Creating Awareness through Visually Stimulating Energy Dashboards & Kiosks

SMART BUILDINGS CENTER
A project of NEEC

INTRODUCTION

There is a growing role for building tenants, visitors, and engineers to play in increasing energy efficiency through behavior change. The purpose of this paper is to uncover how dashboard and kiosk technology can facilitate stakeholder awareness, understanding of alternatives, motivation to act, and persistence of energy savings habits.[1]

Public-facing energy efficiency dashboards contain a wide variety of features and variations, the most basic of which are used to visually convey building performance information to stakeholders. A focus on advancing energy efficiency within buildings, along with the recent technological gains in data collection, storage, and processing, has given rise to the proliferation of energy displays such as dashboards.

In general, dashboard features that convey information to the public can be divided into either software or hardware categories. Common software features of dashboards are a main display page, supporting navigation pages for further information, data collection from a variety of sources, and varying access levels for different target users. On the hardware side, standard features consist of a large screen (often touch enabled) which has quick response time and is American Disability Act (ADA) compliant. In this paper, we define a "dashboard" as the graphical representation of data, which can be viewed via the internet, on a personal device, or with an on-site display screen.

User engagement is the most important consideration when selecting and customizing a dashboard. Defining the target audience and desired outcomes of using the display is crucial to creating an effective design. Visuals should be simple and concise, providing information with just the right amount of detail to hold a user's attention.

Web access to view the dashboard is often the best mechanism for reaching a specific audience, even when they are not viewing a dashboard on-site, such as in a building lobby. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has established a dashboard rating system using Levels 0-3 as indicators of analytical capabilities and overall effectiveness at engaging users.

Public-facing dashboards intended to showcase energy use should, at a glance, provide users with an idea of a building's performance compared to other similar buildings. The dashboard should be large and easy to read, and those dashboards meant for office building kiosks and public spaces have the opportunity to provide more in-depth building performance, with an emphasis on how performance trends over time. Furthermore, dashboards have the ability to feature metrics unique to the particular building in which they reside. For example, highlighting annual operating budgets alongside building energy consumption has the capability to encourage behavior change by linking metrics that are easily understood by those viewing the dashboard. Likewise, multifamily-focused dashboards have the ability to include further capabilities targeted at tenant feedback to improve comfort and energy use.

Using established design principles and understanding the target audience will allow public-facing dashboards to do more than simply serve as visual displays. The right product, customized and maintained correctly, can be an effective tool for engaging with the public and inspiring people to change behaviors that affect energy use.

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[1] This article was compiled as a general survey of the best practices in play at the time the article was published. The SBC is not asserting expertise in the design of dashboards and kiosks.

HOW TECHNOLOGY CAN HELP

While technology alone plays no role in the voluntary adjustment of people's behaviors, it can be a resource for helping to motivate and sustain voluntary behavior changes surrounding energy use. One strategy is to use energy efficiency dashboard technologies to create awareness, generate interest, and provide information to users that will lead to more energy-conserving behavior. These technologies have quickly become a popular way to inform, educate, and engage users in an efficient and straightforward manner.

Dashboards present building performance information visually, pulling large amounts of complex data from building systems in a variety of ways to lead to easy-to-understand graphical displays. These dashboards can be presented via on-site flat screen displays, commonly called kiosks, as well as online either through secure or publicly-accessible websites. They offer different avenues to appeal to different kinds of users.

Dashboards borrow from a widely recognized concept of providing at-a-glance information to influence behavior. Just as a driver might ease up on the accelerator after seeing information presented on the speedometer, dashboards can inform building occupants, visitors, and even facility managers of the building's energy performance in ways that influence adjustments to energy consuming behavior. Dashboards have the additional advantage of being able to integrate interactive features that engage users with educational information.

It is common for building energy consumption to drift[2] upwards 10-30% in the first two years of operation, and dashboards can draw attention to those telltale signs that a building system is not operating as anticipated. Facility managers can use these signs to help prevent and curtail increased energy consumption due to what would be otherwise unnoticed equipment malfunctions.

CORE FEATURES AND TECHNOLOGY DIFFERENTIATORS

The current energy dashboard market is crowded and there are a wide variety of options from multiple companies, each of which has different capabilities that seek to engage the public. The core features and characteristics of energy dashboards can be classified as either software features (data collection, processing, and display), or hardware features (equipment used to physically interact with users). While several companies offer dashboard software or kiosk hardware exclusively, most energy dashboard companies provide a customizable software and hardware package together as a turnkey solution.

