Building Performance Evaluation - Performance Gap & the role of BIM in closing this gap

A Joint Constructing Excellence Sussex Club & BIM Regions Sussex Event

Chair Nicola Thomas, BIM Regions Sussex & ZST architects

About the Speakers

Mat Colmer

Mat Colmer is a freelance specialist in building performance assessment and research.
He has spent the last 10 years leading large-scale projects that seek to optimise buildings through monitoring, learning and continuous improvement.

Dr Sarah Graham

Dr Sarah Graham has 20 years experience in building design. Her credentials include MSc, BEng(Hons), EngD Virtual Environments, Imaging & Visualisation.
She is an expert in BIM & the positive impact it can have on the design process, collaborative working, low energy design, sustainable design/ assessment & energy management.

BPE and the Performance Gap

Mat Colmer

Built Environment Specialist

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@digicatapult

CATAPULT Digital

DIGITAL CATAPULT CENTRE

Digital Catapult

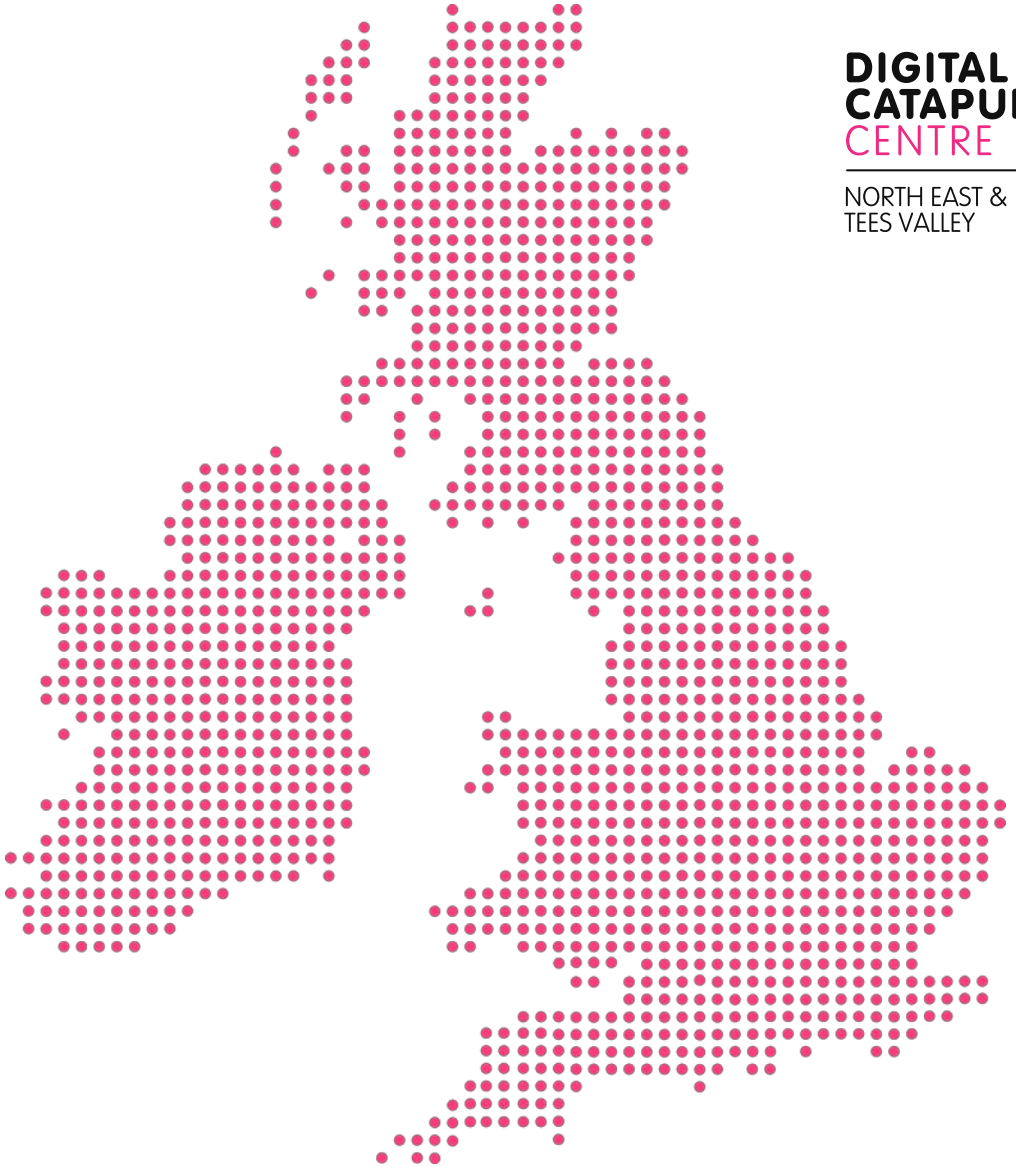
Developing breakthroughs for the UK's data sharing movement

Data driven innovation has the potential to create $300bn of economic value in the next decade

(Mckinsey 2011)

CATAPULT Digital

Five centres across the UK



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We work across the UK with

- Digital communities
- Innovation clusters
- Businesses (all sizes)
- Public sector
- Research
- Government
- Universities and academics
- Not-for-profit organisations

CATAPULT Digital

Our four focus areas

sharing closed data between organisations

sharing personal data in a way that's secure and trusted

sharing content and licensed data more simply

sharing data generated across the Internet of Things

CATAPULT Digital

We help others work together
We never work alone

VTT
open data institute
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CW Cambridge Wireless
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UCL
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Sunderland Software City
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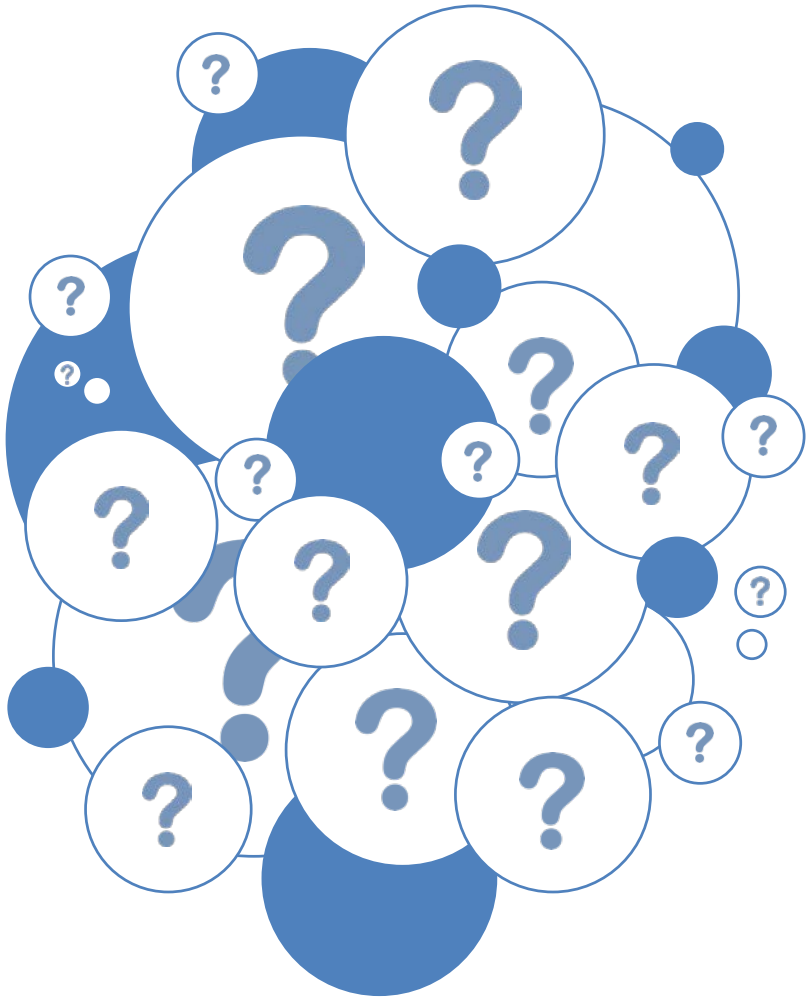
Innovate UK







Why is the performance gap important?



