DATA INTEGRATION FOR UTILITIES AND ENERGY

APPA INSTITUTE FOR FACILITIES MANAGEMENT

INDIANAPOLIS, IND

SEPTEMBER 12, 2023

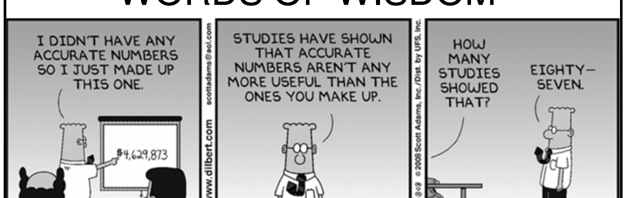
1

PURPOSE OF TODAY'S PRESENTATION

- To provide a broad understanding of:
  - Data Warehouses/Data Marts
  - How to collect the data
  - How to convert data into information
  - Examples

4

WORDS OF WISDOM

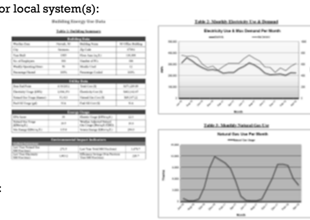


If you torture the data enough, it will confess to anything.

5

DISCUSSION

- Create a report of energy consumption and cost for each building owned by your institution:
  - If served by a District Energy System or local system(s):
    - Chilled Water
    - Steam or Hot Water
    - Electricity
    - Water
    - Fuel-Gas/Oil/Coal
  - If served by the local utility
    - Electricity
    - Fuel-Gas/Oil/Coal
    - Water
  - This year versus last year information:
    - Consumption and cost
    - Hours used and weekly schedule
    - Average number of occupants, i.e. staff, students, faculty
    - Square footage of building including classification(s), i.e. instructional space, administrative, research, housing, etc.
    - Departmental ownership
    - Weather, e.g. average temperatures, % sun, etc.
    - HVAC system type



WHERE WOULD YOU GET THE INFORMATION TO PRODUCE THIS REPORT?

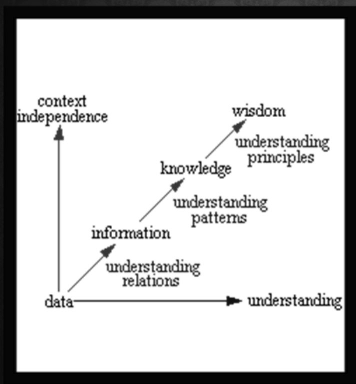
6

THE DATA PROBLEM

7

THE PEOPLE PROBLEM

8



ADDING VALUE TO DATA

9

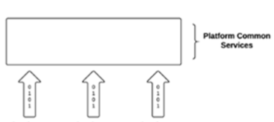
How do you get there?

Best Practices in Data Management
Five Elements for Success

Asset Inventory	Data Access	Tools and Analytics	Organizational Structure	Engagement Communication
Comprehensive	Comprehensive	Flexible	Integrated	Targeted
Centralized	Streamlined	Secure	Centralized	Clear
Verified	Automatic	Accessible	Dedicated Staff	Transparent
Up to Date	Prompt	QA/QC	Streamlined	Mission-focused

