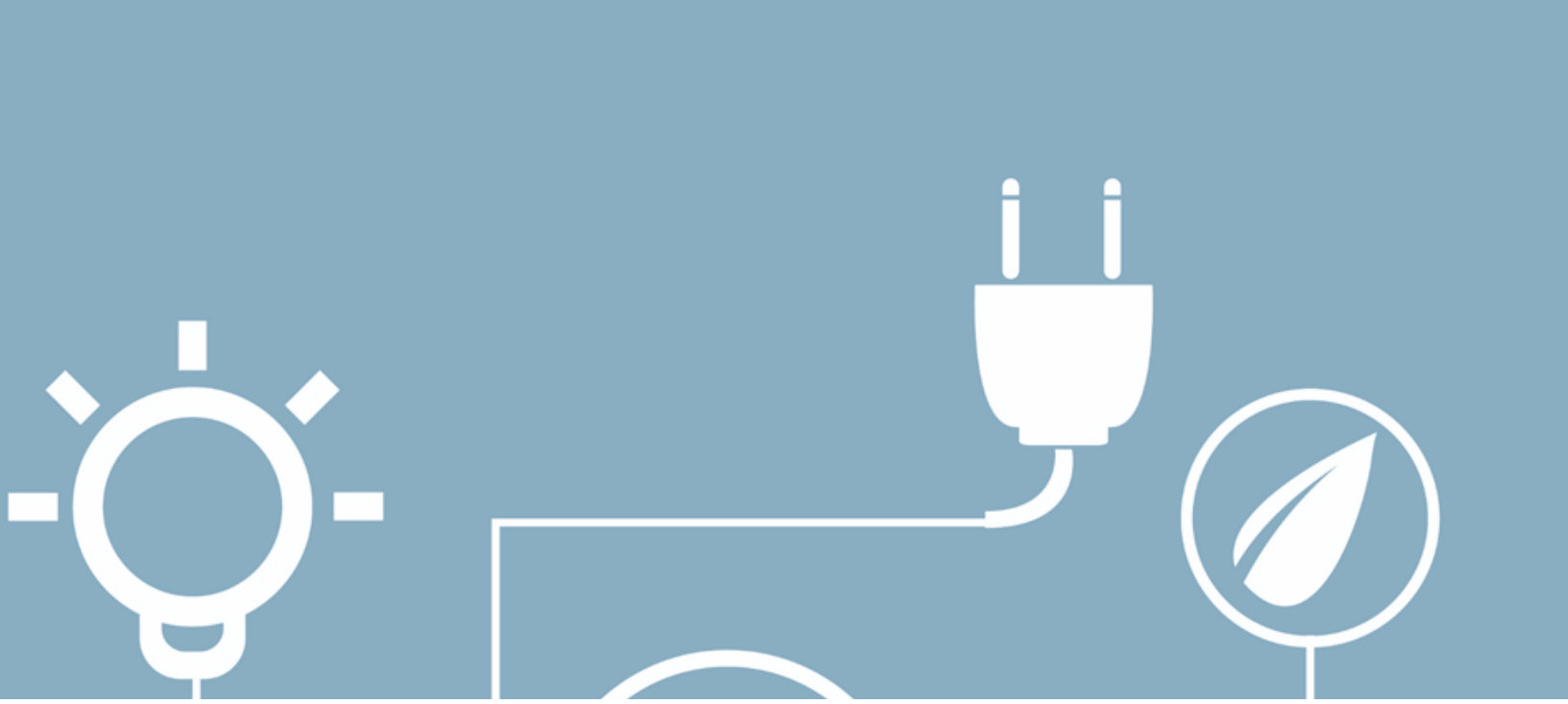

Creating and Using a Building Energy Management System

A Guide to Energy Management Systems (EMS)

5/18/2022

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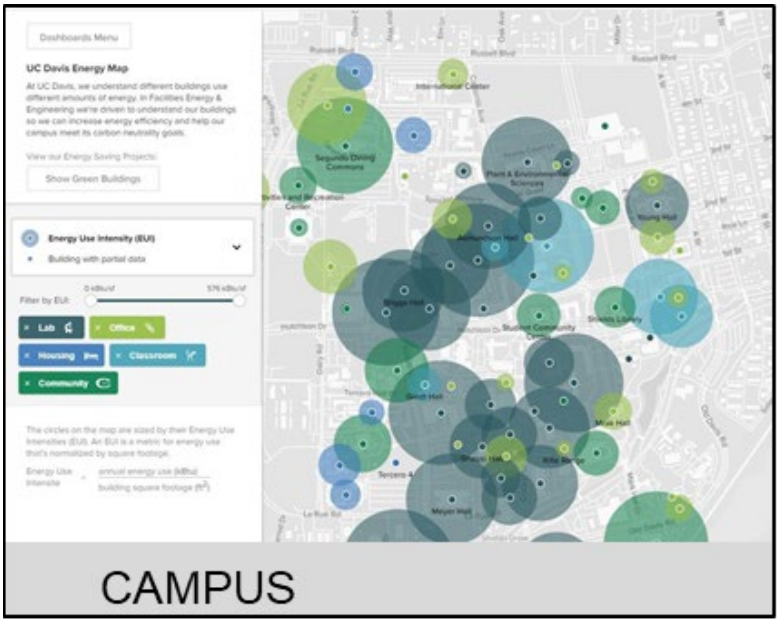
Introduction

Beyond the essential functions and services buildings can directly provide, the information they can generate on how systems are operating and where they are using the most energy can be highly useful to owners, designers, and maintenance operation managers. Today's challenge is knowing what types of building monitoring options exist and if the data can be configured to provide information to meet the different needs of people within the organization. Depending on the size and complexity of an organization, building information may be useful in one or all the following areas:

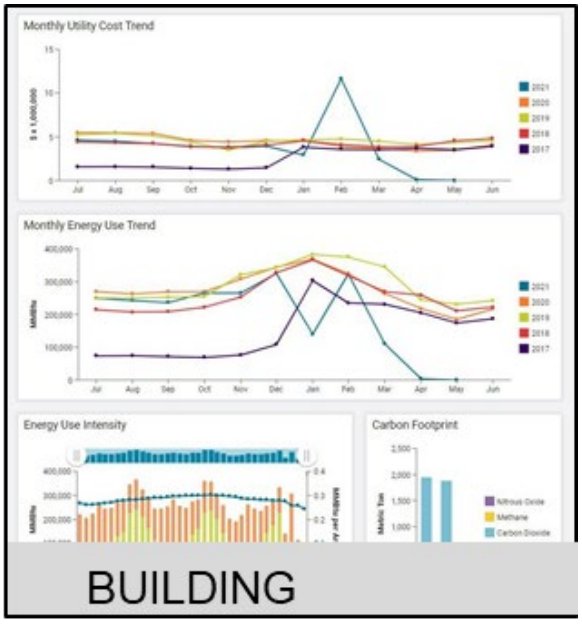
Direct Value	Indirect Value	Supporting Compliance
• Energy, Demand, Cost Measurement and Verification • Reduce System Drift	• Portfolio / Campus Visibility • Enhanced Usability of other Building Systems • Voluntary Certifications (Net Zero Energy)	• LEED Version 4 and Beyond • Building Benchmarking • ISO 50001 • Energy Standards, ASHRAE 90.1 2019

Example EMS Dashboards



CAMPUS

https://ceed.ucdavis.edu/



BUILDING

https://energy.ku.edu

Why is an EMS Needed?

