Active Building Monitoring Specification for Commercial Buildings

Version 1.0, February 2021

0 Introduction

This document forms part of a toolkit, providing information on the core principles of an Active Building and the key design considerations related to each principle.

Purpose

- Provide an explanation of an Active Building
- Provide key benefits of an Active Building
- Provide key design considerations related to each Active Building principle

The document should be read in conjunction with the following documents:

- Active Building Code of Conduct
- Active Building Project Template
- Active Building RIBA Plan of Work Checklists
- The Active Classroom Case Study
- The Active Office Case Study
- Active Building Technology Showcase
- Active Building Glossary
- Active Building Frequently Asked Questions

Use of the Active Building Interactive Process Flow Diagram will assist navigation through these documents and other useful resources.

7 Data Capture

7.1 Introduction

Robust data monitoring and capture systems are critical to enable true Building Performance Evaluation (BPE). To improve building performance, the best research we can do is to go back into a building and understand how it works.

The success of an Active Building depends on the management of the building and its services - the design should facilitate effective management of services, which can be achieved through the data capture system. To facilitate data capture, all environmental services should be sub-metered to allow the use of lighting, fans and pumps, space heating, hot water supply, etc to be distinguished. Sub-metering provides a greater insight into how a building is performing, including energy consumption and generation, and a measure of the energy efficiency of the building fabric and services. It will also allow excessive consumptions to be diagnosed more readily.

Benefits of data monitoring:

- Enable issues to be identified and resolved quickly
- Provide feedback on actual building performance
- Enable the development of planned maintenance strategies
- Enable optimisation of system to save energy and operational carbon
- Enable the development of predictive control strategies
- Educate building occupants on their energy consumption and provide an understanding of how the energy they are using is provided
- Enable controlled import and export of energy, based on factors such as grid Carbon Intensity (CI) or cost.
- Undertake Whole Life Cost (WLC) reporting.
- Provide feedback to occupants on their energy performance, via a robust database and energy display.
- Undertake Building Performance Evaluation (BPE), including Post Occupancy Evaluation (POE).

Tips:

- Determine what you want to capture from the data and how the data collected will be used before deciding on data collection system. For example, data may be used to measure consumption against generation; to monitor indoor air quality (IAQ), such as room temperatures, relative humidity, CO2 levels, etc, it is necessary to know details of the building fabric and external environmental conditions.

- Sub-metering of the following data is useful:
  - Heating
  - EV charging
  - Non-regulated loads
  - Regulated loads

- Consider how building occupants might engage with data captured:
  - Select systems that are simple to operate and easy to manage, e.g. SolarEdge – 1 system can monitor PV installation, EV charging, battery storage, and immersion diverter
  - Access rights to the data
  - Front-end visualisation

Collection frequency should be based on the end use for the data and the type of data - temperatures are unlikely to change rapidly so sub minute monitoring is unlikely to be useful. High frequency monitoring of energy generation can be useful but also presents data storage and analysis issues. If the aim is to understand costs or carbon impacts then 15 minute or 30 minute averages would be sufficient (grid carbon intensity is updated at 30min intervals, as are most of the modern time of use tariffs (e.g. Agile Octopus).

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7.2 Active Learning Loop

One important benefit of data capture is that it can be used to inform future building projects, using the learnings from previous projects. We refer to this as an Active Learning Loop in a "Design, Construct, Evaluate, Improve" cycle.

Several databases exist to encourage learning in this way, but they tend to be under-utilised, due to the inherent 'blame culture' that exists within the construction industry. These include:

- **CarbonBuzz** – an RIBA, CIBSE platform
- **AECB Low Energy Buildings Database**
- **UKGBC Net Zero Case Study Catalogue**

Data from all Active Building projects should be captured in an open access database for a more collaborative, research-led future construction industry. This is the only way the construction industry will be able to meet the climate change targets set locally, nationally and globally.

Visualising energy data to building occupants will also help encourage more efficient use of energy in buildings, hence reducing carbon, as described on page 40.