UK legal target to reduce GHG emissions by 80% by 2050

Buildings account for 35% of UK GHG emissions

- The energy used in homes accounts for more than a quarter of energy use in the UK
- More energy is used in housing than either road transport or industry (Housing Energy Fact File 2013 - DECC)

What we know that buildings (very) often do not perform as well as they are designed to; using more energy and emitting more CO_2 than the designers intended

- Average total domestic carbon emissions 2.6 times higher than design (Innovate UK BPE programme 2016)
- only 1 of the 49 non-domestic buildings had actual carbon emissions that matched the design estimate

Research should lead to solutions

Understanding how real buildings perform is vitally important

We need to learn and share more about the factors and variables that influence performance

This learning must lead to practical solutions

Why can't we pass on information – we have it, but where does it go?

Innovate UK

ZERO CARBON HUB

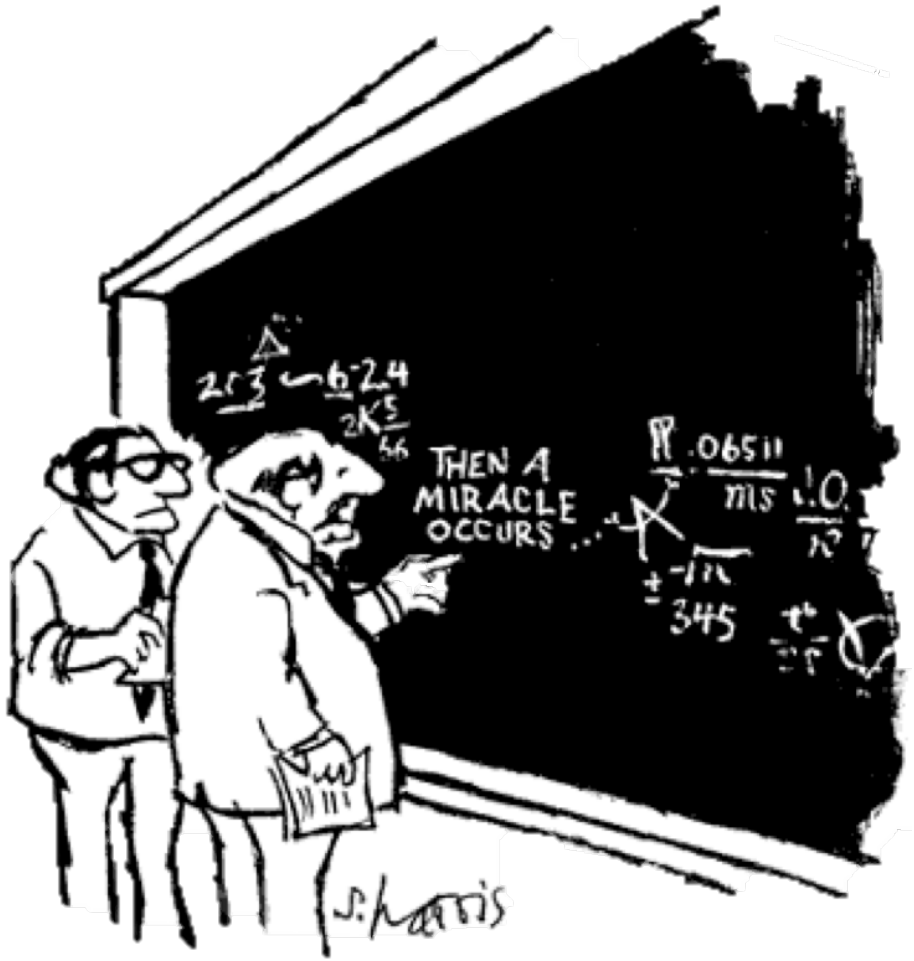
DIGITAL CATAPULT

BUILDING DATA EXCHANGE

What is building performance evaluation?

In order to improve the performance of a building, it is necessary to **understand** exactly what is going on with the building from its design intent, during its construction and when it is in use

Building performance evaluation (BPE) is a form of review which can be used **at any point** in a building's life to understand energy performance, occupant comfort and make comparisons with design targets to ensure that it is performing as intended



"I think you should be more explicit here in step two"

Building Performance Evaluation programme

£8m funding between 2010 & 2014

Case study investigations

Individual buildings & developments

Domestic & non-domestic

Identify factors that encourage good performance

Expose activities that contribute to poor performance

Explore lessons learnt

https://connect.innovateuk.org/web/building-performance-evaluation

Domestic: 53 projects (350 homes, 76 with detailed monitoring data)

- 23 “Early occupation” projects
  - 6 months assessment post construction & initial occupation
- 30 “In-use” projects
  - 2 years detailed performance monitoring and occupant assessment

Non-domestic: 48 projects (55 buildings, 49 with detailed data)

- 8 “Early occupation” projects
  - 6 months assessment of handover
- 40 “In-use” projects
  - 2 years detailed performance monitoring and occupant assessment

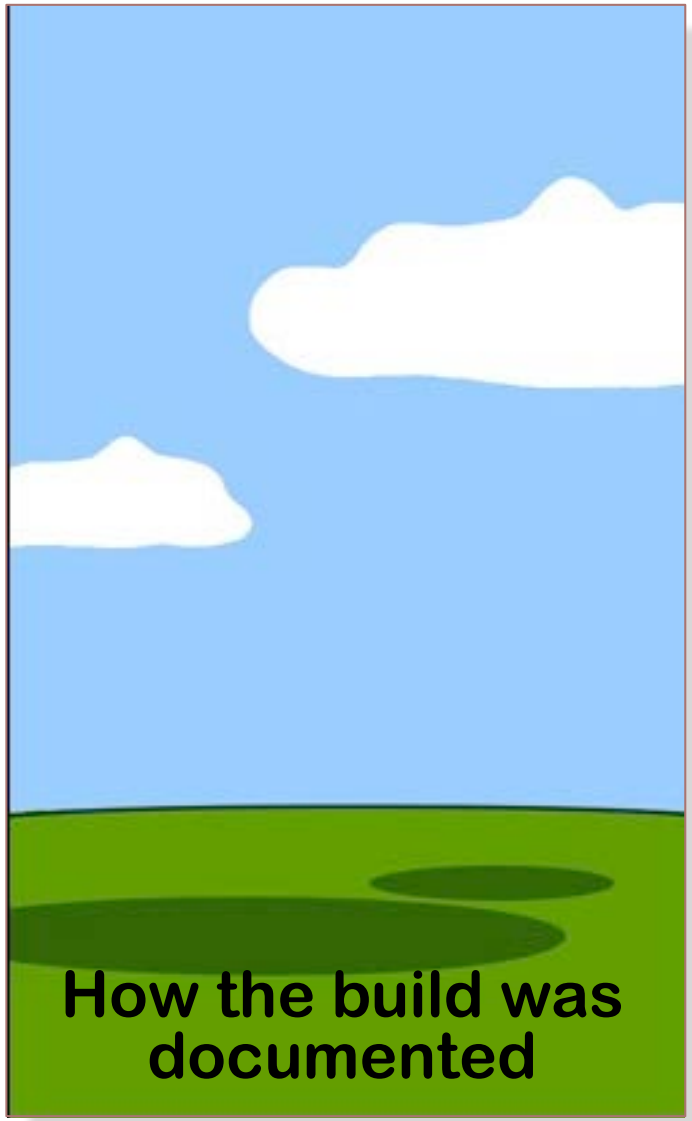
Building Performance Evaluation – in pictures

Images from www.projectcartoon.com

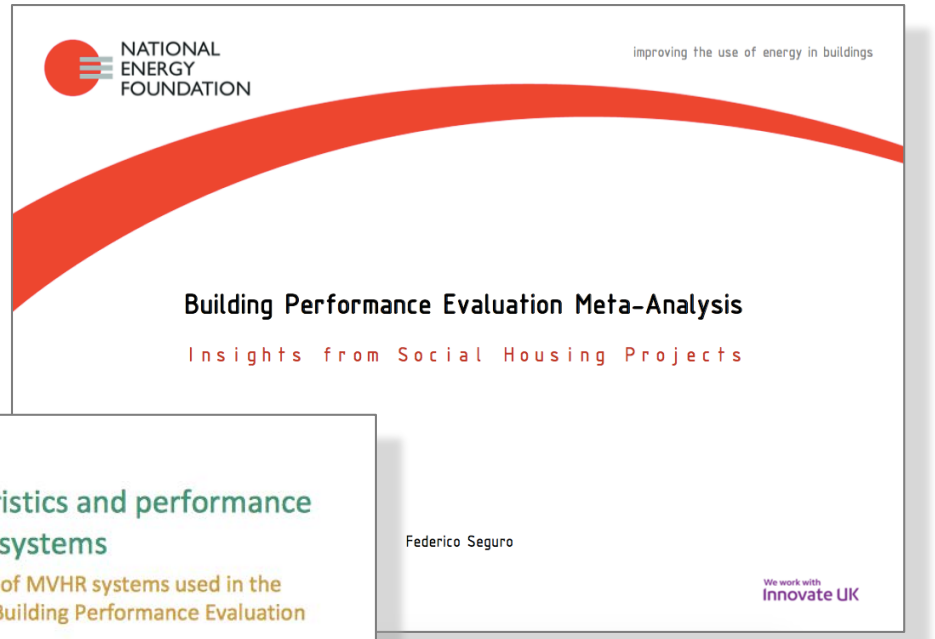
Building Performance Evaluation – in pictures