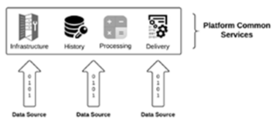
10

Platform Concept



11

Platform Concept

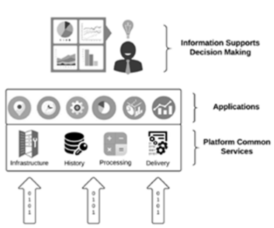


12

Platform Concept

13

Platform Concept



14

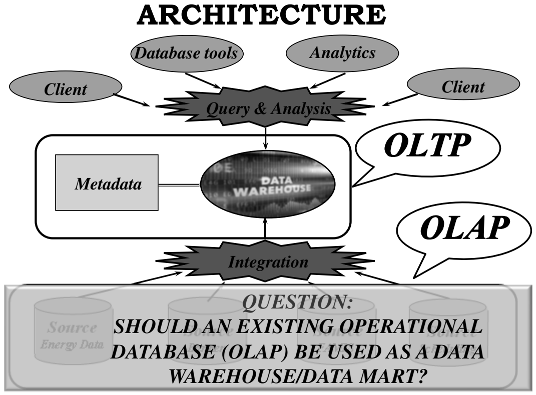
INTEGRATE THE DATA

Data Warehouse operates on an enterprise level and contains all data used for reporting and analysis, while **Data Mart** is used by a specific business department and is focused on a specific subject (business area).

- Aggregate data into a single centralized repository available to all authorized stakeholders
- Integrate the data into consistent subject categories based on how users refer to them
- Apply consistent value representation, units, and descriptors to the data

16

DATA WAREHOUSE/DATA MART ARCHITECTURE



17

MINE THE DATA

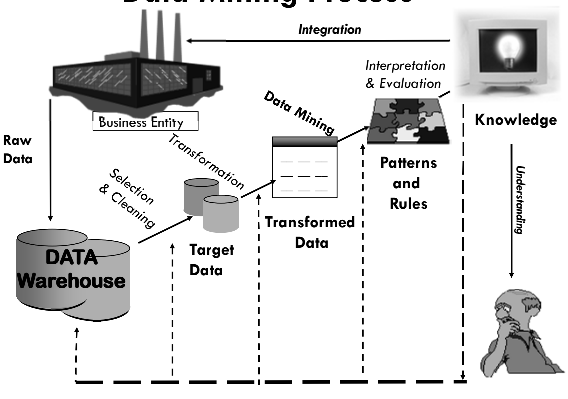
Data mining is the

non-trivial process of identifying

- *valid*
- *novel*
- potentially *useful*
- and ultimately *understandable patterns* in data.

18

Data Mining Process



19

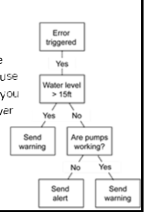
DATA MINING TECHNIQUES

- Classification
  The process uses predefined classes to assign to objects such as "dog", "cat", "hat", etc. These classes describe the characteristics of items or represent what the data points have in common with each other. This data mining technique allows the underlying data to be more neatly categorized and summarized across similar features or product lines.
- Clustering
  Like classification, clustering identifies similarities between objects, then groups those items based on what makes them different from other items. While classification may result in groups such as "shampoo," "conditioner," "soap," and "toothpaste," clustering may identify groups such as "hair care" and "dental health."
- Regression
  A statistical method that attempts to create a mathematical relationship between one dependent variable and a series of other variables (known as independent variables).
- Association
  Association (or relation) is probably the better known, most familiar and straightforward data mining technique. Here, you make a simple correlation between two or more items, often of the same type to identify patterns. For example, when tracking people's buying habits, you might identify that a customer always buys cream when they buy strawberries, and therefore suggest that the next time that they buy strawberries they might also want to buy cream.

20

DATA MINING TECHNIQUES

- Prediction
  Used in combination with other data mining techniques, prediction involves analyzing trends, classification, pattern matching, and relation. By analyzing past events or instances, you can make a prediction about an event.
- Sequential patterns
  Often used over longer-term data, sequential patterns are a useful method for identifying trends, or regular occurrences of similar events. For example, with customer data you can identify that customers buy a particular collection of products together at different times of the year. In a shopping basket application, you can use this information to automatically suggest that certain items be added to a basket based on their frequency and past purchasing history.
- Decision trees
  Related to most of the other techniques (primarily classification and prediction), the decision tree can be used either as a part of the selection criteria, or to support the use and selection of specific data within the overall structure. Within the decision tree, you start with a simple question that has two (or sometimes more) answers. Each answer leads to a further question to help classify or identify the data so that it can be categorized, or so that a prediction can be made based on each answer.



