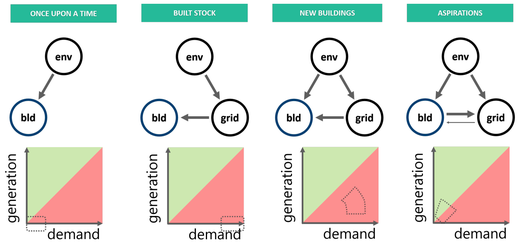
Design, Building Physics and Post Occupancy Evaluation

ACTIVE BUILDING CENTRE RESEARCH PROGRAMME

Introduction

The building sector is the largest single contributor to energy consumption and carbon dioxide emissions. At the same time, it has the potential to play an important role in the anticipated transition to a decarbonised society. How can this be achieved? By harnessing available strategies and technologies to convert buildings into an active part of the grid.



It's all about being active

The aspiration is to move towards **active buildings** that interact with the grid, have a low energy demand and (ideally) generate more energy than they consume (green area above).

SYSTEM'S BOUNDARY	WEIGHTING SYSTEM	BALANCE SYSTEM	TEMPORAL MATCH	MEASUREMENT & VERIFICATION
flows across	normalise units	normalise balance	boosting impact	rating compliance
Physical building(s) & site **Balance** what goes in **Boundary** comparability	**Metrics** kWh_{pyy}, CO_2e, £, ... **Symmetry** bidirectional? **Accounting** value over time	**Balancing period** instant – lifetime **Type** loads, exports,... **Agenda** hard-set requirements	**Load matching** stress on generation **Grid interaction** stress on imports **Whole-systems** transport	**M & V** is it doable? **Rating system** compliance tolerance **Enabling learning** introspection

Yet activeness is hard to define...

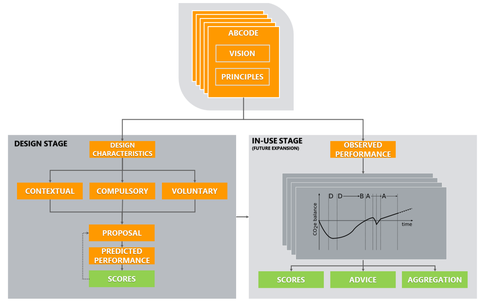
However, there is no clear definition of net zero energy/carbon or active buildings, nor such a building code to design against.

[Figure based on: Sartori, I., Napolitano, A. & Voss, K., 2012. Net zero energy buildings: A consistent definition framework. Energy and Buildings, 48, pp.220–232.]

Scan me if you want to know more!

The Active Building Code

Hence, an Active Building Code is required to provide different stakeholders with a clear **definition** and **evaluation framework** for active buildings.



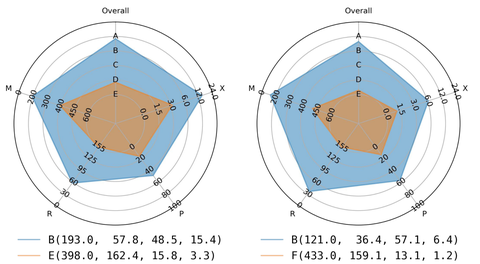
Vision & principles

The vision is to deliver at scale buildings that '**do no harm**' in accordance with two main principles: **whole-life sustainability** and **energy network support**.

Metric	Embodied carbon	Energy required	Renewable energy production	Energy flexibility	Post-Occupancy Evaluation: contractual obligation to in-use review	Obligation to discuss scheme with representatives of local energy networks	Is the building considered an AB?
Label	M	R	P	X			
Units	$kgCO_2 \cdot m^{-2}$	$kWh \cdot m^{-2} \cdot a^{-1}$	$\%\ of\ R$	$hours$			
A	≤ 200	≤ 30	> 100	> 24	Yes	Yes	Yes
B	(200, 300]	(30, 60]	(80, 100]	(12, 24]	Yes	Yes	Yes
C	(300, 400]	(60, 95]	(60, 80]	(6, 12]	Yes	Yes	Yes
D	(400, 450]	(95, 125]	(40, 60]	(3, 6]	Yes	Yes	Yes
E	(450, 600]	(125, 155]	(20, 40]	(1.5, 3]	Yes	Yes	Yes
F	> 600	> 155	≤ 20	≤ 1.5	Yes	Yes	Yes
G	*	*	*	*	No	No	No

Scoring system

These principles are translated into **four metrics** for assisting stakeholders in evaluating the performance of active buildings: **embodied carbon, energy consumption, renewable energy production** and **energy flexibility**.

