

Semi-Automated, Low Touch, and Virtual - Emerging Trends Shaping the Future of Energy Audits

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Better Decisions + Better Technology = Better Buildings
Building Energy Decision and Technology Research Program

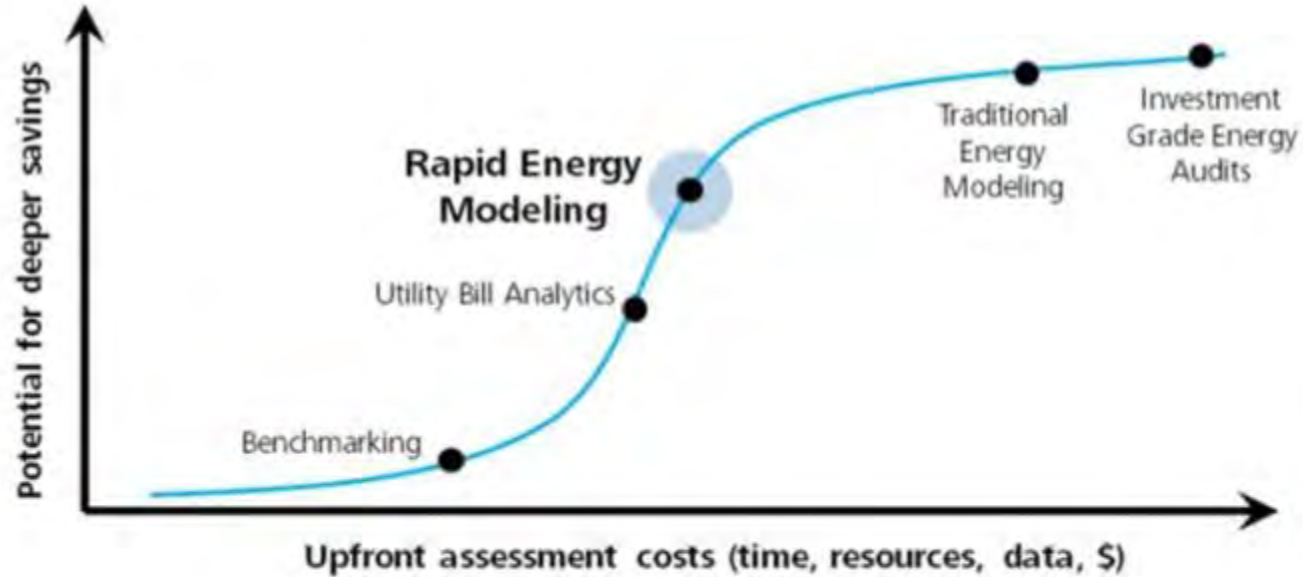
Overview

- Semi-Automated Audits (new Audit tools)
- Automated Model Calibration
- Virtual Audits

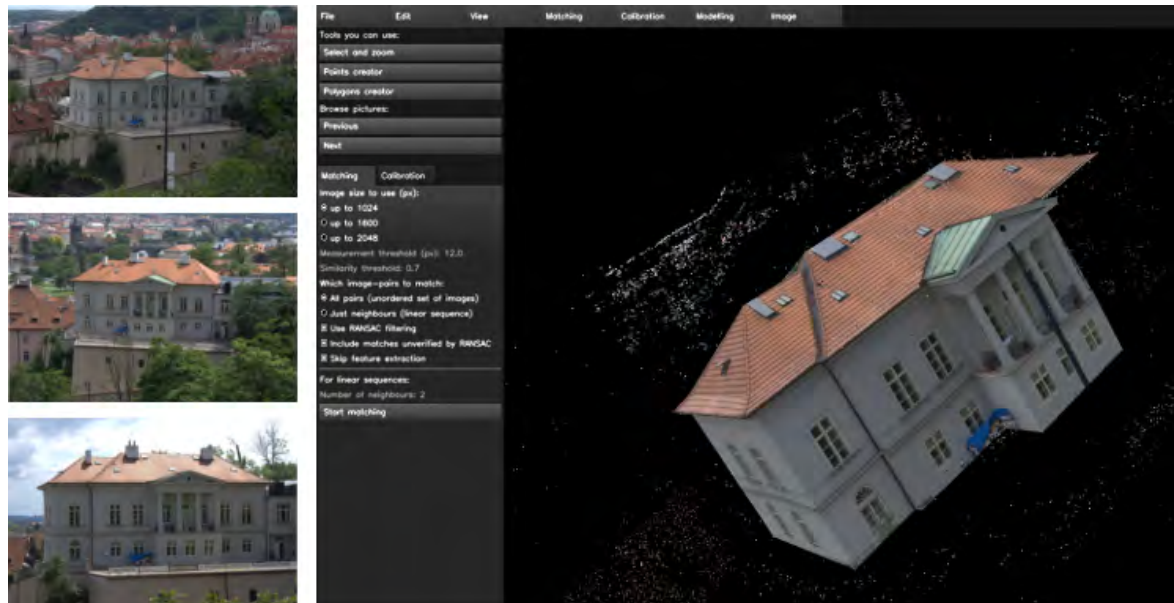
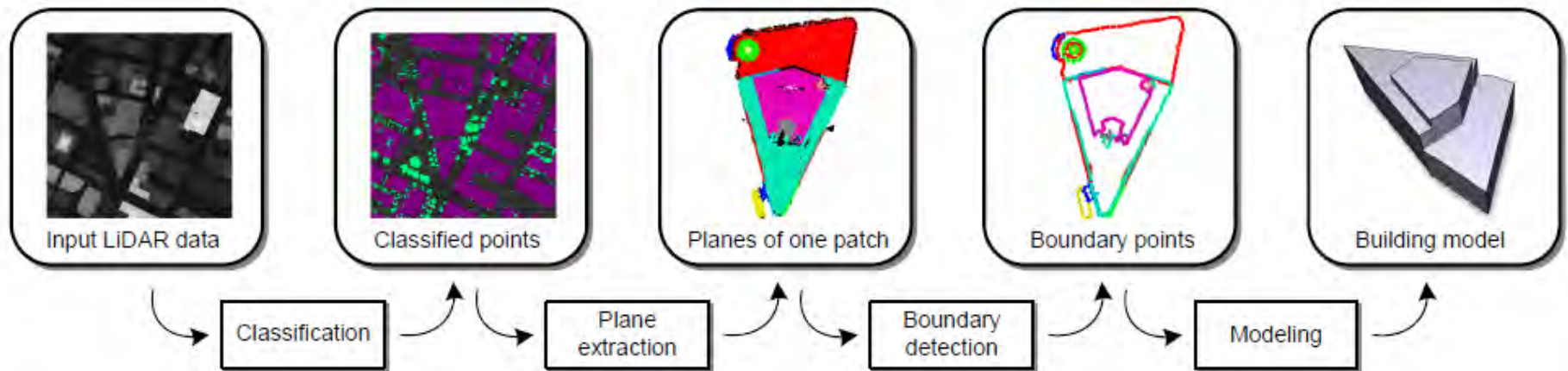
Semi-Automated Audits

