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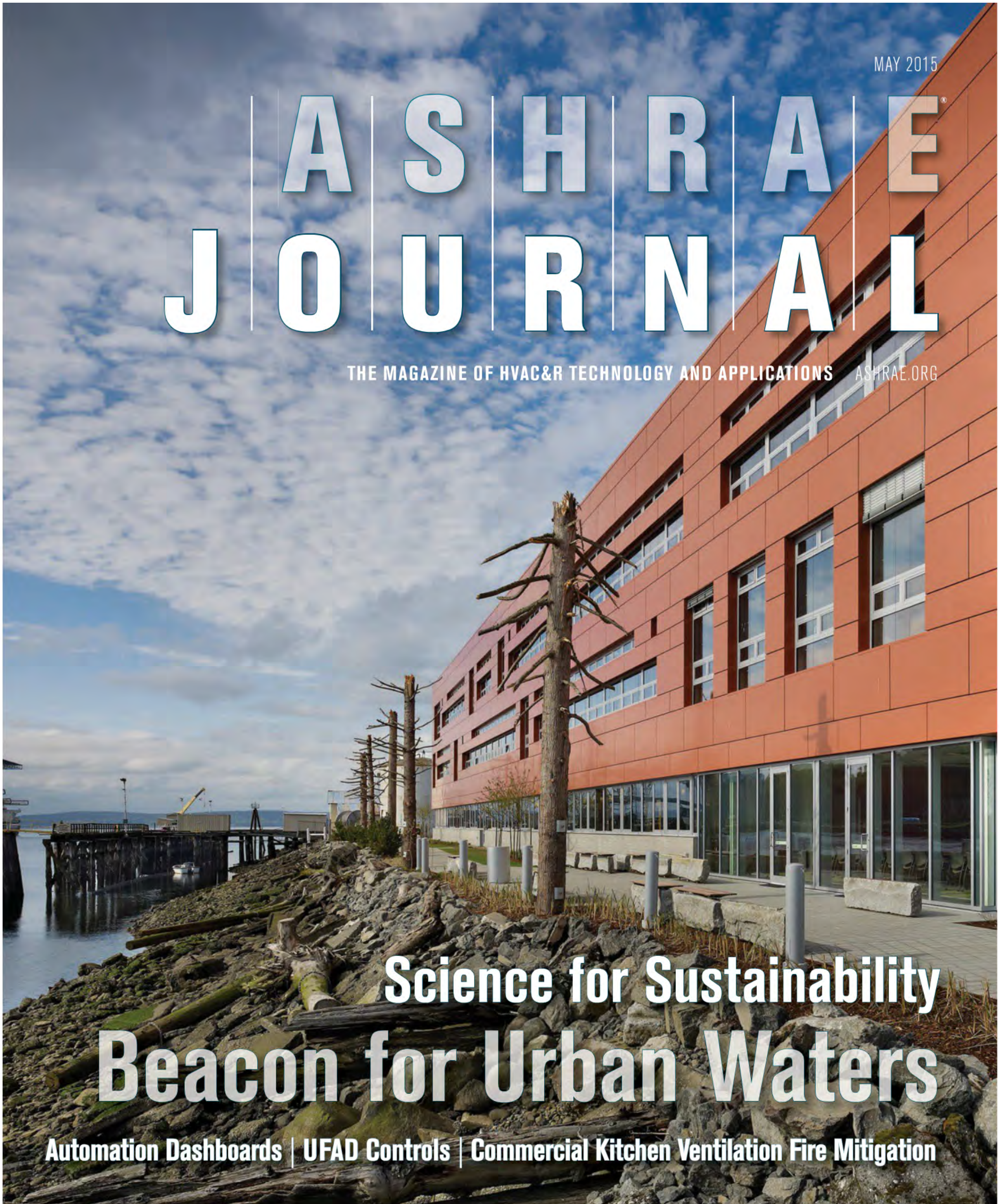

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Criteria for Building Automation Dashboards

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Can you imagine driving a car without a dashboard? The thought seems inconceivable today, yet in 1914, the Ford Model T series was introduced to the world without a dashboard. In the early days of the automobile industry, system reliability and functionality were the primary concern. Speed, fuel economy, and alarms were secondary priorities, if considered at all. As time progressed, so did the needs of the average driver. Cars manufactured today often come standard with dashboards that provide real-time monitoring of fuel economy, and serve as the main interface for auxiliary services such as GPS directions, phone calls, and car audio.

