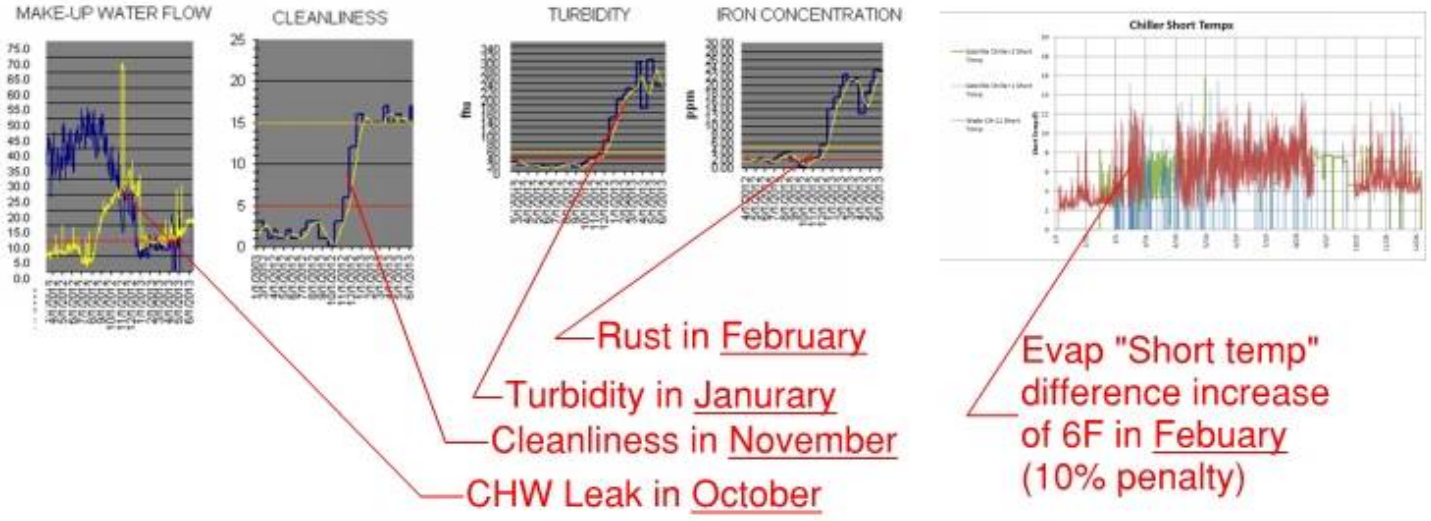



# Big Data – Historical Troubleshooting

## CASE STUDY – Purdue University

Lost Chiller capacity and efficiency

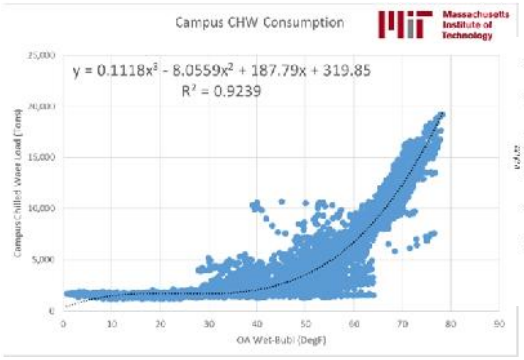
High Short Temperature Difference
Iron Concentration lagged make-up increase by 3 months (rust)
Short temp increased 2 months later



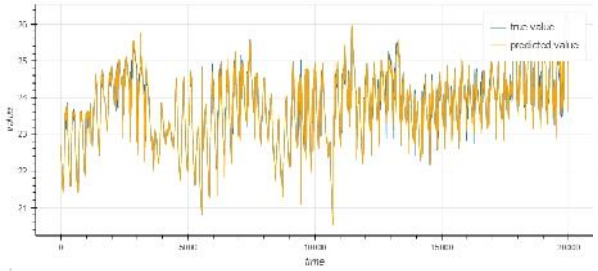
# Big Data – Machine Learning

WHY MACHINE LEARNING:

- Too much data for excel to handle
- Allows for data relationships more than 2D.



