SAND2016-7506C

Energy Exchange

Federal Sustainability for the Next Decade

U.S. Department of Energy

Continuous Commissioning at Sandia National Laboratories

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Sandia National Laboratories

August 10, 2016

Sandia's Sites

Albuquerque, New Mexico

Livermore, California

Workforce: >12,000
Major buildings: 225
Space: 7.4 million GSF

LEED Buildings: 11
Avg. Bldg. Age: 38 yrs.

Physical area :188,000 acres
Paved roads: 49 miles
Unpaved roads: 38 miles

Kauai, Hawaii

Waste Isolation Pilot Plant, Carlsbad, New Mexico

Pantex Plant, Amarillo, Texas

Tonopah, Nevada

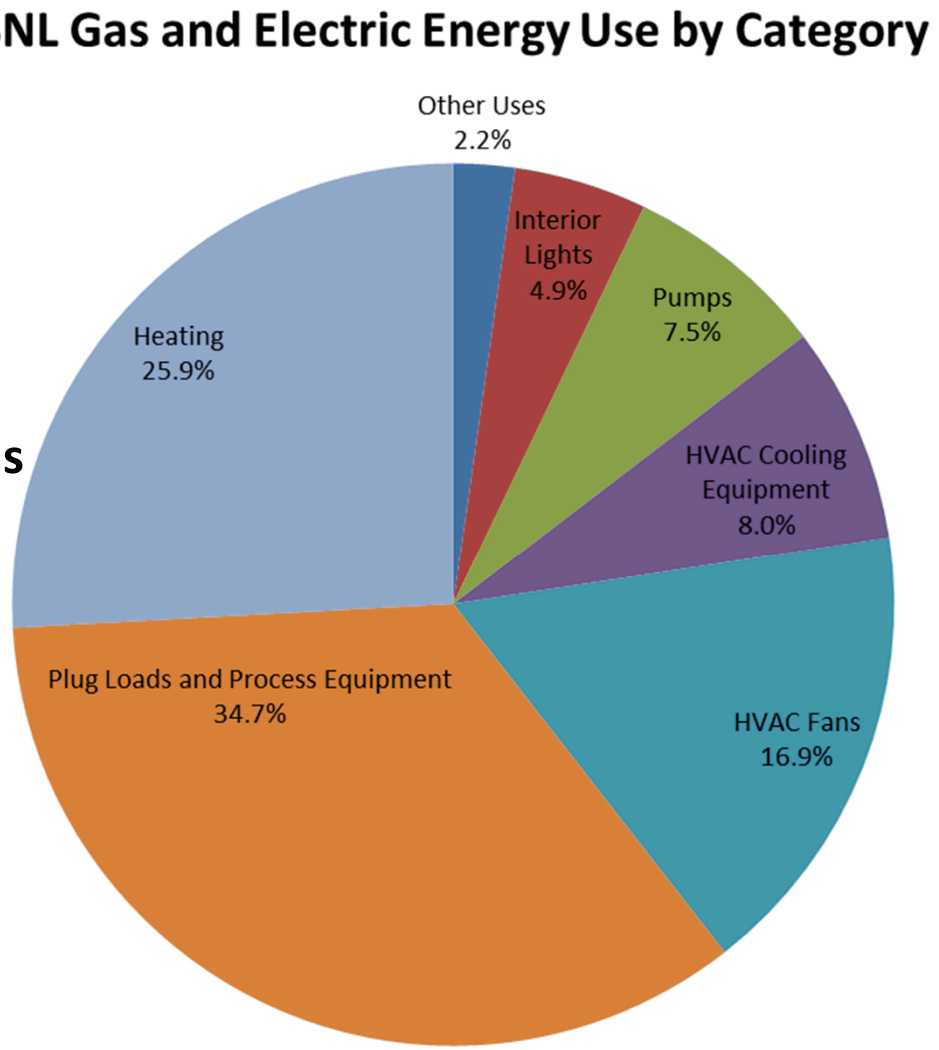
Energy Use Breakdown

Electric: 284,410,778 kWh

Natural gas: 340,278,252 SCF

Total Energy Use: 1,310,730 MBTUs

Total utility costs: over $19M



Buildings and Space

- Building types:
  - Semi-conductor fabrication;
  - Pulsed power reactors;
  - Data centers;
  - High security;
  - Cafeteria;
  - Auditorium;
  - Warehouse;
  - Nuclear facilities
  - Explosive facilities
- Space types:
  - Offices
  - Laboratories:
    - chemistry,
    - biology,
    - electronic,
    - laser labs;
    - computer
  - Clean rooms;
  - High-bays;
  - Computer rooms

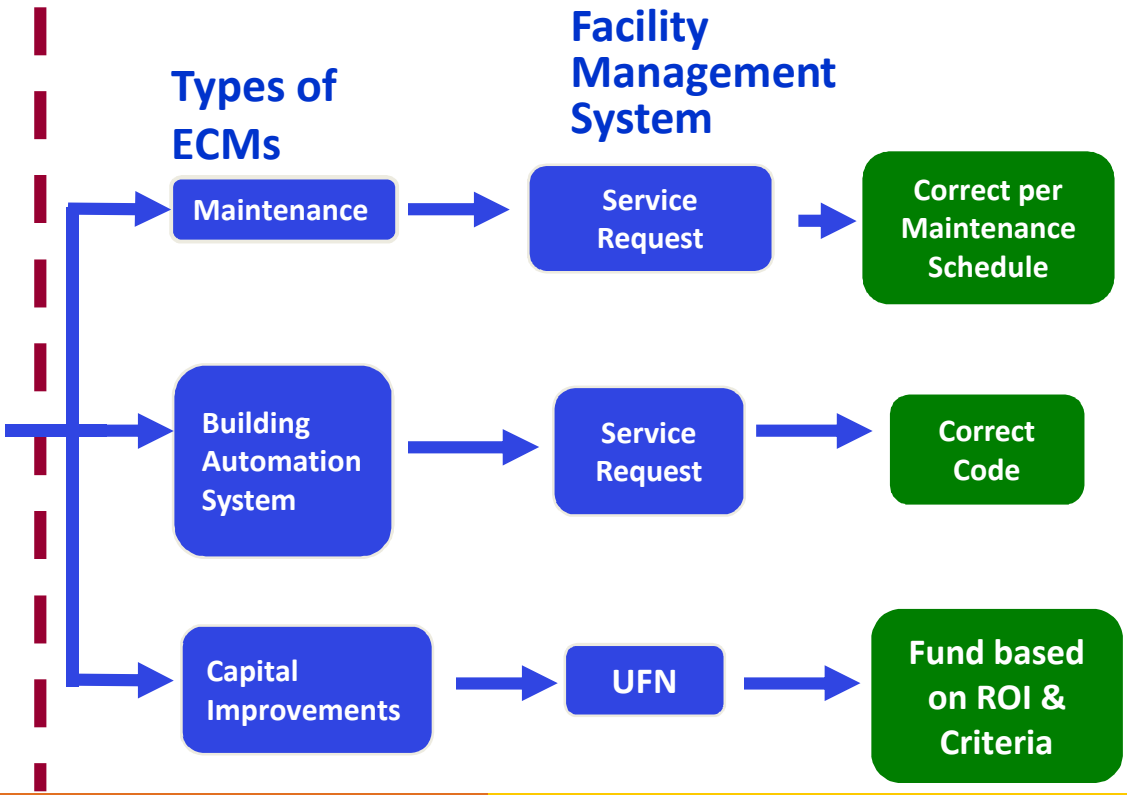
Energy Audits & Retro-commissioning

- **Energy & Water Audits**
  - ✓ 4-year schedule top Energy Consumers
  - ✓ Led by Operations team per process using checklist
  - ✓ ASHRAE Level II