21

HOW IS MACHINE LEARNING RELEVANT TO FACILITIES MANAGEMENT?

Predicting Problems

When a facility manager tracks operations with machine learning, the disruptions in normal patterns are just as relevant as the consistencies. For example, if a process suddenly fails to meet its routine performance levels, it's possible to isolate and replace a failing part — before it becomes a problem. Smart technology can be programmed to set alerts when the facility displays inconsistencies, all through self-monitoring data collection.

Tracking Usage

By establishing operational patterns, it's easy for facilities managers to develop proactive system scheduling: parts ordering, cleaning, routine shutdowns, and equipment replacement can all be arranged at the most cost-effective and efficient times.

22

HOW IS MACHINE LEARNING RELEVANT TO FACILITIES MANAGEMENT?

Optimizing Energy Efficiency

A recent study investigated deep learning for asset optimization throughout a regular office building. The vast system of sensors tracked 35,000 measured data points per minute and drew insights on everything from prioritized elevator scheduling to kitchen odors, automated temperature adjustments, and lighting controls.

While this project proves an elaborate example, smart tech systems can outpace static programs in balancing building load. For example, most usage — even in HVAC and lighting alone — goes beyond the binary weekday/weekend or workday/holiday schedule. Weather events, holidays, and even major sporting events routinely alter attendance levels, and a smart system can mine historical performance data and respond accordingly.

Savvy Storage

In addition to predicting patterns for real-time applications, machine learning tech can also help to sort, prepare, and store data — suddenly, all this information can be significantly more useful to a manager.

For example, a tech can automatically group and sort data according to time of year, a particular machine performance, or even a type of maintenance. These analyzed, categorized data sets prepare the foundation for smart, organized action.

23

CONVERT DATA TO INFORMATION

- Microsoft Office
- Third party reporting tools and applications
- Analytics, AI
- Web applications

Knowing that a tomato is a fruit?
That's Data.

Knowing not to put one in a fruit salad?
That's Knowledge.

24

GROUP DISCUSSION

- What are our FM functions?
- What data is collected by other functions in your organization that you can/want to use?
- What data is collected institutionally that can be used to meet your needs?
- What formats does the data require, i.e. spreadsheet, dashboard, formal reports, etc.?
- Can you currently convert the data into information in the required format(s)? How?

25

EXAMPLE APPLICATIONS

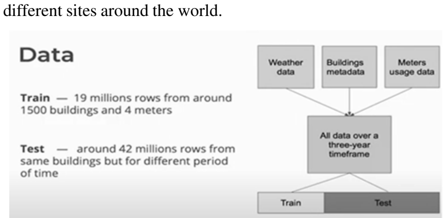
- Convert INFORMATION into KNOWLEDGE
  - Energy Management
  - Operational and Decision Support
  - Maintenance Management
  - Analytics, AI, Fault Detection
  - Reporting

26

ASHRAE- Great Energy Predictor III- A Machine Learning Case Study

The competition focused on predicting the energy savings of a retrofit in the measurement and verification (M&V) process. Assessing the value of energy efficiency improvements can be challenging as there's no way to know how much energy a building would have used without the improvements.

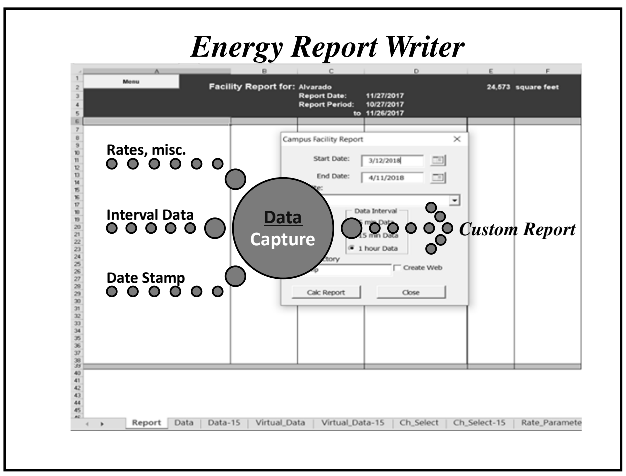
Competitors were challenged to build counterfactual models across four energy types based on historic usage rates and observed weather. The dataset includes three years of hourly meter readings from over one thousand buildings, extensive characterization of the various buildings, and comprehensive weather data at over a 1,000 different sites around the world.



