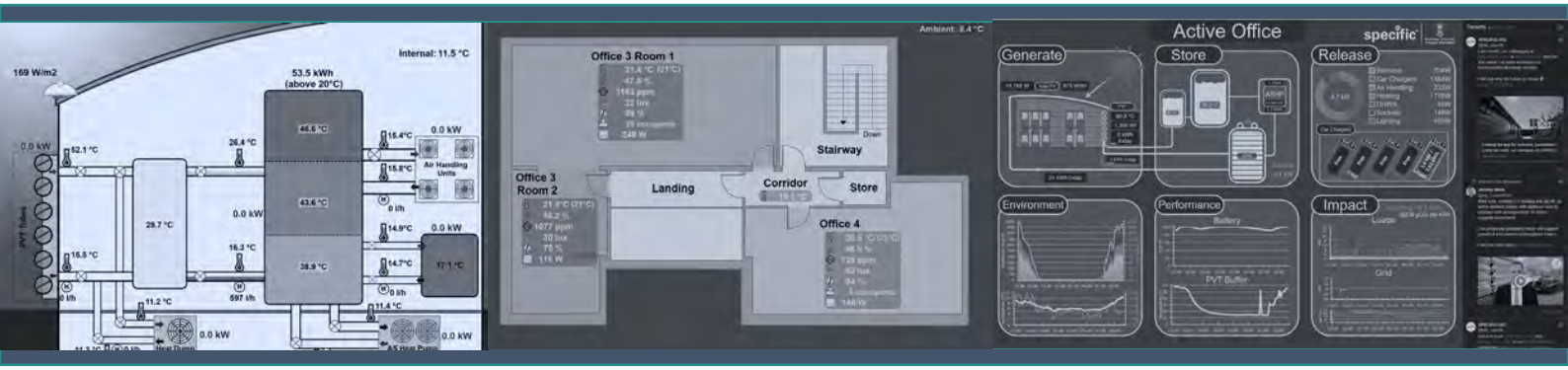
Active Building Energy Dashboard Design Guide

Version 1.0, July 2021



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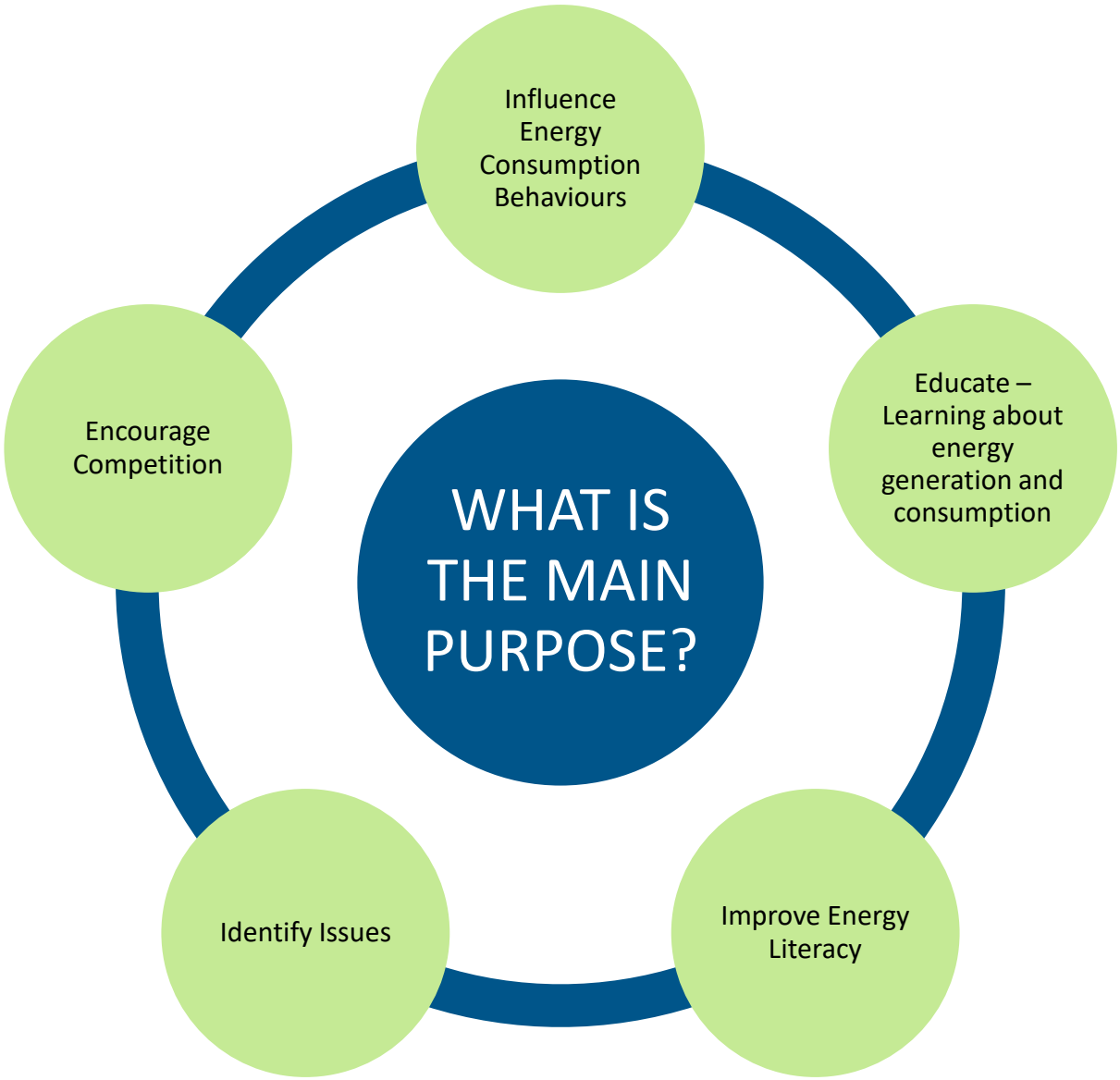
Purpose


WHAT IS THE MAIN PURPOSE?
Influence Energy Consumption Behaviours
Educate – Learning about energy generation and consumption
Improve Energy Literacy
Identify Issues
Encourage Competition

Purpose

The purpose of dashboarding

Reviewing energy consumption in a building is a good idea for multiple reasons. For many businesses and organisations, as well as residential properties, reviewing energy consumption can identify when and where excess energy is being used unnecessarily; it can provide insight as to how a building is used; and, with repeated review, can lead to reductions in energy consumption or carbon emissions by recognising opportunities when they can be reduced. Dashboards provide the most efficient method of energy review, unlike some other methods, which are often unclear or do not contain sufficient levels of detail.

Meter readings

Energy consumption in buildings is largely monitored monthly when a bill appears. Bills are usually calculated for the entire property, and are generally given as a single figure for the month, providing little insight into behaviours within the building. Meter readings provide little opportunity to reduce energy consumption as they are delayed in reaching the building occupant, and are opaque in purpose and scope. (Large non-domestic buildings are an exception, as they automatically monitor their energy consumption every half hour (AMR))

Real-time energy monitoring

With a full array of sensors, real-time energy monitoring becomes possible, enabling building users to understand where and when energy is being consumed. ‘Smart’ meters are an example of this technology, although these usually have just one sensor, which is linked to the external meter of the building (electricity or gas/fossil fuel.) When a building is sub-metered, these can be linked to a smart meter display, and further granularity of energy use or generation is unlocked. These can be reviewed using a proprietary screen provided along with the smart meter, and can encourage a change in occupant behaviour. However, the proprietary screen is usually small and provides only a limited amount of data per building.