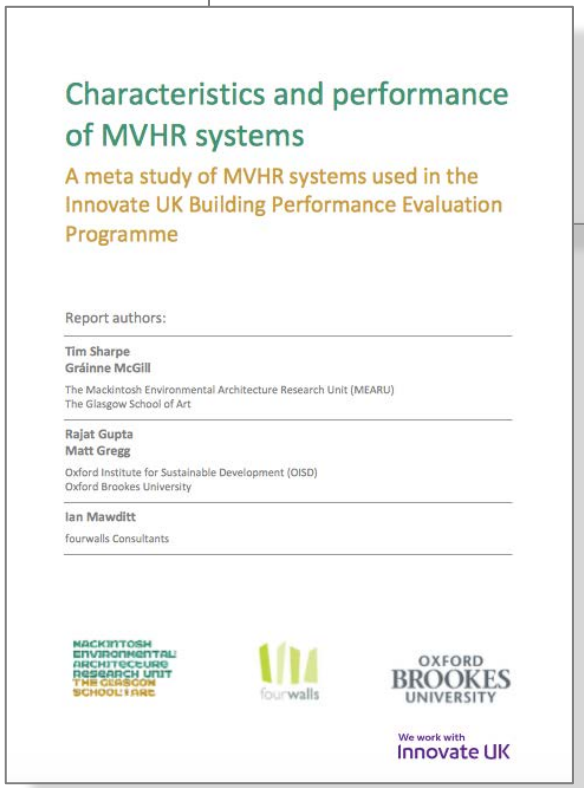
Images from www.projectcartoon.com

Building Performance Evaluation – in pictures



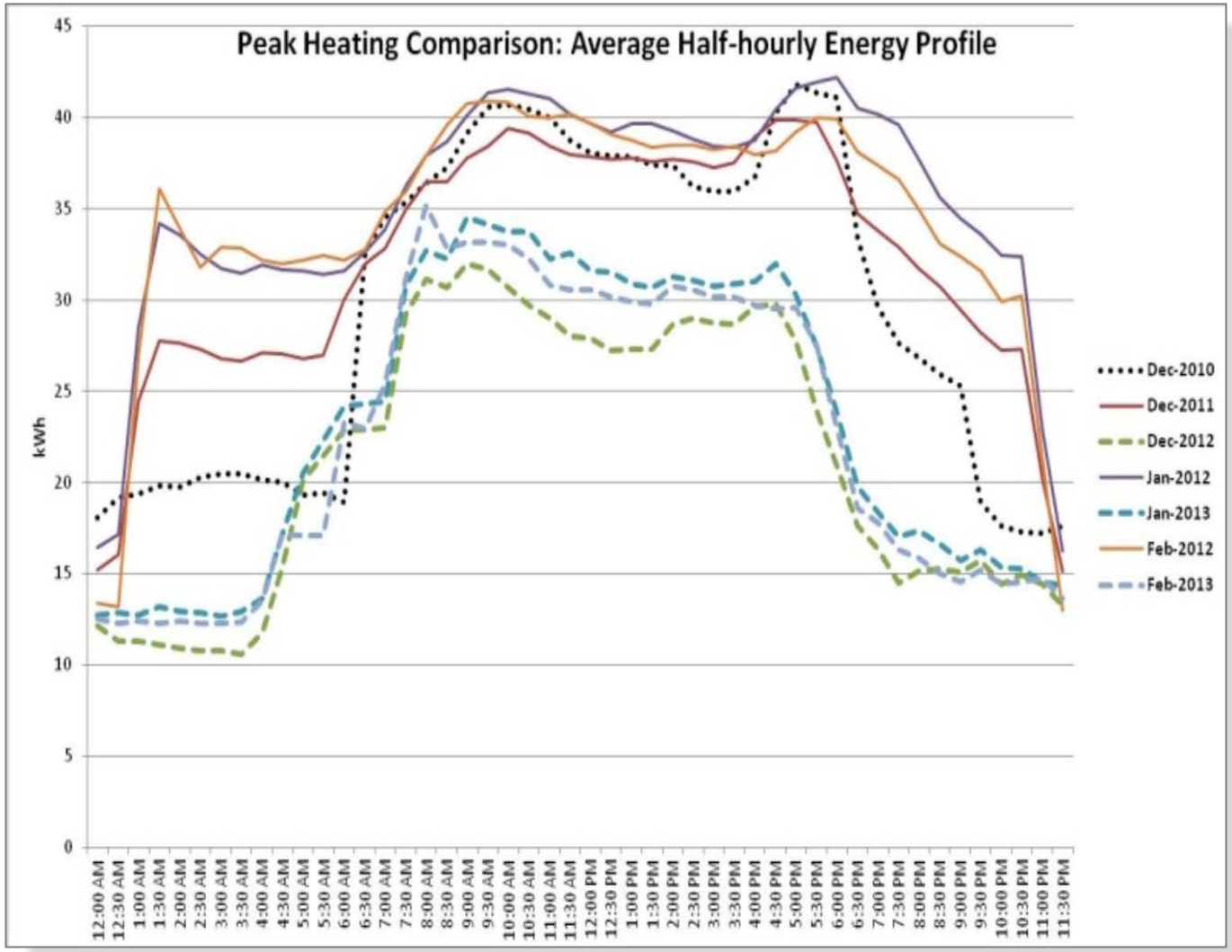
Images from www.projectcartoon.com





connect.innovateuk.org/web/building-performance-evaluation

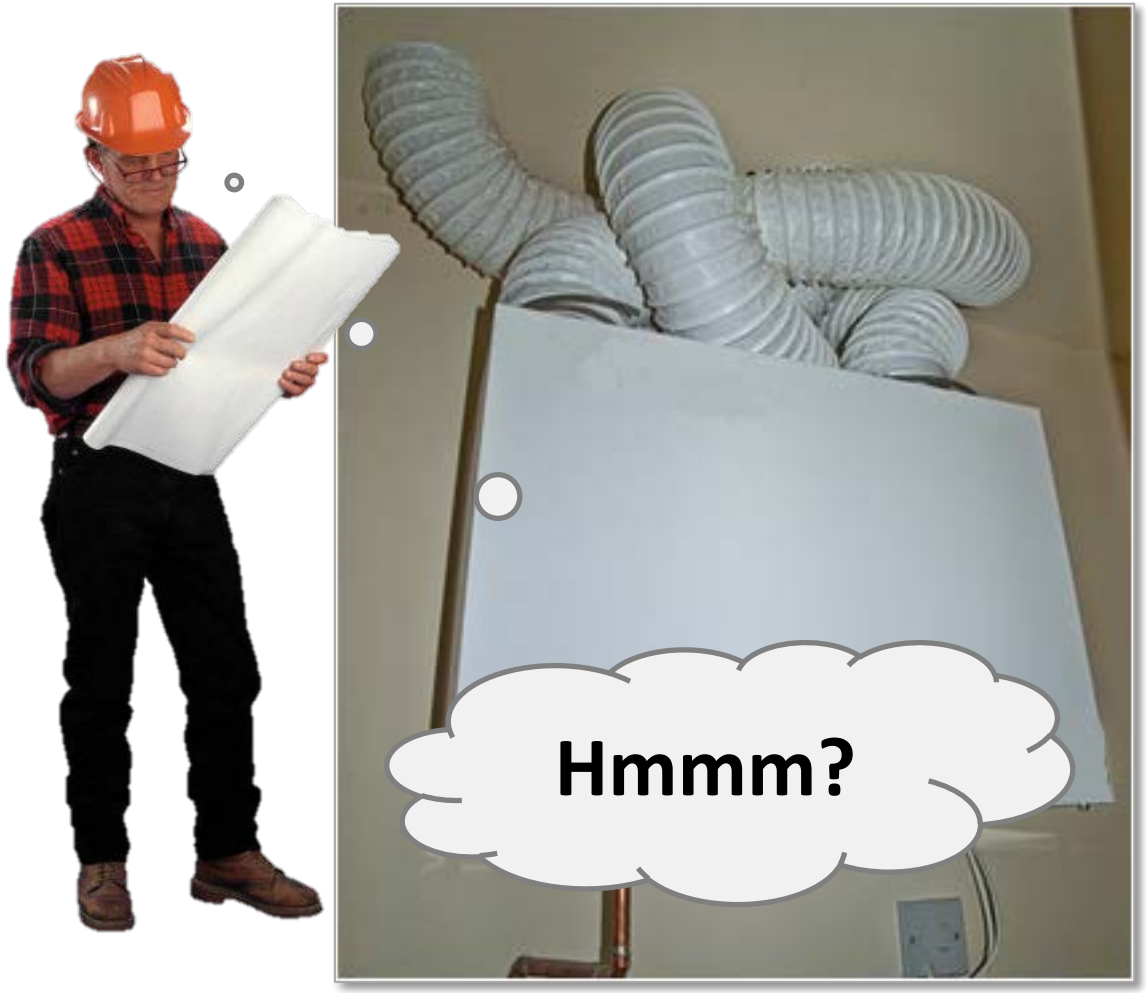
Improving performance - interventions pay