Sometimes an EMS might be necessary to meet a building's compliance requirement. Examples of these include:

LEED v4: Option 1, Path 2 of the Enhanced Commissioning credit requires "monitoring-based commissioning" which is the integration of three components: a permanent energy monitoring system, real-time energy analysis, and ongoing commissioning. The purpose and function of an EMS can satisfy these requirements.

City Ordinance Energy Benchmarking: Many cities throughout California (**i.e.** San Francisco, Berkeley, San Jose, Los Angeles, and San Diego) have established ordinances requiring some level of building energy benchmarking and "energy assessments.**"** The reporting features of an EMS can accomplish these efforts.

Building Energy Standards Standard 90.1-2019: This standard requires submetering of total electricity use, HVAC systems, interior lighting, exterior lighting, and receptacle circuits (ASHRAE 2019a). As local code jurisdictions work to adopt the latest version of ASHRAE 90.1, it will become standard practice to construct and design new buildings with individually submetered end-use loads. Required submeters could be tied into the EMS for interval meter analytics and to process this large quantity of submetered data.

An EMS might be necessary for reasons other than compliance. Some examples include:

The building does not have a Building Automation System (BAS), and therefore unable to access or view real-time energy / performance data.

The building has a Building Automation System (BAS), but has limited functionality:

- Basic HVAC controls with no access to data
- Access only to HVAC data
- No trending or historical data capability
- BAS has access to trend data, but may need a professional to interpret

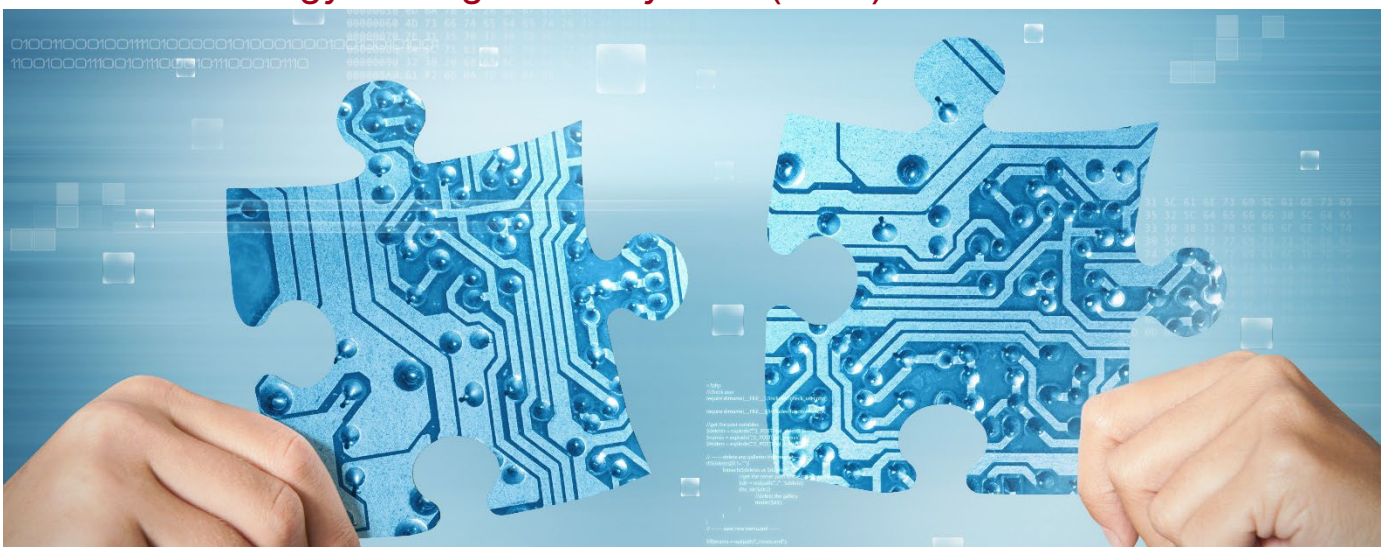
The building has implemented advanced control sequences:

- Guideline 36 – Best in Class Control Sequences
- Automated Fault Detection Diagnostics
- Demand Limiting and Load Shedding

Regardless of the reason, to successfully implement an EMS, it helps to have some examples and basic information about a system and the types of options, graphical displays and analytics that can be implemented

This guide is intended to help owners and designers who may be new to the topic or just looking for a place to start.

What is an Energy Management System (EMS)?



Energy management systems (EMS) are software platforms which compile building data into actionable visual information. Below are some of the capabilities of an EMS that help building owners and facility managers understand the information from their building:

- **Centralize, Normalize, Visualize Data**—Automatically bring data streams together from different sources into a common database. Translate the data in a visual context, such as a chart, to make data easier to understand and present insights.

- **Utility Bill Management**—Track, understand, and process data from utility bills.

- **Interval Meter Analytics**—Automate capturing "real-time," high-resolution meter data and leverage sophisticated analytical tools to document a building's energy-usage patterns.

- **Measurement & Verification**—Identify, quantify, and verify the energy savings performance of individual energy conservation measures or efficiency projects.