Dashboarding

Dashboarding brings all the sensor information for the entire building into one large, customisable, easy to read display for multiple parties associated with the building to access as required. This enables real-time review of the building’s performance, and can encourage behavioural change to reduce energy consumption or promote locally-generated energy consumption over grid-supplied energy. Patterns can be identified and highlighted, allowing Building Managers to make informed decisions about where to make savings. Dashboards can educate building visitors as to how the building works and performs, as well as increasing energy literacy for all users. Dashboarding also enables owners of multiple buildings to bring their entire portfolio together into one display to allow for estate-wide benchmarking and energy reviews.

Story

- Ensure metrics used support the story to be told
- What information will aid the story telling

Story

Establishing the story to tell

Dashboarding is critical in forming a platform from which a story about a building and its vision can be conveyed. It is important at the outset to define the message and establish a set of data to support that story. Suggestions include: energy reduction, carbon reduction, renewable generation and storage, or cost reductions. Different companies or users will have different stories to define. This document is intended to assist in the identification of each piece of the message to shape an efficient dashboard.

Grid flexibility

Active Buildings provide an opportunity for flexibility in the energy market. They can generate, store, and consume electricity locally, reducing their demands on the grid at peak times. A dashboard shapes this story by focussing attention on when the building is generating, when it is storing, and when it is using the battery-stored energy, against the background of real-time grid carbon intensity monitoring. Carbon savings and grid demand alleviation are stories that can be shown on a dashboard for building users and occupiers alike to view.

Carbon Emissions

The UK Government has set ambitious targets to reduce carbon emissions and all organisations now have a legal responsibility to adhere to these targets, some setting their own goals. A dashboard can encourage the reduction of emissions by showing energy consumption in real-time, enabling users to change their behaviour to reduce consumption and, by extension, emissions. The dashboard can also highlight historical trends as to how their building and systems contribute to reduced carbon emissions either over time or against similar buildings in terms of benchmarks.

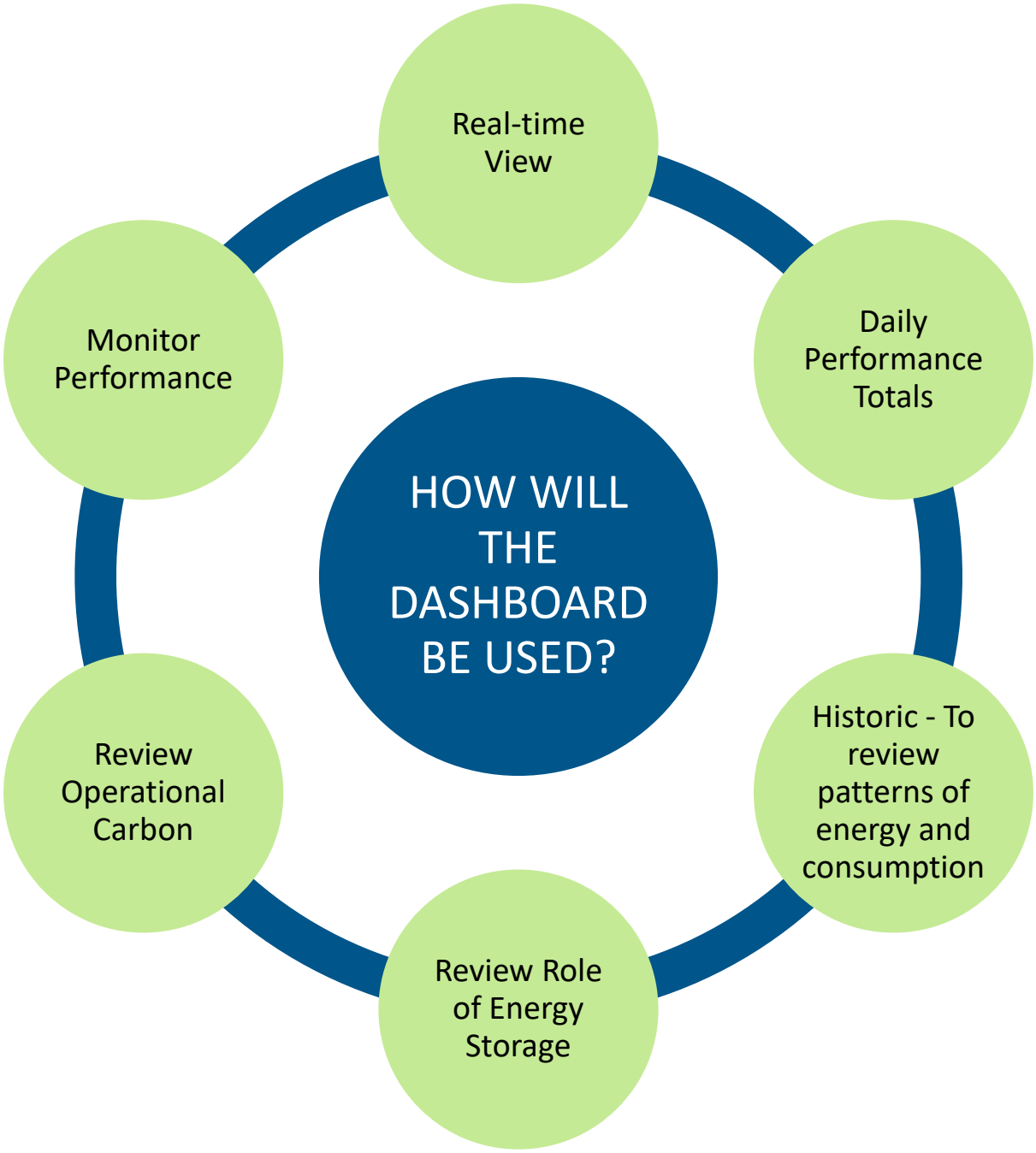
Energy consumption vs generation

Generating more energy than consumed is a positive approach to delivering zero carbon emissions. Although this is out of reach for the vast majority of buildings, demonstrating comparisons between how much energy is generated locally versus the amount of consumed energy provides a clear comparison of the building's performance and highlights opportunities to reduce the disparity between the two. A concise story of reduced consumption versus increased generation is a useful story to provide occupants, visitors, and building owners.

Cost savings

This is generally the most desired of all metrics to track when monitoring building performance. Energy consumption and carbon emissions are all components which combine to cost a building owner money. Saving energy directly translates to reducing costs. Dashboarding can build a story for a building owner and their Facility Manager to track how their interventions directly affect overall costs related to a building's operation. Historical trends can be tracked and displayed against grid and fuel energy costs, while projections against various proposed interventions can be quickly deployed to compare return on investment (ROI) and operational expenditure (OPEX).