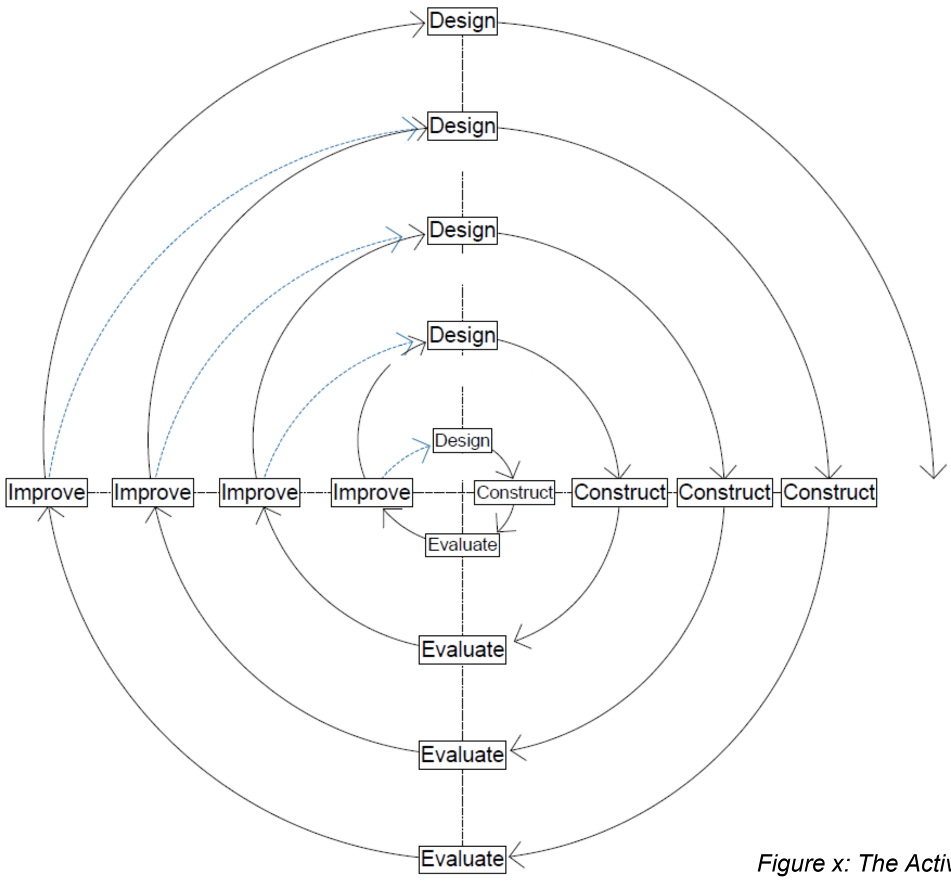

Figure x: The Active Learning Loop

LETI Data Disclosure Recommendations:

- Metered data
- Report – upload 5 years of data to CarbonBuzz platform

7 Data Capture

7.4 Energy End Use Groups

The table below describes the main building energy end-use groups in buildings.

End-use group	Description
Space heating/cooling	Likely to bt the largest component of building energy use. Correlated to climatic region, control strategy, and occupancy patterns. Parameters to consider include external temperature, internal temperature, outdoor humidity, wind speed, heating/cooling system set points
Domestic Hot Water	Second largest component of building energy use. Defined as the energy required to heat hot water to an adequate temperature for occupant and appliance use. Used for personal hygiene and cleaning. Correlated to the number of occupants, preference, bath/shower, frequency and duration of bath/shower, energy rating of appliances, etc.
Lighting	Correlated to building type, occupancy profiles, and the types of lighting systems such as halogen lamps, fluorescent lamps, LED, etc.
Cooking	Correlated to the type of cooking device, such as gas hob, electric oven, microwave, number of occupants etc.
Small power/appliances	Devices include personal computing, electronics and kitchen appliances. Energy use correlated to occupancy
Systems	Devices or equipment that operates continuously in the background, includes communications equipment, fire alarm protection and alert devices, WiFi devices
Process Loads	Unregulated loads associated with processes taking place within the building that require energy. These can be significant in industrial or engineering buildings
EV charging	Depending on how many EV charge points are included, this could be the largest energy use.

7.5 Building Loads

It is important to be aware of the load categories for developing control strategies that schedule building activities, energy storage activities and grid import/export. Building loads typically fall into the categories described in the table below:

<table>
<tr><th colspan="4">Load mix</th></tr>
<tr><td colspan="3">Non-storable Load</td><td>Storable Load</td></tr>
<tr><td colspan="2">Non-shiftable Load</td><td>Shiftable Load</td><td rowspan="3">Power consumption decoupled from end-use service: Batteries, heating, cooling, DHW, EVs</td></tr>
<tr><td>Non-curtailable Load (Baseload)</td><td>Curtailable Load</td><td rowspan="2">Power consumption can be moved without affecting the end-use service: Laundry, dishwasher, tumble dryer, vacuum cleaner, etc</td></tr>
<tr><td>Power consumption cannot be shifted or interrupted: Security alarm, fire alarm, control systems, freezer, refrigerator, etc</td><td>Power consumption cannot be shifted, but the load can be interrupted: Lighting, computers, TV, etc</td></tr>
</table>

The loads listed in Table X are not exhaustive. Some buildings may also have other loads not mentioned in the table.