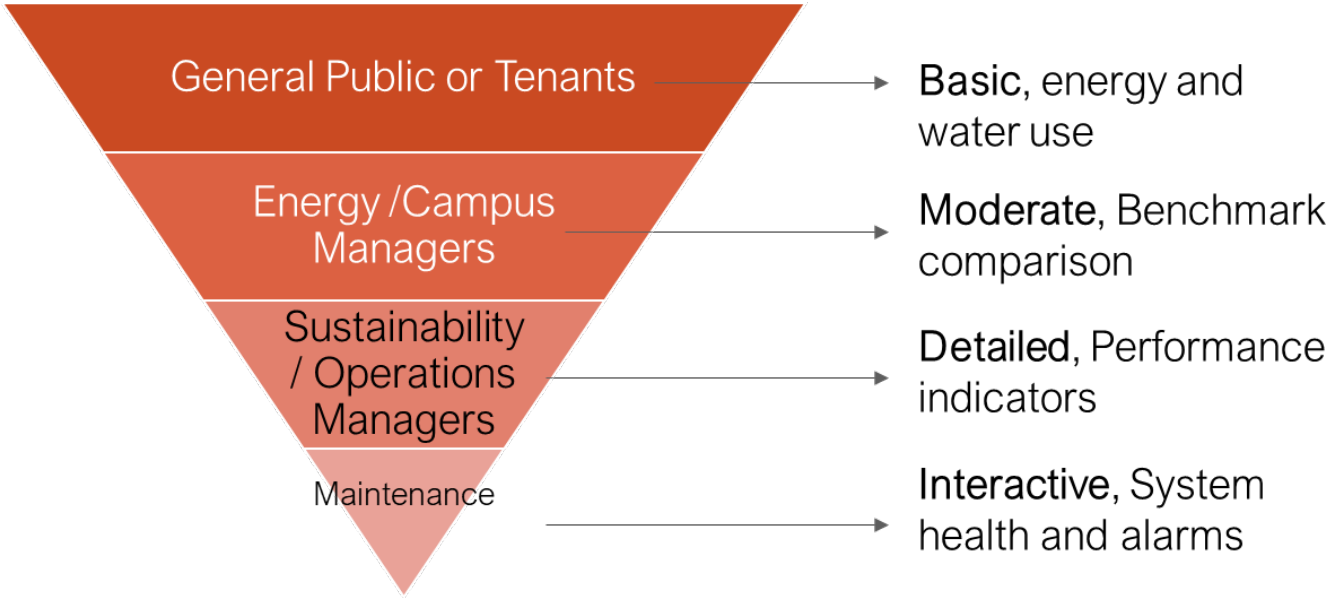
- **Automate Fault Detection Diagnostics (AFFD)**—Automatically detect equipment-level or system-level performance and operational issues and diagnose their causes.

- **Supervisory Control**—Perform automated control changes to underlying building systems for optimization.

- **Operation & Maintenance (O&M) Optimization**—Provide tools to integrate the above capabilities with O&M processes to increase efficiency.

Who Uses an EMS?

The purpose of an EMS is to display building operational performance data so that users can understand how their building is functioning and, most importantly, be able to act on the information. When designing an EMS, it is important to understand the role of the system's user since there are varying degrees of sophistication and, depending on the EMS's identified user(s), some of the system capabilities as listed in the section above may not be necessary. The example figure below demonstrates various views that could be appropriate for different user groups.



User Group	Level of Sophistication	EMS Capabilities	Additional Details
General Public or Tenants	Basic	Centralize, Normalize, Visualize Data	Relevant metrics to a number of people, comparable with other metrics such as carbon emissions
Corporate Leadership, Campus Managers, or Project Managers	Moderate	Building Use Benchmarks Utility Bill Management	Ability to compare metrics to other buildings, ability to see usage by fuel types, review data month over month, and forecast energy demand & costs
Sustainability Managers, Energy Managers, Operations Managers	Detailed	Measurement & Verification Interval Meter Analytics	Ability to see where energy is used by end use, provide system health metrics on a scale of risk and cost
Building Operations and Maintenance Staff	Interactive	Supervisory Control Automate Fault Detection Diagnostics Operation & Maintenance Optimization	Ability to identify system operational deficiencies and provide risk level and action required Details on where in a system an issue has occurred

EMS Selection Considerations

When selecting an EMS, it is important to consider the types of options available and how the system will impact the team designing, delivering, and operating the building.

Energy Management System Procurement & Vendor Options

For building owners, purchasing an EMS requires understanding many options. The table below summarizes the basic options and example vendors.

Options	Example Vendors	Pros	Cons
Standard software products are typically purchased with a one-time fee, are licensed according to number of installations, and include limited support with no additional services	Wattics Energy Cap Energy Manager	No ongoing fees/costs Protect critical information by keeping in-house Enhance internal team skills Improve speed to answer	Limited support services Limited customization
Application Service Providers (ASP) offer solutions in which the ASP owns, operates, and maintains the software and servers for web-based applications that are usually priced according to monthly/annual fees	SIEMENS SIMATIC Energy Management Software Esight Energy BuildingOS (AcuityBrands)	Includes data & IT management (i.e. automatic software upgrades) Can be customized for user interface and analytics Reduced up front costs for infrastructure Ability to run from the internet 24/7 from any device	Ongoing fees Security risks
Turnkey solution providers offer fully packaged solutions that include pre-installed software, hardware and accessories in a single 'bundle'	Skyspark Vendors Clockworks Analytics EnergyCAP	Can be customized for user interface and analytics Servers can be hosted on-site or remotely Can pair with outsourced expert team for support Ability to run from the internet 24/7 from any device	Ongoing fees Higher upfront costs Security risks

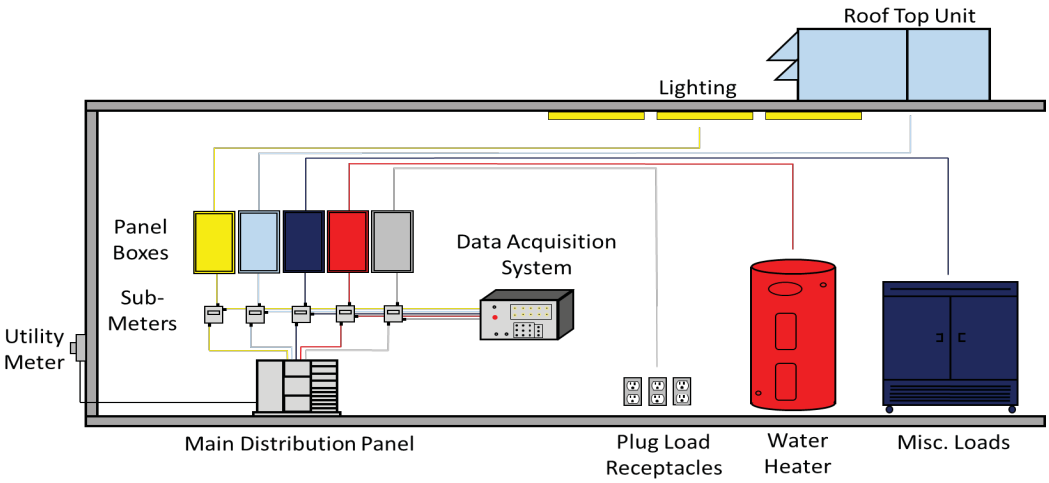
EMS Design & Construction, Commissioning, and Operations Considerations

When approaching the decision to integrate an EMS into the design of a building project, specific considerations should be addressed during the design and commissioning process, as outlined in the following table.