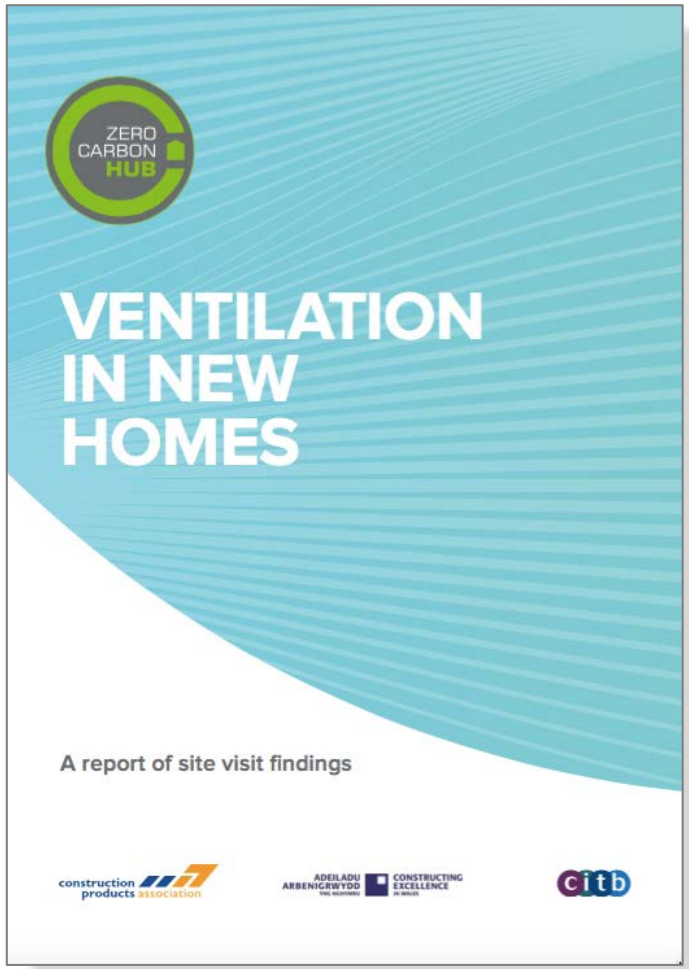
Progressive build up of data and better understanding of operation enabled the Bluebell team to **make interventions to improve performance**, particularly over the heating season

Over two years the energy demand was reduced by 26% giving a saving of **£11.5k** (€15.5k / $17.4k)

Ventilation – delivery improvements



Real findings



Systems may provide inadequate ventilation when in use

There can be excessive noise from systems

Indoor air quality is more stable in MVHR equipped houses – although this does not necessarily mean that the air quality is good

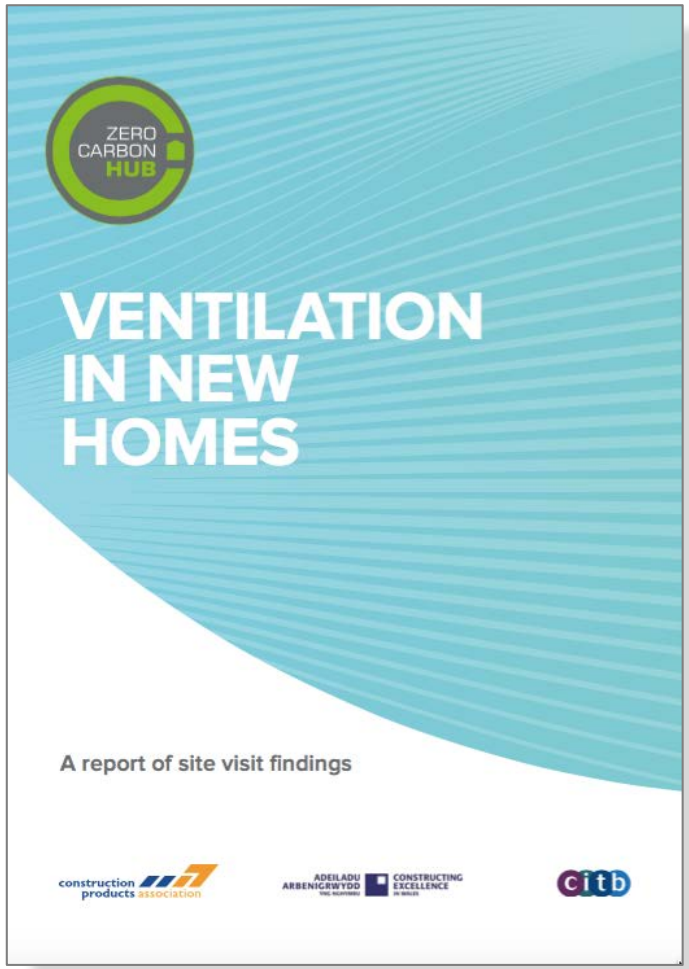
Installation and commissioning requires a lot of attention

Poor maintenance regimes significantly impact performance

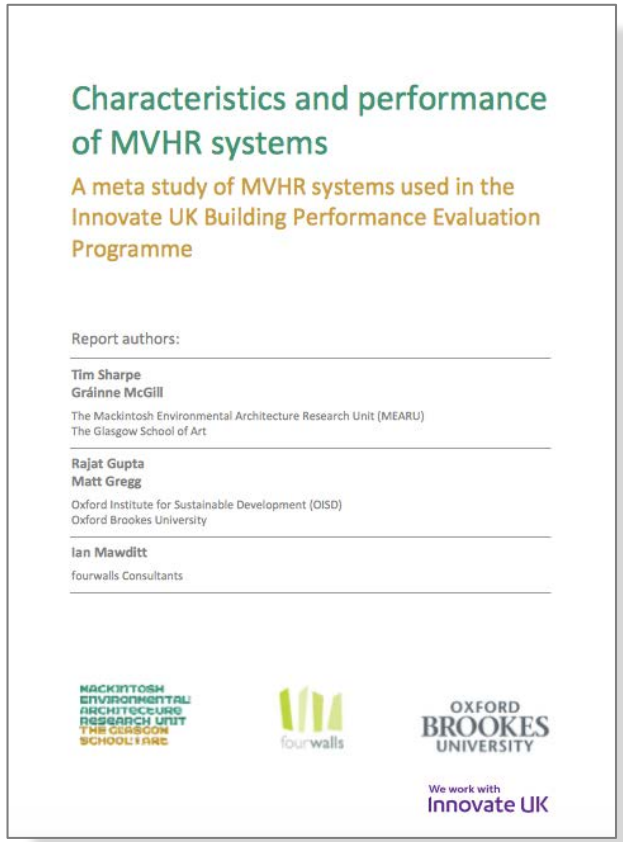
System usability for occupants requires attention