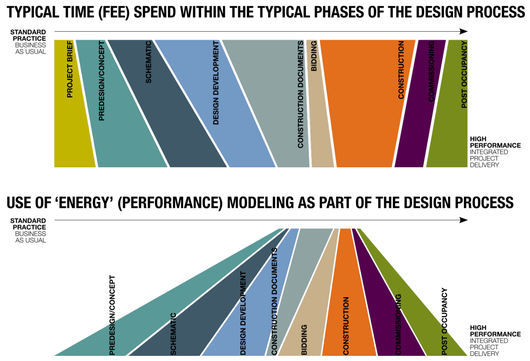


Communicating performance

A **spider diagram** can summarise the performance of an active building or community (with respect to these four metrics) and help stakeholders compare design alternatives.

The ZEBRA tool

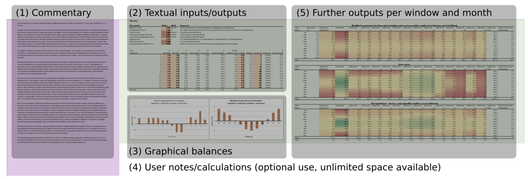
ZEBRA is a **modelling tool** developed to help those new to the design of low energy/carbon or active buildings take important decisions, before it is too late or too expensive to modify.



Why?

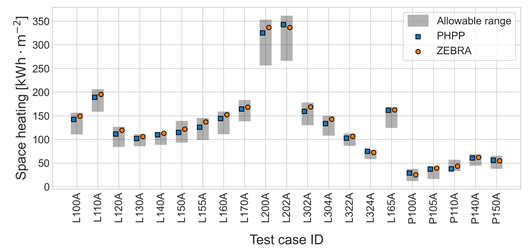
Performance modelling is a central part of the building design process and the integrated project delivery.

[Image adapted from: AIA, 2012. 'An Architect's Guide to Integrating Energy Modelling in the Design Process'.]



ZEBRA's interface

In ZEBRA, building physics, sustainability and design lessons (1) are prioritised. Users can then insert the required information (2) and get feedback on their potential design decisions (5).

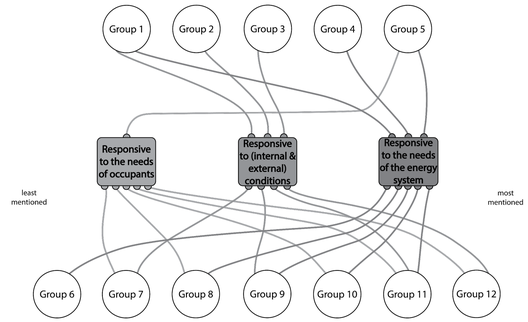


Performance

The core algorithm is that of ISO 52016-1, which performs as expected according to the ASHRAE Standard 140.

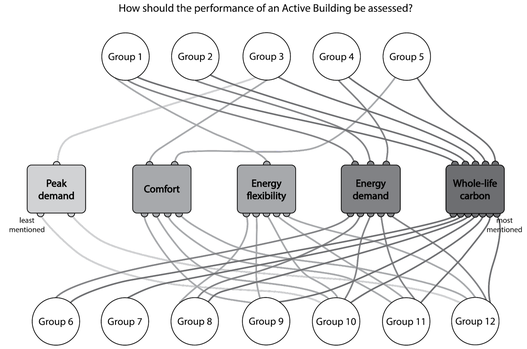
Stakeholder perceptions

Thirty experienced industry practitioners participated in twelve **focus group discussions** around active buildings.



What is an active building?

All stakeholders interpreted 'active' as **responsive**, with such a responsiveness referring to the needs of occupants, internal or external conditions and/or the needs of the grid.



How should its performance be assessed?

Opinions varied from one focus group to another, as they were divided between **energy** and **carbon metrics**.

For further reading

- Fosas, D., Nikolaidou, E., Roberts, M., Allen, S., Walker, I., Coley, D., 2021. Towards active buildings: Rating grid-servicing buildings. Building Services Engineering Research and Technology, 42(2), p.129–155.
- Nikolaidou, E., Fosas, D., Roberts, M., Allen, S., Walker, I., Coley, D., 2020. Buildings as energy infrastructure, not passive consumers. Active Building Centre Research Programme.

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