Design / Construction Considerations	• Include a specification in the contract documents that describes details of the EMS: (1) which meters and data points will be included on system (2) what metrics (KPIs) will be evaluated (3) what fault detection diagnostics programmed and (4) how will data be visualized. • Incorporate standard data management practices, such as standardize point naming, metadata assignments, open standard protocol requirements, etc. to ensure consistency. • Provide a plan / drawing which accounts for the integration of all systems into the BMS and/or EMS.
Commissioning Considerations	• Include commissioning scope to ensure all meters and systems giving data are properly commissioned to ensure the EMS gets good data.
Operations Considerations	• Ownership team member needs to understand functionality of system and how to respond to the information that EMS presents.

Sub-metering and data acquisition design configuration

The number of sub-meters installed can be determined by the design team, provided the data acquisition system accurately totals all energy



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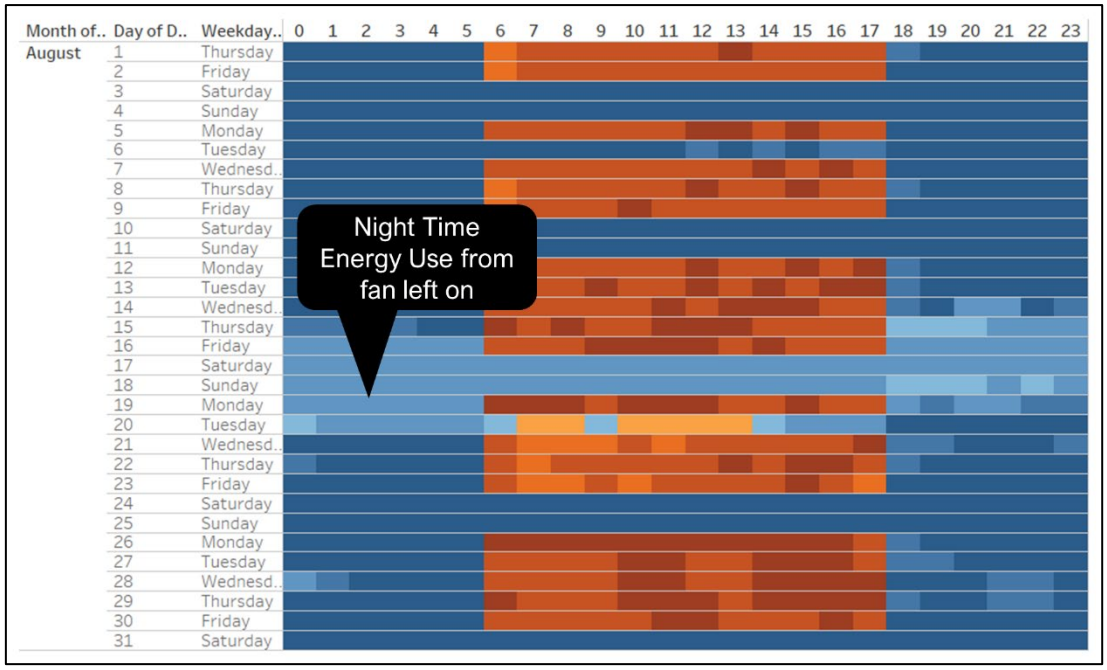
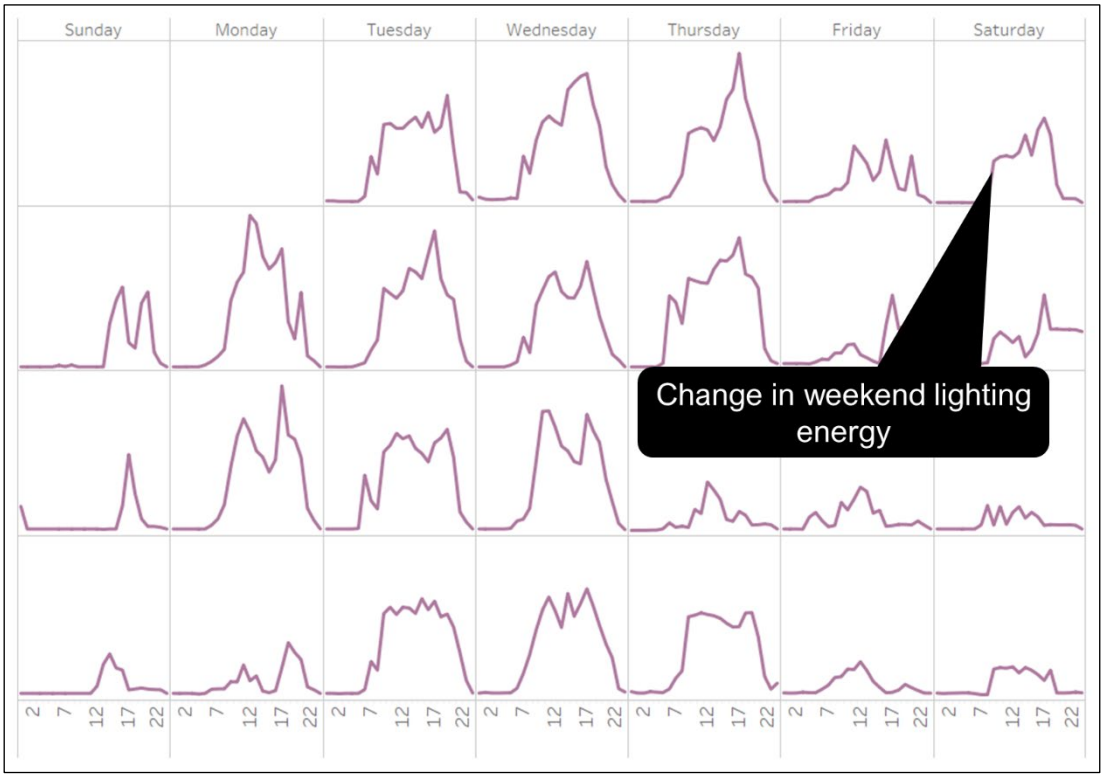
Energy Management System Uses and Example Visualizations

TRACKING ENERGY USE

Heat Map identifying a building's HVAC system operating at full capacity overnight.