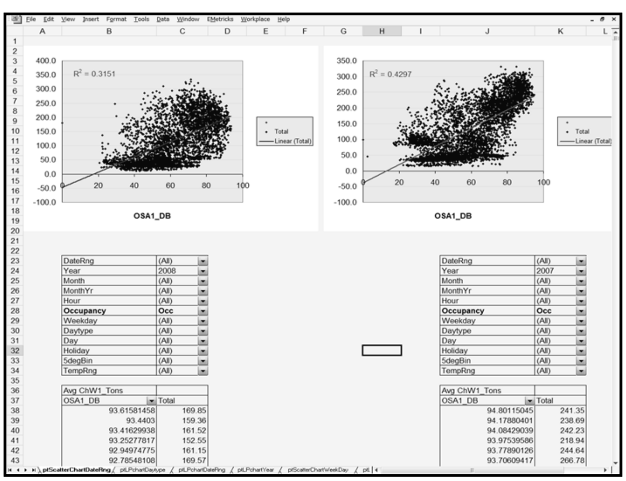
27


Building Utility Metering Panel
Centennial_Engineering
Values
Setpoints
Alarms

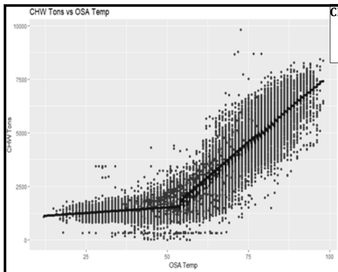
28


Energy Report Writer
Facility Report for: Alvarado
Campus Facility Report
Start Date:
End Date:
Rates, misc.
Interval Data
Date Stamp
Data Capture
Custom Report
Calc Report
Close
Report
Data
Data-15
Virtual_Data
Virtual_Data-15
Ch_Select
Ch_Select-15

29

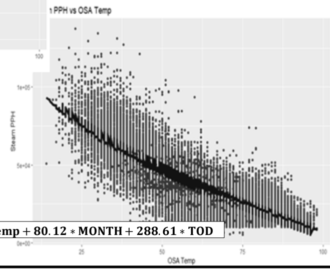

R² = 0.3151
R² = 0.4297
OSA1_DB
OSA1_DB
Avg ChW1_Tons
Avg ChW1_Tons

30



CHW Tons = $OSA.Temp < 54$:
$1000 + 10.4 * OSA.Temp$
$OSA.Temp \geq 54$:
$-5740.44 + 131.36 * OSA.Temp + 47.08 * MONTH$

ANALYTICS

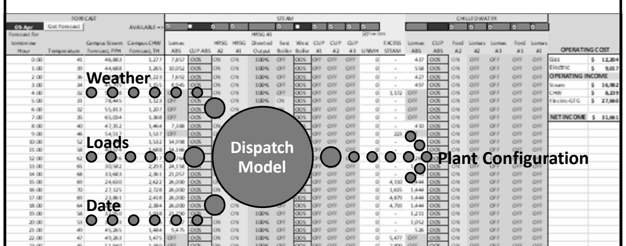


26,210 coincident campus steam and chilled water load, time-of-day, day-of-week, month, and outside temperature data points .

