Active Buildings and whole life values

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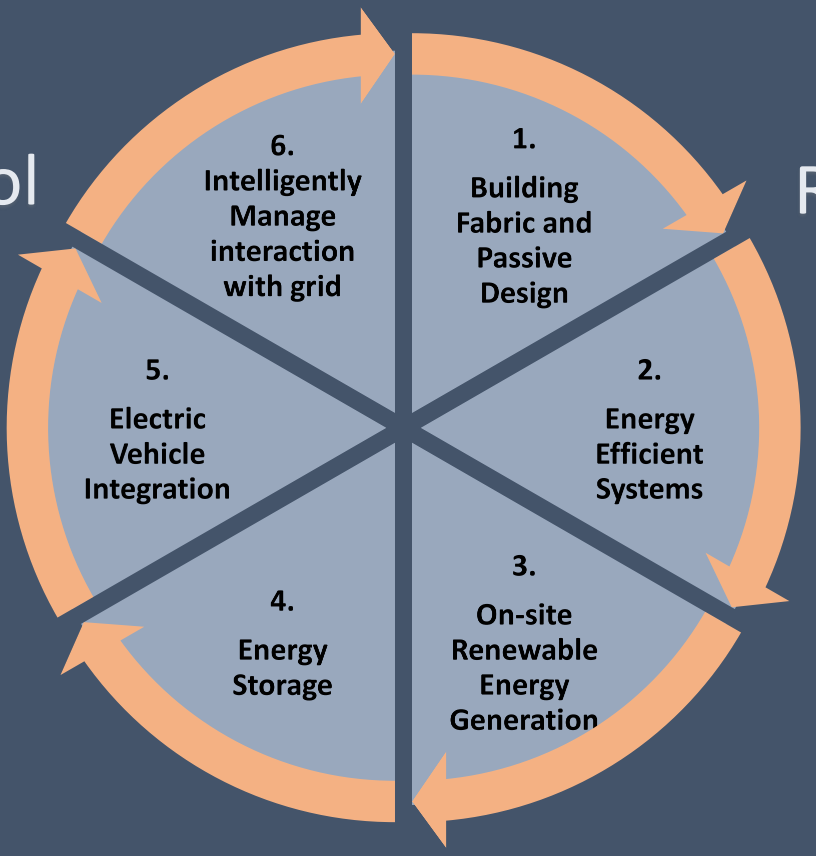
13th August 2020

Active Buildings

"An Active Building supports the energy network by intelligently integrating renewable energy technologies for heat, power and transport"

Active Buildings

specific®



1. **Building fabric and passive design** – integrated engineering and architectural design approach including consideration of orientation and massing, fabric efficiency, natural daylighting and natural ventilation. Designed for occupant comfort and low energy by following passive design principles.

2. **Energy efficient systems** - intelligently controlled & energy efficient systems to minimise loads - HVAC, lighting, vertical transportation. Data capture via inbuilt monitoring to enable performance validation, optimisation and refinement of predictive control strategies.

3. **On-site renewable energy generation** - renewable energy generation to be incorporated where appropriate. Renewable technologies should be selected holistically, given site conditions and building load profiles combining, where applicable, both photovoltaic and solar thermal technologies.

4. **Energy storage** - thermal and electrical storage should be considered to mitigate peak demand, reduce the requirement to oversize systems, and enable greater control, with a view to supporting the local infrastructure through time shifting of demand and controlled export.

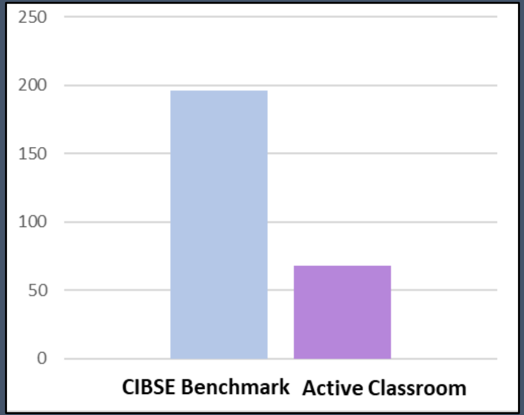
5. **Electric vehicle integration** - where appropriate Active Buildings integrate electric vehicle charging. As technology develops, bi-directional charging will allow electric vehicles to deliver energy to buildings as required, participate in demand side response, and work with the wider building control systems.