Standard Software Features

Energy efficiency software is a key component of the growing building efficiency industry. With many companies competing in the energy dashboard market, it is important to clearly identify the core attributes of effective energy efficiency dashboard software and what features are necessary to successfully engage users. Several common features are identified below, representing a dashboard tailored to engage a variety of users.

Main Display
The main display should capture the attention of a person walking by and provide relevant information in an efficient manner. The main display is the most important "real estate" in the kiosk form of dashboards; as such, the graphics should be clear and concise, and highlight the most important parameters to provide a starting point for raising awareness. Cluttering the main page with too many graphs and charts leads to confusion and disinterest on the part of users and often times distracts from the primary goal of the main page: to quickly inform.

Image credit: Lucid Energy

2 "The Energy Dashboard Solution"; Pitcher, J., Watson, R.; Greentech Media (April 2012) http://www.greentechmedia.com/articles/read/Guest-Post-The-Energy-Dashboard-Delusion-Part-1

Secondary Navigation Pages

Secondary navigation pages provide further in-depth information about particular topics on building performance. These pages should be easily accessible from a dashboard navigation pane on the main display and may provide additional information such as:

- Breakdown of each utility into daily, weekly, and monthly averages
- Links to other buildings' main displays in the network of building dashboards
- Competition/comparison page among different spaces or buildings
- Sustainable building design features
- Tips to reduce energy consumption
- LEED education page (applies towards LEED credit)
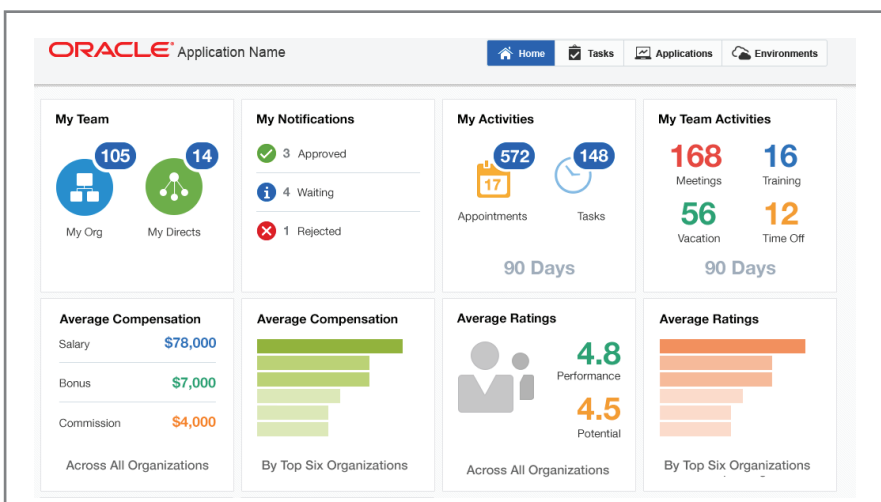- User login to check further granularity information

Image credit: Oracle

This tiered arrangement encourages users to dive deeper into aspects in which they are most interested, without overloading the main page with information.

Data Source

Most dashboards source raw data from an existing central building controls system, then manipulate it for more quantifiable visual presentation.[3] It is important to know whether a building site has the infrastructure in place to report and store queried data for the dashboard to utilize. Many building monitoring systems have presentation software available as add-ons. Assessing compatibility between data sources and the dashboard software before software selection will ensure that the interoperability between them is seamless yet flexible.

Access

Whether the information is displayed on a kiosk or accessible online, not all users will need or benefit from the same kind of information. Multiple levels of access allow users to view only the information that pertains to their particular needs. Public or guest users will generally have the most basic access, often the ability to view consumption trends, comparisons, and other general site information. Tenants might have further desire to see how their behavior is specifically affecting building energy consumption and may have access to more granular data and information on specific environmental conditions (temperature, light levels, etc.) or individual occupancy statistics. Facilities personnel and managers will have access to the most detailed level of information with energy use by system and location information. Typically, these professionals also have rights to change dashboard reports and control user access. Incorporating various levels of user access allows the dashboard to effectively target more audiences by providing as much or as little detail necessary.