Use Pattern


HOW WILL THE DASHBOARD BE USED?
Real-time View
Daily Performance Totals
Historic - To review patterns of energy and consumption
Review Role of Energy Storage
Review Operational Carbon
Monitor Performance

Use Pattern

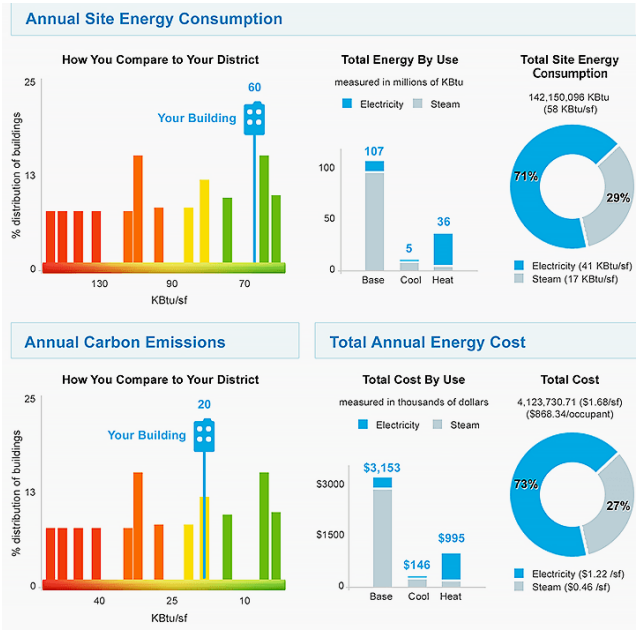
Dashboarding provides the opportunity for building owners and users to review the energy generation, storage and use in a building in a concise manner. As a learning tool, a dashboard is efficient in allowing users to identify energy patterns within a building, enabling them to make proactive choices to reduce carbon emissions associated with the building.

Real-time View

A distinct benefit of dashboards is that they enable the review of energy consumption and generation in real-time. Users can review live data using the dashboard display. Examples of live data to review include solar generation, battery storage, heating consumption, electrical consumption, and internal and external temperatures. Real-time views allow in-use identification of carbon emissions to inform and encourage behavioural change of occupants.

Daily Performance Totals

Dashboards are customisable, but one method of understanding building usage over time is to tally daily performances and record them for comparison against other days, weeks, months or years. This allows owners and occupiers to gain an appreciation for how external conditions or building use anomalies (such as an increase in visitors or large hosted events) can impact on the daily consumption totals for the building. Comparing these totals against other dates also enables a deeper understanding as to how the building performs over time.



Historic Review

Real-time review alone is insufficient to derive a comprehensive understanding of a building's performance. Reviews of building performance over time allow users to see how behavioural change impacts the building, and prepares building owners for conditions ahead, which may have been present in the past. Building Managers, too, can quickly identify anomalies and learn lessons from a building with an appropriate level of historically presented details about their building. Dashboards enable historical tracking of building energy consumption and generation, with customisable displays showing daily, weekly, monthly or annual consumption and generation figures in one place.

Role of Energy Storage

Energy storage enables carbon emission reductions, as buildings can store low-carbon energy (either self-generated or grid-supplied during periods of low grid carbon intensities) and consume it during periods when grid-supplied energy is at peak carbon intensity (CI). Dashboarding tracks when the battery is charging, and when it is being used. Tracking grid CI is also a useful metric when battery storage is deployed within a building.

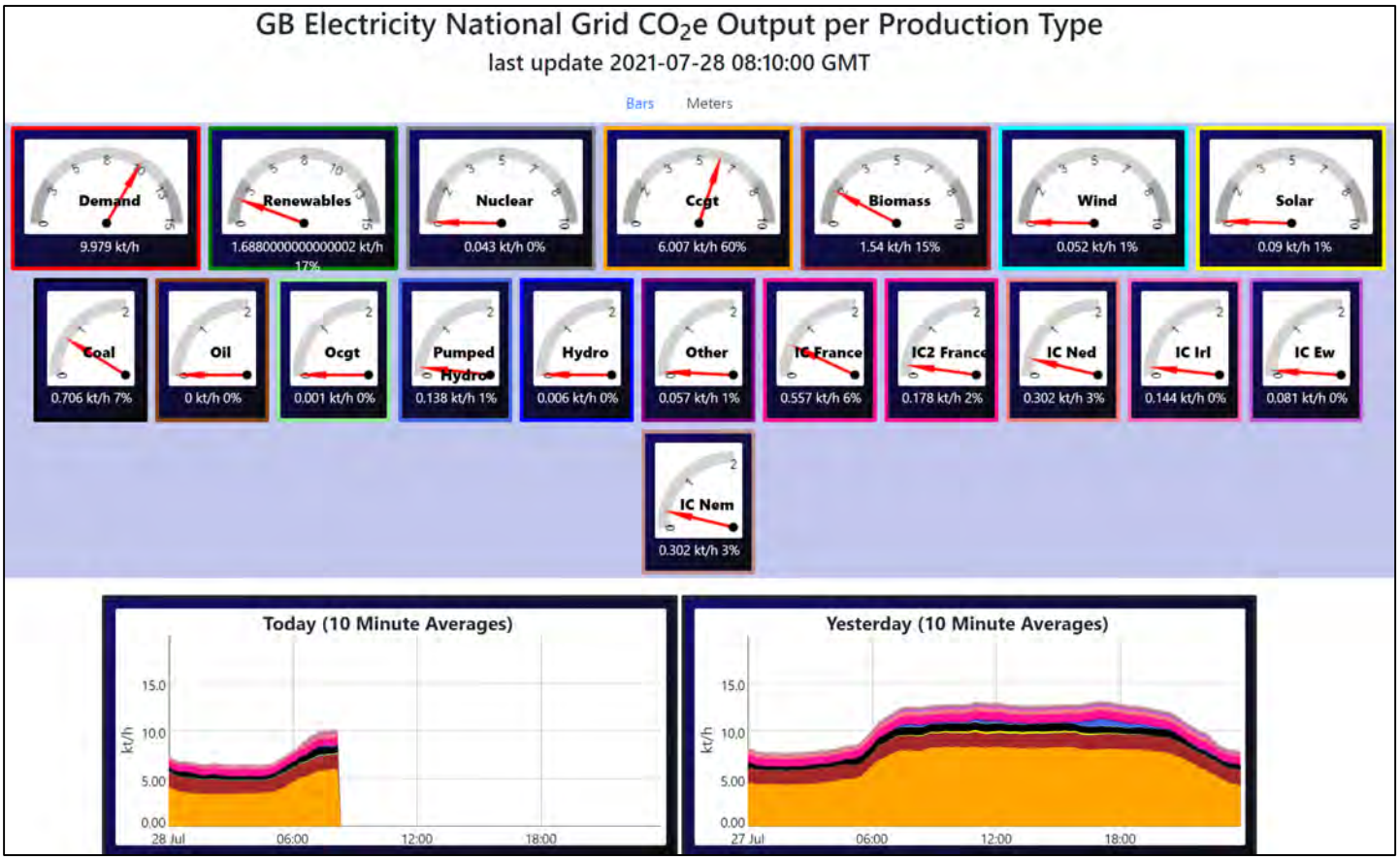
Operational Carbon

Operational energy use is the most popularly tracked metric in a building, for good reason. Energy consumption costs money, so tracking consumption also tracks cost. However, energy consumption also means carbon consumption. Grid-supplied electricity has an associated carbon emissions metric which is in constant flux depending on the carbon mix of the grid at any one time. This can be tracked in real-time alongside consumption, allowing building users and owners to understand the carbon impact of their systems and buildings. Locally-generated electricity and energy storage are two methods of introducing significant carbon reductions at a building level. Changing energy behaviour is a third opportunity to reduce carbon. Dashboards track energy consumption, carbon emissions, energy storage and localised energy generation, providing historical and real-time data on where emissions can be saved.