zerocarbonhub.org.guidance

For further information



https://vimeo.com/163384704



zerocarbonhub.org.guidance

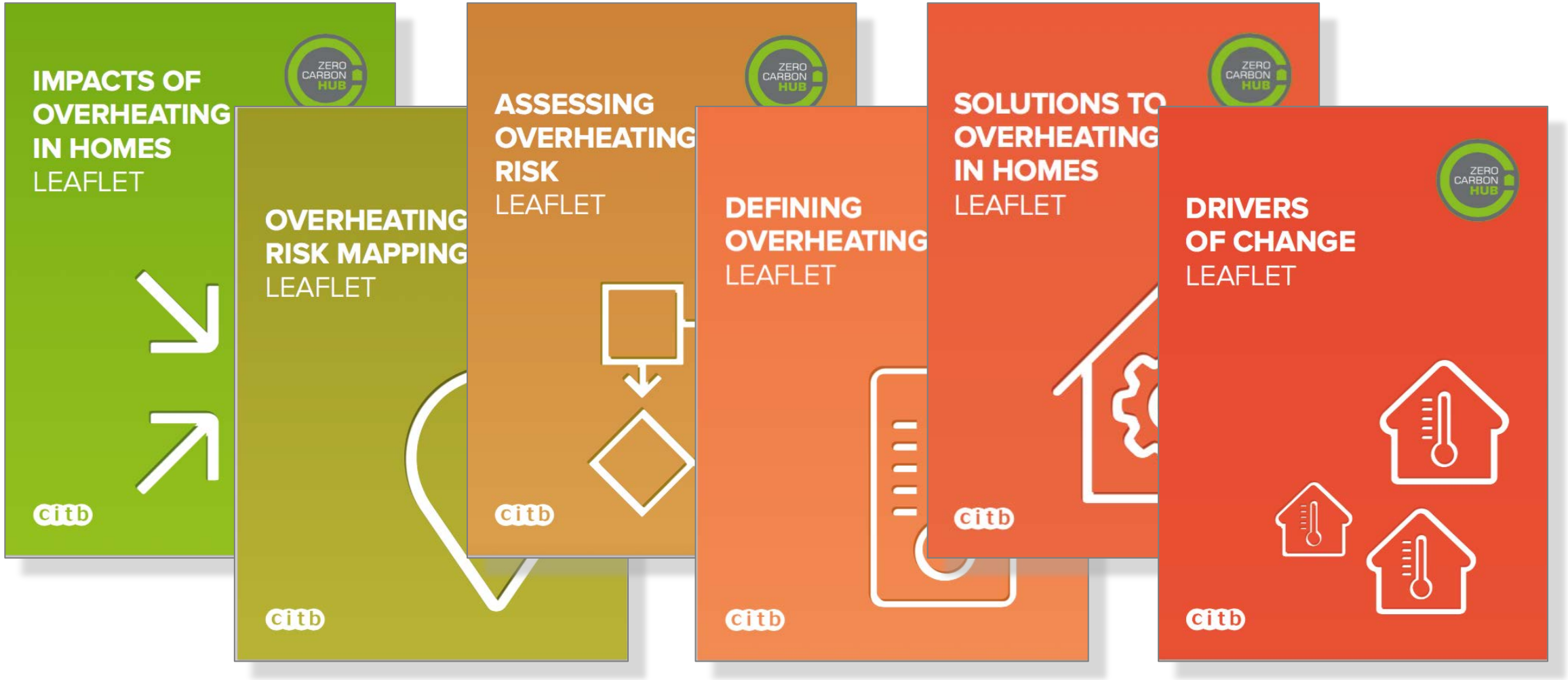
http://radar.gsa.ac.uk/4073/

Are we able to identify overheating risks?

1 Site context 2 External temperature 3 Solar gains 4 Internal gains 5 Building design

Illustration adapted with permission from 'Understanding Overheating – Where to start' (NHBC Foundation NF44, 2012)

Overheating in homes



zerocarbonhub.org/guidance

Practical resources

zerocarbonhub.org/guidance

DIGITAL CATAPULT | BUILDING DATA EXCHANGE

Introducing the Building Data Exchange

www.bdx.org.uk

Mat Colmer
Built Environment Specialist
mat.colmer@digicatapult.org.uk

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THE BDx AIMS TO….

Unlock

Innovate

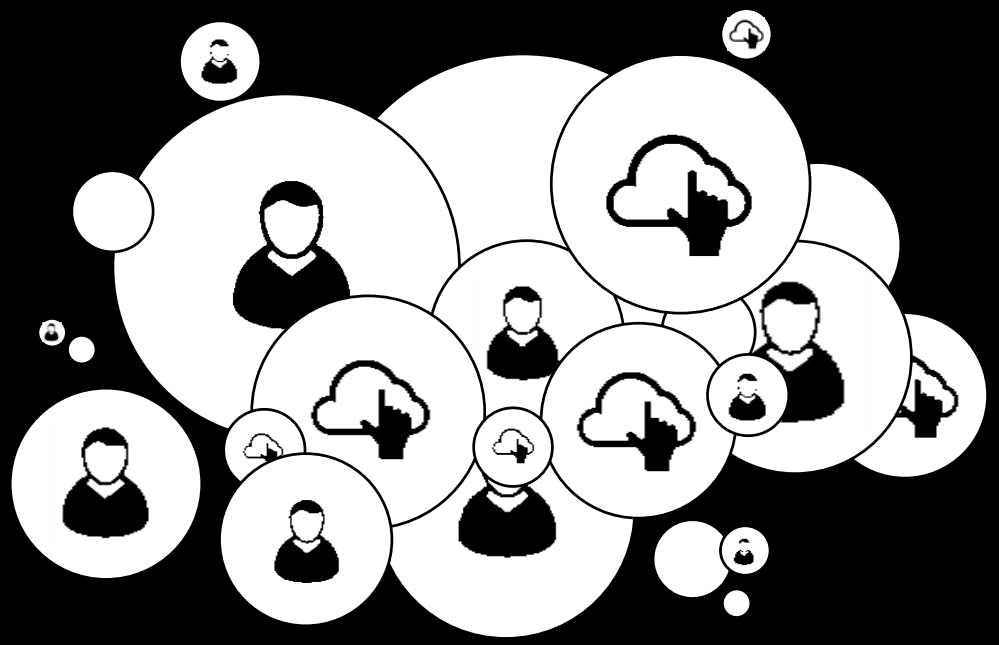
Discover

Engage

THE BDx AIMS TO....

Stimulate the adoption and exploitation of data

1. **Open** Innovate UK built environment data
2. **Create access** to data to encourage **learning** and opportunities for data-driven
3. **Accelerate the transfer** of digital skills within construction and BPE practitioners