6. **Intelligently manage integration with micro-grids & national energy network** – in addition to intelligent controls, Active Buildings manage their interaction with wider energy networks, e.g. demand side response, load shifting & predictive control methods.

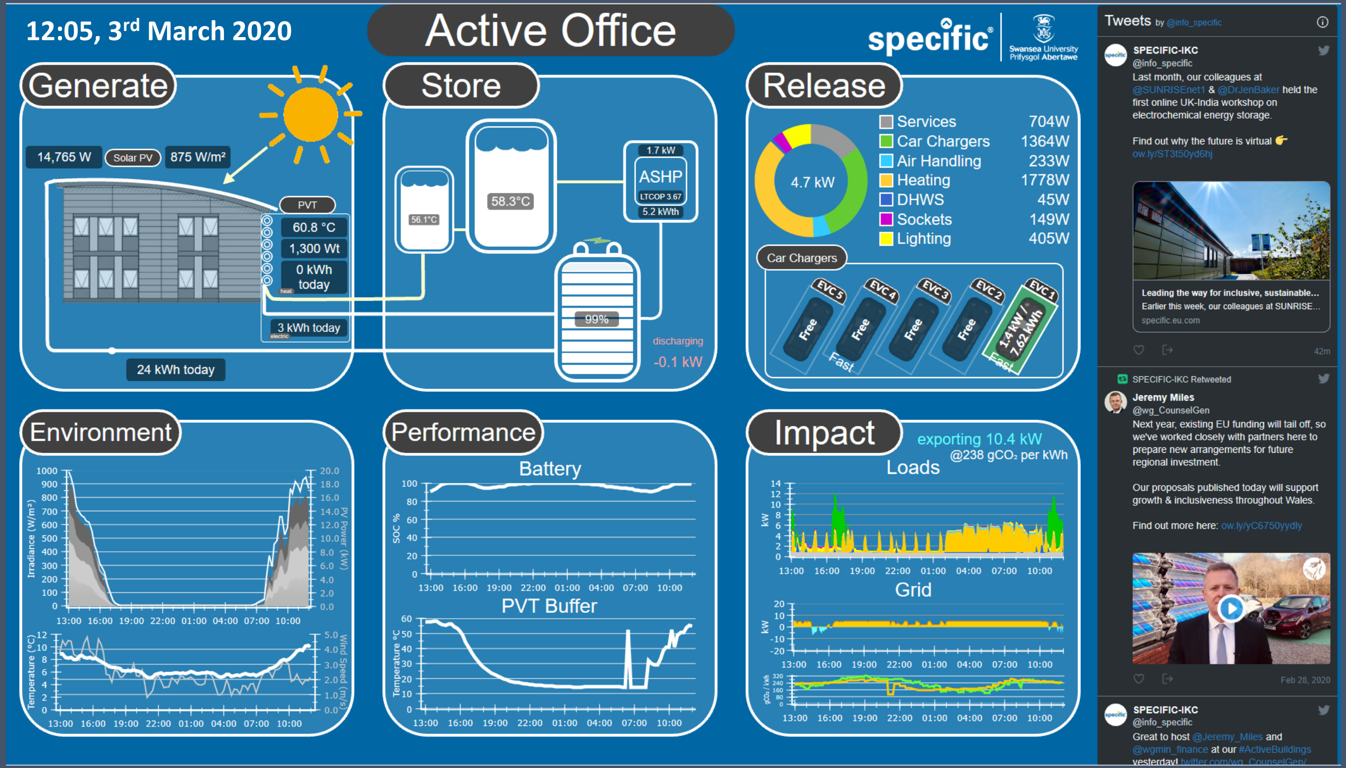
Case Study: The Active Classroom

<u>Key Facts</u>

- Constructed in 2016
- Solar PV, solar thermal, battery storage, novel resistive heating system, new form of construction
- Generated 5.5MWh excess electricity 2017–2018 (enough to travel 26,000 miles in a Nissan Leaf)