Monitor Performance

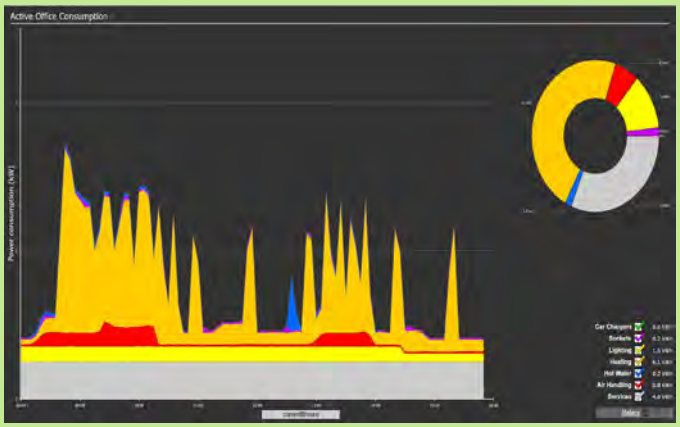
All of the above methods of dashboarding a building combine to provide an efficient and clear method of monitoring performance. Historical data, real-time data, grid carbon intensity tracking, and renewable energy data combine to provide clear insight into how a building performs over time. Using this overarching central data repository and display is essential for learning lessons and driving down consumption and emissions within a building.

Extract from https://gridwatch.co.uk/co2-Emissions



Audience – Dashboards for different users

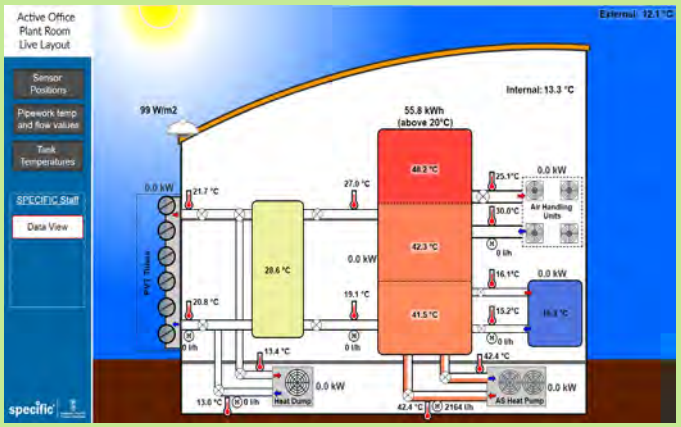
BUILDING OCCUPANTS



Consumption Dashboard

To convey daily operational energy consumption

FACILITIES MANAGEMENT TEAM



Plantroom Thermal Dashboard

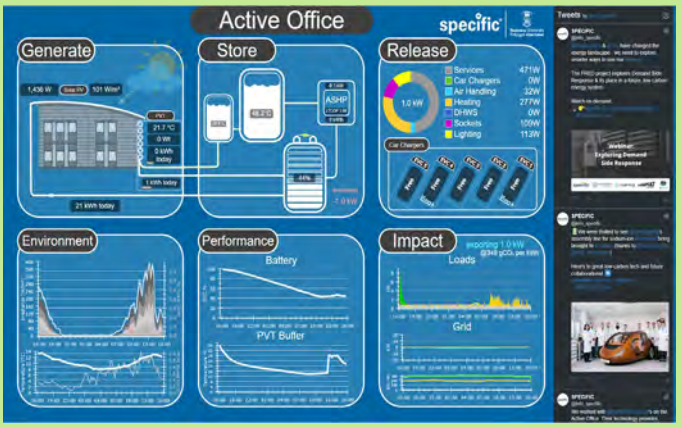
To aid fault finding and optimisation of the energy systems

ORGANISATION MANAGEMENT

Building Overview Dashboard

A detailed overview of the energy data to aid operational decision making

VISITORS



Public Display Dashboard

A graphical representation of energy generation, consumption and storage data in real-time

Audience – Dashboards for different users

Dashboards are the most efficient method of providing a clear overview of building energy use. Although different dashboard users will need different information, multiple dashboards can be created from one database for each different user. It is important to consider each user type when designing different versions of the dashboard.

Building Occupants/Users

Building users offer the greatest opportunity for changing behaviour based on learnings from the outputs displayed via the dashboard. This audience will require a dashboard that provides real-time data, daily totals, and historical tracking. Localised energy generation, energy storage, and grid carbon intensity are also useful metrics to track to encourage behaviour change. Building occupants just need to view energy tracking at building level. It is generally recommended that dashboards for building users are provided either via a mounted display in a foyer or break room, or through a privately-accessed web page (URL) accessed from a mobile device or personal computer.

Facility Managers

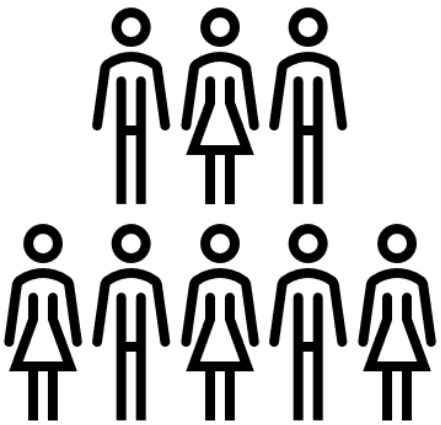
This audience requires a far more detailed dashboard, providing data associated with each system (heating, thermal storage, battery status, sub-metered electrical zones, electrical generation devices, etc.) Whereas other audiences do not require such detailed outputs, Facility Managers will need to track system performances to ensure optimal performance and identify faults. This audience will also require a detailed overview of performance over time to appreciate the impact of changes made to systems to ensure building operational optimisation. It is usually recommended that these displays are accessed using proprietary software from a personal computer or mobile device.