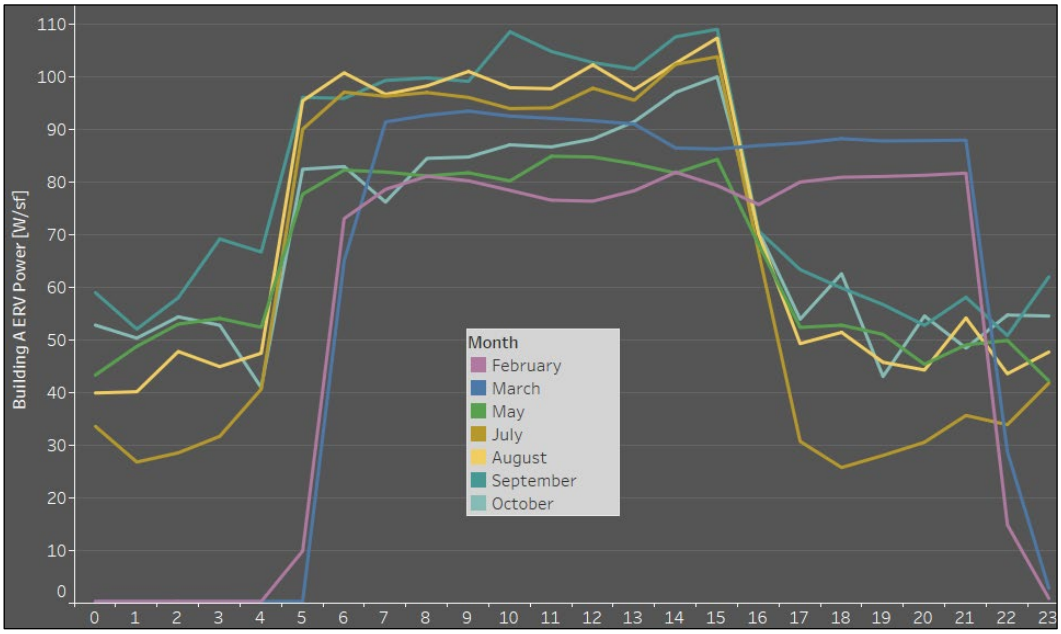
Calendar View of lighting sub-meter showing an abnormal profile over the weekend.



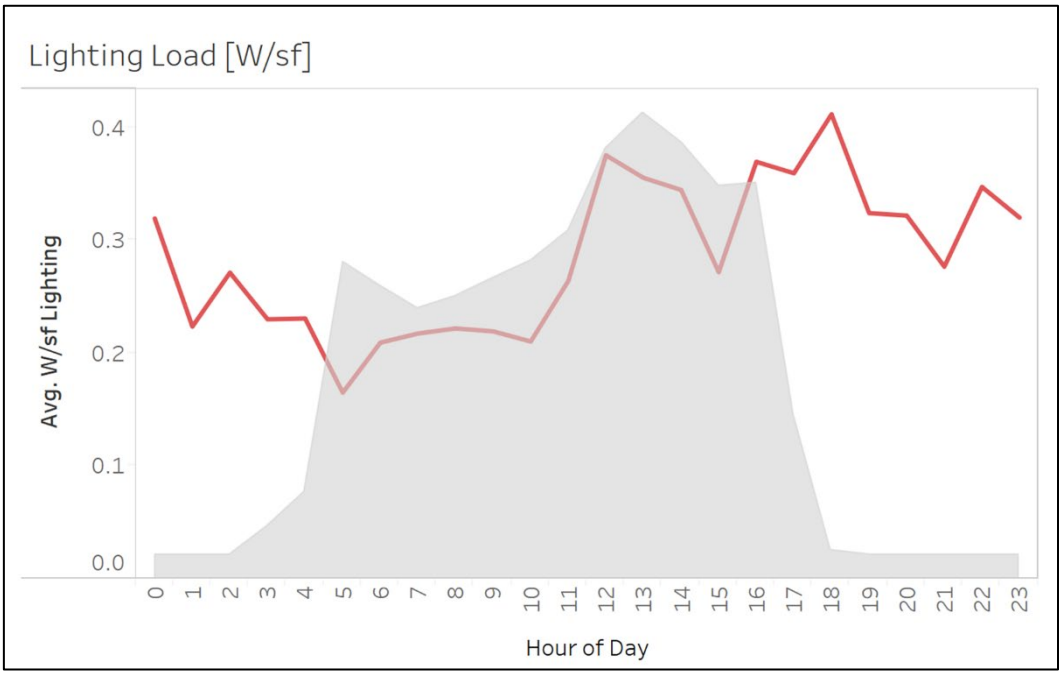
Red Car Analytics dashboard example

TRACKING ENERGY USE (Cont.)

Overlay showing a reduction in today's plug load power draw overnight compared month over month or day over day to see changes in usage.



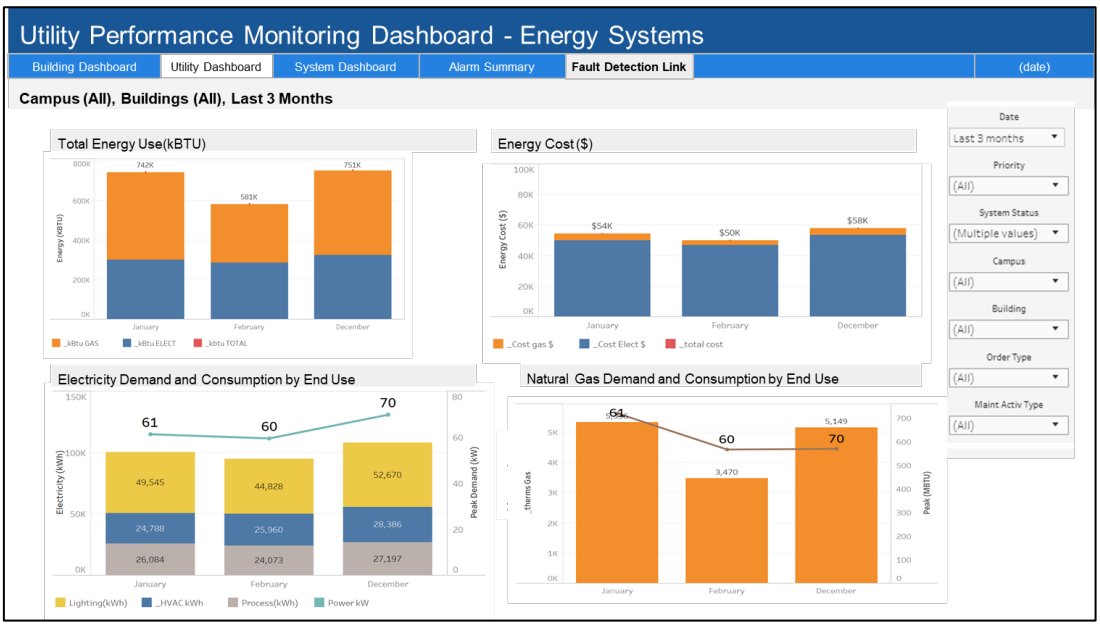
Trend Analytics delivering a notification that the building's lighting system is operating outside the expected profile (shown in red) of building systems historically (shown in grey).