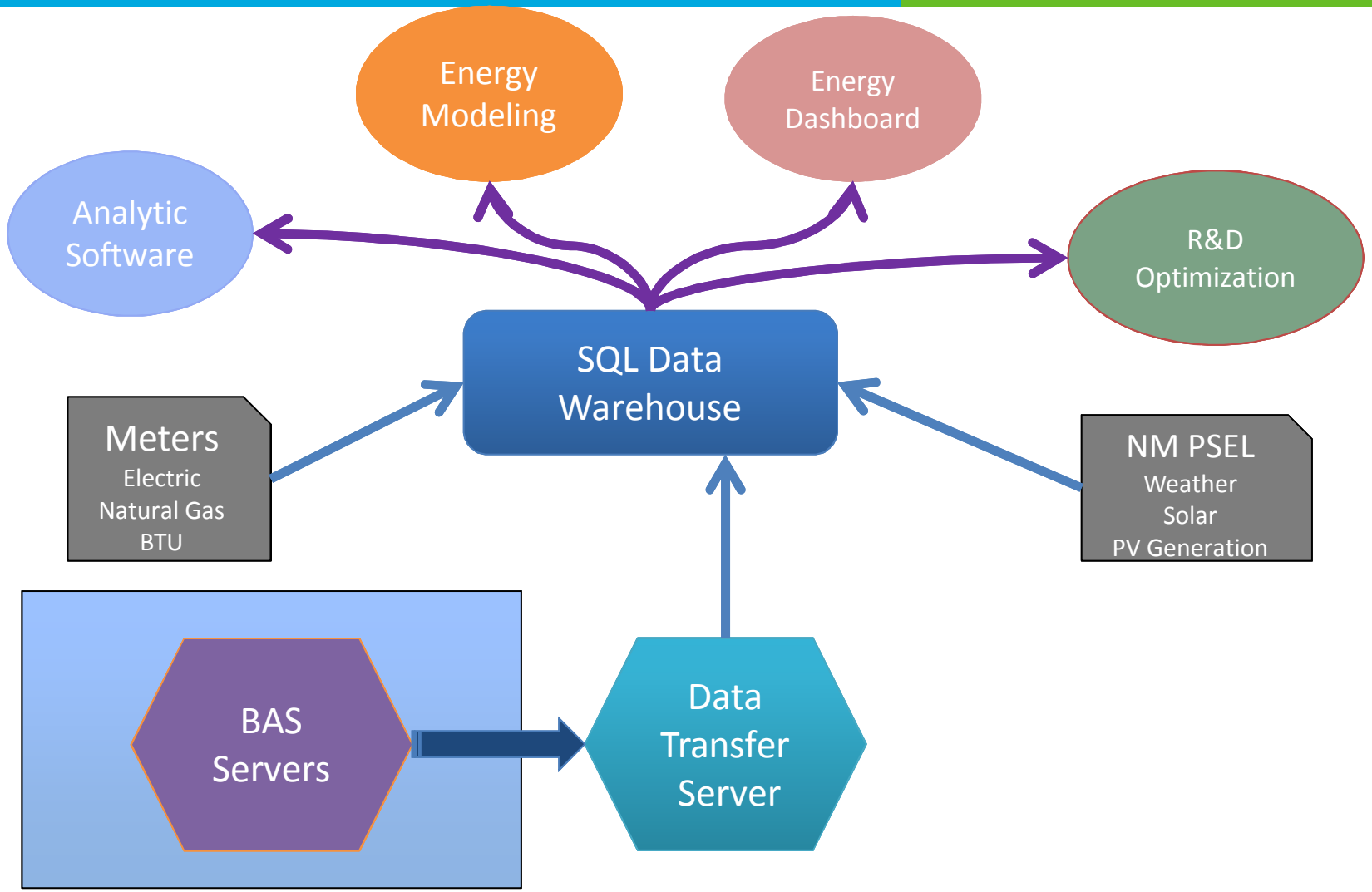
Conduct Audit → Complete Report

- Load Profile & Energy-Use Baseline
- Annual Load Profiles & Energy Use to verify savings
- Energy Models

- **Retro-commissioning or Energy Conservation Measures (ECM)**
  - ✓ Identified & implemented per SNL Facilities processes



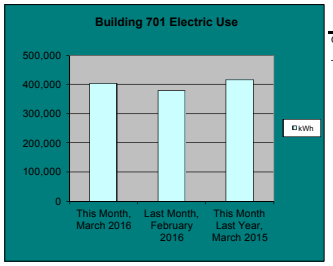
Energy Data Warehouse



Energy Dashboard

Energy Dashboard

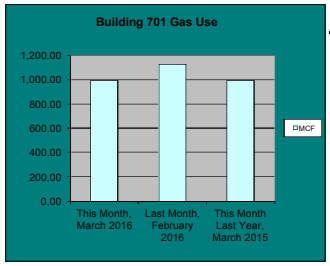
Electrical Use Awareness Bulletin



Building 701
Graphs are displayed in kWh

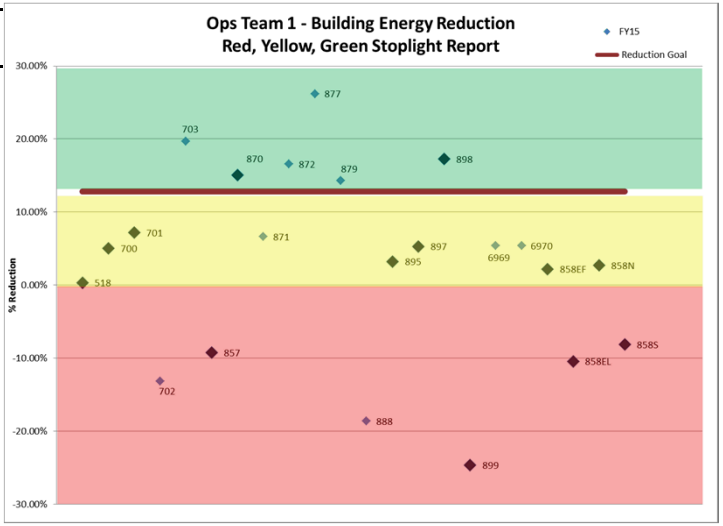
The average use per day in kWh was 13,018

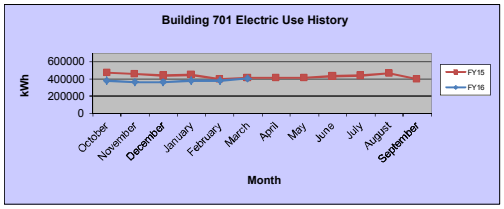
Gas Use Awareness Bulletin

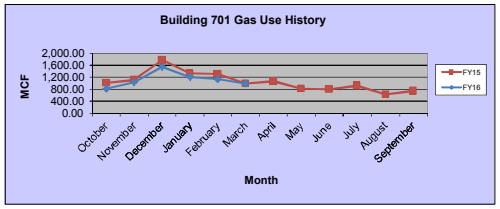


Building 701
Graphs are displayed in MCF

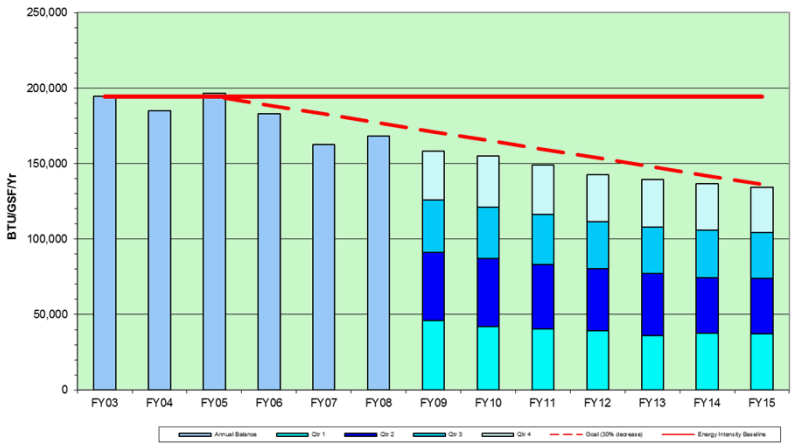
The average use per day in MCF was 32.06