Other Considerations

The other major considerations to take into account when selecting energy efficiency dashboard software are costs and the location of the manufacturer. Many companies provide software capable of presenting a building's energy performance, with costs varying from free (e.g., open-source software) to thousands of dollars per installation. Typically, packaged systems cost more, but provide more of a turnkey operation compared to sourcing

Standard Hardware Features

The hardware is how the user physically interacts with the dashboard software. A core distinction is whether it has online access (unlimited) or site network access (limited). While typically more expensive, online dashboards provide value for users who are aware of the information available and motivated to go online to check on desired elements. This has the added benefit of allowing access to information on personal devices, providing greater flexibility for users. Limited access hardware, on the other hand, has the principal purpose of displaying building energy information to the public in kiosk form and comes with a smaller price tag. Depending on the location and intended audience, limited access kiosks are a viable option that provides many of

3 "9 Key Attributes of Energy Dashboards and Analytics Tools"; Sinha, S., Taparia, S.; GreenBiz (August 2013) http://www.greenbiz.com/blog/2013/08/28/9-key-attributes-energy-dashboards-and-analytics-tools

Kiosk Features

Most kiosks today that focus on engaging with the public utilize a large screen with touch-enabled navigation. Kiosks can be free-standing or wall-mounted and should be secured to avoid theft or damage. Location and position of the kiosk is crucial for maximizing user interaction. Informative kiosks should be placed in high-traffic areas, avoid glare from sunlight, and be easily identifiable with signage. It is important to ensure kiosks are ADA-accessible and comply with all other standards.

▍DASHBOARD TECHNOLOGY MARKETPLACE

Energy efficiency dashboards have flooded the market-place in recent years, with demand for information about a building's energy performance being one of the largest driving forces. These products are the result of new technology companies finding a niche in the market and well-known building controls companies looking to expand their product capabilities.

To help characterize the various features and capabilities that different dashboards may offer, ASHRAE[4] has catego-rized them into the following four levels of user engagement:

Level 0: No real-time data is collected or presented on these dashboards, but the user interface is graphical and looks similar to other dashboards. Static building informa-tion is meant for hypothetical approximations of energy use, such as comparing how changes in lighting technolo-gy might impact a building's overall utility bill, and allows users to see the effects of changing parameters.

Level 1: Live display dashboards show real-time data of various building performance metrics. They often include simple analysis capabilities, such as current and historical data comparisons, but provide no integration with building controls. Public facing dashboards are most commonly Level 1, allowing users to take in information about building systems, but not access any of these systems through the dashboard. These dashboards are best suited for limited network access kiosks.

Level 2: The next level of interaction adds analytics, integrated controls, and web services. Real-time and historical data can be collected and manipulated to perform a variety of analyses. These dashboards also provide web-based communication between electronic devices, freeing the software to be viewed on virtually any internet accessible device. Additionally, Level 2 dash-boards can be the main graphical interface for any Building Automation System (BAS), allowing the user to

change set points and operation parameters from the dashboard. These dashboards allow interactive user inputs that affect building performance. This level of engagement is intended for informed and involved users, such as facility managers, to actively participate in and influence energy use.

Level 3: Primarily used for constant commissioning, Level 3 dashboards are fully integrated with a BAS collecting massive amounts of data. With robust analytics, fault detection, and diagnostics, facility engineers receive alerts and warnings for common system malfunctions that often increase energy consumption. This level of engagement is commonly geared towards facilities personnel, who can benefit greatly from the advanced analytics provided by these dashboards.

Several benefits and considerations of prominent technologies are given below as a comparison:

Product and Dashboard Level	Benefits	Considerations
Deck Monitoring Dashboard (Level 1)	▸ Varying levels of customization ▸ Integrates with stand-alone	▸ Limited analysis capabilities ▸ A la carte pricing structure ▸ Limited experience with

While both Level 0 and Level 1 dashboards do well to inform the public about energy use data and have the ability to influence behavior change, deeper energy savings within the building can be realized when integrating the building systems with these dashboards. For public spaces that are attempting to engage the public as well as gain insight and manage energy use, a level 2 dashboard is a common choice that strikes the right balance between a device that provides interaction and control at a relatively modest cost. Because Level 2 dashboards can serve as the interface for a BAS system that may already be in place, they are a natural choice for enhancing a building control system at little additional cost.