www.bdx.org.uk @digicatapult

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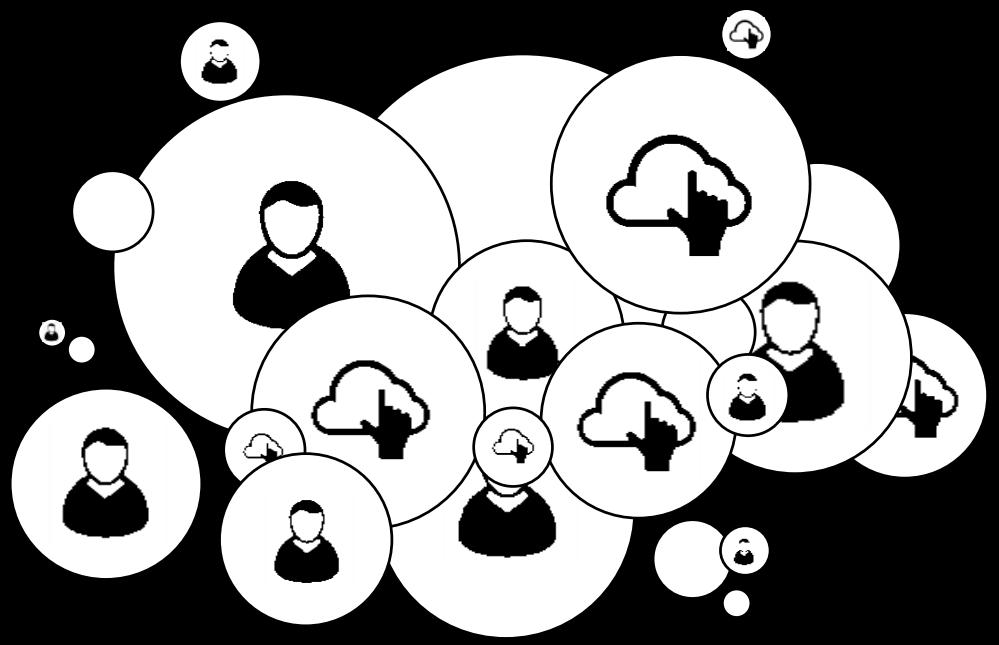
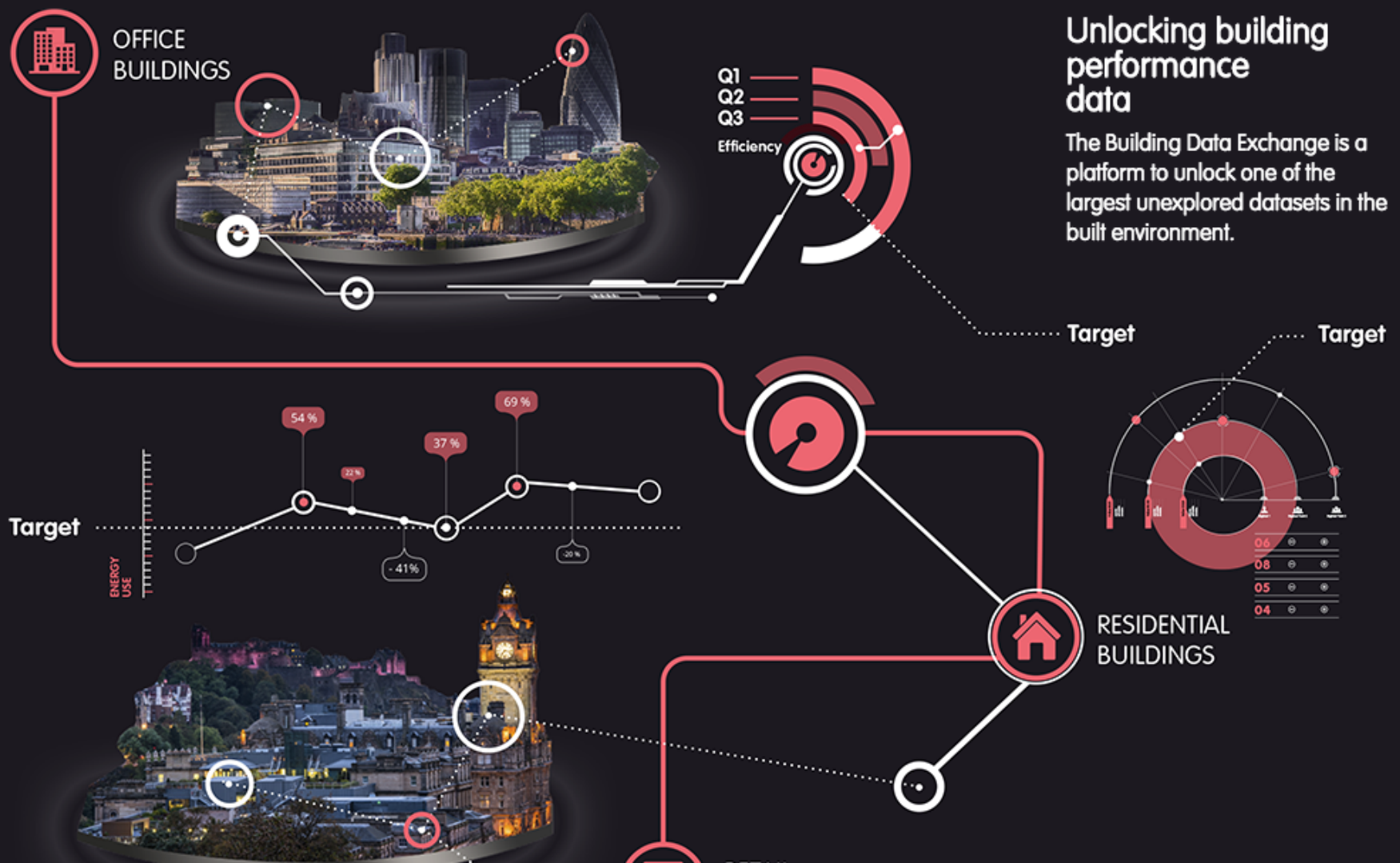
GROWING RESOURCE

Stimulate the adoption and exploitation of data strategies

- An on-going programme
- Industry Advisory Group
- Innovation Pit-Stops
- Exchange of data
- Hackathons





Unlocking building performance data

The Building Data Exchange is a platform to unlock one of the largest unexplored datasets in the built environment.

93 Reports

Airtightness | Commissioning | Control systems | Design | Hot water | Energy demand | Fabric

Handover | Heating systems | Low and Zero Carbon Technology | Metering and monitoring | Internal conditions | Occupant satisfaction | Ventilation

Refine search with Tags

Tags:

- DOMESTIC
- FREEHOLD
- LEASEHOLD
- MIXED TENURE
- NONE

Bessemer Grange Primary School & Children's Centre

Findings of a two-year Building Performance Evaluation (BPE) study of the 1950s Bessemer Grange
an Early Years Centre extension constructed in 2010. The school is in Southwark, South London. Do

EDUCATION (PRIMARY SCHOOL) | NON-DOMESTIC

University of Bath Campus Woodland Court Building

In-use and Post Occupancy Evaluation in Low Carbon Apartments

Project brief

This study focuses on a development in West Yorkshire completed in 2011. The site consists of 14 flats and a communal area, which are home to individuals over the age of 55. The properties are constructed to Code for Sustainable Homes Level 4.

The properties are heated via a district heat main fed from two ground source heat pumps, that feed a 500l buffer tank which in turn is pumped to each flat before being distributed via an underfloor heating manifold. The domestic hot water is also provided by the heat pumps.

Key findings

Key findings indicate that the residents are largely satisfied with the development and are comfortable within their homes. It is however apparent that successfully integrating the heat pump system has been difficult and options are available that may improve the operation and performance of these going forward.

Innovate UK ref: 450083

Sector: Domestic

Project type: in use

Organisation name: Connect House

Structure category: Masonary

Sustainability rating: Code level 4

Tenure: Social rent

Ownership: social

	Design	As built	
SAP	90	86	-4
Air tightness	3	5.87	+2.87
TPER	15.47	18.92	+3.45

Project report

Part of BPE programme.

Preview report

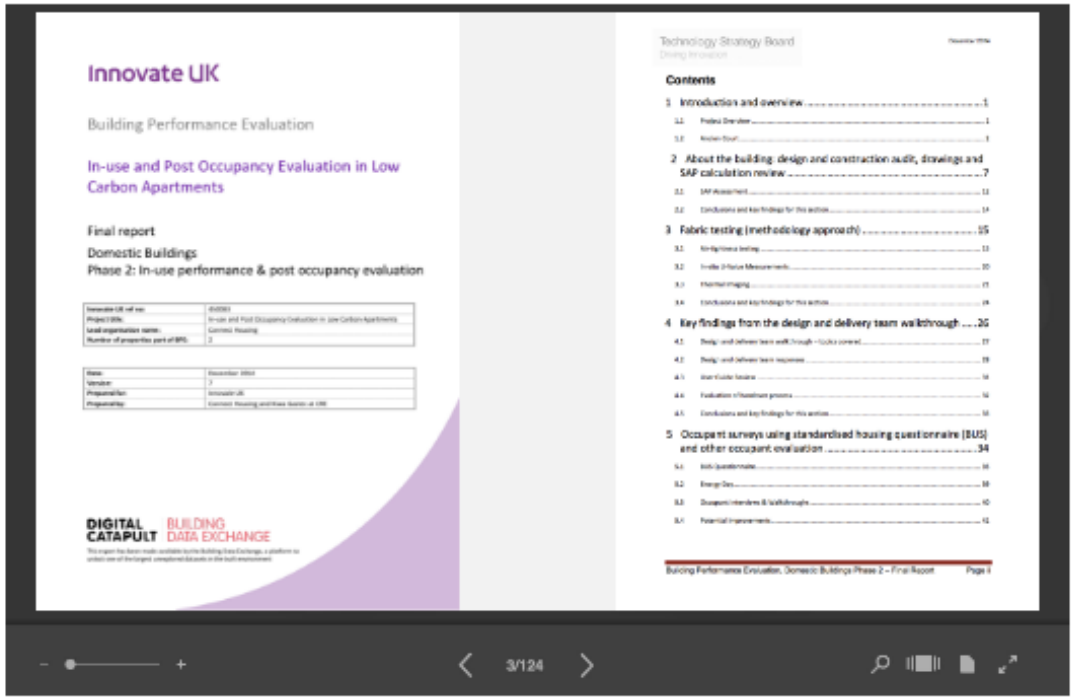
Download full report

Metering and monitoring data on embed

View Metering and monitoring data

Occupants satisfaction survey responses

View building user survey



Innovate UK

Building Performance Evaluation

In-use and Post Occupancy Evaluation in Low Carbon Apartments

Final report

Domestic Buildings

Phase 2: In-use performance & post occupancy evaluation

DIGITAL CATAPULT BUILDING DATA EXCHANGE

Technology Strategy Board

Contents

1 Introduction and overview 1

2 About the building: design and construction audit, drawings and SAP calculation review 7

3 Fabric testing (methodology approach) 15

4 Key findings from the design and delivery team walkthrough 26

5 Occupant surveys using standardised housing questionnaire (BUS) and other occupant evaluation 34

Building Performance Evaluation, Domestic Buildings Phase 2 – Final Report Page i

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Exchange – very challenging

- What data is important
- Information is not complete and uniform
- What is wanted might not exist
- Information is scattered
- Information is not neutral or objective - unsure of provenance
- Data is buried in PDFs
- Organisations do not know what they have – very poor data strategies
- Platforms for sharing are not known
- Not all data can be shared
- How do we **describe**, associate and maybe integrate data?