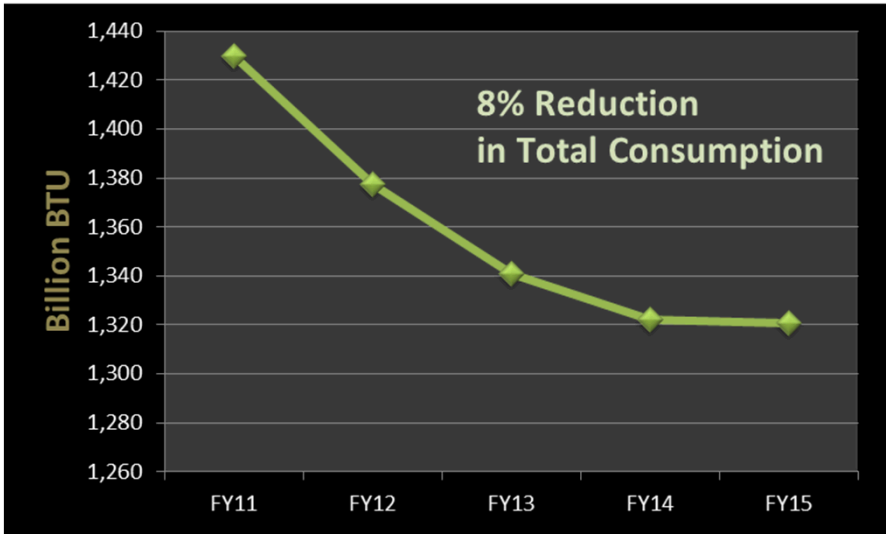






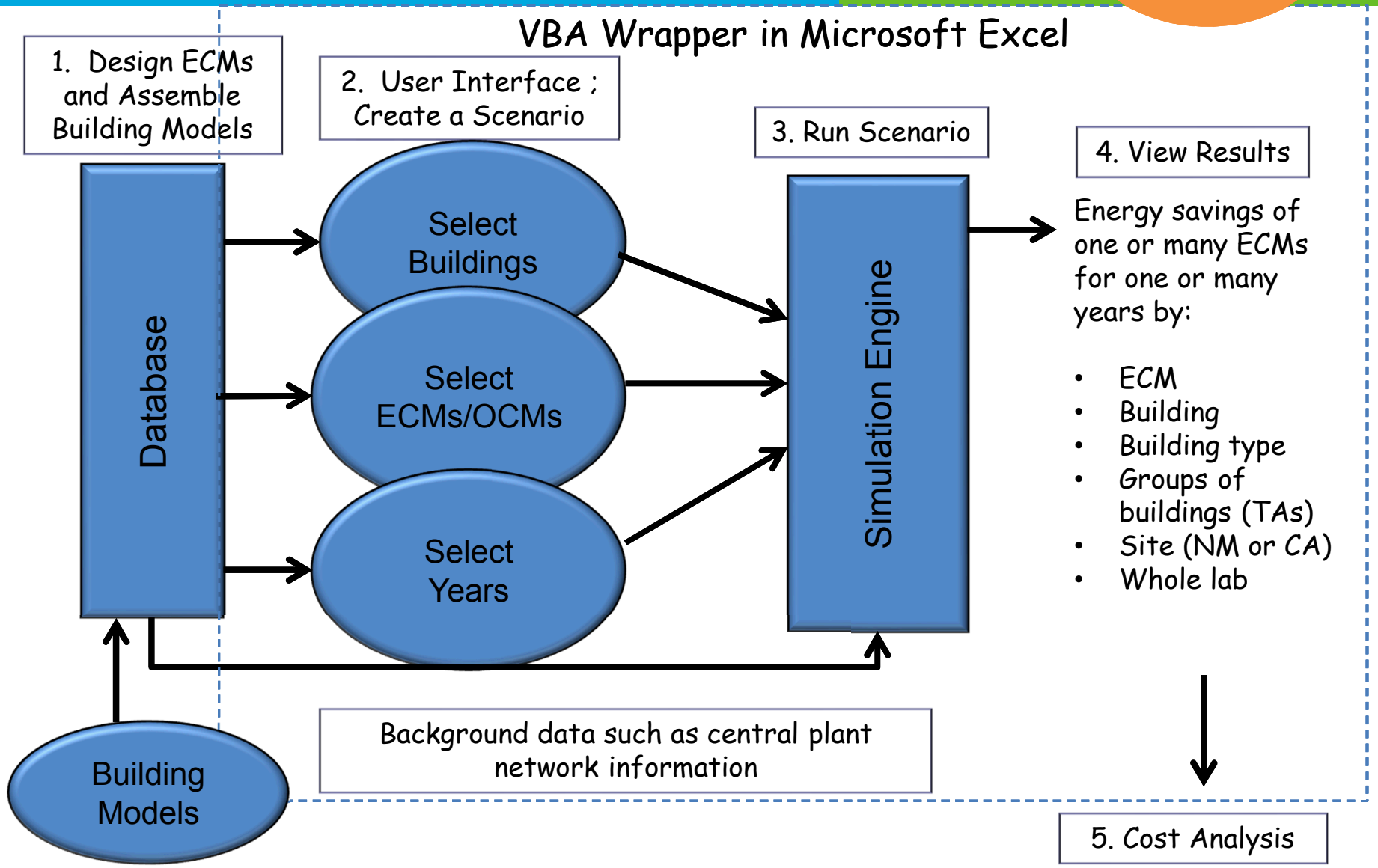
Regular Building Energy Intensity





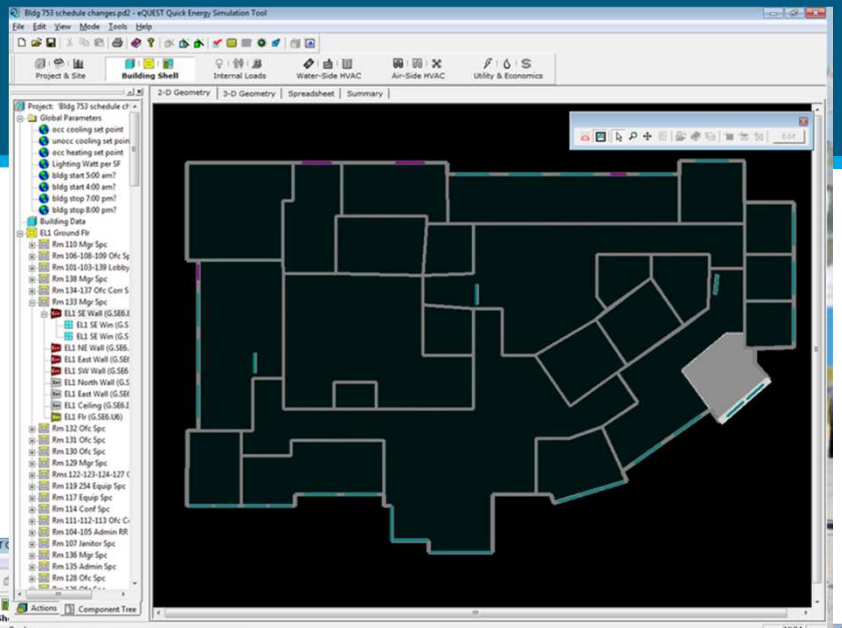
IX Building Module Architecture

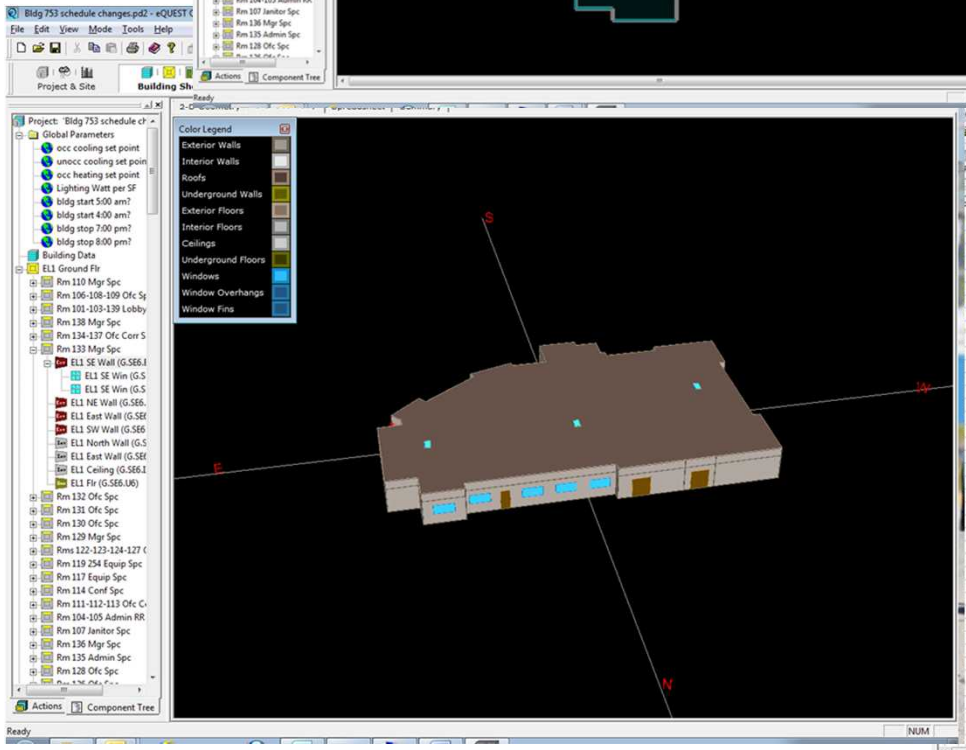
Energy Modeling

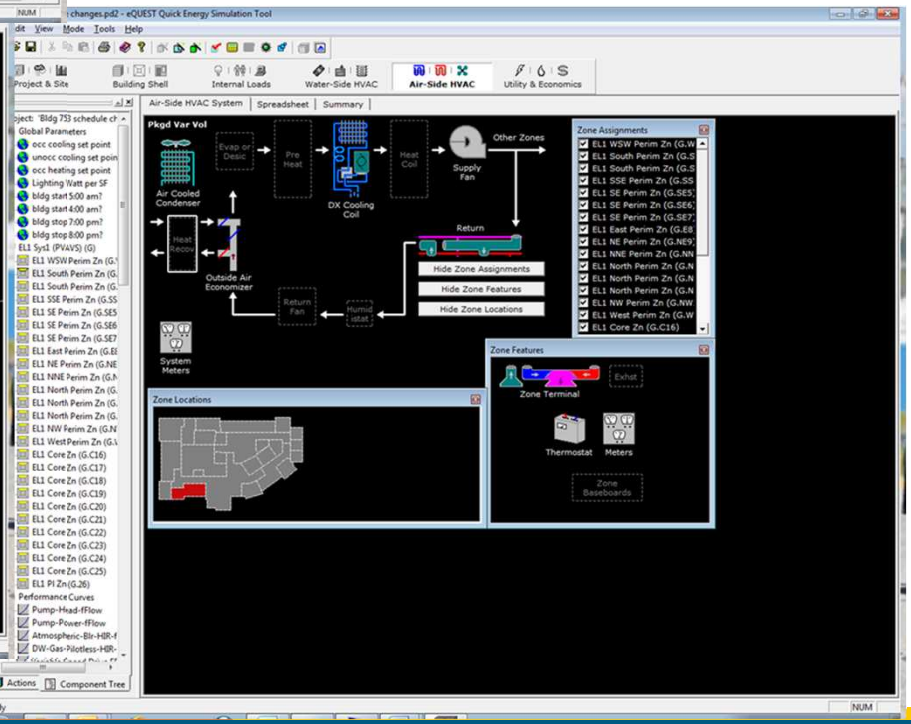


Energy Modeling

eQUEST

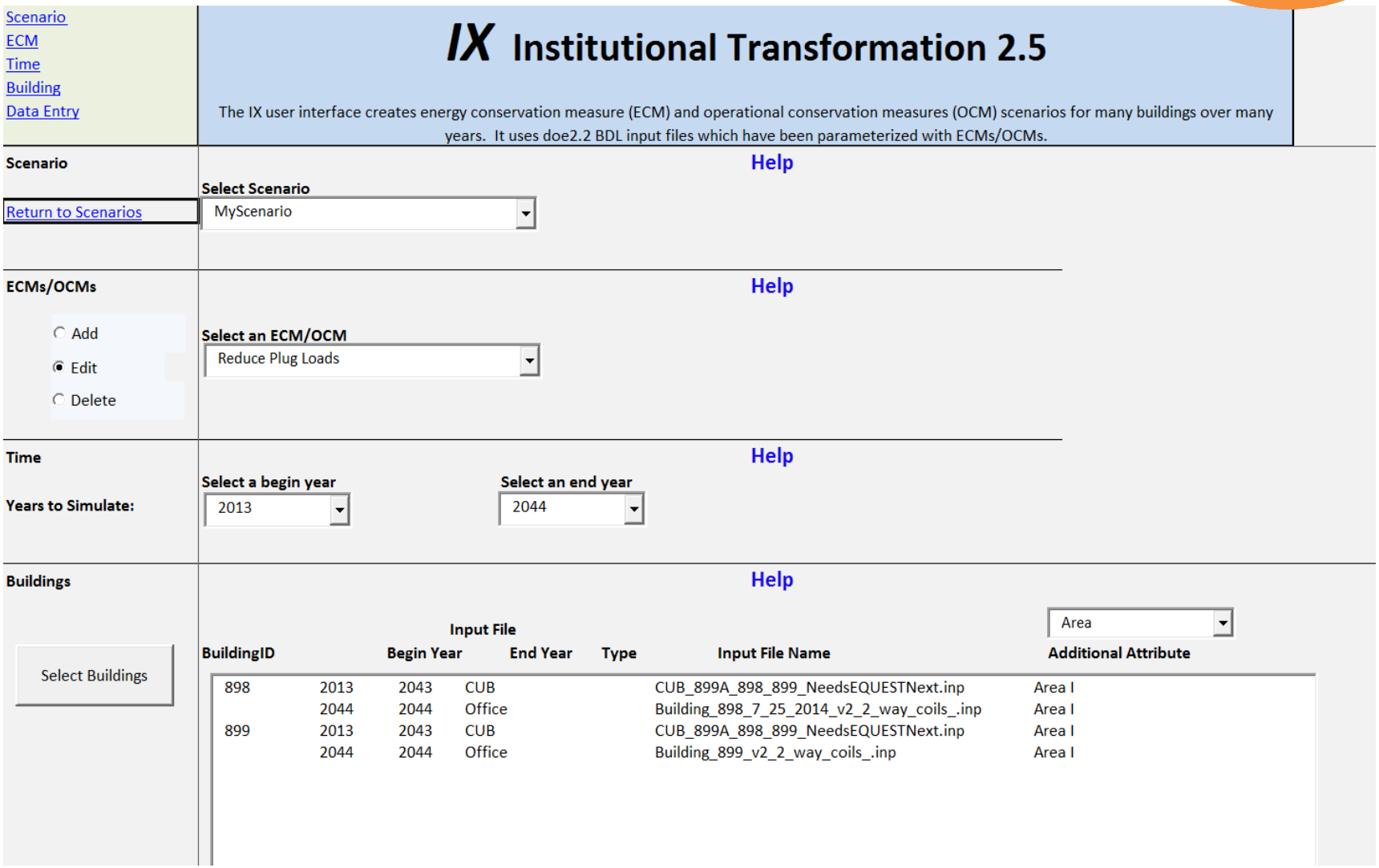






IX Software

Energy Modeling



Results

Energy Modeling

Return to Scenarios

Select Scenario

CUB899A

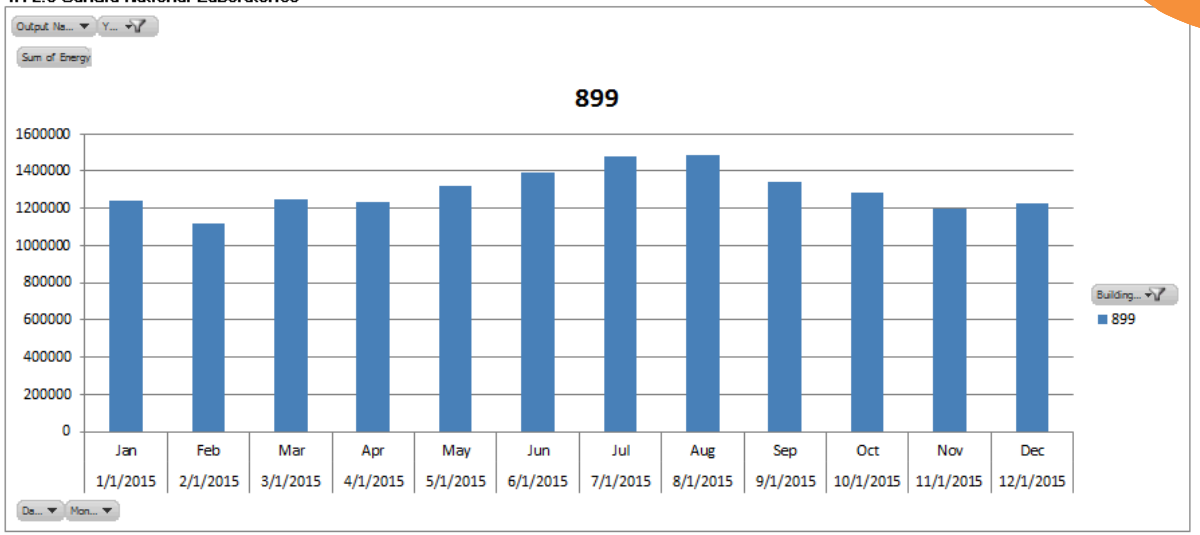
Additional Filter Attribute