Building Owners

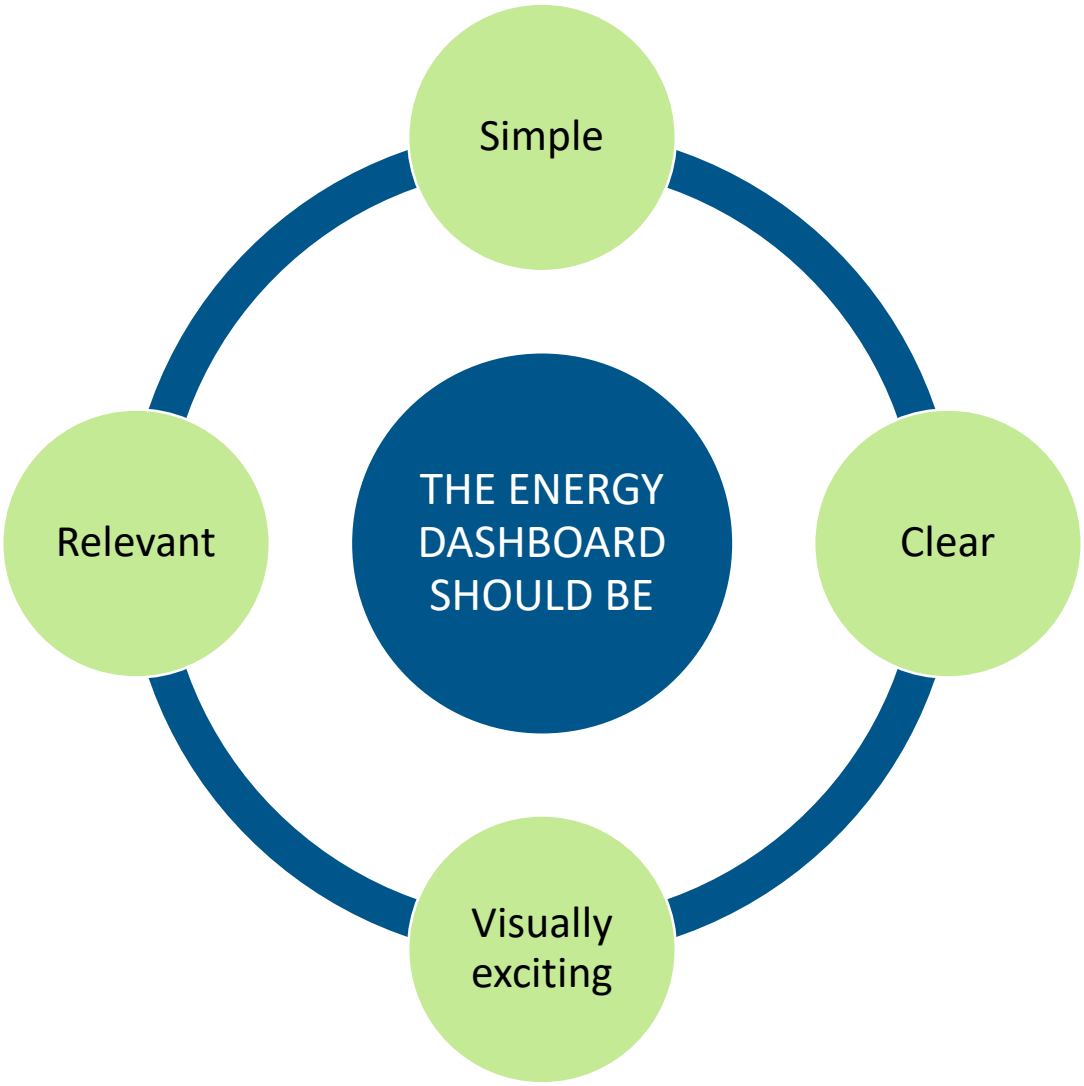
Building owners will not necessarily require real-time data; but rather a trend line of energy performance, to enable them to review the performance of their building and the energy costs from both a financial and carbon viewpoint. This dashboard will have historical data, weekly comparison metrics, and overall generation, storage and consumption metrics. Facility Managers will be able to provide detailed information at any time upon request. It is usually recommended that these displays are made available through a private website (URL) for viewing on a personal computer or mobile device.

Building Visitors

This is an opportunity for dashboards to become an advertisement board for the building, its occupants, and owners. Visitors will be able to see how well the building is performing in real-time, gain an appreciation as to how the individual systems come together to drive efficiency within the building, identify how and where low-carbon systems are being utilised, and understand the vision of the building in one clear display. These displays are popular in a building foyer, on a company's website, or on a robust screen mounted externally on the building.



Key Design Decisions



The dashboard should convey the message you want to tell

What?
Energy generation and consumption; Demand shifting; Connection to electricity grid.

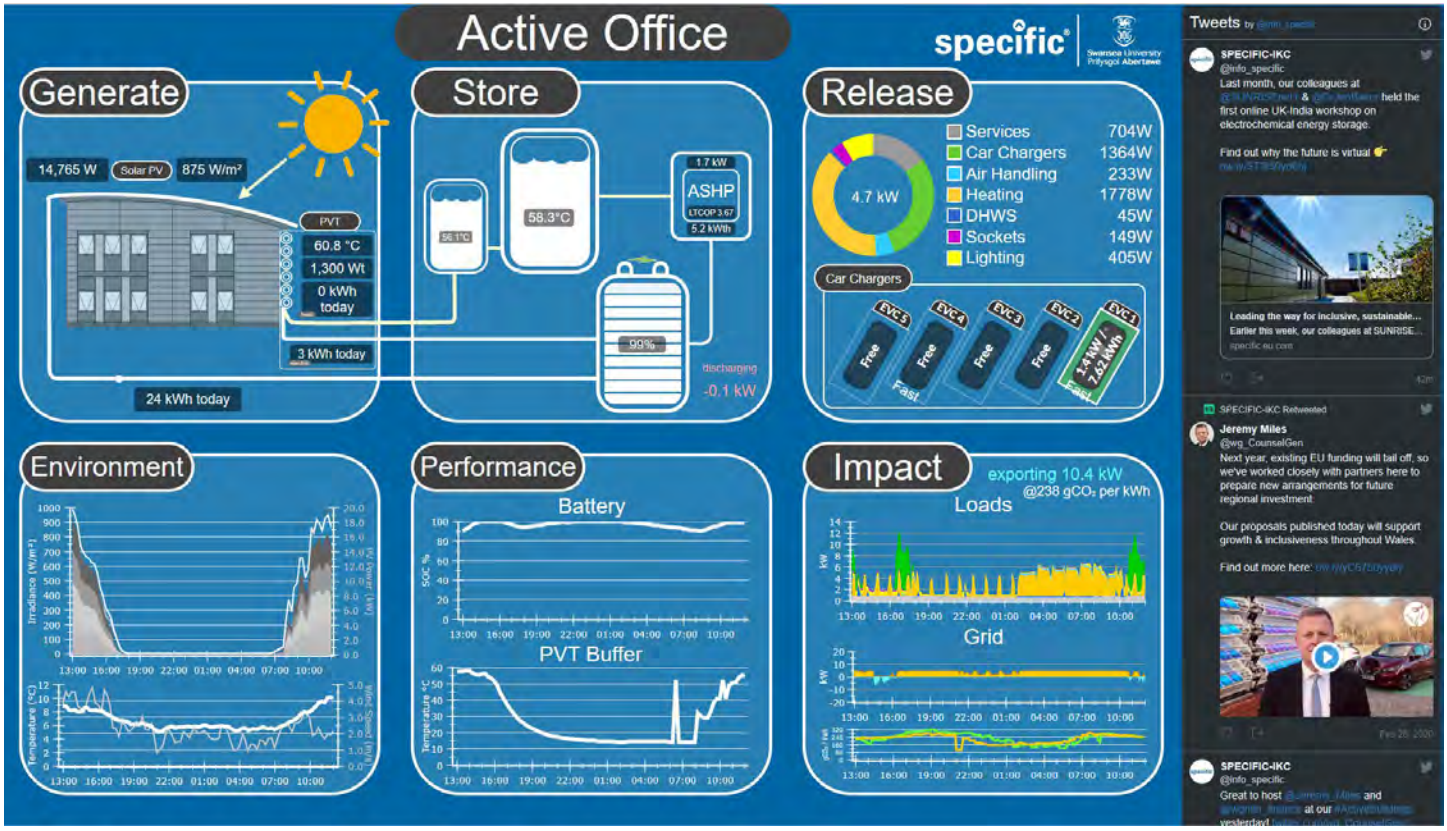
Where?
Which building does it relate to; where are the systems illustrated.