- Generate building geometry automatically
- Tablet, Smart-Phone, Laptop based tools for entering data during a walkthrough
- Tools generate building energy models for later analysis

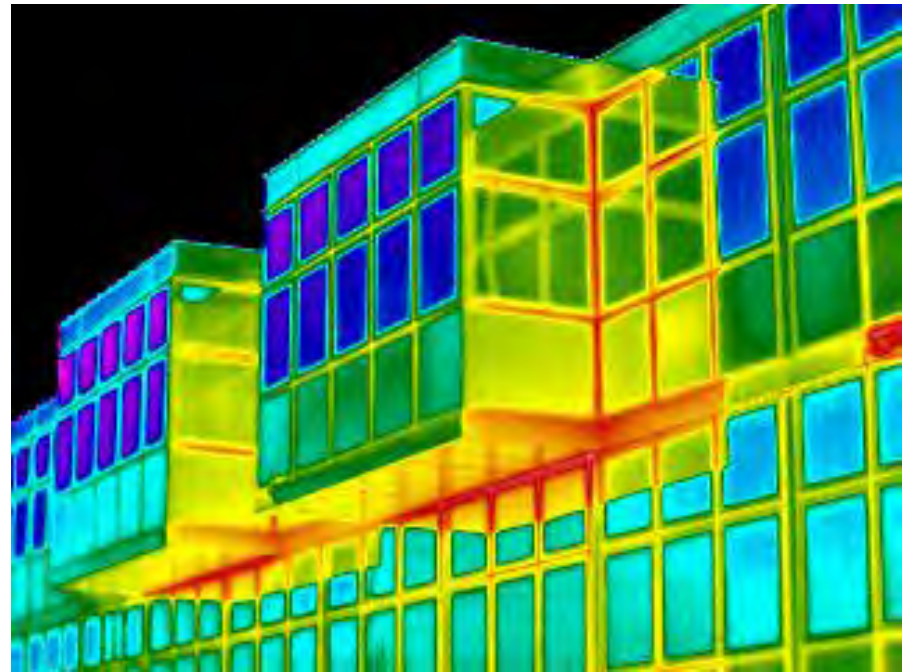
Rapid Modeling



Automated Building Geometry Generation



Tablets and IR imaging for Walkthrough Data Entry



Example Pump Input Form

The screenshot shows a software interface for a Pump Input Form. The interface is divided into several sections:

- Top Navigation:** Includes a home icon, a "New" button, and a breadcrumb "Demo BL...".
- Sidebar:** A vertical list of navigation options: "New", "Existing", "Layout", "Construction", "Light Fixtures", "Windows", "HVAC", "Plug Loads", "Process Loads", "Water Fixtures", "Occupants", "Utility Bills", "Schedules", and "Notes".
- Pump Details:** A section containing:
 - Manufacturer:** Taco
 - Pump Type:** OH5
 - Maximum Pump Speed:** 1450.0
 - Rated Flow Rate:** 114.0
 - A "More details" button.
- Motor Details:** A section containing:
 - Horsepower:** 5.515570049999999
 - Synchronous Speed:** 900.0
 - A "More details" button.
- Data Entry Table:** A table with two columns: "Count" and "Location".
 - Count:** A text input field containing the value "1".
 - Location:** A dropdown menu.
 - Differential Head Pressure (Feet of Head):** A text input field containing the value "0".
 - Drive Type:** A dropdown menu.
 - A "Delete" button is located at the bottom right of the table area.
- Notes and Schedule:** On the right side of the table, there are two sections:
 - Notes:** Includes a "(+) Add Note" button.
 - Schedule:** Includes a "(+) Add Schedule" button.
- Bottom Right:** Includes "Cancel" and "Save" buttons.

Example Lighting Input Form

The screenshot displays a software interface for entering lighting data. The interface includes a sidebar menu on the left with the following items: HVAC, Plug Loads, Process Loads, Water Fixtures, Occupants, Utility Bills, Schedules, and Notes. The main content area shows a list of lighting fixtures, each with a description and a 'Select' button. The fixtures listed are:

- Generic T8 17W Linear Fluorescent
- Generic T8 25W Linear Fluorescent
- Generic T8 32W Linear Fluorescent
- Generic U-bend T8 32W Linear Fluorescent
- Philips Linear Fluorescent T8-F25T8 ADV830 ALTO
- Sylvania Linear Fluorescent T8-FO32/835/ECO/2/30

A 'Back' button is located at the bottom right of the main content area. The footer of the interface contains the text: © concept3D 2014 | © simuwatt is a Registered Trademark of concept3D Corporation - All Rights Reserved.