Area

Units

kBTU

IX 2.5 Sandia National Laboratories



Sum of Energy	Column Labels
Row Labels	899
1/1/2015	
Jan	1237878.958
2/1/2015	
Feb	1120519.157
3/1/2015	
Mar	1250657.665
4/1/2015	
Apr	1231619.184
5/1/2015	
May	1322914.739
6/1/2015	
Jun	1393051.508
7/1/2015	
Jul	1476[illegible]
8/1/2015	
Aug	1484082.378
9/1/2015	
Sep	1340243.365
10/1/2015	
Oct	1285415.175
11/1/2015	
Nov	1200110.234
12/1/2015	
Dec	1226640.87

IX uses a pivot table of the results database to make reducing to specific results or aggregating to site-wide results easy.

Energy Saving Opportunities

Energy Modeling

Energy Conservation Measures

Initiative	Savings
Lighting retrofits	0.5%
Digital Control Conversions	6-10%
Free-cooling heat exchangers	
Central Plant Upgrades	
Clean Room modifications (filters and reduced air flow)	

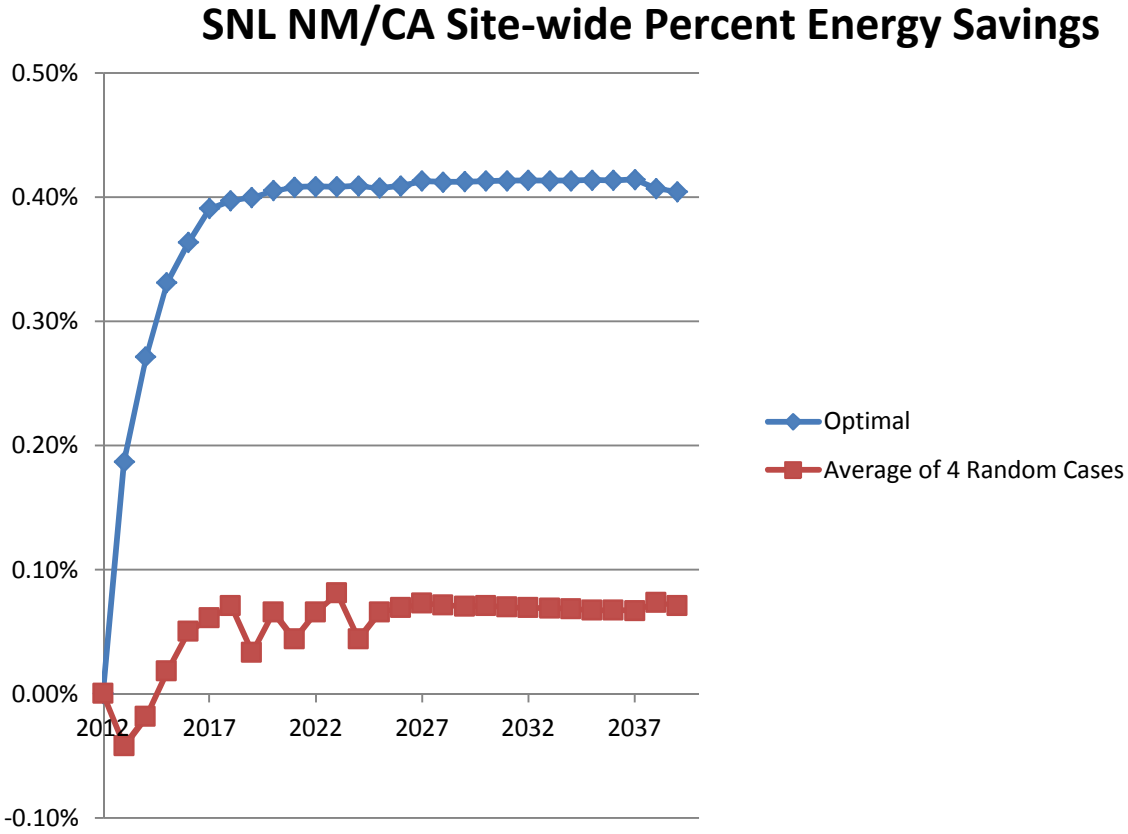
Operational Conservation Measures

Initiative	Savings
Office (T Set and Operating hours)	1-1.5%
Lab (T Set and Operating hours)	3-7%
Ventilation setback (labs)	2-3%
Eliminate 24/7 operations	2-3%
Retro-commissioning, Analytics	1-2%