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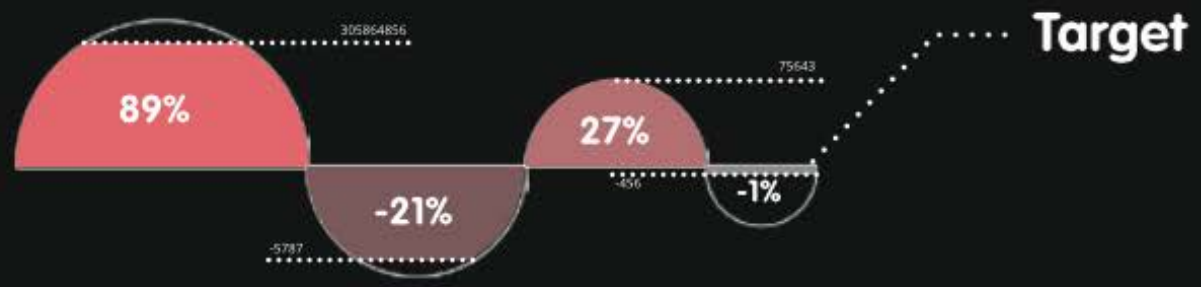

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buildingdataexchange.org.uk

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We work with Innovate UK

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Digital Catapult

mat.colmer@digicatapult.org.uk

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Sussex BIM Region Event

BIM and Building Performance

Introduction

Building Performance

BIM & Soft Landings

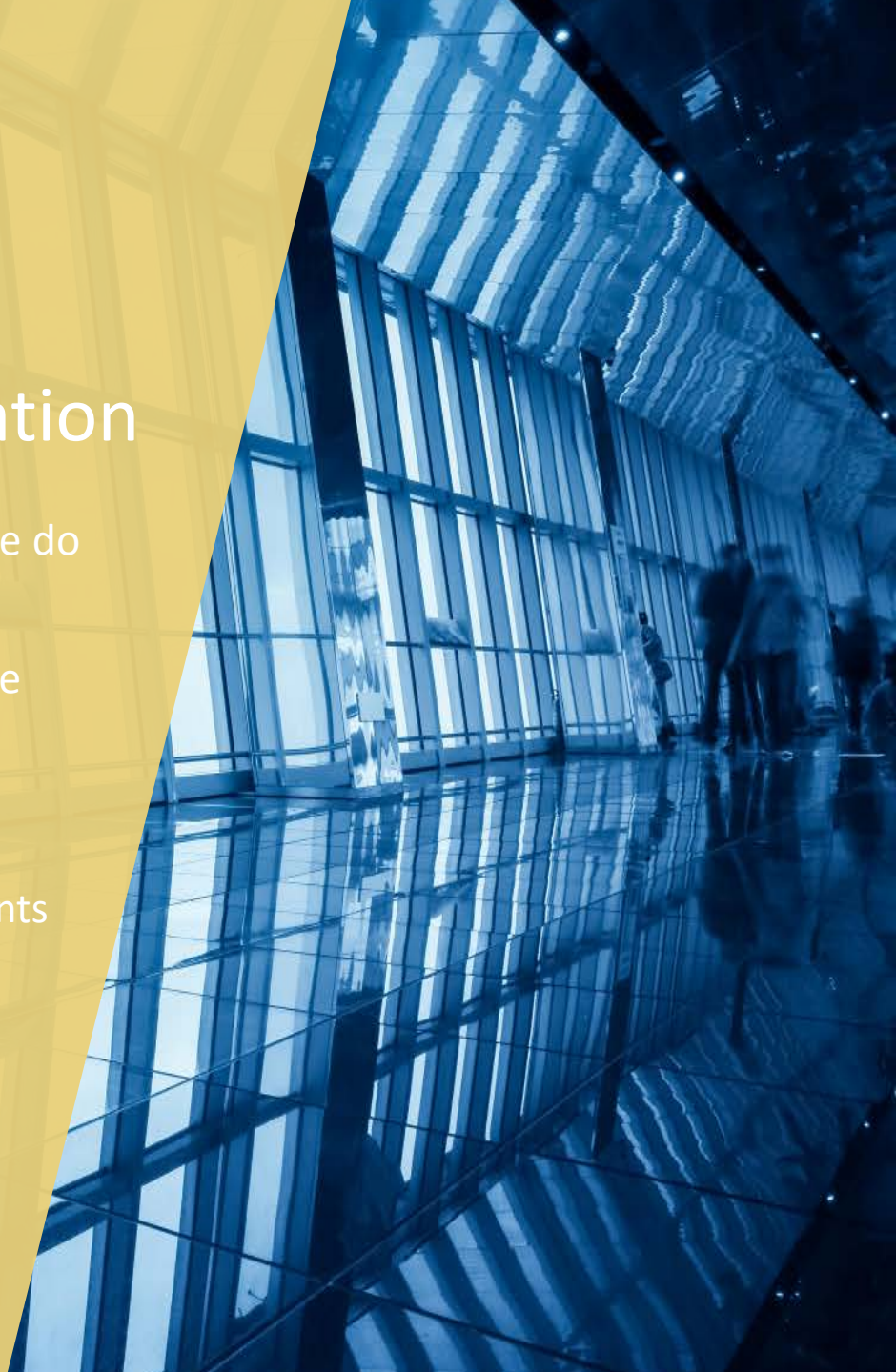
Case Studies

Pioneers of Building Simulation

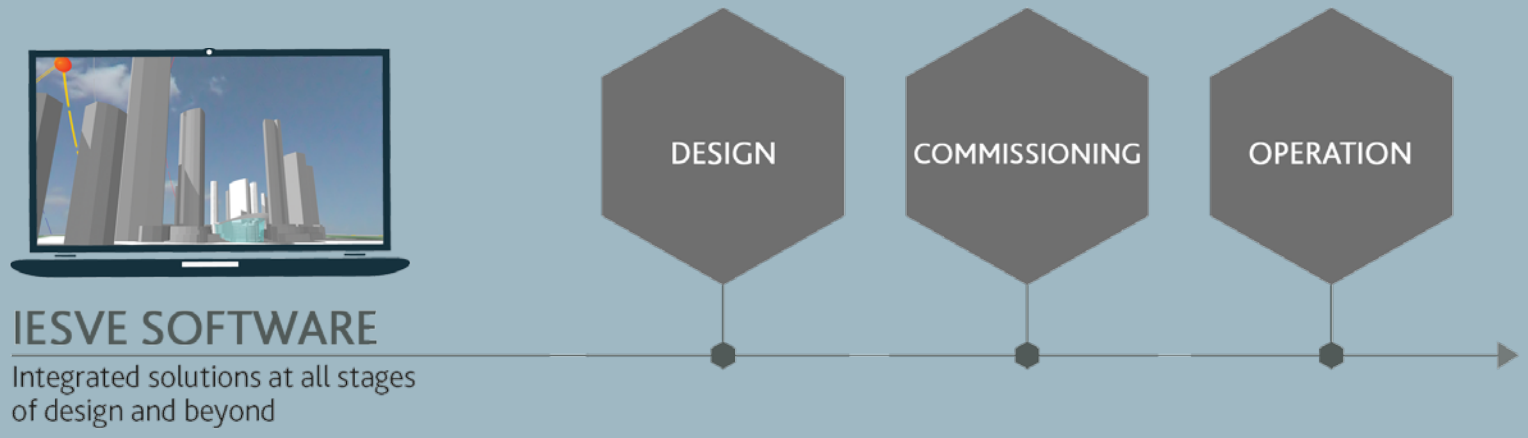
VE Technology & IES people at the core of all we do

Located in Glasgow, Dublin, Paris, Atlanta, San Francisco, Vancouver, Pune, Dubai & Melbourne

In over 140+ countries IES are helping…
Architects, Engineers, FMs, Cost Consultants, BREEAM Assessors, LEED Assessors, Developers, ESCOs, Contractors, Local Authorities, Governments & Academia



An Integrated Approach



Building Performance

Building Performance

"This Agreement…aims to strengthen the global response to the threat of climate change by...holding the increase in the global temperature to well below 2C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5C above pre-industrial levels."