Semi-Automated Audits Will

- Speed up audit process
- Help detect and reduce audit errors
- Standardize audit information and details
- Speed up energy model generation
- Facilitate more complete assessment of energy savings opportunities and better characterization of risks of underperformance

Automated Model Calibration

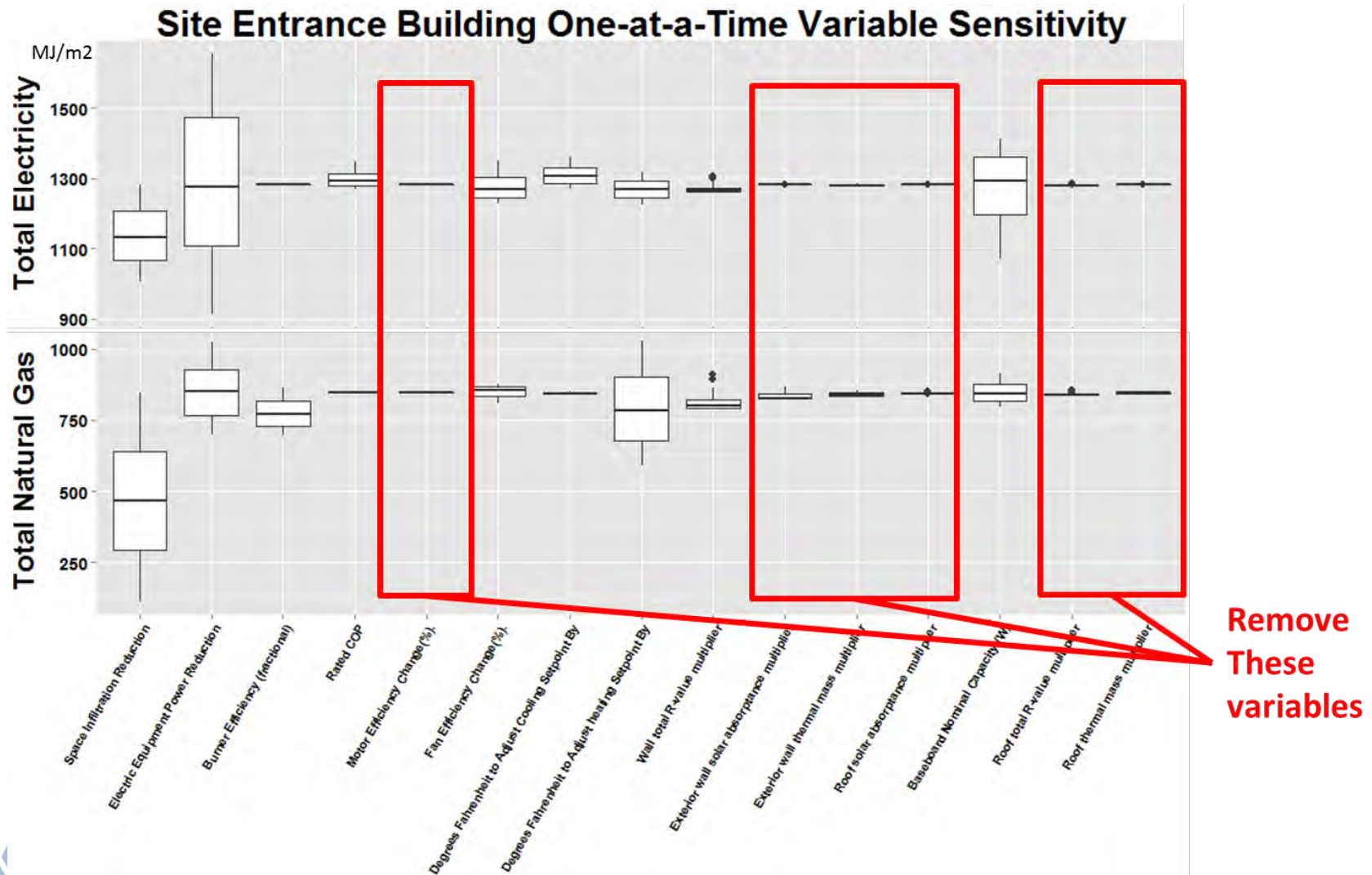
- Wouldn't it be great if we could simply hit the “Easy Button” to calibrate a building energy model?



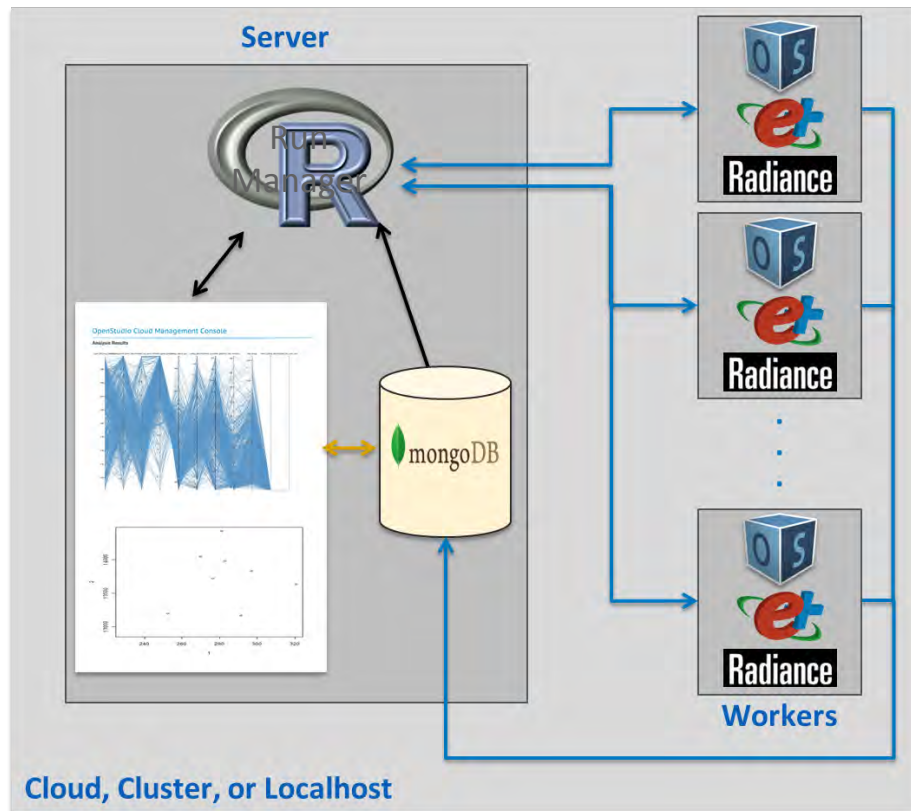
Several Different Automated Calibration Methods