Moving up to a Level 3 dashboard is less common in existing buildings, but is becoming more popular due to the awareness of building energy use over time. Although Level 3 dashboards have the ability to essentially act as continuous issue-tracking tools, they often require support infrastructure to take advantage of the robust analytical capabilities. Frequently, multiple sensors and meters need to be installed in the building to provide

[4] "Criteria for Building Automation Dashboards"; Shadpour, F., Kilcoyne, J.; ASHRAE Journal (May 2015)

inputs for the control system to monitor and for the dashboard to visualize the outputs. While Level 3 dashboards have the capability to drive energy consumption down the farthest, the potential savings experienced may sometimes be outweighed by cost of equipping a building to provide that level of data.

Dashboard	Features	Limitations
Deck Monitoring Dashboard (Level 1)	- Varying levels of customization - Integrates with stand-alone submetering or an existing BAS - Actual vs. Predicted usage - Report Generator - Software and hardware packages available	- Limited analysis capabilities - A la carte pricing structure - Limited experience in building monitoring
QA Graphics EEED (Level 1&2)	- Integrates with any BAS - Real-time monitoring - Design a BAS with a graphic interface - Award-winning dashboard designers	- Limited customization - High installation cost
NREL Energy DataBus (Level 2)	- Free, open source software - Completely customizable - Building Agent incorporation	- Limited technical support - No design support
Lucid Building Dashboard® (Level 1,2&3)	- Integrates with any BAS - Real-time monitoring - Design a BAS with a graphic interface - Award-winning dashboard designers	- Limited customization - High installation cost
Building Controls Companies – Johnson Controls, Honeywell, Seimens, Schneider Electric (Level 2&3)	- BAS-based graphical displays - Constant commissioning capabilities	- Requires higher technical acumen - Requires proprietary infrastructure to realize full benefit

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boards have the capability to drive energy consumption down the farthest, the potential savings experienced may sometimes be outweighed by cost of equipping a building to provide that level of data.

ENGAGEMENT MODEL OVERVIEW

Similar to how car dashboards are evolving rapidly to provide more choices and increasingly complex data, energy efficiency dashboards also come with a range of information offerings and display choices. However, many dashboards fail to engage their target audience for a variety of reasons, most commonly because of an overload of information or poor placement in a building. Successfully engaging stakeholders starts with understanding the dashboard's primary objectives and core elements. Key considerations of a dashboard's layout can be summarized by six general principles,[5] which can help realize an effective and engaging design:

1. Display data targeted at a single core user type

2. Select a dashboard type that speaks to the core user's key performance indicators

5 "Designing and Building Great Dashboards – 6 Golden Rules to Successful Dashboard Design"; Quintero, S.; Geckoboard (July 2012) https://www.gecko-board.com/blog/building-great-dashboards-6-golden-rules-to-successful-dashboard-design/#.VU0to_lVikr

3. Lay out and group graphics logically
4. Ensure the data is relevant to target audience
5. Present the most important metrics only
6. Determine the most appropriate data refresh rate

In general, targeting concise, well laid-out, and relevant content at a single audience will increase the changes that they choose to interact with it and find useful. For example, selecting a dashboard geared towards a facility manager that wishes to gain insight into the building controls would require a near real-time refresh rate of data so they can track building consumption with events taking place and make changes as necessary. However this same type of refresh rate is not as necessary for a dashboard intended to act as a one-way device to provide information to the public.
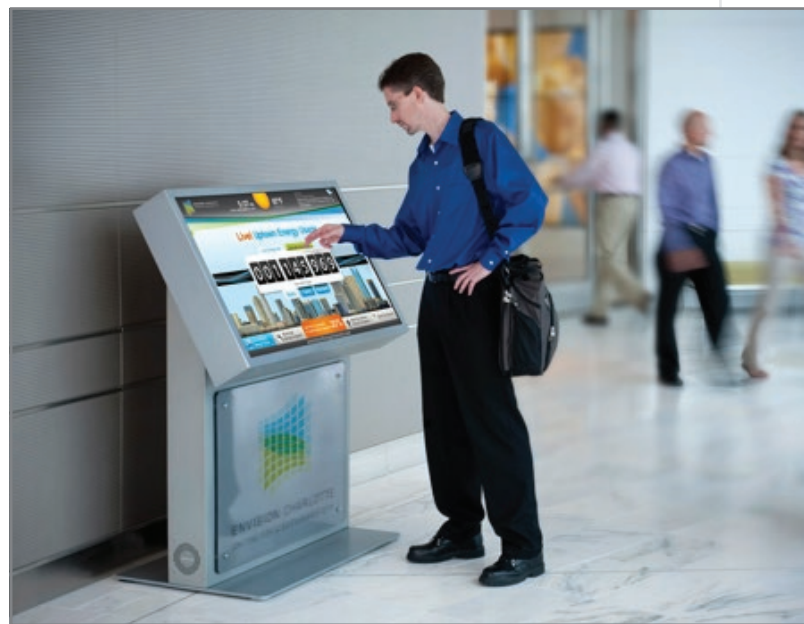