Building operations share similar principles with the operation of a motor vehicle: both run on "fuel," both require continuous maintenance for proper operation and longevity, and both can be optimized to operate at greater efficiencies. However, while the automobile dashboard has become a universal industry standard, the majority of buildings still operate without the convenience and effectiveness of this valuable feature. It is time for the building industry to catch up. This article proposes a rational basis for evaluating the performance criteria of building automation dashboards.

What is a Dashboard?

The term "dashboard" originally applied to a barrier of wood or leather fixed at the front of a horse-drawn carriage or sleigh to protect the driver from mud or other debris "dashed up" by the horses' hooves. The term has gained popularity in the computing industry since the Hewlett-Packard Company released Dashboard for Windows in 1992. While the specific definition of the term varies by market, a commonly accepted definition includes "a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance."[1]

For most observers, the term energy dashboard brings to mind images of sleek lobby displays for LEED-certified buildings that tout "green facts" or total facility emission reductions in terms of "trees planted" or "cars

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taken off of the road." While these items are certainly eye-catching and intuitive to the casual observer, they only scratch the surface of the potential of building dashboards. Today's dashboard users have the ability to acquire real-time customized data from sources never available before and to make informed decisions to continuously optimize building operations.

Need for Classification

All dashboards are not created equal. The term "dashboard" today continues to be flaunted when marketing any screen-based display with flashy graphics and energy related charts. But what do you get when you decide to purchase a dashboard?

Prospective dashboard users should know:

- Is the dashboard strictly related to facility energy use or does it also provide insight into building automation systems?
- Can the dashboard be individually customized for my facility's HVAC technician, as well as the building manager, and CEO?

There are currently no universal dashboard classification standards that establish performance criteria for rational evaluation of the requirements for energy or building automation dashboards. A uniform reference for comparing services and functionality is necessary and would be an invaluable tool when choosing between dashboard software packages. Unfortunately, this tool does not exist today.

Three essential elements to consider when selecting dashboard software include:

- **Intuitive Graphics.** Are the graphics clear and intuitive so that they are easily understood without resorting to supplemental instructions?
- **Analytical Tools.** Do the dashboard analytical tools have the capability to integrate multiple live and historic data sources to provide real-time decision-making information?
- **Ease of Customization.** Can the dashboard be easily customized to adapt to the program requirements of maintenance, operations, and financial building personnel?

This article presents a rational method for categorizing building automation dashboards to indicate required features at each level so that owners, operators, designers, and contractors can discuss their needs in the same terms. The proposed classification is established with levels similar to the ASHRAE categorization of the building energy audit process.[2]

The proposed method of classification includes four dashboard levels. Each level contains the functionality and toolsets provided in all lower levels.

The Industry Speaks

An original survey performed by the authors of more than 100 HVAC professionals including facility managers, engineers, and control technicians was conducted to gauge industry interest in dashboards for this article. Participants were asked to list the dashboard features that interest them the most. The following list indicates the most popular features in prioritized order:

- Real-time energy costs;
- Fault detection and diagnostics;
- Integrated facility control;
- Weather data;
- Integrated lighting control;
- Renewable energy system monitoring;
- Trend analysis;
- Remote access;
- Manual override notification; and
- Fire alarm system monitoring.

The same survey revealed that 73% of participants indicated that the ability to customize a dashboard was "very important" to them, and 58% indicated that they would prefer a custom third party dashboard interface to their existing HVAC control graphics.

Level 0: Static Data Dashboards

We start at Level 0 with dashboards that use static data sets only. These dashboards are typically created by engineers to illustrate the relationship among several potential conditions during the facility planning process. Level 0 dashboards can be thought of as "interactive reports." Instead of presenting a printed report with fixed assumptions for projected rates and tariffs, the Level 0 dashboards allow the user to see how changes in rates or efficiencies will affect their key performance indicators. The intent of the Level 0 dashboard is to provide an intuitive graphical interface that allows the user to quickly manipulate large data sets and calculate a key variable such as payback period, projected budget, or comparative life-cycle costs.