Red Car Analytics dashboard example

BUILDING BENCHMARKS & ENERGY PERFORMANCE

Benchmarking comparing energy use for each end use category over three months. Being able to track energy use and cost easily by building.



Red Car Analytics sample campus dashboard

Normalization of multiple buildings by floor area can help identify where opportunities on a campus exist for improved efficiency.

Compare Mrak Hall with other buildings:

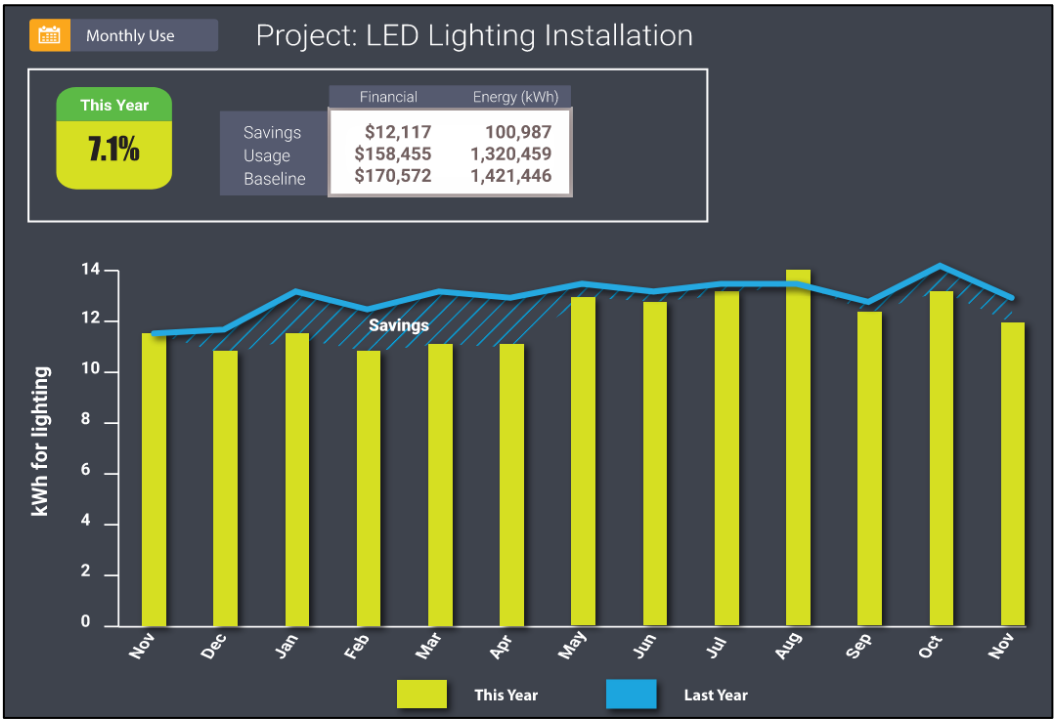
☑ Lab ☑ Office ☑ Housing ☑ Classroom ☑ Community ● Normalized by Sq. ft.

Building	Total EUI	Electricity EUI	Steam EUI	Chilled Water EUI	Annual Cost
Mrak Hall	**69**	**27**	**33**	**9**	**$57,991**
Meyer Hall	445	90	217	138	$711,845
Hutchison Hall	442	65	336	41	$502,122
Young Hall	405	33	335	37	$375,389
Life Sciences	400	121	89	190	$255,934
Segundo Dining...	383	110	216	57	$156,495
Genome & Biome...	350	107	129	114	$539,490
Briggs Hall	326	94	158	74	$490,851
Earth and Phys...	324	85	130	109	$203,192
Chemistry Annex	316	94	151	71	$269,150
Robert Mondavi...	264	85	99	80	$267,877

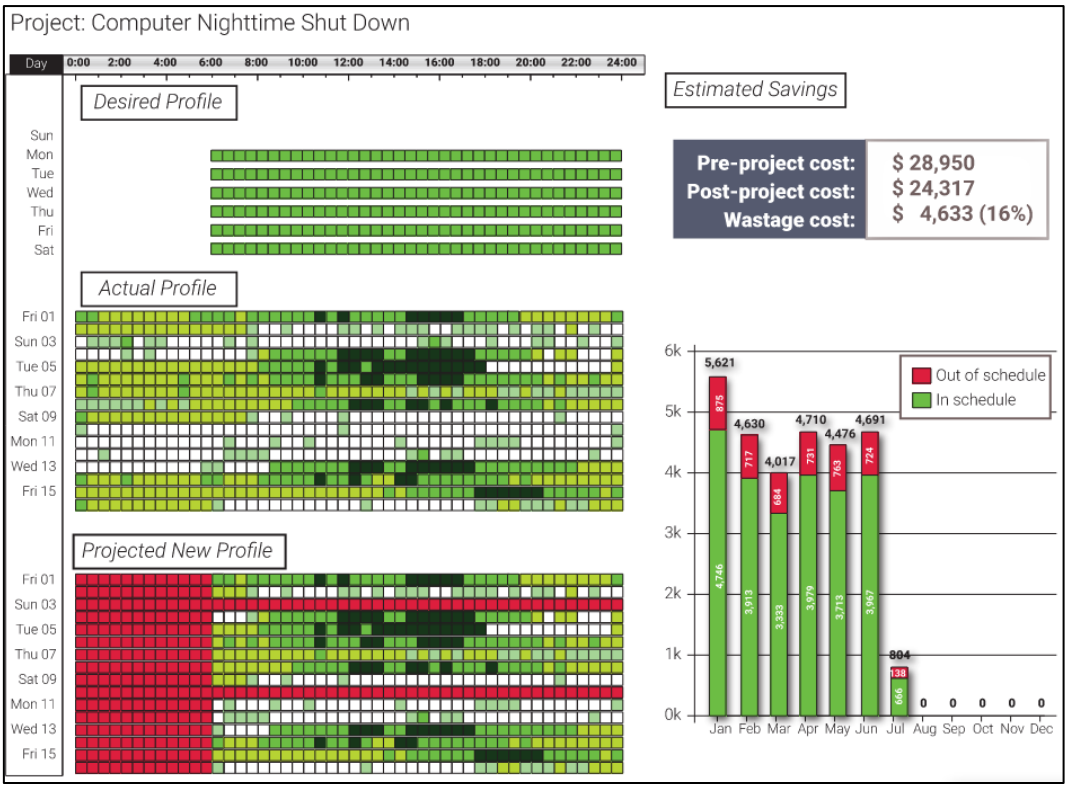
UC Davis Campus Dashboard

MEASUREMENT & VERIFICATION

Project Tracking
comparing lighting energy use before and after replacing all lights with light emitting diodes (LEDs).