- Machine Learning
- Bayesian Calibration
- Systematic Optimization

Step 1: Sensitivity Analysis To Select Variables for Calibration



Step 2: Generate A Lot of Computer Models



Apply Machine Learning

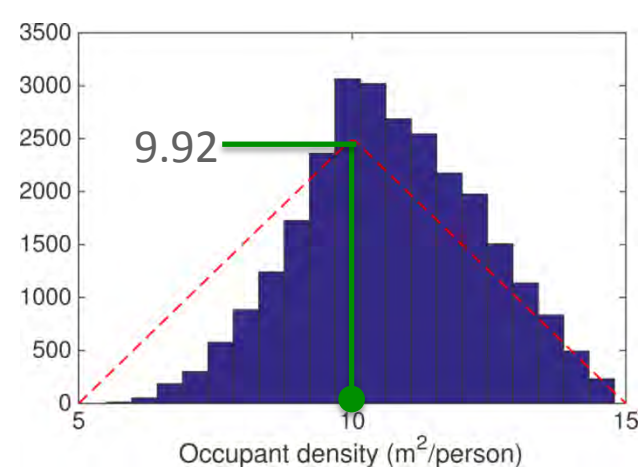
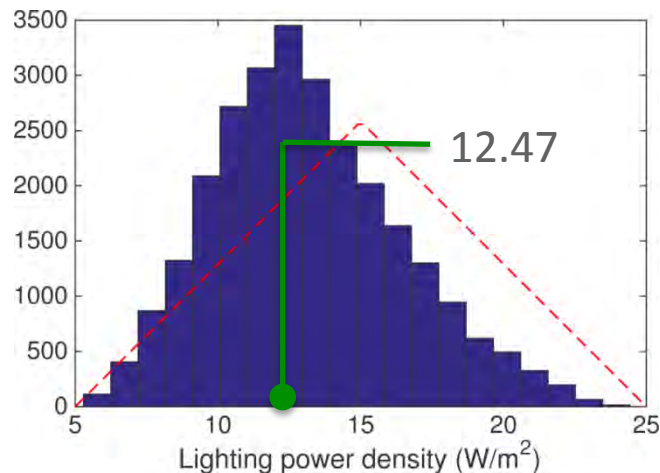
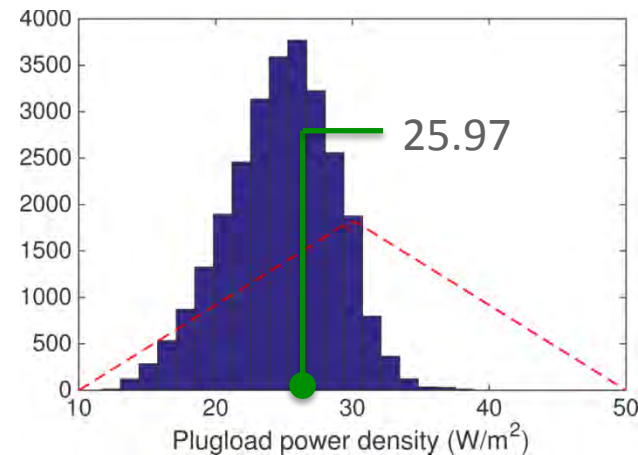
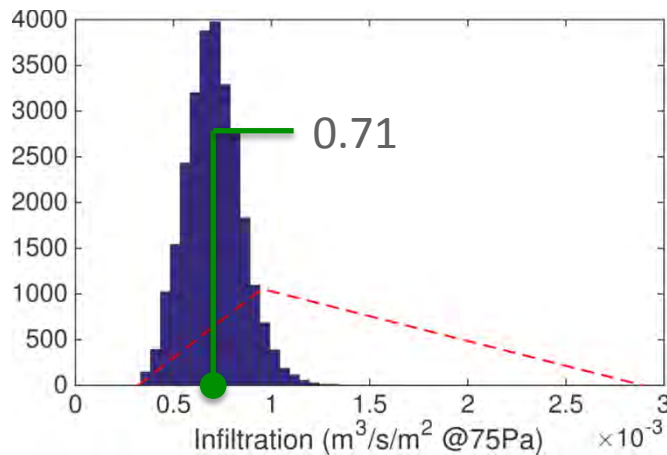
- Linear Regression
- Non-Linear Regression
- Feedforward Neural Network
- Support Vector Machine Regression
- K-Means with Local Models
- Gaussian Mixture Model with Local Models
- Self-Organizing Map with Local Models
- Regression Tree (using Information Gain)
- Time Modeling with Local Models
- Recurrent Neural Networks
- Genetic Algorithms
- Ensemble Learning (combinations of multiple algorithms)