The proposed categories begin with Level 0 rather than Level 1 because the Level 0 is not accessing or displaying any real-time live data even though it may have the look and features of a live data dashboard. Data sources commonly used in Level 0 include building energy simulation results, historic interval meter data, and other large static data sets from which valuable insight can be derived. Level 0 dashboards are most frequently used for master planning purposes when comparative "what-if" analyses of building life cycle and projected construction costs allow an owner to make better informed capital planning decisions.

Figure 1 is a sample of a Level 0 dashboard that shows an interactive campus master energy plan.[3] Comprehensive cost and energy savings calculations are drawn upon to provide a dynamic analysis of energy efficiency and renewable energy opportunities. Projected inflation rates and financing rates can be adjusted to show how they impact the bottom line.

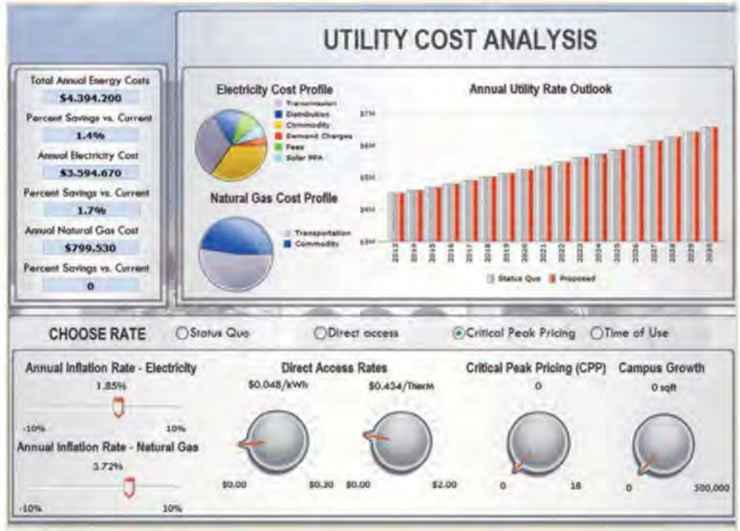

FIGURE 1 Level 0 dashboards allow manipulation of static data sets. The relationship among multiple variables and options can be demonstrated in an intuitive display.

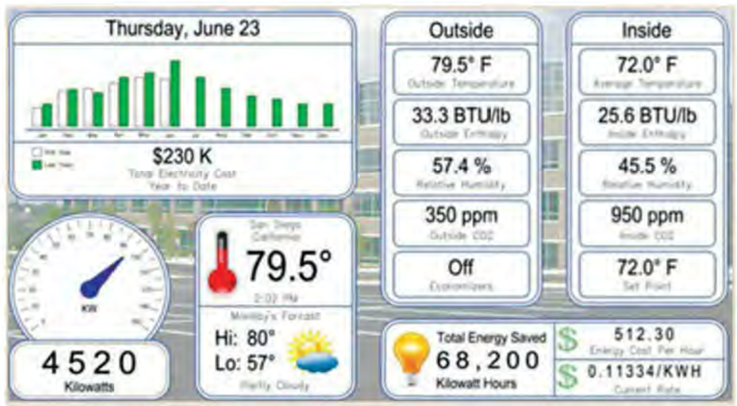

FIGURE 2 Level 1 dashboards typically display facility energy performance data streamed from energy meters and the building automation system.

Level 1: Live Display Dashboards

The most commonly perceived version of an energy dashboard is provided at Level 1 where live data sources are displayed. The Level 1 dashboard will typically display real-time energy data, building characteristics, LEED performance, and "green tips." These dashboards can exist as physical display kiosks located within the building or as virtual displays to be accessed over the internet. The goal of the Level 1 dashboard is to create occupant awareness through the display of actual building performance, demonstration of real-time sustainable design features, tips on how to be efficient, and other educational features.