Steam PPH $= 142,984.75 - 14,107.34 * \sqrt{OSA.Temp} + 80.12 * MONTH + 288.61 * TOD$

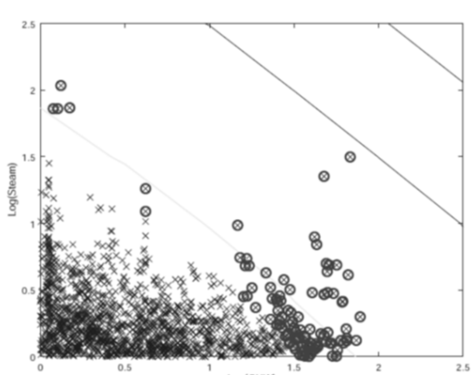
31

Operational and Decision Support



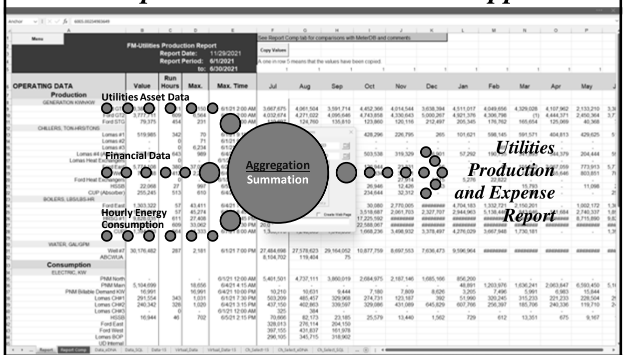
32

ANALYTICS
FAULT DETECTION AND DIAGNOSTICS



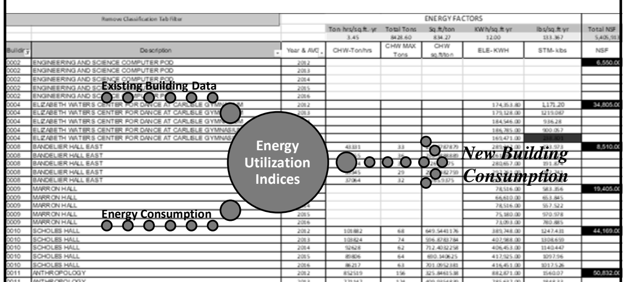
33

Operational and Decision Support

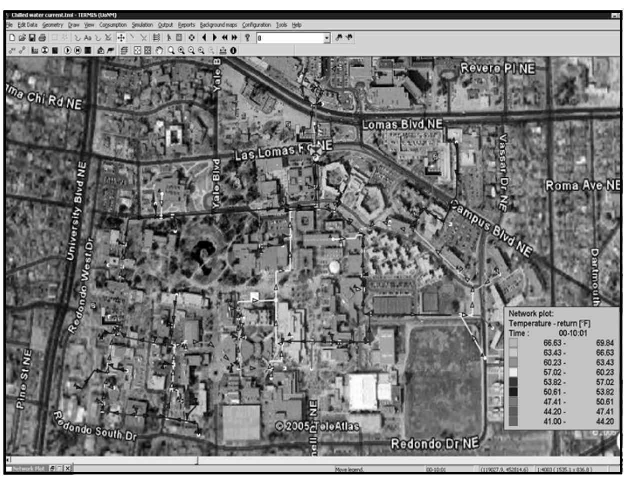


34

Operational and Decision Support



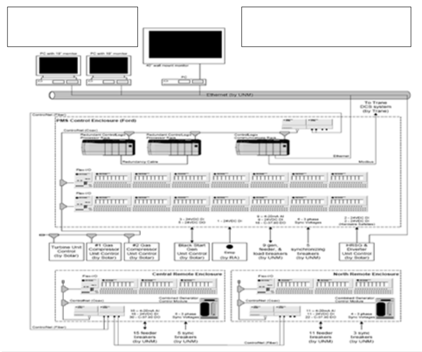
35



36

QUESTIONS & ANSWERS

Thank You!



37