Energy Savings
Estimation allowing a user to input a desired profile for plug loads based on a conservation measure (e.g. nighttime computer shutdown).



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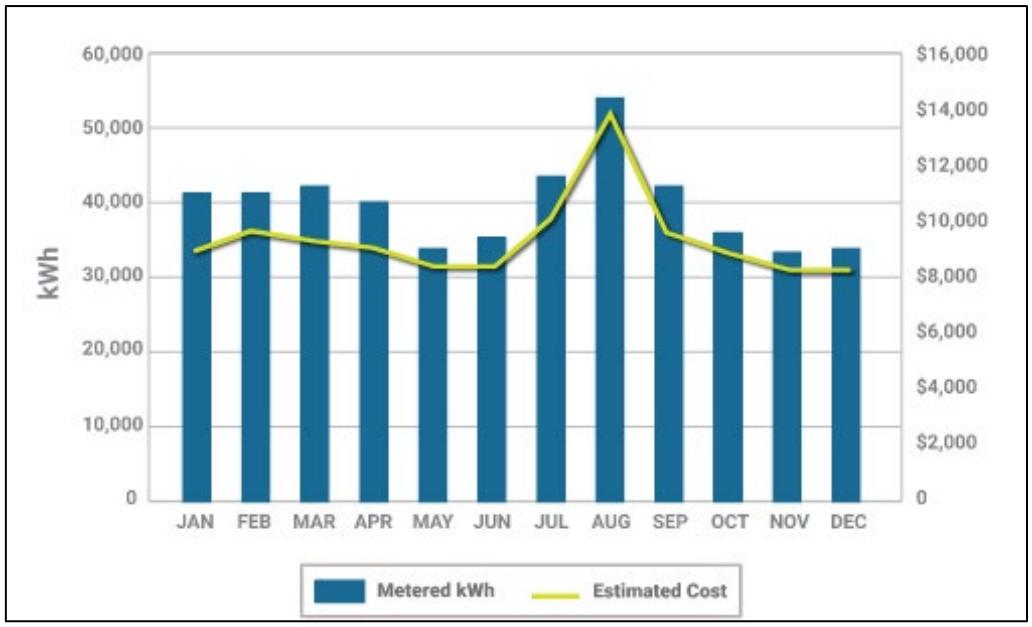
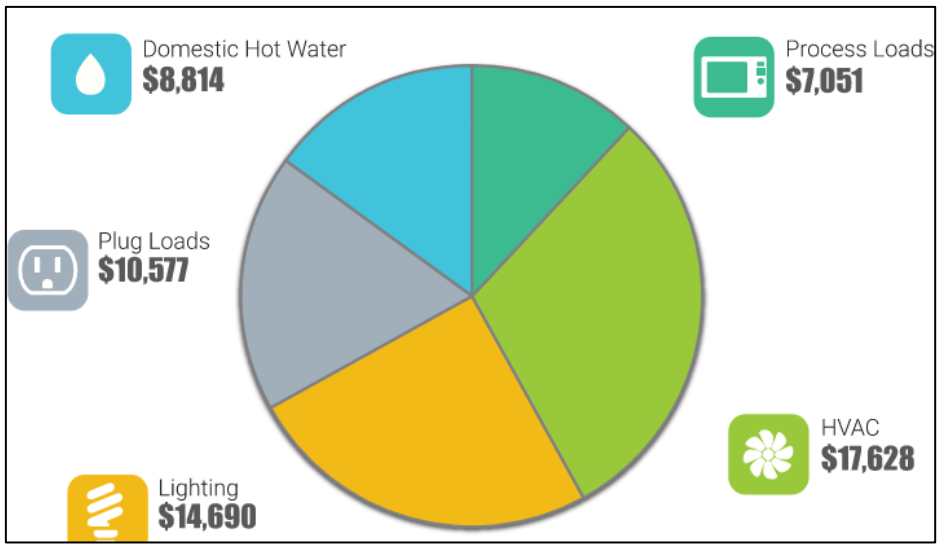
UTILITY BILL ANALYSIS

Cost Estimation

allowing a user to input their utility rate structure and applying that rate structure to estimate the cost of the metered data use at both the whole building level and the end use category level.