When?
Live (real time); historic; daily totals; running totals from start of building occupation.

Data shared on a building Energy Dashboard can vary as widely as building designs. Depending on the mix of energy sources, there are a number of key statistics to include. At the Active Office, Swansea University, SPECIFIC have shared the following data. The table shown below is indicative and should be considered as an example, which can be adapted to suit individual projects.

Theme	Technology/Feature	Key Information	Units
Energy Generation	Solar PV	Total current generation	Watts (W)
		Current generation by area	W/m^2
		Total accumulative generation today	kWh
	Solar Thermal (T)	Temperature of collector	°C
		Current generation	W_{th}
		Total accumulative generation today	kWh
	Solar Thermal + PV (PVT)	Temperature of collector	°C
		Current thermal generation	W_{th}
		Current electrical generation	W
		Total accumulative generation today	kWh
Energy Storage	Electrical Storage	Amount full	%
		State of Charge	kW
	Thermal Storage	Temperature	°C
	Heat Pump	Energy supply to storage	kW
		Total energy supply today	kWh
		Lifetime COP (energy supply/energy used)	W
Release	Energy Consumption	Services, EV charging, Air Handling, Heating, DHWS, Sockets, Lighting	W
	EV chargers	Availability	Yes/No
		State of Charge	kWh
Environment	Thermometer	Current External Temperature (tracked)	°C
	Anemometer	Current Wind Speed (tracked)	m/s
	Pyranometer	Solar irradiation available (tracked)	W/m^2
	Solar PV	PV power generating (tracked)	kW
System Performance	Electrical Storage	Live state of charge (tracked)	%
	Thermal Storage	Temperature (tracked)	°C
Impact	Loads (Consumption)	Energy consumption by use (tracked)	kW
	Energy Supply	Live export/import	kW
		Live carbon intensity of supply (tracked)	gCO_2/kWh
Optional	Live Social Media Ribbon		

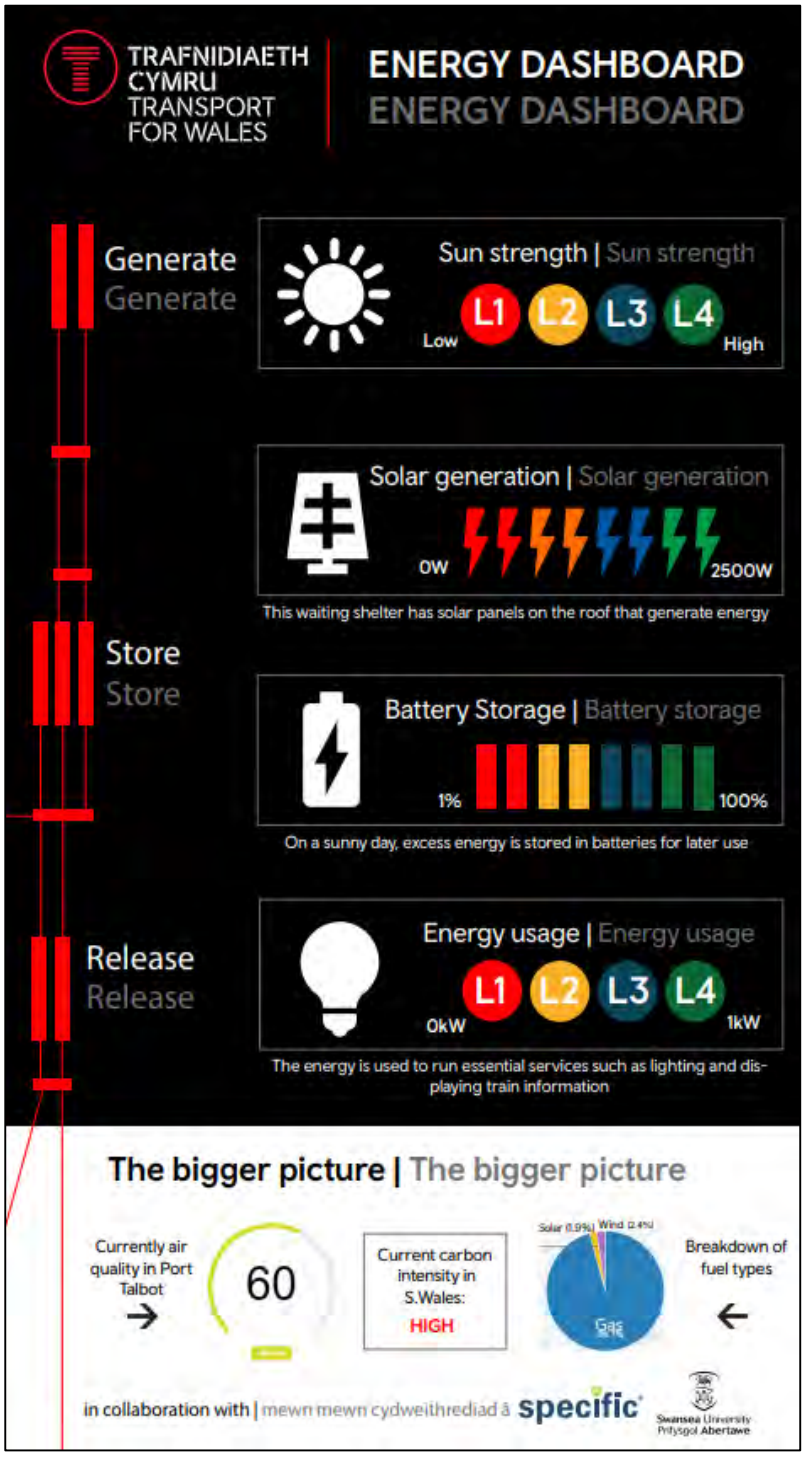
Example 1 – The Active Office Energy Dashboard



The Active Office Energy Dashboard is useful for informing building users about the balance of energy consumption and generation and how this relates to the wider energy grid. Active Buildings, which aim to regulate energy flows in relation to the peaks and troughs of grid consumption, are considered as energy nodes within the wider grid infrastructure. By highlighting when and how much renewable energy the building generates, when it is stored, and how much is released and at what time, visitors can quickly appreciate how the building's systems complement its users and the grid. SPECIFIC have also added their social media feed to the right of the dashboard to maintain a link between the building and the project's aims and ongoing work.

This example is very much a real-time energy dashboard, which is one of the primary aims of a successful dashboard. A benchmarking graphic, demonstrating how efficiently the building has performed in comparison with other offices across the UK could also be added. This would enable visitors to gain valuable feedback as to how the energy performance of the Active Office compares to other similar buildings, allowing for a more holistic understanding as to how the building delivers low-carbon operational energy and has low grid consumption when compared with a *"business-as-usual"* approach.

Example 2 – The Active Rail Shelter Energy Dashboard



Multiple examples of Energy Dashboards exist for various installations from buildings to power stations. In effect, the purpose of an energy dashboard is to provide relevant information about the performance of a collection of systems. A building will largely report on how its systems of heating, hot water, renewable energy generation and air quality are performing. In this example, an Active Rail Shelter is reporting on how its systems of renewable energy generation and storage are performing, based on the demands on the system and the quality of light available to it (demand and supply). The Active Rail Shelter for Transport for Wales (TfW) also includes a general air quality index and carbon intensity metric near the bottom of the dashboard as relevant extra information.