Image credit: Envision Charlotte

LOCATION AND PLACEMENT MATTER

Deciding where and how to display a dashboard in a building is a critical element of design that can easily be overlooked. Placing a dashboard kiosk in a high-traffic area ensures that passersby will have the opportunity to interact with it. But an almost equally important consideration is the angle at which the kiosk is displayed. Mounting a kiosk flat against the wall is useful for displaying information about the building, and allows the information to be seen over a large distance. However it generally does not immediately invite interaction from the public due to the similarity with television and monitor displays that are traditionally one-way communication devices. When mounted horizontally or at an angle, however, as is often the case in stores that sell mobile and tablet devices, users quickly understand that the device is meant for interaction[6] and are invited to engage with it.

Choosing the correct location and angle to foster engagement is highly dependent upon which audience is being targeted. For office building lobbies or open public spaces, a small, horizontally-mounted kiosk can be lost among the other features of the space. In these cases, large, vertically-mounted screens are likely better choices to encourage engagement because they can be seen by a large number of people at once and stand out when placed in a large space. Similarly, for multi-family buildings, a vertically-mounted monitor may be useful for displaying tenant information in a lobby, with separate, online access available via mobile devices for building occupants to dive deeper if they wish. Horizontally-

mounted dashboards are likely better suited for smaller building and multi-family lobbies, or dedicated public spaces that have specific features to highlight, and can allow time for users to interact.

DESIGN AND AESTHETIC BEST ORACTICES

Building dashboards need to be concise representations of the parameters important to a building's performance using easily understandable graphics. General design aesthetics best practices include:

- Limit logo number and size
- Keep navigation tabs simple; images are best
- Use common symbols for menus (question mark for help, gear for settings, etc.)
- Keep consistent color schemes
- Limit data points to fewer than four significant digits
- Provide information in equivalent values (pounds of CO_2, trees planted, cars off the road, etc.)

Understanding the various data visualization options and how to best apply them to engage the target audience is critical when setting up a dashboard. Several visual elements are described below with examples of the types of information they are best suited to convey.

Beyond the aesthetic appeal of visuals, the entire dashboard experience needs to be engaging and capture

6 "Is that a Kiosk? How to Best Position Your Public Touchscreen Display for Use"; Shamonsky, D.; ICS Insight Blog (May 2014) http://www.ics.com/blog/kiosk-how-best-position-your-public-touchscreen-display-use

attention. For kiosks, large and bright screens are the best way to attract people who are just passing by and allow multiple users to view the dashboard at once. Sounds and alarms, or tutorial videos, can also be effective tools for engaging users and keeping them interested, though acoustical impacts to surrounding spaces are important when considering placement. A fast response time along with an icon to show when input is being processed is also crucial to keeping the user engaged, particularly as people become more and more accustomed to fast technology processing speeds with computers and mobile devices.

Over time, dashboard content can become stale, and without changing metrics or re-formatted displays, user interest in the devices has the potential to wane. It is especially important to select a dashboard that has the flexibility to be customized over time to keep content current and to add features that may become useful to display. Doing so increases the chances that users will view the dashboard as a communication device instead of an outdated and non-interactive building fixture.