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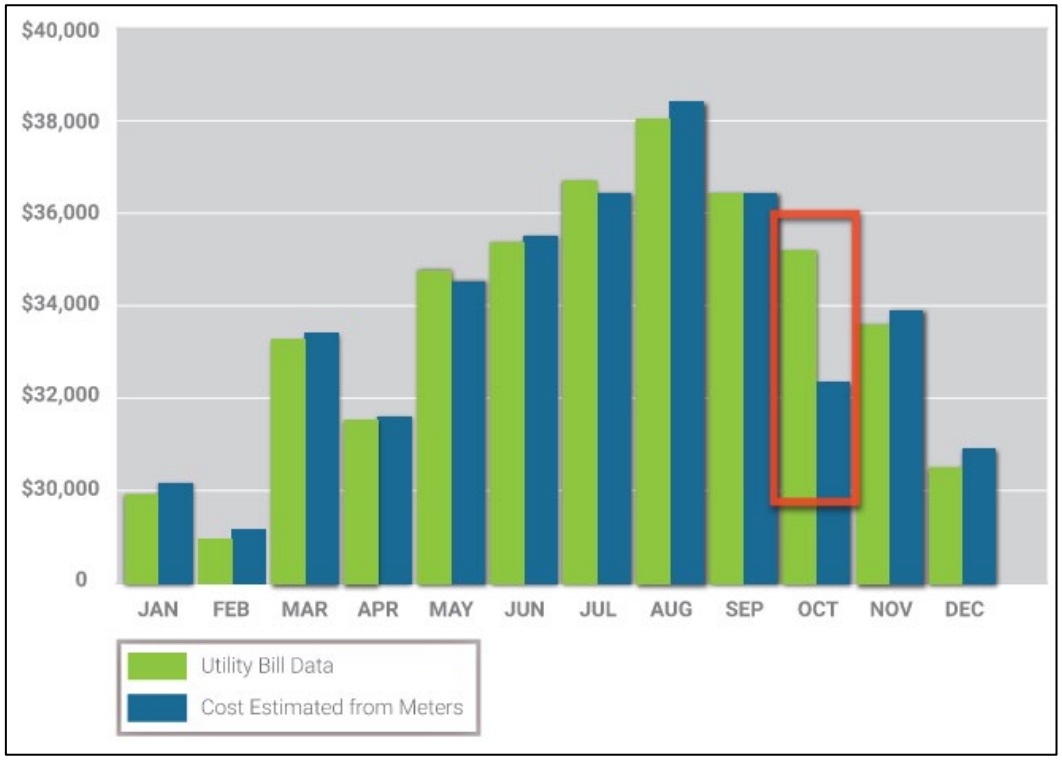
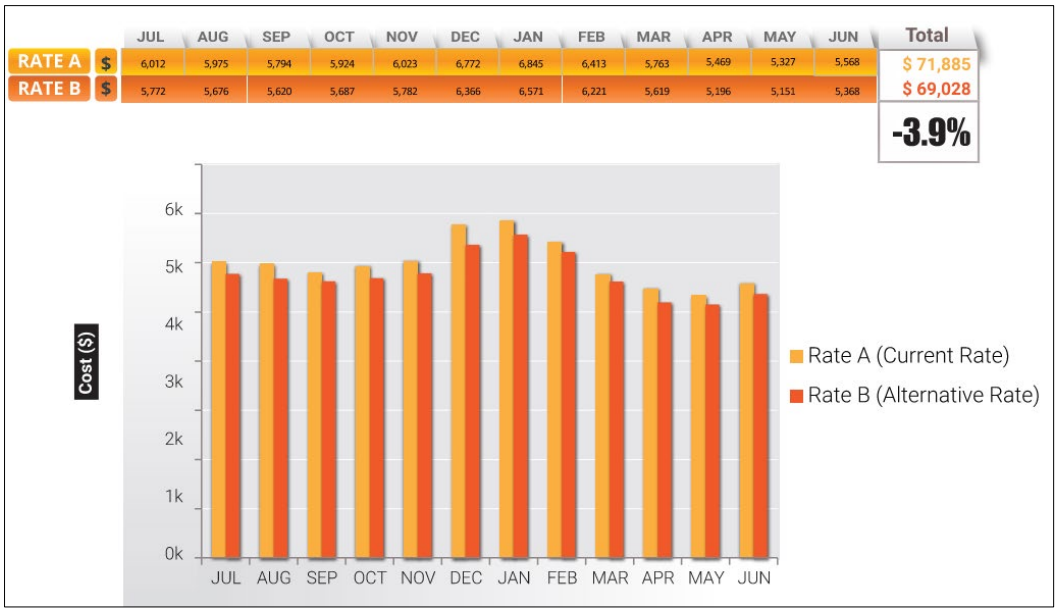
UTILITY BILL ANALYSIS (CONT.)

Utility Bill validation showing a comparison of the building energy costs estimated from the metered data and the actual utility bills.



"What if?" Utility Bill Analysis comparing the building's energy costs using the current rate structure to the costs if another rate structure was used.



		JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	Total
RATE A	$	6,012	5,975	5,794	5,924	6,023	6,772	6,845	6,413	5,763	5,469	5,327	5,568	$ 71,885
RATE B	$	5,772	5,676	5,620	5,687	5,782	6,366	6,571	6,221	5,619	5,196	5,151	5,368	$ 69,028
														-3.9%

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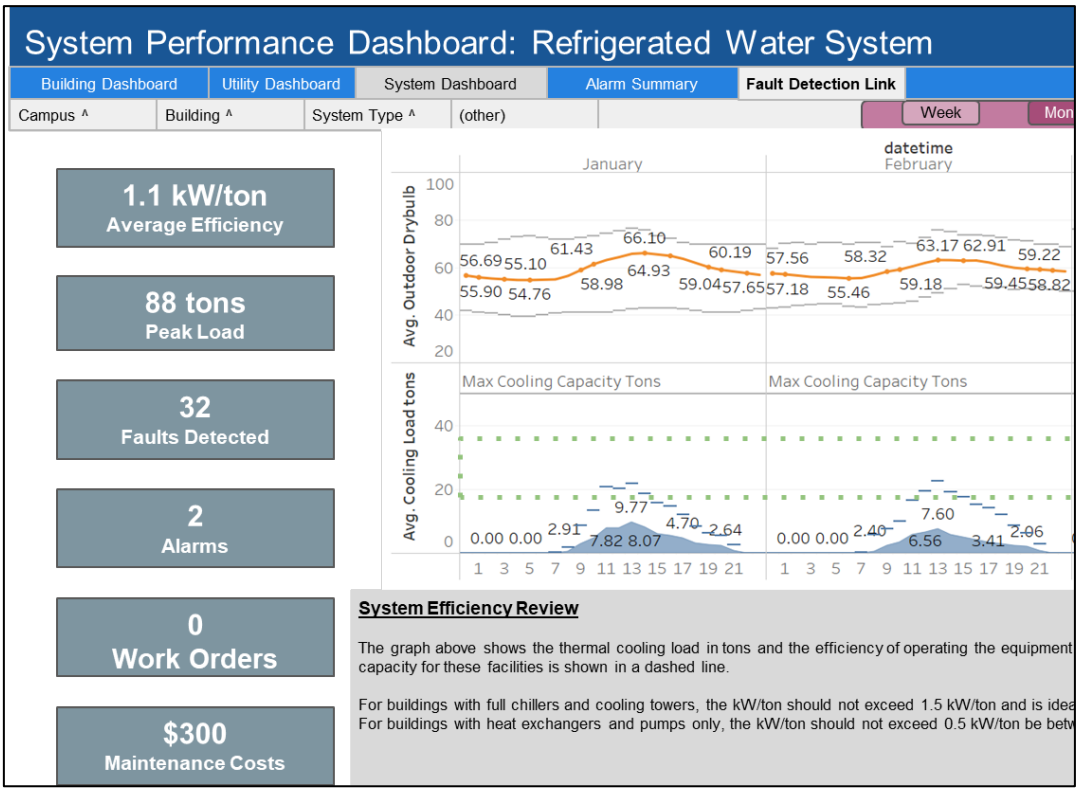
DATA QUALITY VERIFICATION

Clear dashboards of system efficiency metrics and limits can help users observe uncharacteristic data spikes and possible errors.



Red Car Analytics sample system efficiency dashboard

Created by Red Car Analytics

Red Car Analytics is an impact-driven energy consulting company specializing in energy modeling and building commissioning. The company is on a mission to improve building design and operations to achieve zero carbon results by focusing on solutions for buildings that have the potential to scale quickly and be easily implemented.

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