Relevant is a key word here as dashboards need to relate to the intended users. The dashboard for TfW has been designed to provide clean and clear information for their primary audience: a train passenger waiting for their train on an open platform. At a glance, the user can see how the intensity of the light is contributing to the generation of electricity by the shelter, how much of the battery is being charged (or discharged), and how heavily the shelter is drawing from that renewable energy source. Additionally, as aforementioned, the passenger can see how clean the air they are breathing is while they await their carriage, and check the carbon intensity of grid-generated electricity in real-time.

As described in this document, he design of the dashboard should be driven by the end user.

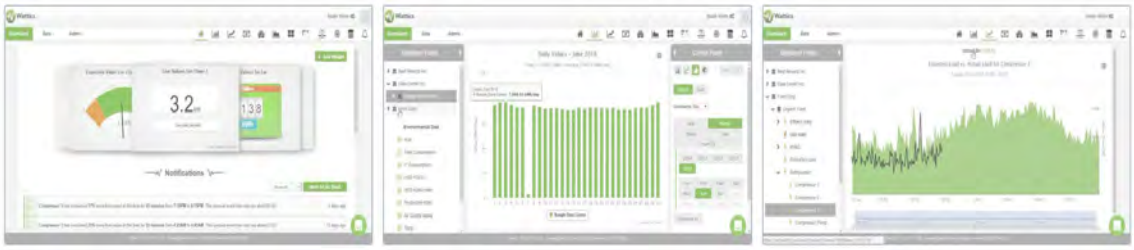
Further information on the Active Rail Shelter can be found at:
https://www.specific.eu.com/transforming-transport-the-uks-first-active-rail-shelter/

Available Software Platforms

For the Active Office Energy Dashboard, SPECIFIC used the DG-Lux (available at www.dglogik.com) IoT platform which brings all the data generated by the different building systems together in one unifying piece of software.

Other IoT application platforms exist, some of which have been reviewed below:

1. Wattics



Product Overview	
Developer	Wattics
Software type	Energy management
Client OS / Deployment	Web / Cloud-hosted
Pricing	
'Player' version	- starts at £25/month (Unlimited sites and one user)
'Composer' version	- starts at £100/month (Unlimited sites and users)
'Maestro' version	- starts £200/month (Composer features plus Branded software)

Key Features
- Real-time analytics (including trends and tariff data)
- Measurement and verification
- Alarms and Events
- Analyse and compare consumption data/trends
- Data import/export
- User management
- Operation wastage and power quality analysis

2. EnergyCAP

Product Overview	
Developer	EnergyCAP
Software Type	Energy management and utility billing
Client OS / Deployment	Windows and Web / Cloud-hosted
Pricing	
Enterprise	£25/meter/year for 250 meters
Express	£17/meter/year for 100 meters
Consultant Platform	£18/meter/year for 250 meters
Professional	Contract for pricing (annual license)

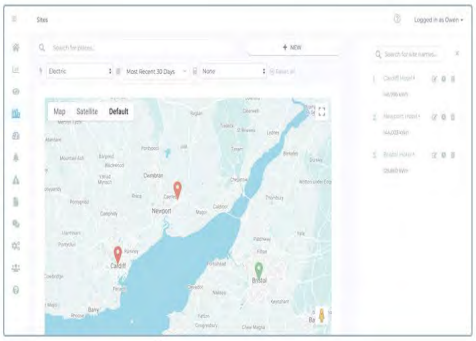
Key Features
- Account and Meter tracking
- Bill accruals and bill audits
- Accounts payable export
- Electronic bill import
- Energy contract administration
- Issue tracker
- Workflow management

3. OpenDEM

Product Overview	
Developer	Amzur Technologies Inc.
Software type	Energy management & Utility Billing
Client OS / Deployment	Windows, Mac, Linux, iOS, Android, Web / Cloud or On-Premises
Pricing	
Starting price	- £7100 (perpetual license)
Target Markets	
Utilities (Elec., Water & Gas), Solar/PV, Renewable Energy, Department of Energy, Universities, Power plants, Smart metering, Smart cities	

Key Features & Services
- Energy monitoring, measurements, & archiving
- Distributed resource management
- Energy information system
- Forecasting
- Communication and control
- Data visualisation
- Optimisation platforms
- Microgrids

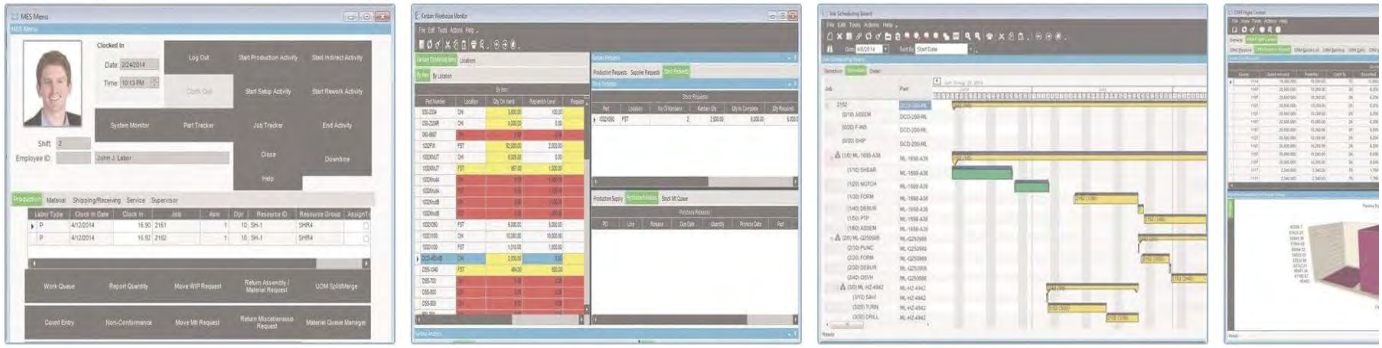
4. Surple



Product Overview	
Developer	Surple Energy Limited
Software Type	Energy management
Client OS / Deployment	Cloud-hosted
Pricing	
Starting price	£50/ month

Key Features
- Elec, Gas, Water consumption data compatibility
- Insightful energy report generation in seconds
- Cloud-based & powered by machine learning
- Energy usage visualisation across portfolios
- Flexible alarming & targeting tools
- Anomaly detection with user notifications
- Not linked to one specific supplier or data source