Integrated mixture of
Commercial, Research, and
Open Source software

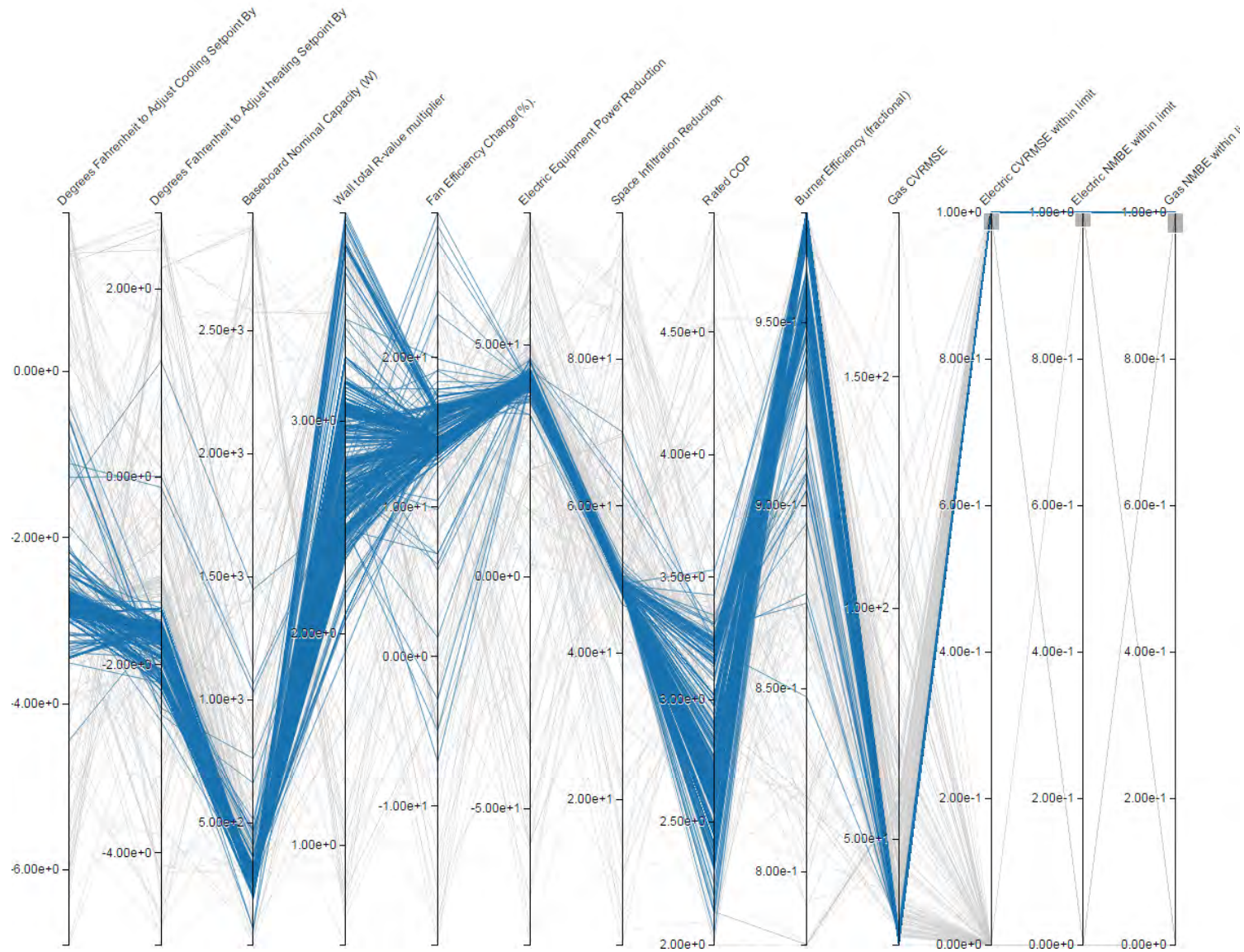


Bayesian Calibration

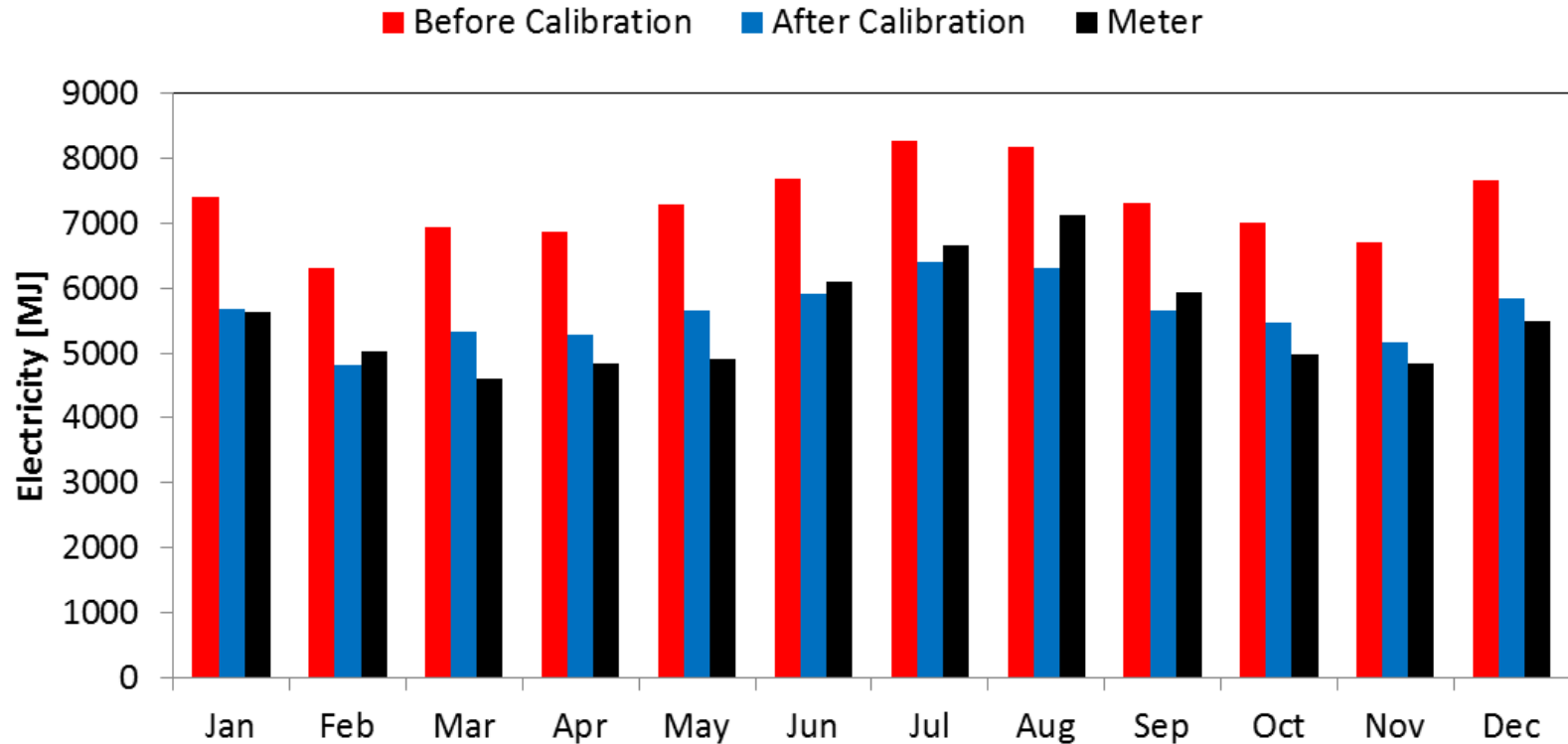
- Assume inputs uncertain - Reduce uncertainty of inputs to reduce difference between model and data