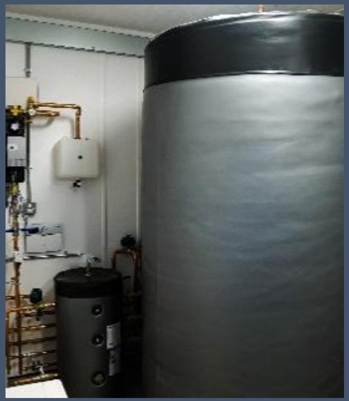


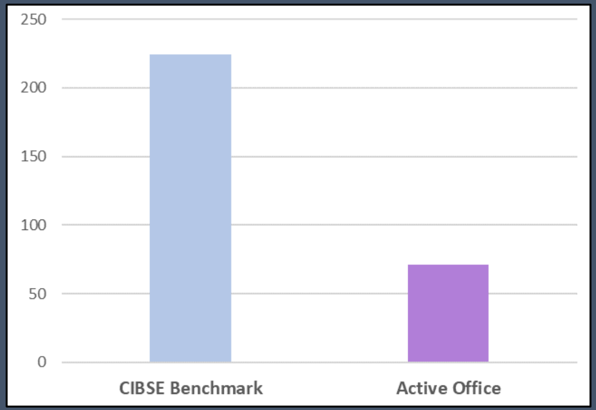
Case Study: The Active Office



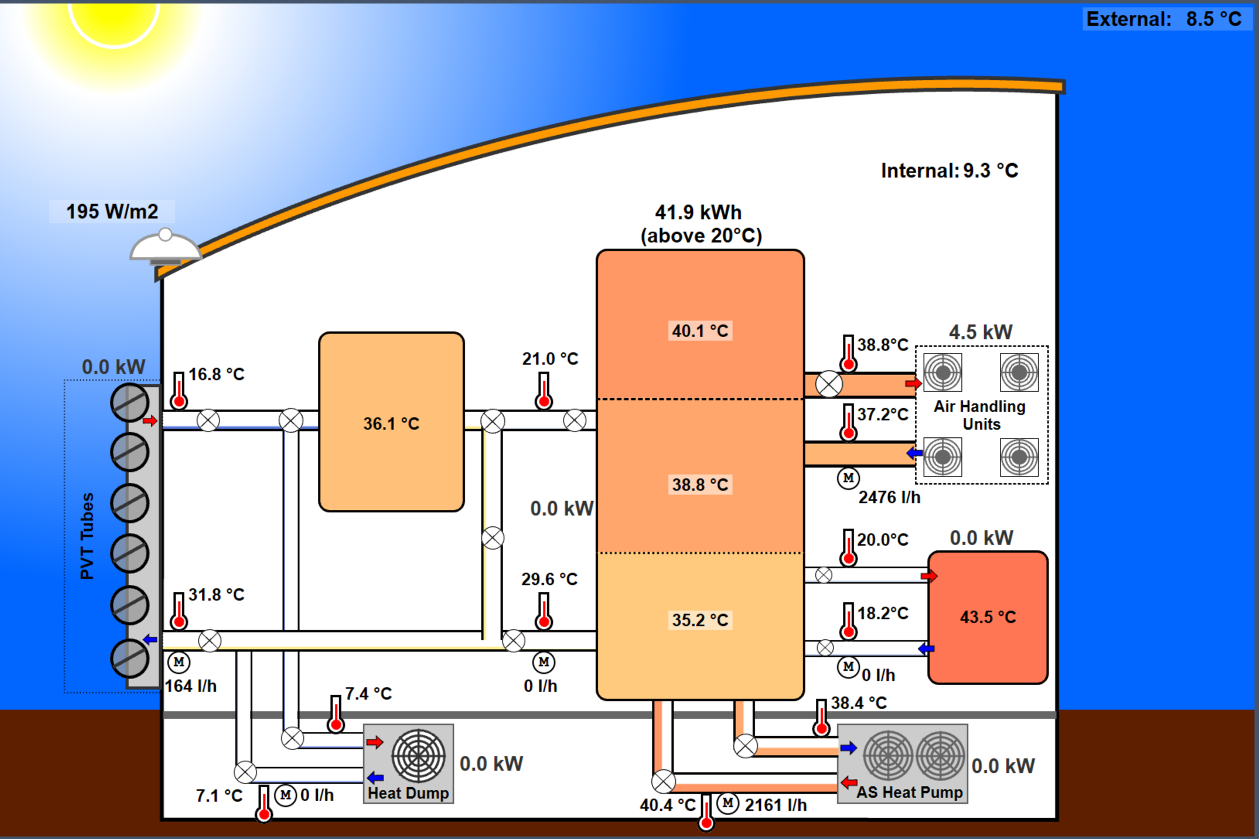
Key Facts

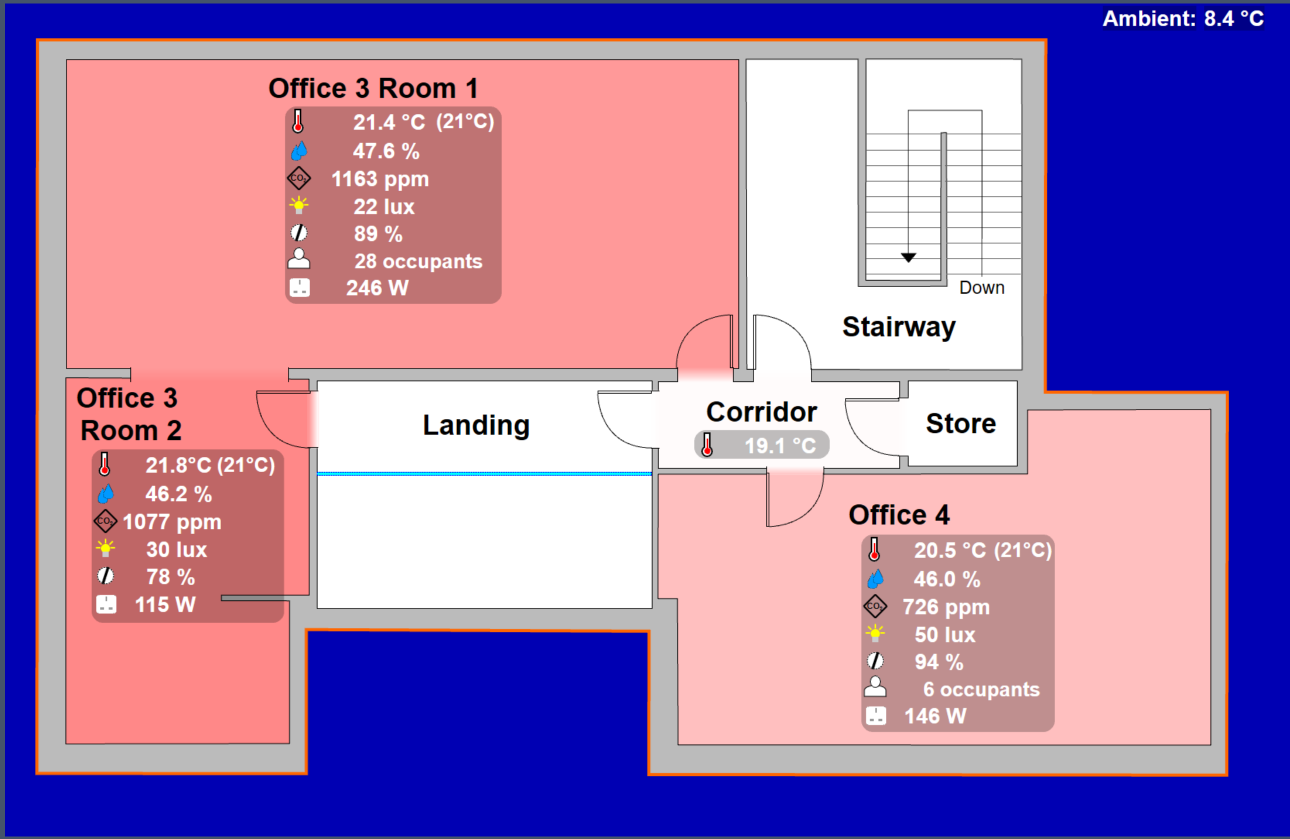
- Constructed in 2018
- Solar PV (curved profile), combined solar thermal and PV (PVT), battery storage, thermal store
- Data collection
- Optimised and predictive controls
- 33% less carbon emissions