Level 1 dashboard display data is typically derived from sources such as energy meters, building automation systems, trend data, and LEED scorecards. The Level 1 dashboard can display the energy use intensities of multiple buildings at an enterprise level or compare a single building's current monthly energy use to the previous year. The level of detail for the data provided in a Level 1 dashboard can range from whole building energy use down to sub-metered systems or equipment. *Figure 2* shows a sample live data energy-efficiency dashboard.

Level 1 dashboards are intended for monitoring and display purposes only. Additional analysis is often not available or limited to a few "out of the box" tools such as utility rate or bill analysis engines.

Level 2: Integrated Control and Analytics Dashboards

Level 2 dashboards introduce three additional capabilities: analytics, web services, and integrated controls.

Analytics

Perhaps the biggest buzzword in the building automation industry today is analytics. Promises of advanced analytics seem to be part of the marketing materials for every building intelligence software proposal.

But what are analytics? The term analytics applies to software that provides usable information resulting from systematic analysis of data and statistics. Essentially, analytics are number crunching software packages working behind-the-scenes to generate the dashboard key performance indicators. While Level 1 dashboards may contain a few simple analytic functions, the Level 2 dashboard enables the programmer and user to produce customized analytical tools to focus on specific elements relevant to individual users.

For instance, if an HVAC technician is interested in seeing if a central chilled water plant is operating more efficiently after implementing a new chiller staging sequence, the analytical function could be set up as follows:

- Use trend data from the building automation system to average chiller plant power usage per ton hour delivered.
- Leverage historical weather databases to normalize the data per cooling degree day.

Once the analytic is produced, it is available to continue tracking the central plant performance or to be applied to other central plants in additional buildings.

Web Services[3]

Web services establish standardized methods for integrating analytical applications over an internet protocol network. They allow exchange of data and communication between electronic devices. The web services are software systems designed to support machine-to-machine interaction over various networks.

Often, web services use eXtensible Markup Language, or XML. XML provides a practical method to package data so that it can be transferred between various internet applications. It is basically a data file protocol to simplify the process to package, tag, store, and find data.

Building automation systems may use simple object access protocol (SOAP) to access XML and HTML files from various web services to obtain the data necessary to support the analytic programs. As the price of energy rises, web services, XML and SOAP will likely play a significant role in reducing energy consumption cost by providing the information required to make operating decisions in a timely manner.

Integrated Controls

The widespread use of open communications control protocols such as BACnet in today's smart building systems has opened the marketplace to integration companies who offer a single source solution to integrated supervisory control of field level equipment controllers from different manufacturers.

With this advent of third-party software platforms that can replace a DDC hardware manufacturer's front end graphics, building operators now have a choice to leave their standard graphics behind and produce customized building automation dashboards.

By adding the capability to send commands to digital control systems, Level 2 integrated building automation dashboards can become the primary graphical user interface for building monitoring and operation. Level 2 building automation dashboards offer the added advantage of being able to overlay energy usage, trend plots, and other key performance indicators on top of standard HVAC equipment graphics enabling users to diagnose equipment operation at a glance. Additionally, building automation dashboards which integrate other smart building systems such as lighting control, fire alarm, and CCTV offer the capability to display multiple building systems on the same graphic floor plan as shown in *Figure 3.* With Level 2 dashboards, supervisory control sequences which span several building systems become possible. By assigning certain HVAC systems and lighting circuits to each building occupant's key card, access by a single occupant during off hours can trigger the building automation dashboard to only enable those systems required to light and condition the spaces occupied by that tenant.

Level 3: Ongoing Commissioning Dashboards

Level 3 dashboards bring a third level of analysis to the dashboard. It provides an instrument that continuously mines the "big data" generated by smart building systems to optimize each system. The recent rapid increases in building automation server power and storage capacities have led to a trend to store more and more historic data. It is not uncommon today for facilities to trend every point in their BAS at 15 minute intervals for an entire year. Sorting through this data to look for patterns simply isn't possible with conventional means.

This trend has led to the emergence of a market for automated fault detection and diagnostics, or FDD. FDD consists of overlaying software platforms which analyze historic databases with a goal to identify faults and determine their root causes. FDD can also document actions taken to correct those faults and monitor the resulting energy and cost savings. Enabled with FDD software, a Level 3 dashboard can automatically alert a user of system failures and deviations, identify the root cause of an issue, calculate deviations between actual and optimal performance, and prioritize remedies by importance and potential operating cost savings.