Systematic Optimization



Typical Automatic Calibration Results

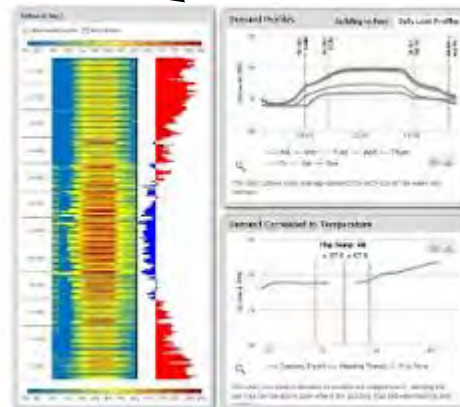
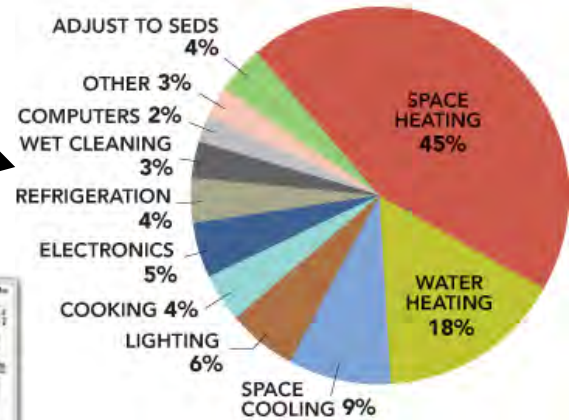
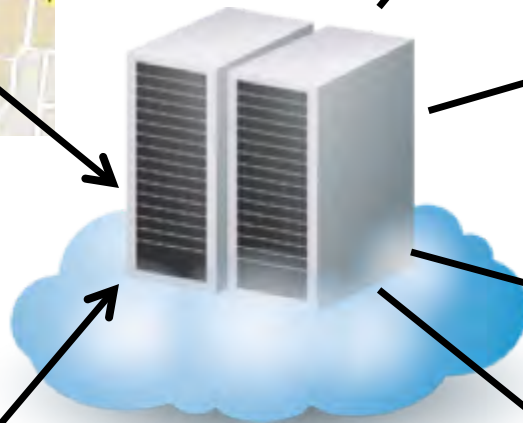
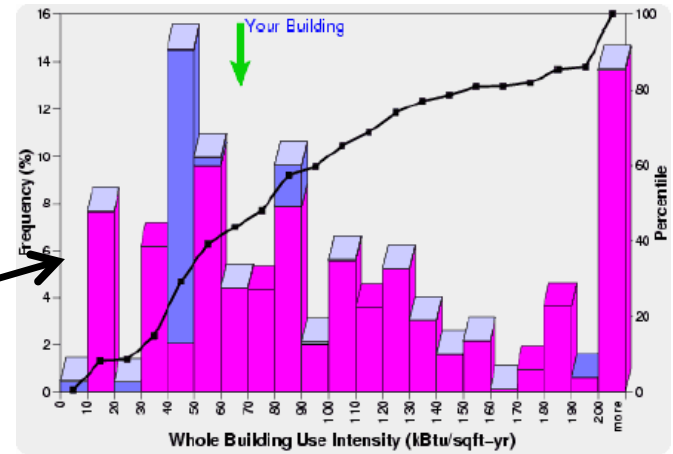
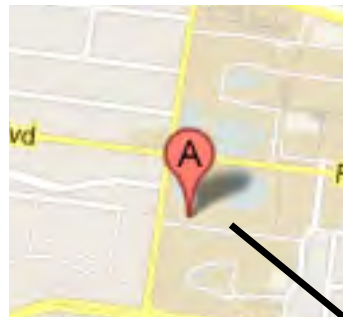


MBE (%) Electricity		CVRMSE(%) Monthly	
Before Calibration	After Calibration	Before Calibration	After Calibration
32.5%	2.1%	53%	9%