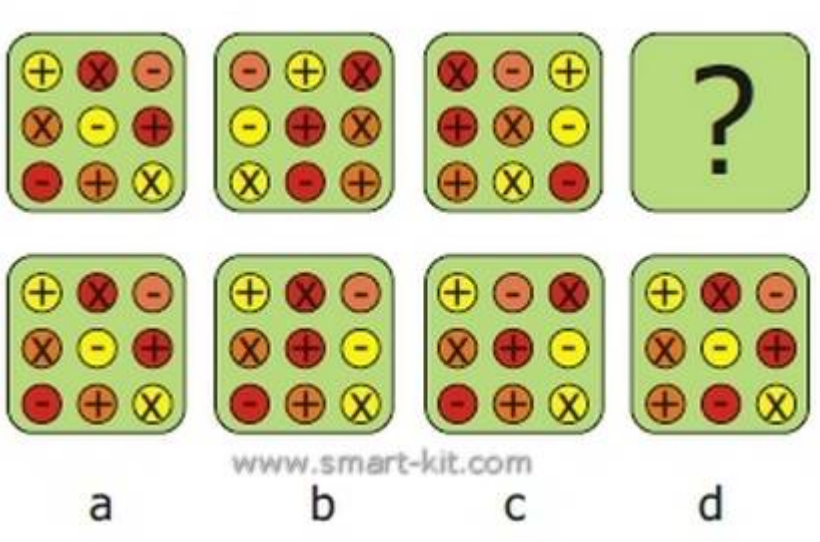

**2-D Analysis**




**Multi-dimensional Analysis**

WHAT IS MACHINE LEARNING:

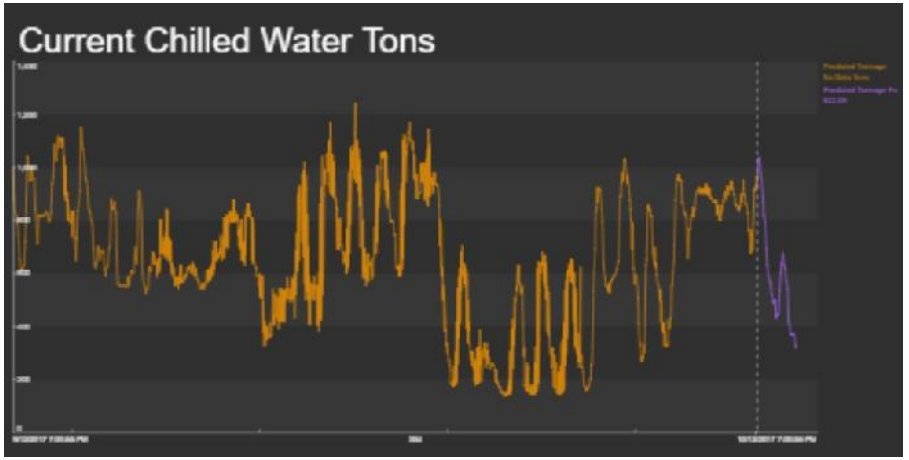
- In its simplest form, Machine learning is pattern detection
- Predicting what comes next..



# Big Data – Machine Learning

**MULTI-DIMENSIONAL DATA RELATIONSHIPS**

- EXAMPLE: Building Chilled Water Load
  - OA Wet-bulb
  - Time of Day
  - Day of Week (weekend/weekday)
  - Month of year
  - Holiday and Class Schedule
  - Solar Angle
  - UV Index




- "My building is consuming 500 Tons right now, is that good or bad?"

# Big Data – Machine Learning

**APPLICATIONS**

- Active prediction model that self-corrects as more data is evaluated.
- Component dispatches based on value of energy, time of the day use.
- M&V for pre-optimized operation and post optimized operation.
- Missed target alarms with live benchmarking. Compare BTU/Sqft and if this is beyond the prediction, alert facility executives.
- Component level alarms for missed targets

# Big Data – Training

## Operators Training

We spend considerable effort in optimizing systems but fail to realize the importance of SYSTEM training for the plant operators.

By empowering the operators, they become a part of the optimization and will help in sustaining the path of continuous improvement.

"thanks for your help with the plant. To be honest you were the **first engineer to actually listen** to the guys and make changes that made sense."

- Matt Mehl, Operator, Bristol Myer Squibb

Harvard University

Chilled water operators training at Lockheed Martin

I. Overall Comment

Great class , learned a lot about our system. The teacher is very sharp on what he does .

II. What part you found most useful

That we have enough supply to be able to put the rest of the plant on chill water.