7.6 Data Capture Priorities

Any data captured from systems will enable fault detection in addition to optimising energy consumption, balancing energy flows and learning about actual performance of systems against information provided at design stage. Table x below lists the suggested monitoring to include in an Active Building.

Energy Consumption Data	Benefit/Value
Space Heating Circuits	Measure how much energy is needed to provide temperature setpoint. Potential issues in maintaining setpoint include open windows and doors and building fabric issues. Enable fault detection
Domestic Hot Water System	Measure amount of energy (kWh/litre) needed to meet demand. If low hot water usage then self discharge could be significant. Monitoring when it is used could enable improved efficiencies linked to generation (ensuring legionella control is maintained)
EV Charging	Measure impact of EV charging on overall energy consumption
Services - Comms equipment, fire alert equipment, security devices	Measure baseload energy consumption of the building Ascertain whether any energy savings could be made to baseload
Lighting	Measure performance of lighting against designed performance
Small Power - Sockets, unregulated energy	Measure unregulated energy consumption
Air Handling Systems	Measure amount of energy needed to provide required ventilation levels
Indoor Air Quality – room temperature (ºC), CO_2 level (ppm), relative humidity (%), occupancy (binary), windows/ventilation (% open)	Ensure comfort levels are maintained Identify any system faults, underperforming of systems, or design faults
Environmental Data	
External ambient air temperature (ºC)	Measure real life performance of energy generation technologies
Solar irradiance (W/m2)	Measure real life performance of energy generation technologies
Wind speed (km/h) and direction (degree)	Measure effects of wind speed and direction on performance of systems
Humidity (%)	Measure the affect of moisture in the air on generation and consumption
Rainfall (mm)	Measure the affect of rainfall on energy generation and consumption
Weather forecasting	Enable decision making on import and export of energy, depending on predicted weather
System Data	
Battery State of Charge	Help optimise control of energy flows Measure performance against depth of discharge
Lifetime coefficient of performance (LTCOP) of heat pumps	Measure actual efficiency of heat pumps against anticipated performance
Temperature of thermal store	Measure amount of energy needed to maintain store at required temperature
Daily Generation & Consumption (kWh/m^2)	Determine whether the building is Net Zero Energy
Carbon intensity of Grid (CI)	Control export and import of energy accordingly
Energy Source – on-site generation, grid	Measure true operational carbon of the building
Energy prices	Control export and import of energy accordingly

7 Data Capture

Load profile and specific parameters will vary depending on building type. Table x below shows typical building loads and parameters influencing energy consumption in **residential buildings**, as an example.

Building Location	**Kitchen**
Region	Cooking – Hob, Oven, Microwave, Grill, Toaster
City	Kettle
Number of occupants	Coffee Machine
From 08.00 to 13.00	Food processor
From 13.00 to 19.00	**Refrigeration**
From 19.00 to 00.00	Refrigerator
From 00.00 to 08.00	Freezer
Architectural Characteristics	**Washing**
Year of construction	Washing machine
Size of property	Tumble dryer
Walls and roof materials and colour	Dishwasher
Level of insulation	**Cleaning and ironing**
Shading	Vacuum cleaner
Refurbishment activities	Iron
Building Services Systems	**Lighting**
Heating – control, heat source, emission system	Filament lamps, halogen lamps, fluorescent lamps, LED lamps
Cooling – type, energy class, no. of rooms served	**Audio/Video**
Domestic Hot Water - type	TV, monitor, DVD players, home theatre
Solar Thermal Collectors	Radio, stereo, hi-fi
Flat/vacuum	**Computing/Internet**
Number of modules	Desktop PC
Angle of Pitch	Laptop/tablet
Orientation	Printer
Solar PV Array	**Personal care**
Peak power	Hairdryer
Angle of Pitch	Hair straightener
Orientation	**Other equipment**
	Power tools, lawnmower, etc

7 Data Capture

7.8 Resources

1. BRE, 2018. *Post-Occupancy Evaluation (POE)*. https://www.bre.co.uk/page.jsp?id=1793

2. BSRIA. 2020. *Building Performance Evaluation*. https://www.bsria.com/uk/consultancy/building-improvement/building-performance-evaluation/#:~:text=Building%20Performance%20Evaluation%20(BPE)%20is,domestic%20and%20non%2Ddomestic%20buildings.

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4. RIBA and Hay, R. Bradbury, S. Dixon, D. Martindale, K. Samuel, F. Tait, A. 2016. *Pathways to POE, Value of Architects*. University of Reading, RIBA. https://www.architecture.com/knowledge-and-resources/resources-landing-page/post-occupancy-evaluation#available-resources