In an FDD application, a set of rules is created by which all network data points are run through to continuously check for deficient system operation or deviation from a particular sequence of operation. Most FDD platforms available today come with a set of standard rules to identify common HVAC system deficiencies such as:

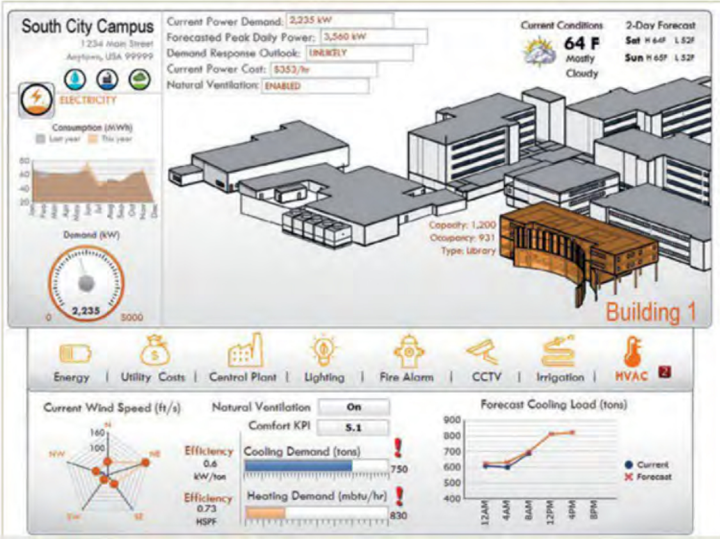

FIGURE 3 Level 2 dashboards can offer a single customized graphical user interface to monitor and control multiple facility disciplines. Overlaying energy performance data and trend analytics on operational interfaces gives operators the data required to run their facilities more efficiently.

- Simultaneous heating and cooling;
- Short cycling of equipment;

• Degraded heating or cooling functions;

• Suboptimal economizer operation;

• Non-functioning sensors;

• Setpoints overridden; and

• Equipment not operating with schedules.

Custom rules can be developed with a Level 3 dashboard to address specific project requirements and conform to unique sequences of operations. An FDD program can be programmed to not only identify specific faults but document their duration, evaluate their cause, and determine the economic operating costs associated with each fault. The goal of these efforts is what industry insiders call "actionable intelligence" to provide notifications of conditions, which can be addressed to immediately improve performance. *Figure 4* shows a sample FDD dashboard graphic.

FIGURE 4 Level 3 dashboards can provide automated fault detection and diagnostics (FDD) software to continuously identify and display conditions resulting in sub-optimal energy performance or thermal comfort conditions.

The fault detection and diagnostics market is still in its infancy. Most of the available platforms come from third party applications offered in a software-as-a-service (SaaS) model in which the software is licensed on a subscription basis and centrally hosted.

Many forward thinking owners are preparing for the emergence of the mainstream market of FDD "apps" by standardizing the protocols for labeling and storing data. By organizing their historian databases in an open relational database-management-system (DBMS) such as standard query language (SQL) and providing a consistent point naming or tagging standard across their networks, they can significantly reduce the effort and cost to map their point databases to any combination of ongoing commissioning and FDD applications they chose. The ultimate goal is a system configuration where multiple applications from several manufacturers are accessing a facility's DBMS server simultaneously and providing vendor-specific reports to accomplish individual facility objectives.

Conclusion

As the market for energy and building automation dashboards continues to expand, there is an increasing need to provide a rational basis to classify standard and advanced dashboard features. Rational building automation dashboard classifications are necessary to allow an "apples to apples" comparison when choosing between platforms.

This article presents four levels of dashboards ranging from interactive analysis of static data to ongoing continuous analysis of live streams of building automation "big data" sets. Armed with a better notion of the overall range of available dashboard toolsets and the required amount of effort to accomplish each Level, facility owners and operators can select an application which best suits their needs.

For the industry to see the full inherent value and possibilities in energy and building automation dashboards, we must first provide the language and structure to characterize them. This effort is long overdue.

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