Managing Campus Wide Energy

Getting Beyond the Spreadsheet

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Plan for the implementation of building data analytics on a large campus.

Understand hurdles that may be encountered and how they can be overcome.

Evaluate the resulting benefits that can be gained from detailed energy meter monitoring.

Identify potential issues that can be uncovered with a building analytics tool.
Sandia National Laboratories Overview

881 buildings across all sites
About Sandia National Laboratories

• Grew out of World War II effort to develop first atomic bombs
• Began in 1945 as the Z Division, the ordnance, design, testing and assembly arm of Los Alamos National Laboratory
• Department of Energy (DOE), National Nuclear Security Administration (NNSA) Laboratory
# Sandia National Laboratories Mission & Facilities

## Research & Development

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
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<tbody>
<tr>
<td>🧪</td>
<td>Nuclear Weapons</td>
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<tr>
<td>✅</td>
<td>National Security Programs</td>
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<tr>
<td>🎯</td>
<td>Defense Nuclear Proliferation</td>
</tr>
<tr>
<td>🌍</td>
<td>Energy &amp; Homeland Security</td>
</tr>
<tr>
<td>📏</td>
<td>Advanced Science &amp; Technology</td>
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</tbody>
</table>

## Types of Facilities

<table>
<thead>
<tr>
<th>Icon</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>📡</td>
<td>Clean Rooms, Data Centers</td>
</tr>
<tr>
<td>🧪</td>
<td>Chemical Bio, Radiological Labs</td>
</tr>
<tr>
<td>⚙️</td>
<td>Manufacturing R&amp;D, Testing</td>
</tr>
<tr>
<td>🌡️</td>
<td>Chilled Water &amp; Hot Water Plants</td>
</tr>
<tr>
<td>🏡</td>
<td>Offices, High Security, Cafeterias, Warehouses, and High Bays</td>
</tr>
</tbody>
</table>

700+ fume hoods
Sandia Energy Management Program and Goals

**Energy Mission**

Reduce energy, natural resources, environmental impact, and energy costs as a commitment to the Federal government, DOE/NNSA, and our local community.

**Drivers and Goals**

1. Reduce EUI for all sites **30% below 2003**
2. Guiding Principles for High Performance Sustainable Buildings (HPSB) for **15% of buildings**
3. **RCx** for **33 buildings** and **energy audits** for **60 buildings** every 4 years (top 75% energy use)
4. Advanced metering for buildings **greater than 5,000 square feet**
5. Monthly energy management and benchmarking (measure, manage, & report)
Data Analytics Overview

- Deploying analytics software for the NM and CA campuses
- Energy meter monitoring – 700+ energy meters
- Detailed BAS monitoring – currently 15,000 points
  - Vision for 120,000+ BAS points
- A lot of data = a lot of spreadsheets!

Ongoing Cx
Proactive Maintenance
CHALLENGES
#1 – Navigating the Options

- Evaluated BAS solution
  - Challenging to diagnose
  - Couldn’t see the patterns
- Large number of FDD/EIS options available
  - Met with vendors, viewed demos, researched capabilities
  - Met with organizations using analytics

**Solution:** Utilize the BAS for control and critical alarms, implement a 3rd party software tool onsite focused on data analytics
#2 – BAS and Network Limitations

- Architecture is 20+ years old, RS485 network
- Limited ability to add more trends
- Worked with BAS vendor to evaluate potential upgrades
  - Performed tests with BAS vendor and Analytics vendor on full IP Based Ethernet platform
  - Tested integration options including BACnet, and Web APIs

**Solution:** CSV data transfer solution at this time - moving toward BAS upgrade with Ethernet, new controllers, and upgraded BAS platform
#3 – Getting Buy-in – Integrating Analytics

Presented to top management

• Results from BAS Analytics pilot project
• Benefits of data driven approach to managing operations and energy
• Benefits for on-going commissioning and energy audits
• Benefits of proactive maintenance and energy savings

Challenges

• Staff not familiar with technology, already busy
• Alarms (Failure) vs Faults (Inefficiencies, Issues, Opportunities)
• Exploratory process – current conditions vs. root cause

Solution: Get buy-in from stakeholders, perform training, designate energy team member as first point of responsibility
### #4 – Data and Issue Overload – Prioritize Faults

**Solution:** Refine rules for different user groups, use tracking system to note status/progress of issues

<table>
<thead>
<tr>
<th>Rule</th>
<th>Duration</th>
<th>Tue 4th</th>
<th>Thu 6th</th>
<th>Sat 8th</th>
<th>Equip</th>
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</thead>
<tbody>
<tr>
<td>AHU Cool and Econ Conditions</td>
<td>15.43hr</td>
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<td></td>
<td>x 7</td>
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<td>AHU DAT Sp Not Met</td>
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<td></td>
<td>x 5</td>
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<td></td>
<td>x 3</td>
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<td>AHU Econ and MAT Not Equal OAT</td>
<td>15.5hr</td>
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<td></td>
<td></td>
<td>x 2</td>
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<tr>
<td>AHU No Econ and Low OAT</td>
<td>18.5hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AHU On During Scheduled Unocc</td>
<td>1.08hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Gap (Non-Meter Points)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Gap (SiteMeter Points)</td>
<td>144hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment On Chillers Off</td>
<td>2.94hr</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Equipment Short Cycling</td>
<td>73hr</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>VAV Flow Error</td>
<td>32.75hr</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Zone Reheat Failure</td>
<td>14.25hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Zone Temp too Cold</td>
<td>6.25hr</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Zone Temp too Hot</td>
<td>54hr</td>
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</tbody>
</table>