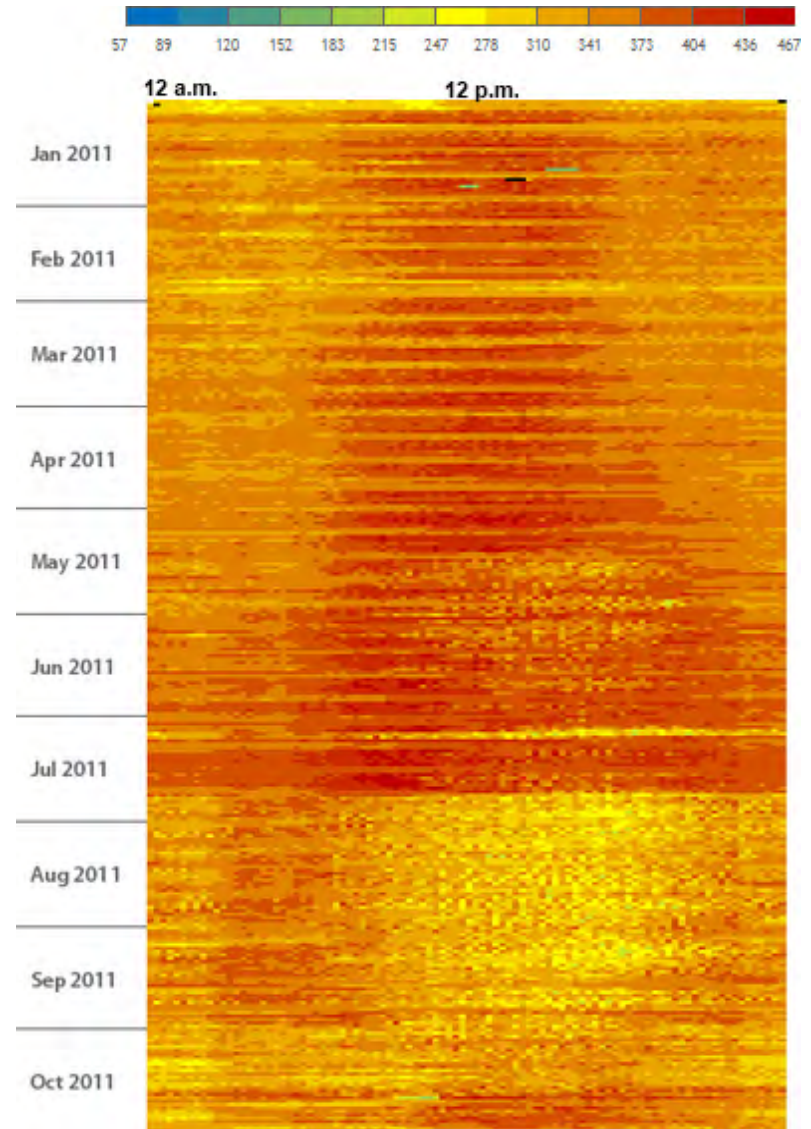
Automated Calibration Will

- Improve the quality of energy models
- Improve the confidence of model predictions
- Reduce the risk associated with retrofit savings guarantees

“Virtual” Audits



Comparison of Interval Data from Two Buildings



Example Report

580 Harrison Ave Boston MA

Current Use Utility Packages ▾ ECMs

Package Comparison

	Total Annual Savings*	Installed Cost	Simple Payback Period	CO2E Reduction	Annual Energy Savings
Short Term	\$10,662	\$9,261	0.9	13%	13%
Mid Term	\$21,228	\$65,372	3.1	22%	23%
Long Term	\$25,885	\$296,700	11.5	27%	38%
Additional ECMs**	\$2,515	\$11,653	4.6	3%	2%

*Total savings also includes annual and non-annual O&M.

**Totals represent sum that could be overstated as interactive effects not considered.

Package ECMs & Performance Summary

Data Center: Upgrade to new Super T8 fluorescent lighting with Electronic ballasts

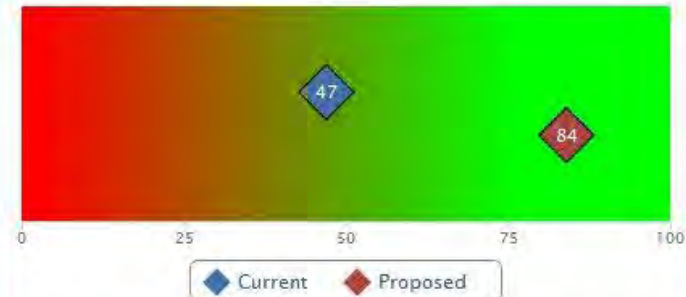
Data Center: Upgrade 40-watt incandescent exit signs with new 0-watt self-luminous exit signs

Office: Replace Existing Water Heater with a 94% efficient Gas Water Heater

CO2 Reduction:	135 tons	kW Reduction:	34%
Energy Star Increase:	37 points	kWh Reduction:	179,553
Cost Reduction:	29%	Therm Reduction:	1,978

Performance Metrics

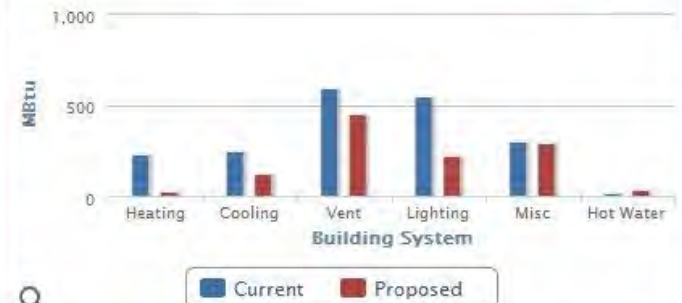
Energy Intensity Cost Energy Star CO2



This is the current and proposed ENERGY STAR ratings for the building. The number shows the % of buildings that it outperforms for energy.