Image credit: Envision Charlotte

BEST PRACTICES BY BUILDING TYPE

Public Spaces
Large, inviting touch screen kiosks with simple and straightforward graphics are best suited for public spaces. These dashboards are typically Level 1, and are focused as marketing pieces to showcase energy efficiency. There are no requirements for energy analytics or detailed breakdowns. Users will typically access these dashboards only once and spend several minutes at the display. Typical goals would be for the user to walk away understanding how the building's energy consumption compares to similar buildings in metrics that are understandable to them—e.g., if the building is using more or less energy than anticipated, and basic building information, such as any renewable technologies that may be present. Dashboards intending to be viewed by the public should be sure to include environmentally-conscious features on the main page to visually connect consumption data to what can be seen in the building.

Offices
Aside from providing basic building information to the general public, dashboards in office buildings seek to engage office tenants on a continuous basis. The most impactful visuals often involve a breakdown of energy consumption, actual and historical comparison of the building's performance, and, if online access to the kiosk is possible, individual logins to engage customers on their mobile and work devices. Level 2 dashboards with web-enabled and BAS integration capabilities are best suited for office buildings. In these cases, users generally understand the building and may be interested in trending performance and achieving goals. The dashboard navigation pages can explore building systems and performance relationships in further detail since users are likely to spend more time with these dashboards. Providing continuous feedback on energy performance—such as monthly reports, notifications when goals are achieved, alerts when energy consumption is high, or results from occupant competitions—is important to keep users engaged over time. This functionality can also support targeted education campaigns that pair more specific action strategies with real-time results.

Multifamily
Similar to those used for office buildings, dashboards focused on multifamily facilities should have all the capabilities of Level 2 dashboards. Multifamily facility dashboard users are more likely interested in their specific energy consumption rather than the building as a whole and often want to see how they compare to their neighbors. Numerous studies have shown that energy comparison to neighbors can influence behavior that results in reduced energy consumption. Pairing these results with recommendations is critical to achieving even deeper savings. In addition to kiosks in the lobby, each tenant should have personal access to view their energy consumption online and have further control of system performance through scheduling and set points whenever possible. Resident training and guidance on
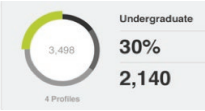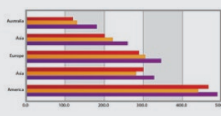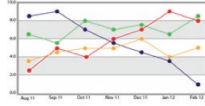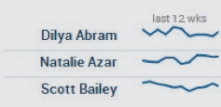
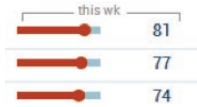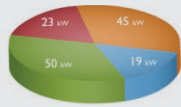| Visuals		Description	Examples
Number and Secondary Stat		Shows a value and statistic about a single parameter	Real-time energy consumption and percentage increase or decrease
Bar Charts		Displays quantitative values of series of related parameters	Energy consumption by month; various buildings' energy consumption
Line Graph		Graphs parameter(s) over time	Daily or hourly consumption comparing actual vs. predicted
Sparkline		Digit with unlabeled recent trend line and real-time values of a single parameter	Real-time power consumption and recent consumption
Bullet Graphs		Compares actual, targeted, and predicted values	Energy consumption goals
Pie Chart		Circular representation of values that sum to a whole	Breakdown of building energy consumption by end use

Image Credit: Dundas Data Visualization, Dashboard UI, and QA Graphics

these controls are also important to maximize the potential for influencing behavior change.

CONCLUSION

Energy dashboards can be effective tools to inform users of a building's performance and spur behavioral changes that reduce energy consumption. However, the design, placement, and overall relevance of the content are all key to effectively engaging varying target audiences. Keeping the visuals simple and relevant, as well as providing a pleasant experience and environment to

interact with the dashboard are important to keep users engaged.

Trends indicate that over time the public will access information more and more through mobile and connected devices. These devices will act as gateways to influencing behavior change, and it is possible that providing the public with building energy information via dashboards linked to mobile platforms will provide a means to effectively change behavior. To reach this goal, dashboards need to grab the attention of the user. When properly designed, dashboards can help reduce energy consumption of entire facilities by stimulating occupants to think about energy consumption and how they affect it.

About the Smart Buildings Center

The Smart Buildings Center (SBC) is a project of the Northwest Energy Efficiency Council (NEEC), which is a non-profit industry association of the energy efficiency industry. The SBC supports growth and innovation in the Pacific Northwest's energy efficiency industry, serving as a hub for industry activities and raising the visibility of energy efficiency companies and projects.

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