Cool Roofs - Percentage Savings

Energy Modeling

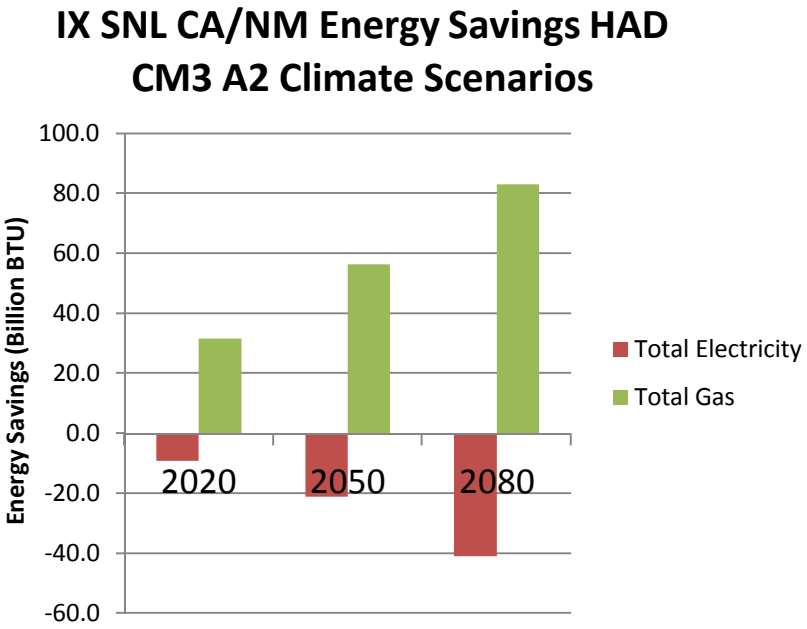
- Site-wide energy savings for this ECM is only 0.4%
- If cool roof and insulation costs are high, other ECMs may be more desirable

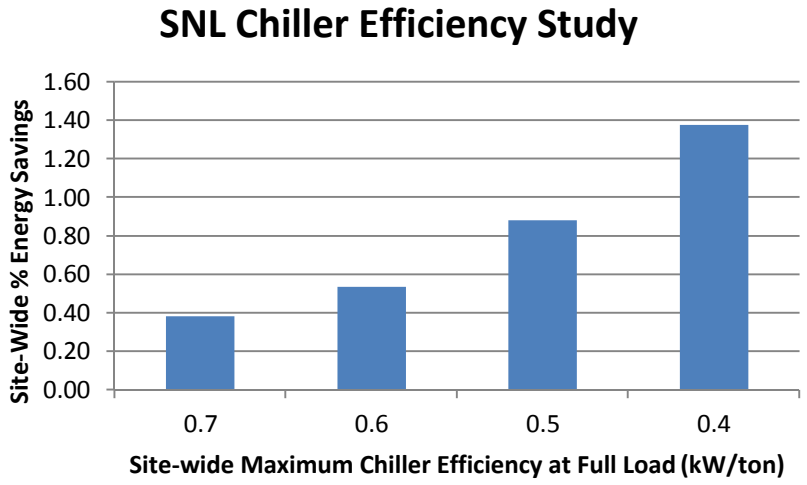


Institutional Transformation (IX)

Energy Modeling

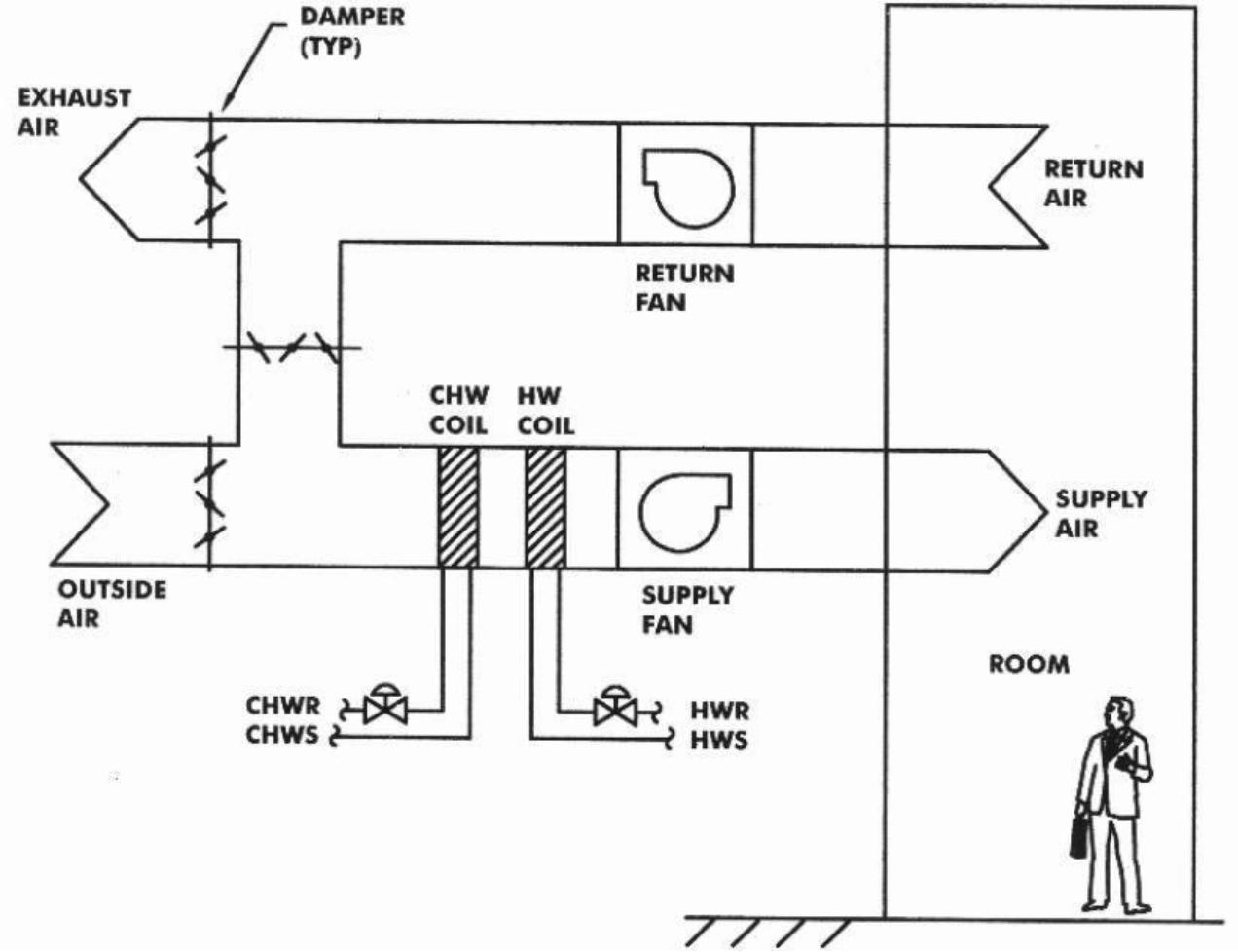
- Parameter studies of many
  - Buildings
  - Energy conservation measures (ECM)
  - Years
- Climate
- Current version 2.5
- Future version 3.0