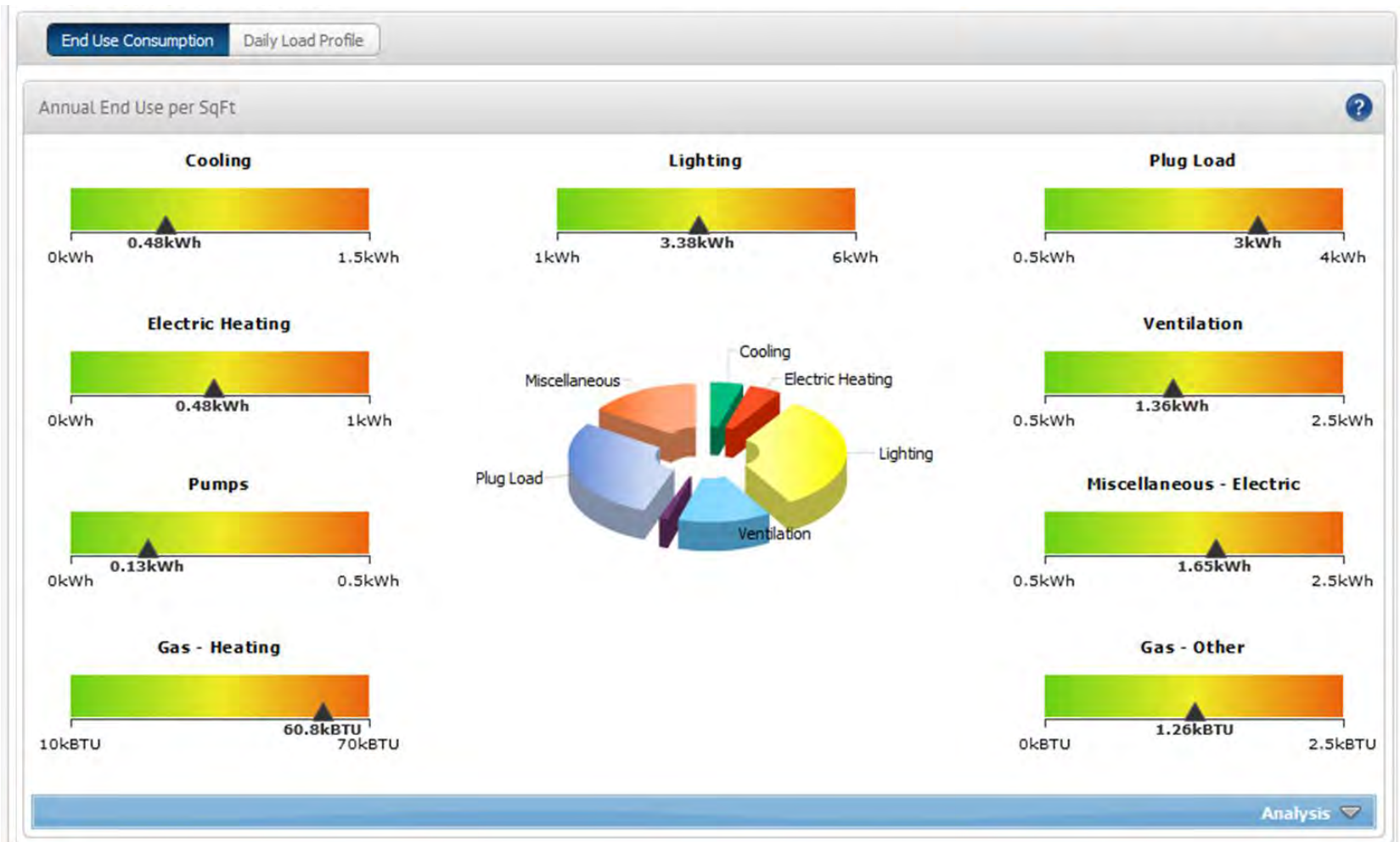
Consumption By System

% of Total Units ▾



The chart shows the current and proposed energy consumed by the various building systems on an annual basis.

Example Report



Example Report

Alex's Account | Logout
Home | Admin | KGS Admin | Help | Client: Demo Site | Module: Gato module...

Diagnostics

The Diagnostics module provides a prioritized, searchable list of identified faults and energy saving opportunities across your portfolio.

Search Criteria

View By

- ☒ Building
- ☐ Equipment Class
- ☐ Equipment
- ☐ Analysis

*Select Building:
Demo Headquarters

Display Interval

- ☐ Half Day
- ☒ Daily
- ☐ Weekly
- ☐ Monthly

Date Range
*Start Date:
06/11/2014
*End Date:
06/11/2014

Top Priorities
Top:
All

Text Filter
Notes Summary:

Generate Data

[Download Current Diagnostics Page](#)
[Download Full Diagnostics Results](#)

34 data records found for 6/11/2014 to 6/11/2014 in daily intervals.

Building	Equipment	Analysis	Start Date	Notes Summary	Cost	E	C	M	Actions
Demo Headquarters	AHU-3 (Air Handler)	AHU Coils	6/11/2014	Simultaneous heating and cooling. Leaking heating valve. Cooling occurring over open heating coil. No supply temp reset.	\$461	10		6	
Demo Headquarters	AHU-1 (Air Handler)	AHU Coils	6/11/2014	Simultaneous heating and cooling. Leaking cooling valve. Cooling occurring over open heating coil.	\$100	10		6	
Demo Headquarters	AHU-4 (Air Handler)	AHU Coils	6/11/2014	Simultaneous heating and cooling. No supply temp reset.	\$33	10		4	
Demo Headquarters	AHU-1 (Air Handler)	AHU Fan	6/11/2014	No static pressure reset. Fan off, should be on.	\$10	4		7	
Demo Headquarters	AHU-5_HD (Air Handler)	AHU Fan	6/11/2014	Fan on while unoccupied.	\$8	2		4	
Demo Headquarters	Chiller 1 (Chiller)	Centrifugal Chiller ...	6/11/2014	Condenser refrigerant pressure out of range. Chiller outlet temp not tracking setpoint.	\$0	2	7	10	
Demo Headquarters	VAV1-3 (Zone Equipment)	Zone Unit	6/11/2014	Supply flow lower than setpoint. Sensor error.	\$0		10		
Demo Headquarters	VAV1-2 (Zone Equipment)	Zone Unit	6/11/2014	Supply flow lower than setpoint. Room air temp higher than setpoint.	\$0		10		
				Room air temp lower than setpoint. Stuck					

Virtual Audits Will

- Ongoing analysis and data mining can be used for fault detection and diagnostics and assess changes in building performance
- Provide information about basic opportunities to prioritize a full walkthrough audits between several buildings

Summary

- Rapid Energy Modeling and Semi-Automated Audit tools will make it easier for auditors to provide good audits at reduced cost
- Automatic model calibration tools will reduce the need for expert modelers and provide auditors with more confidence in their recommendations
- Virtual audits can help diagnose building problems and prioritize which buildings that should have more standard audits

Questions?