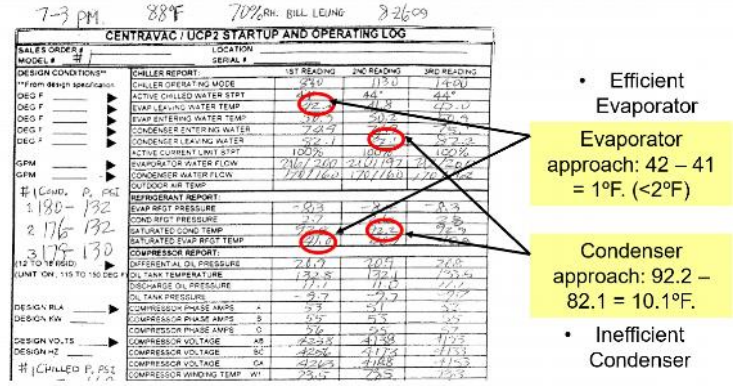
III. Other areas you like to cover for the future training

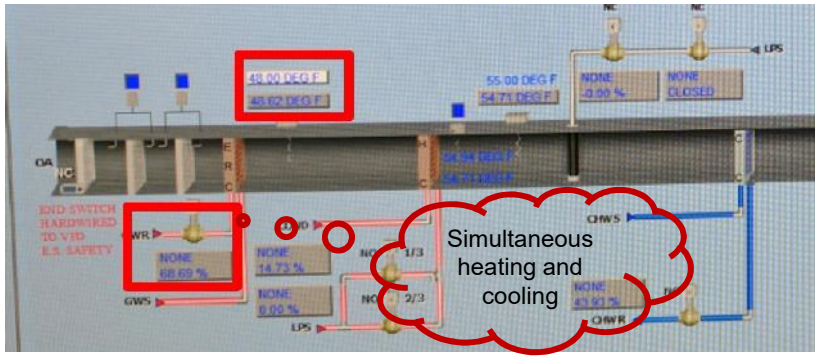
With his knowledge , I would like to see what he can do with the hot water system.

Lockheed Martin

# Big Data - Training

- **Must understand the system and capture <u>tribal knowledge</u>**
- **Complex plants likely <u>do not want full automation</u>**
- **Process must gain <u>operator's trust</u>**
- **<u>Partial Optimization</u> can be achieved with operator cheat sheet**
- **<u>Operator Interface</u> must have operator buy-in and context**
- **Optimization will <u>drift</u> if operators are not on board**



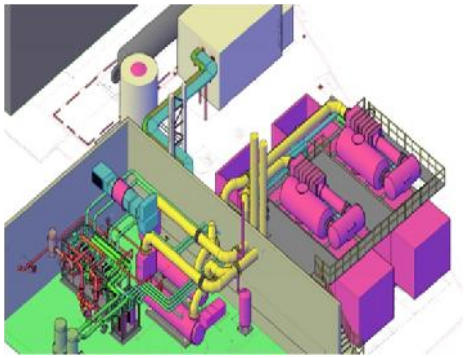



# Big Data – Points to Ponder

- Can Big Data be used to optimize Systems?
  - Yes. Big data is very helpful in optimizing system.
- Energy has 3 components – Can we identify them?
  - Energy components – Generation, distribution and utilization
- How was historical data used in Purdue University for diagnostics
  - Water leak linked to the increase in turbidity to increase in evaporator fouling leading to 10% penalty on energy consumption.
- Can Big data help in evaluating if the campus is able to fully utilize the equipment installed capacity.
  - Yes. Big data helps in revealing if the equipment is able to provide full capacity or it is bottlenecked due to input conditions.
- Can Machine Learning use multiple criteria in predicting performance.
  - ML is a powerful tool useful when more than two dimensions need to be evaluated in order to derive a decision.

## Our Company

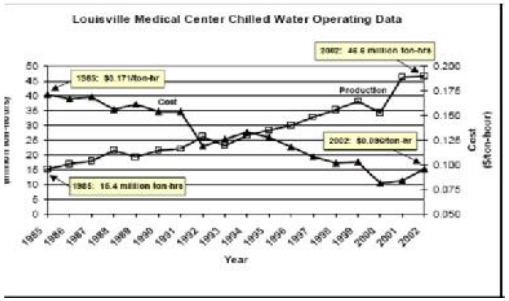
- Engineering Consulting Company primarily focused on Central Utility Plants, Cogeneration and commissioning.
- Over a decade, WM Group has saved substantial energy and reduced carbon footprint for many customers.
- Solutions range from simple operating changes to optimization of plants to master planning for campuses.
- WM Group has gained the reputation of being the best in optimizing systems.



# Thank You

## Expertise

- Review of Existing Systems
- Master Planning
- Detailed Design
- Feasibility Studies
- System Optimization
- Equipment Procurement
- Field Services
- Commissioning & Startup
- Operator Training
- Offline Plant Operation Advisory
- Peer Review
- Expert Witness

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