Basic Central Air System

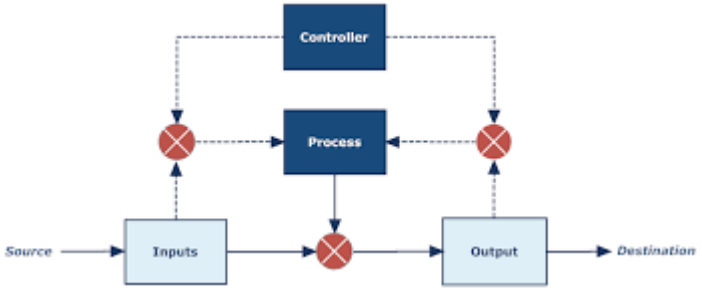
Analytic Software



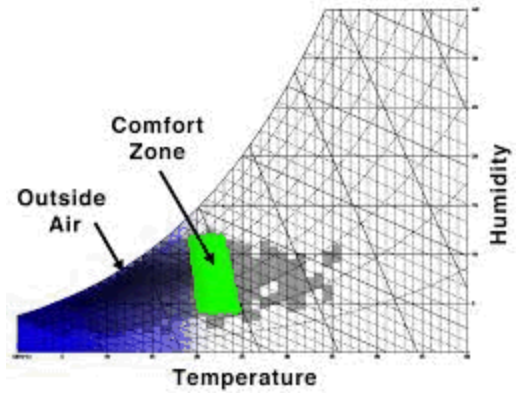
Building Operations

Analytic Software

Manner of delivery is as important as outcome …
- Automatically Driven
- Stability via Tested Programming
- Optimized Sequencing
- Proven Efficiency Using Employed Metrics
- Self Diagnosing Reliability



DIGITAL CONTROL



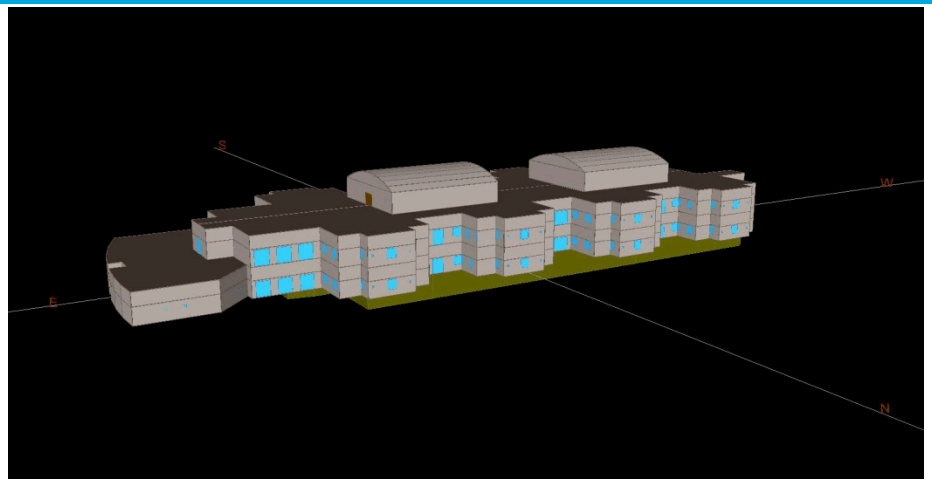
OUTCOME [70 Degree Air]

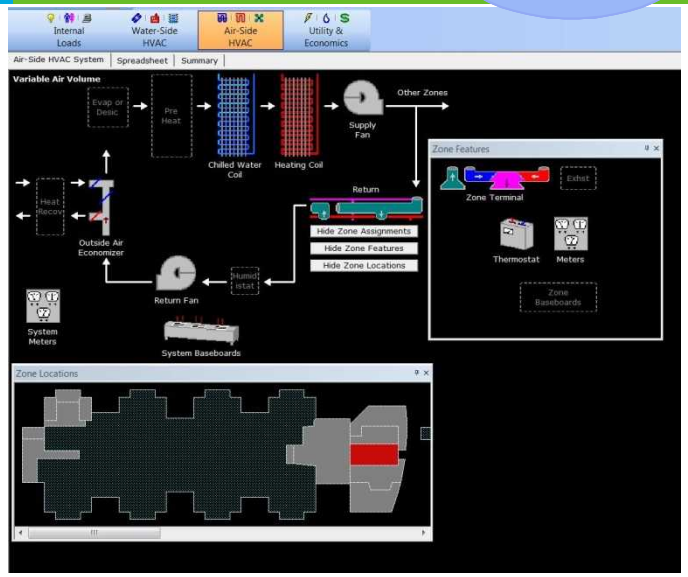
Purely End Result Oriented…
- Operator Driven
- Reliable
- Metrics: Non Existent
- Field Efficiency is Subordinated
- Unrealized Design Intent

TWO METHODS: SAME OUTCOME
DIFFERING ENERGY IMPACT

Case Study – Sensor Disturbance

Analytic Software





- Office/Lab Building
- Cooling options: chiller and evaporative cooling
- Fall day
  - 75 degrees F; 15% Relative Humidity
- Building temperature is with limits and occupants are not complaining.
- Chilled water valve is open, electric chiller is running and economizer/evaporative cooling system is off.
- ***WHAT WENT WRONG?***

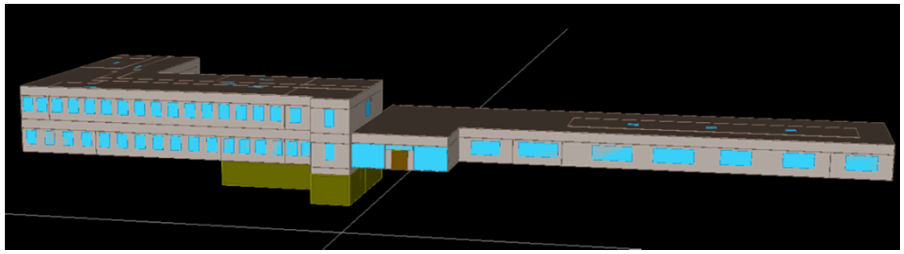
Case Study – Human Disturbance

Analytic Software

- Office Building: carpet was cleaned during the weekend.
- HVAC system was placed in 24/7 operations to remove carpet cleaning odors.
- eQuest model; encountered difficulty in calibration process.
- ***WHAT WENT WRONG?***

Analytics Pilot Project

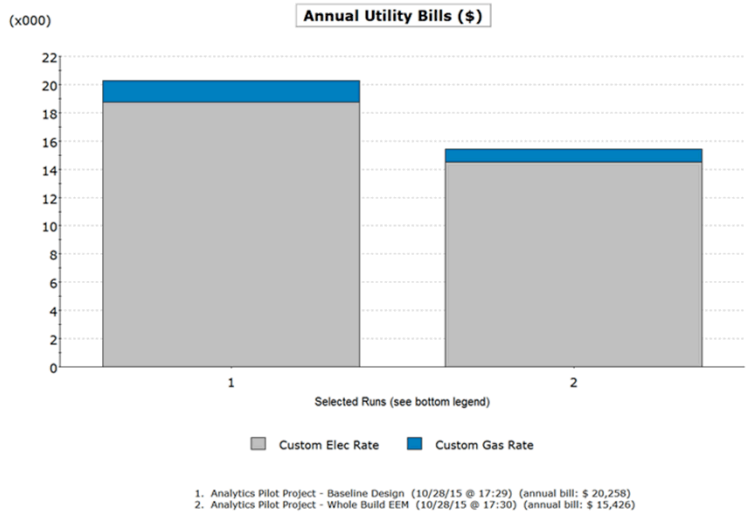
Analytic Software

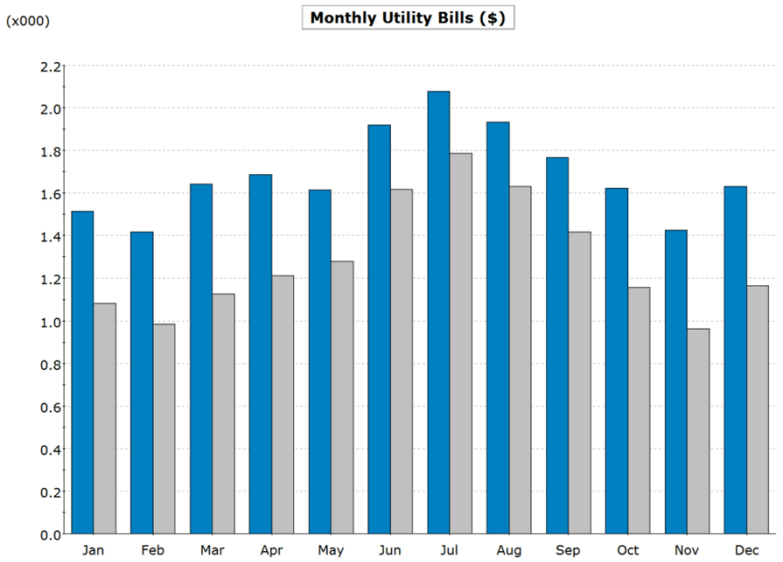


- *ONE BUILDING - ALBUQUERQUE SITE*
- *25 RULE BASED ANALYTICS*
- *USE ENERGY MODEL TO PREDICT COST AND ENERGY SAVINGS*

eQuest Runs Based on Findings from Pilot Project

- AHU Start Time Not Optimized (1.5 hour excess run time)
- AHU Fan Speed Fixed
- AHU Supply Air Temperature Fixed
- AHU Economizer Not Implemented
- Hot Water Supply Temperature Fixed