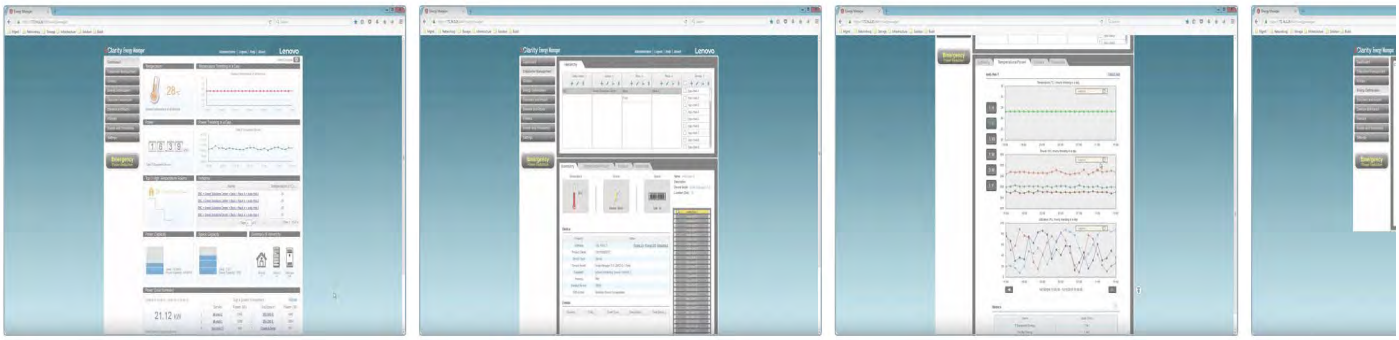
5. Epicor E10 ERP



Product Overview	
Developer	Epicor Software Corporation
Software type	Manufacturing, ERP and Supplier Relation Management. (SRM)
Client OS / Deployment	Windows, Mac, Web / Cloud, On-premises
Pricing	
-£125/ month / user	

Key Features
- Track, measure, and monitor entire business from top floor to shop floor & materials to product
- Real-time visibility - plant & business operations
- Easily adaptable to new methods & requirements
- Business cost reduction
- Process streamlining

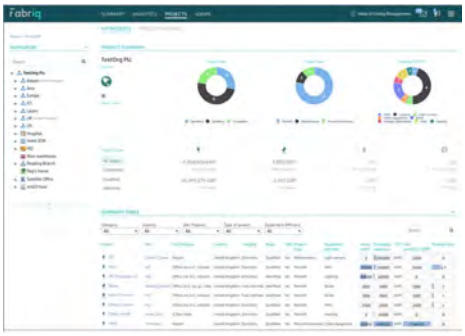
6. XClarity Energy Manager



Product Overview	
Developer	Lenovo
Software Type	Energy management
Client OS / Deployment	Web / Cloud-hosted
Pricing	
Not available online	
Smart Management	
- Data centre hierarchy management	
- Low utilisation server identification	
- Severe power characteristics analysis	
- Event management	
- Emergency power reduction	

Key Features
- Manage power consumption & temperature
- Customisable management console
- Track items via rooms, rows, racks and devices
- Track CPU and memory power consumption
- Monitor inlet temperature
- Optimise via power limits
- Cooling, low-utilisation, and workload placement analysis
- Reduce platform power consumption
- Establish policies
- Workflow management

7. EnergyDeck



Product Overview	
Developer	EnergyDeck, Fabriq
Software type	Energy Management
Client OS / Deployment	Web / Cloud-hosted
Pricing	
- £70/ month	

Key Features
- Energy and Waste Management
- Benchmarking, Bill audits, Bill importing
- Cost/Use reporting
- Greenhouse Gas Tracking
- Emissions Inventory, Monitoring & Management

8. Energy Elephant

Product Overview	
Developer	Energy Elephant Ltd
Software Type	Energy management
Client OS / Deployment	Web / Cloud-hosted
Pricing	
- £450/ month	

Key Features
- Benchmarking, Bill audits, database & importing
- Budgeting and forecasting
- Cost/Use reporting
- Emissions Inventory, Monitoring & Management
- Greenhouse Gas Tracking

Other prominent IoT / building energy management packages currently available on the market (pricing not available online) include:

9. ETAP Energy Management Software
10. PlaceOS | Smart Building Solutions
11. SpaceOS | Workplace Experience Platform
12. DEXMA Energy Intelligence
13. SkySpark
14. Strata

Hardware Options

Once the data is selected for display and analysis, the next decision is how to visualise the data for interested parties. Modern day equipment varies between mobiles and external display screens, and there are advantages and disadvantages to each different hardware option. Reviewing who the information is for and how it is to be used will be the most useful guide to decide which type of equipment to embrace: mobile phones, tablets, internal monitors, or external monitors.

Users:
How many users do you want to be able to access the data at one time? Offering the data on a tablet is convenient and portable, but limits the number of individuals accessing the data at once.

Data:
How much data do you want to display at once? Large screens can accommodate numerous graphs and details all at once; apps on mobile phones will require the user to either zoom in or scroll through the graphs to obtain all the data.

Access:
When do you want to provide access? An internal display allows for users to view the data during business hours only; an external display can be viewed 24/7.

Display Quality:
The quality of the displayed data will depend on such aspects as the number of pixels in a display or the rendering software employed to create the graphics for display.

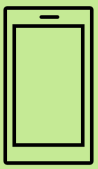
Interaction:
How interactive do you want the dashboard to be? Mobile phones or touch-screens enable direct manipulation of the display; whereas fixed screens will rely on either a full display or a cycling of graphics, which can be efficient but possibly distracting.

Security:
Where security is a concern, a robust, outdoor monitor with a theft-resistant secure fixing is the safest option, as it will be dust and moisture-proof (ip68) and vandal-resistant. Mounting a screen internally improves the security somewhat, as buildings can be locked when not in use. Hand-held tablets will always pose a theft risk, as they are portable, small and light.

Energy Use:
It is wise to consider the energy consumption of the chosen hardware device. A display that is on continuously provides the convenience of enabling a data overview at any time, but will constantly drain power from the building. Mobile device access requires no on-site monitor at all, eliminating the need for power to display a dashboard.

Summary of Hardware Options

MOBILE



- Single viewer
- User can choose what data to view or query
- Viewable any time, remotely
- Scrolling required
- App/ website
- No hardware investment required

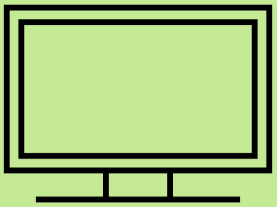
TABLET

- 2-3 viewers
- Customisable display
- Interactive/ swipeable
- Viewable any time, remotely
- Portable
- App/ website
- Low hardware investment

SCREEN

- 10-20 viewers
- Static or cycling display
- Large to include most, if not all, data on one screen
- Internal installation
- Available during business hours only

HEAVY DUTY SCREEN



- 30+ users
- Static display
- Expensive
- Bullet/Vandal proof
- External installation possible
- Larger screen size to include all data on one screen
- Publicly visible

Summary of Energy Dashboard Benefits

As we move towards a low-carbon society, it is critical that all building users become familiar with their energy consumption, understand where the energy they use is coming from and have an awareness of the wider impacts of their energy consumption. In other words, everyone needs to become more *"Energy Literate".*

Energy Dashboarding is a direct, effective method of educating building users, and can provide an effective *"nudge"* to influence users into modifying their behaviour in relationship with their building. As the adage goes, Think Globally, Act Locally.

VALUE

- Make use of monitoring equipment installed and data collected
- Use of data to reduce energy consumption, carbon emissions and energy costs

ENGAGEMENT

- Improve Energy Literacy of building occupants, visitors, management
- Help tell the Active Building story to visitors and collaborative partners
- Identify issues quickly
- Introduce an element of competition (within an estate of buildings; between companies or departments)

CULTURE

- Create a data-driven culture
- Encourage knowledge sharing and an open and honest culture
- Influence behaviour - Encourage people to connect their activities and behaviour to energy consumption
- Influence decision making on building improvements, maintenance regimes, continuous improvement

TRAINING

- Use as a simple tool to explain the building energy systems