Case Study: The Active Office





11.00, 7th November 2019

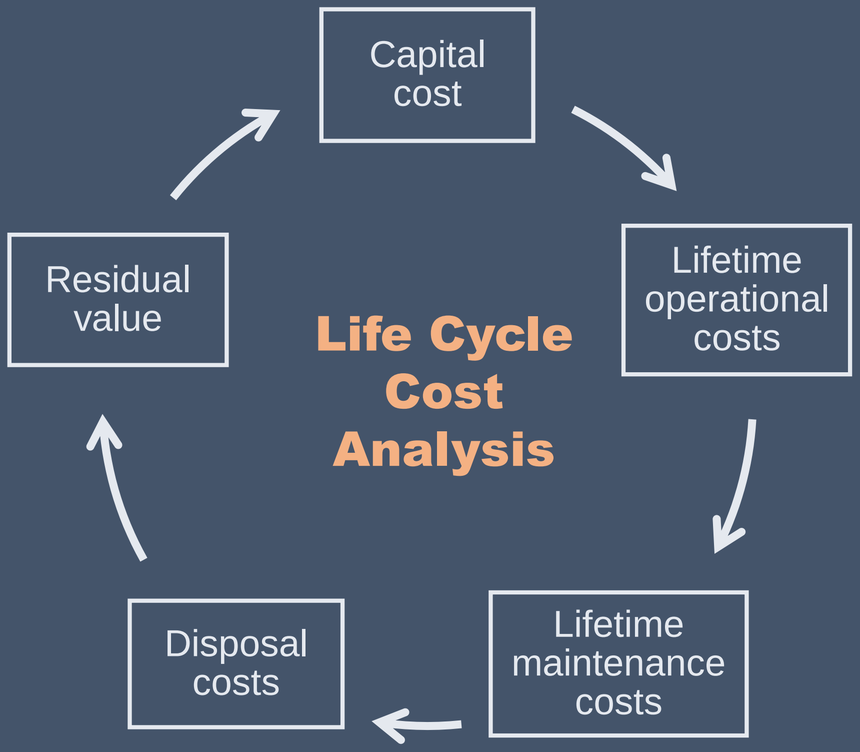
WLC v LCC

Life Cycle Cost (LCC)

costs associated directly with construction and operation of a building

Whole Life Cost (WLC)

LCC + costs such as land, income generated from a building and support costs associated with the activity within a building - usually calculated by clients, using LCCs prepared by construction industry professionals



Why WLC is important?

Construction 2025 target to reduce WLC by 33% by 2025

Encourages the use of best value building designs and reduces the costs and disruption of unplanned repairs and maintenance

Helps clients and design teams to make well informed design decisions, to select the most suitable building materials, components and systems

WLCs are substantially greater than capital costs – it is estimated that the operational expenditure can be up to 5 times as much as the capital cost

Sources:
https://www.gov.uk/government/publications/construction-2025-strategy
https://www.bregroup.com/services/advisory/design/whole-life-costing/
https://constructingexcellence.org.uk/wp-content/uploads/2015/03/wholelife.pdf

RIBA Plan of Work 2020 and life cycle values

- Integrate WLC considerations into **Client Requirements** and **Business Case**
- Develop high level **WLC Plan**

- Set out requirements for WLC in **Project Brief**
- Specify measurable outcomes + targets for WLC
- Determine scope of LCA

- Review **Architectural Concept** against WLC
- Incorporate outcomes for whole life carbon and WLC into **Architectural Concept**

- Use embodied energy + carbon assessment to test relative impacts of design options as part of WLC
- Develop **specification** of sustainable materials + products that balances LCA, maintenance regime, durability, adaptability + cost

- Develop **specifications** that balance LCA, maintenance regime, durability, adaptability and cost

- Consider impacts of variations to **design** or **specification** on LCA, building performance and WLC

- Support assessment of sustainable outcomes for life cycle value

- Monitor operational costs for inclusion in WLC assessment and provide feedback on in use costs as part of POE work
- Gather operational cost data to assess life cycle value and consider life cycle impacts of services and fabric maintenance and repair regimes

Source:
https://www.architecture.com/-/media/GatherContent/Test-resources-page/Additional-Documents/2020RIBAPlanofWorkoverviewpdf.pdf

Case Study: LCC of Active Office

A LCC Comparison Report commissioned in June 2019, comparing the Active Office to a standard office building of the same size over a 60-year period, undertaken by Faithful & Gould (F & G)

Duration: 3 months

F & G Team:
1 Life Cycle Cost Champion
2 Quantity Surveyors
1 Graduate Quantity Surveyor
1 Maintenance Expert
1 Building Physicist

SPECIFIC Team:
1 Architect
1 Technology Director
1 Data Analyst

Activities:

2-day workshop between SPECIFIC and F & G Team

Weekly Update Meetings

Data Collection:
- Active Office Energy Database
- Data on Maintenance Regime
- Cost Data
- Design Drawings & Specifications
- Product/technology Datasheets