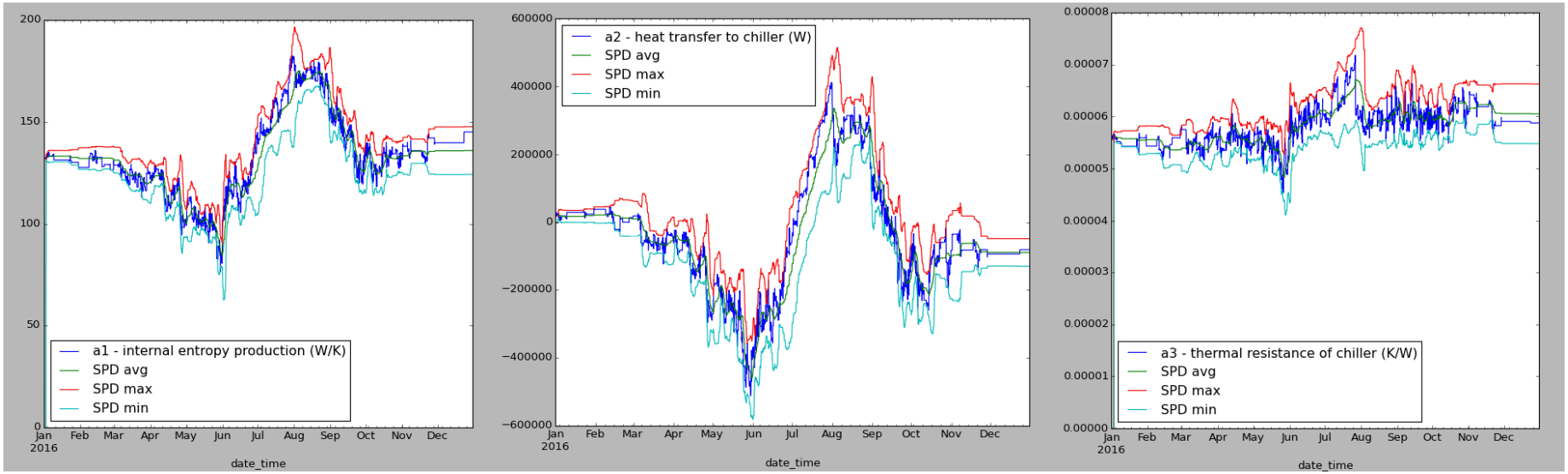


Advanced Fault Detection

R&D Optimization

- Fault criteria which vary with time
- Rules based on gray-box model parameters
- Parameters estimated by Kalman filtering

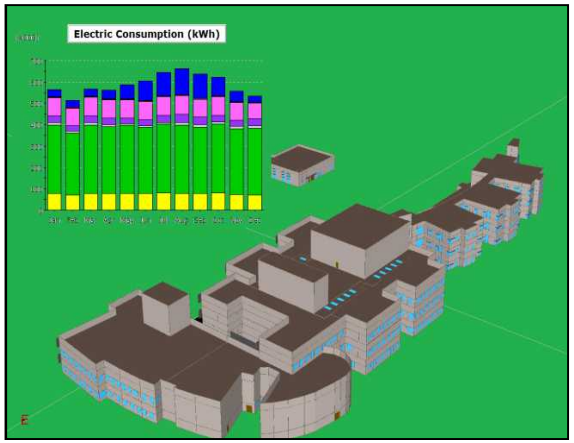
Building 899A 150 ton screw chiller fault detection



Big Modeling and Data

R&D Optimization

119 Doe2 Models and IX



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Model Parser

```
  CurChar = Mid(CurCharBlock, BlockPos, 1)
' Mode 1 - move through delimiters
  ' Now check our state
  If InDelimit Then
      InDelimit = False ' This will be undone if CurChar is a delimiter
      LastWasPeriod = False 'undone later if it turns out this is true
      LastWasNewLine = False 'undone later if it turns out this is true
      Select Case CurChar
        Case vbCr, vbLf, " ", "=", ","
            InDelimit = True
            If CurChar = vbCr Or CurChar = vbLf Then
               LastWasNewLine = True
            End If
        Case """"
            InQuotes = True
            WordStart = BlockPos
        Case "("
            If Not CurlyAndParenthesisDoNotApply Then
              InParenthesis = True
            End If
            WordStart = BlockPos
        Case "*"
            InStars = True
            WordStart = BlockPos
        Case "$"
            InComment = True
            Select Case PrevChar
               Case vbCr, vbLf
                  LastWasNewLine = True ' This means that the comment lasts the enti
```

Class Modules
- clsBuildingFile_shared
- clsBuildingInformation_shared

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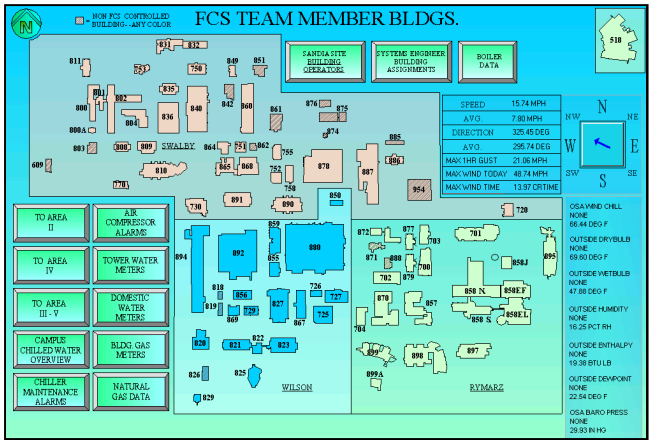
250,000 Data streams



Advanced Analytics

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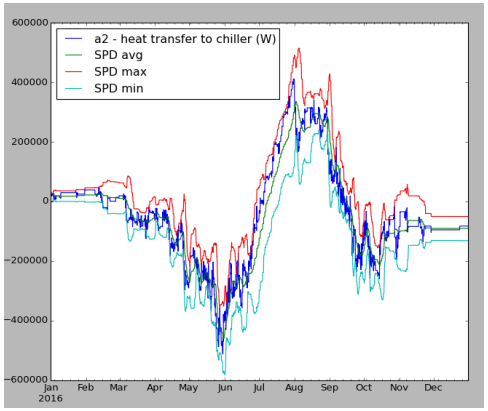

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Capability to approach sustainability with an unprecedented level of detail

Robustly detect faults

QUESTIONS

THANK YOU!

THE TEAM

- Jerry Gallegos
- Daniel Villa
- Marlin Addison
- Birk Jones
- Mary Bultmann
- Jim Sweeney
- LaTonya Walker