*Hundreds of faults every day*
TRIUMPHS
#1 – Integration of Various Data Sources

- Successful integration of multiple data sources
- CSV, SQL, API restful; will add active BAS connection
- *Reduce time spent analyzing data in spreadsheets!*

**Locally Hosted FDD**

- VMWare and Internal Web Access
- Meter databases
- BAS CSVs/scripts
- Weather database

*Meter and BAS data from 2 campuses*
#2a – Identify Operational Issues

- Fault #1: AHU Cool and Heat
- Fault #2: AHU Econ and Heat

Simultaneous heating and cooling, should be economizing
#2b – Identify Operational Issues

- Fault: AHU Duct Static Pressure Not Resetting

Air Handler Fault: Static pressure not resetting and is at high constant level
#2b – Identify Operational Issues

BAS Shows AHU Static Pressure Setpoint is met

No BAS alarm so operation looks normal to facilities staff
#2b – Identify Operational Issues

Related Zone Faults: Zone Air Flow Setpoint Not Met & Zone Temp Too Hot

Zone Airflow Fault:
- Damper 100% open
- No Air Flow is driving increase in air handler static pressure setpoint
- Causes excess energy

Zone Temp Too Hot Fault

BAS has approximately 8,000 Zones. Analytics auto detect issues across large number of building systems.
#2c – Identify Operational Issues

- Fault: AHU On During Scheduled Unoccupied

**Before fix**
- BAS looked normal
- Hidden issue with BAS controller not scanning programmed Start/Stop times

**After fix**
- AHU running during unoccupied hours
- AHU supply fan status ON 24/7
- AHU schedule after fixing at BAS controller
Detailed Site Monitoring – 205 sites

#3a – Energy Monitoring and Dashboards

![Energy Monitoring and Dashboards](image_url)
#3b – Energy Monitoring and Dashboards

## Key Performance Indicators

### Energy Monitoring and Dashboards

<table>
<thead>
<tr>
<th>Site</th>
<th>Elec kBTU/Sf</th>
<th>Elec kWh</th>
<th>Elec kWh Delta Prev Year</th>
<th>Elec kWh Prev Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM Bldg 0827</td>
<td>168 kBTU/ft²</td>
<td>1,604,110 kWh</td>
<td>6%</td>
<td>1,546,833 kWh</td>
</tr>
<tr>
<td>NM Bldg 9963</td>
<td>166 kBTU/ft²</td>
<td>71,349 kWh</td>
<td>23.7%</td>
<td>61,518 kWh</td>
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<tr>
<td>NM Bldg 0518</td>
<td>146 kBTU/ft²</td>
<td>2,301,100 kWh</td>
<td>-1.3%</td>
<td>2,352,210 kWh</td>
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<tr>
<td>NM Bldg 0720</td>
<td>137 kBTU/ft²</td>
<td>529,424 kWh</td>
<td>-4.3%</td>
<td>255,406 kWh</td>
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<tr>
<td>NM Bldg 0755</td>
<td>135 kBTU/ft²</td>
<td>408,609 kWh</td>
<td>1%</td>
<td>428,437 kWh</td>
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<tr>
<td>NM Bldg 0899</td>
<td>132 kBTU/ft²</td>
<td>1,316,194 kWh</td>
<td>-20.7%</td>
<td>1,703,460 kWh</td>
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<tr>
<td>NM Bldg 0898</td>
<td>128 kBTU/ft²</td>
<td>112,480 kWh</td>
<td>120.8%</td>
<td>20,170 kWh</td>
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</table>
#4 – Identify Meter Issues

<table>
<thead>
<tr>
<th>Site</th>
<th>Rule</th>
<th>Duration</th>
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</thead>
<tbody>
<tr>
<td>CA Bldg C943 (BAS)</td>
<td>Energy Zero</td>
<td>720hr</td>
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<tr>
<td>CA Bldg C555-956</td>
<td>Energy Zero</td>
<td>720hr</td>
</tr>
<tr>
<td>CA Bldg C964</td>
<td>Energy Large Delta Regression</td>
<td>3hr</td>
</tr>
<tr>
<td>CA Bldg C966</td>
<td>Energy Negative</td>
<td>45min</td>
</tr>
<tr>
<td>CA Bldg C967</td>
<td>Energy Large Delta Regression</td>
<td>14hr</td>
</tr>
<tr>
<td>CA Bldg C972</td>
<td>Energy Large Delta Regression</td>
<td>301hr</td>
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<tr>
<td>CA Bldg C973</td>
<td>Energy Large Delta Regression</td>
<td>7hr</td>
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<tr>
<td>CA Bldg ROWDCTR</td>
<td>Energy Zero</td>
<td>720hr</td>
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<tr>
<td>CA Bldg VM_Site</td>
<td>Energy Large Delta Regression</td>
<td>6hr</td>
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<td>NM Bldg 0516</td>
<td>Data Gap (Meter Points)</td>
<td>1440hr</td>
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<tr>
<td>NM Bldg 0605</td>
<td>Data Gap (Meter Points)</td>
<td>720hr</td>
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<td>NM Bldg 0700</td>
<td>Data Gap (Meter Points)</td>
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<tr>
<td>NM Bldg 0702</td>
<td>Energy Data Spike</td>
<td>41hr</td>
</tr>
<tr>
<td></td>
<td>Energy Zero</td>
<td>120hr</td>
</tr>
</tbody>
</table>

Hour of the week regressions to get weather normalized baselines
THE PATH FORWARD
Benefits – Eliminate Drift

Median simple payback of 2.5 years and median source energy savings of 11%
Key Steps to Get Started

1. Identify stakeholders
2. Evaluate system capabilities and gaps – start plans for upgrades
3. Assess tool options
4. Start with a pilot
5. Plan for action – identify key roles and responsibilities
Questions?

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