Presentation to SPECIFIC team

Produce Final Report

Case Study: LCC of Active Office

Assumptions and Caveats

- Used predicted prices for energy supplied by BEIS
  - No account for different energy prices at different times of the day
  - No predictions after 2032, so prices used stabilised after this time (although likely to reduce)

- Capital costs of products and technologies based on Q3 2018
  - The consultants could only use real cost data, whereas batteries and other technologies predicted to fall dramatically over coming years

- The LCC was baselined, with no sensitivity analysis

- Based on 1st year of occupation, i.e. during commissioning phase
  - We reduced energy consumption by 12% during the second year
  - PVT tubes were not installed for first 6 months of occupation – savings on heat pump usage not included

- No historic data available for the newer technologies, so only warranty information could be used

Case Study: LCC of Active Office

Assumptions and Caveats

- Assumed technology would be replaced at end of warranty period
- Assumed additional maintenance costs, whereas:
    - Batteries are self-maintaining
    - The PV roof needs no maintenance
    - There are no moving parts in the PVT tubes

Omissions/Unknowns

- No business model considerations, e.g. energy trading
- The predicted costs of new technologies over the 60-year period
- Expected lifespan of technologies used
- Future costs of carbon

Case Study: LCC of Active Office

Summary

- Operational energy costs were 29% lower than the standard office
- Operational carbon was 33% lower than the standard office
- Renewal, Maintenance and Operational costs were higher (overall the Active Office cost 22% more)

  (Due to the demonstration nature of the building, there is an element of redundancy of systems and some additional complexity to enable flexibility)

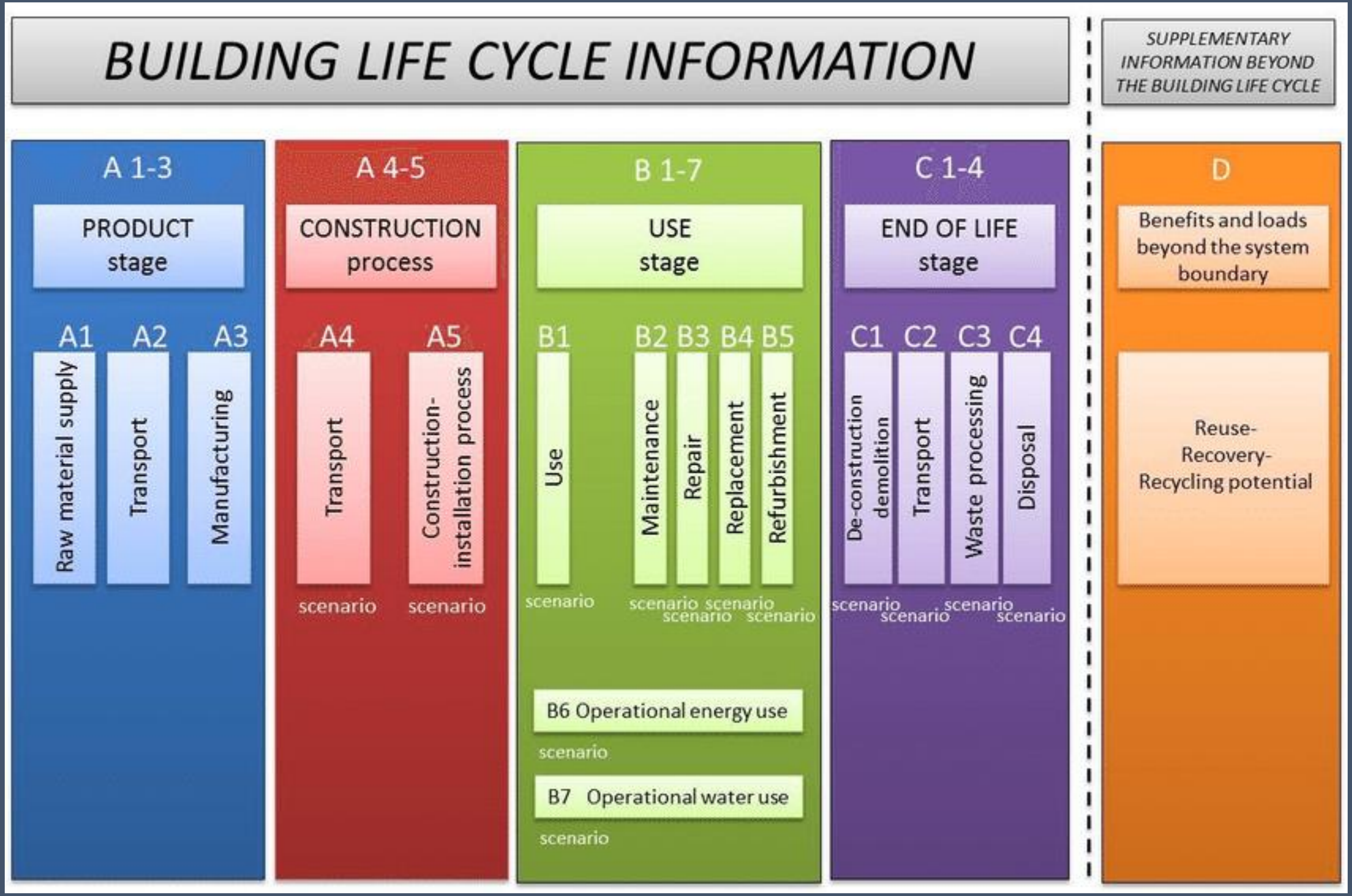
- Considering an intelligent approach to energy trading would reduce WLC
- Assumptions such as zero value at the end of battery life is unrealistic, but value is as yet unknown
- Renewal costs for the PV roof, batteries and PVT tubes are unlikely to remain the same for 60 years
- Technology costs were magnified due to the scale of the building
- Active Buildings can avoid infrastructure costs, the approach may be more beneficial with scale

Case Study: LCC of Active Office

Future Work

- Operate the building and batteries more strategically to drive the carbon and financial costs down further
- Batteries still have 80% life left in them at end of warranty period, and trends indicate battery prices reducing – these are key factors to consider
- Undertake a sensitivity analysis to determine anticipated cost reductions, building lifetime and technology lifetimes
- Reconsider other low temperature heating systems, in lieu of AHUs
- Re-run the exercise with some design changes – less technology flexibility built in for e.g.
- Explore Value Creation – business models using variable tariffs; income generation; reduced infrastructure costs; reduced climate change impact

LCA Description



Case Study: LCA of Active Classroom

Key Highlights

- Able to get sufficient information from construction drawings for quantities of materials used in the building
- Having a good structure for organising building elements and materials is key for being able to interpret the analysis (RICS New Rules of Measurement with groups and elements for building components provides a good industry framework to do this)
- Need to have a clear understanding of what is being assessed, how it is being assessed, why it is being assessed and what is the assessment going to be used for

Case Study: LCA of Active Classroom

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Challenges

- Matching of materials with information from underlying LCA database can be challenging for novel or uncommon materials - leading to increasing uncertainty

- Limited information available for building services, both in the way that mechanical and electrical drawings are prepared and in the limited inclusion of material information in LCA databases

- Challenging to validate assumptions (regarding material composition, manufacturing processes, life expectancy, etc) for novel and innovative materials used in new constructions

- Sources of uncertainty arise from issues, such as:
  - material quantities differ from that calculated off drawings
  - material specification differs from what is listed on drawing
  - assumptions regarding source of materials if unknown (includes material processing, transportation)
  - maintenance and refurbishment cycles

- Information needed to undertake a detailed LCA study is not available during early stage design, making design decisions without negatively impacting the whole-life environmental impacts is a challenge (addressing this is the main topic of my PhD research)

Case Study: LCA of Active Classroom

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RICS Level Assessment of the Classroom
(these values are still under review and are likely to be refined following further investigation)

- RICS level assessment of the Active Classroom indicates that the embodied carbon of the Substructure and Superstructure contribute between 650-700kgCO_2e/m^2
    - This does not include MEP systems nor batteries and other technologies incorporated within the Active Classroom (which is the focus of further study)
- Embodied Impacts (including Life Cycle Stages A1-A3) of the substructure and superstructure account for approximately 45% of the whole-life impacts of the building
    - This assumes a 60 year building operation life and does not account for any benefits from the building being designed to be disassembled and capable of being rebuilt

RIBA 2030 Climate Challenge target metrics embodied carbon in non-domestic buildings:

- < 1,100kgCO_2e/m^2 current benchmark
- < 800kgCO_2e/m^2 by 2020
- < 500kgCO_2e/m^2 by 2030

Thank you for listening

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www.designingactivebuildings.blog

https://www.specific.eu.com/what-are-active-buildings/