Building Performance

2.4 billion

growth in global population by 2050

50% → 70%

Growth in city dwellers between now and 2050

2 billion

Additional city dwellers by 2050

36 million

Additional households in the world's 20 largest cities alone by 2025

4.9 billion

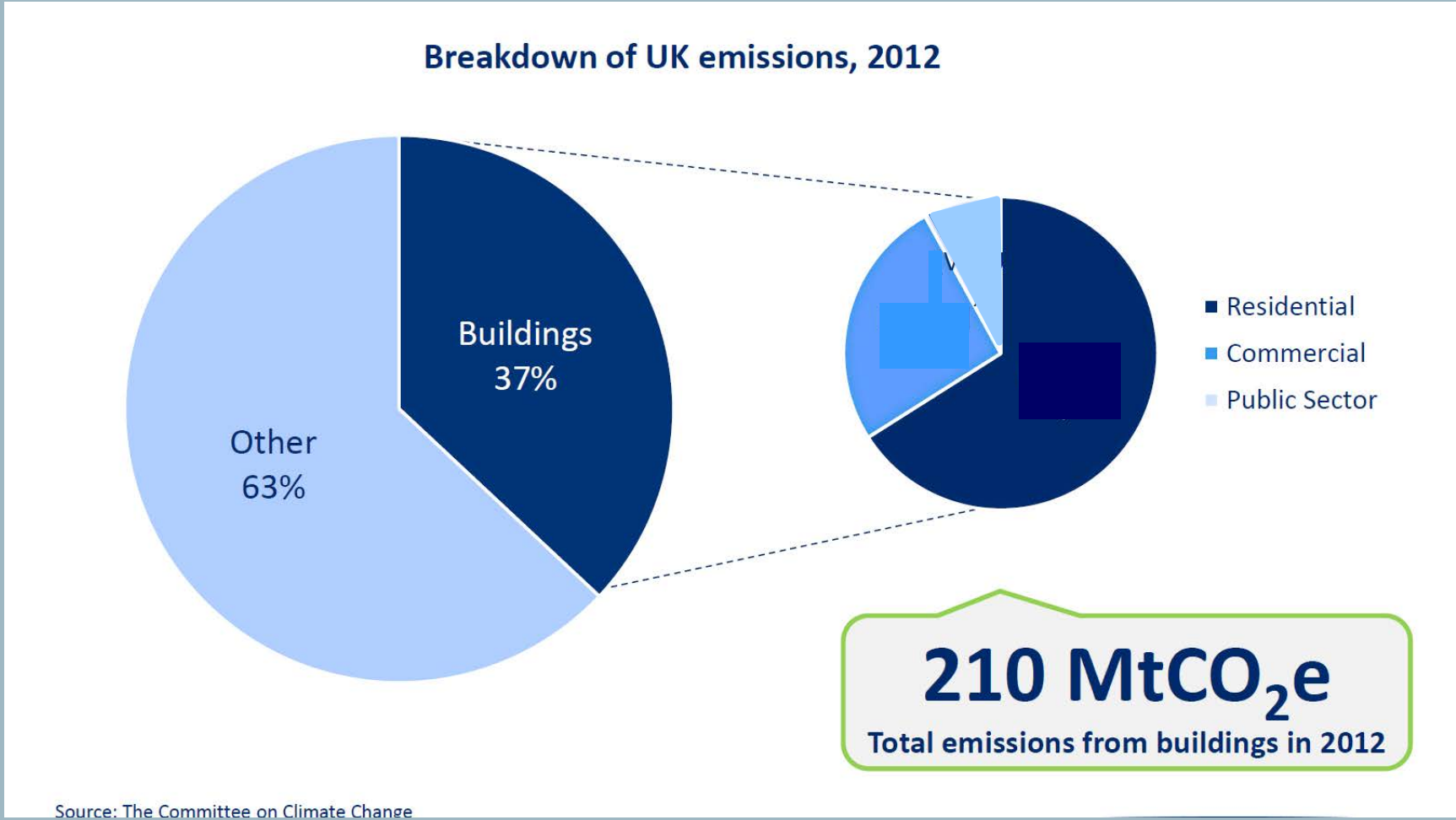
Additional middle class people by 2030

$15 trillion

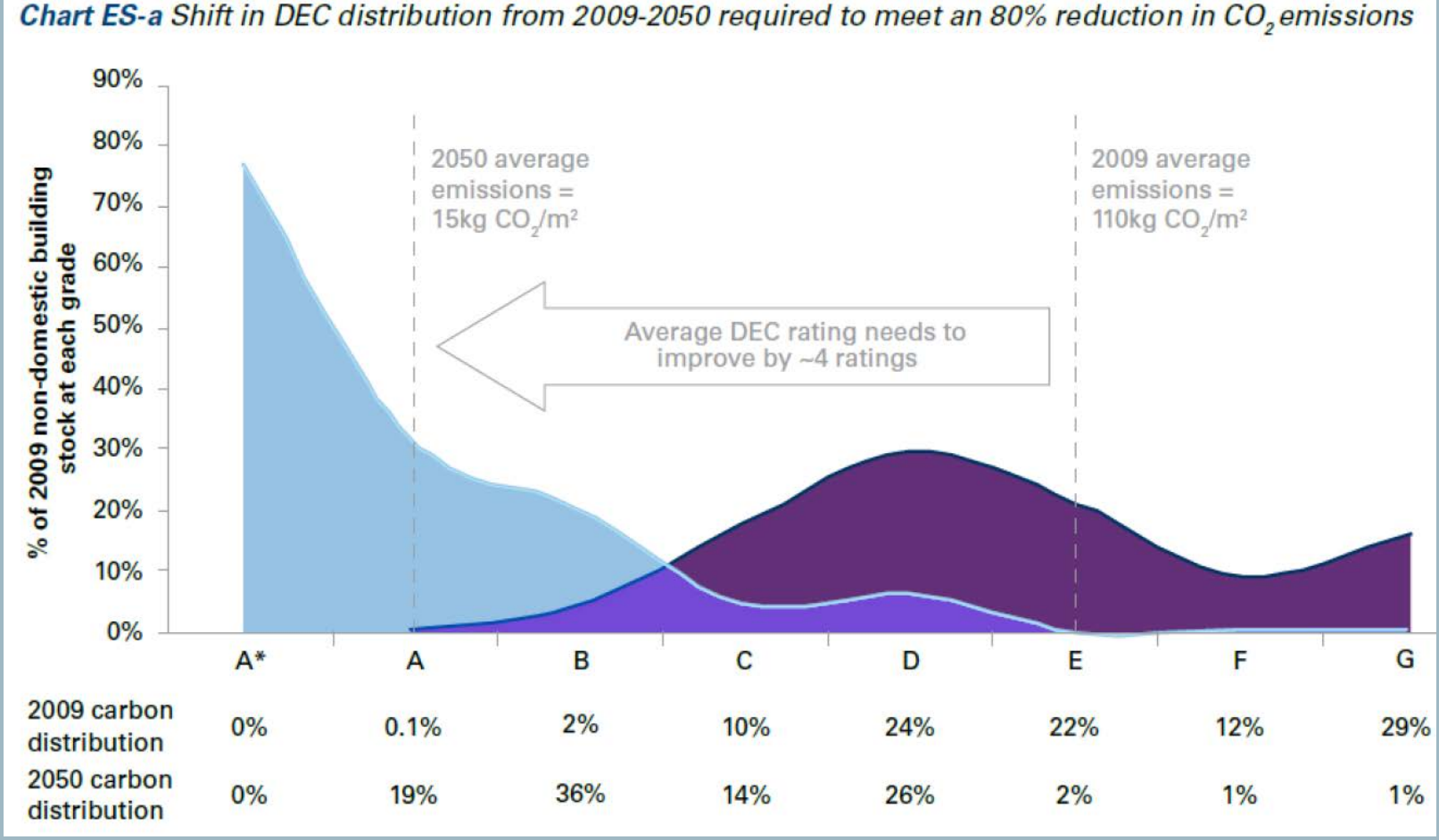
Global construction output by 2025

The Carbon Trust

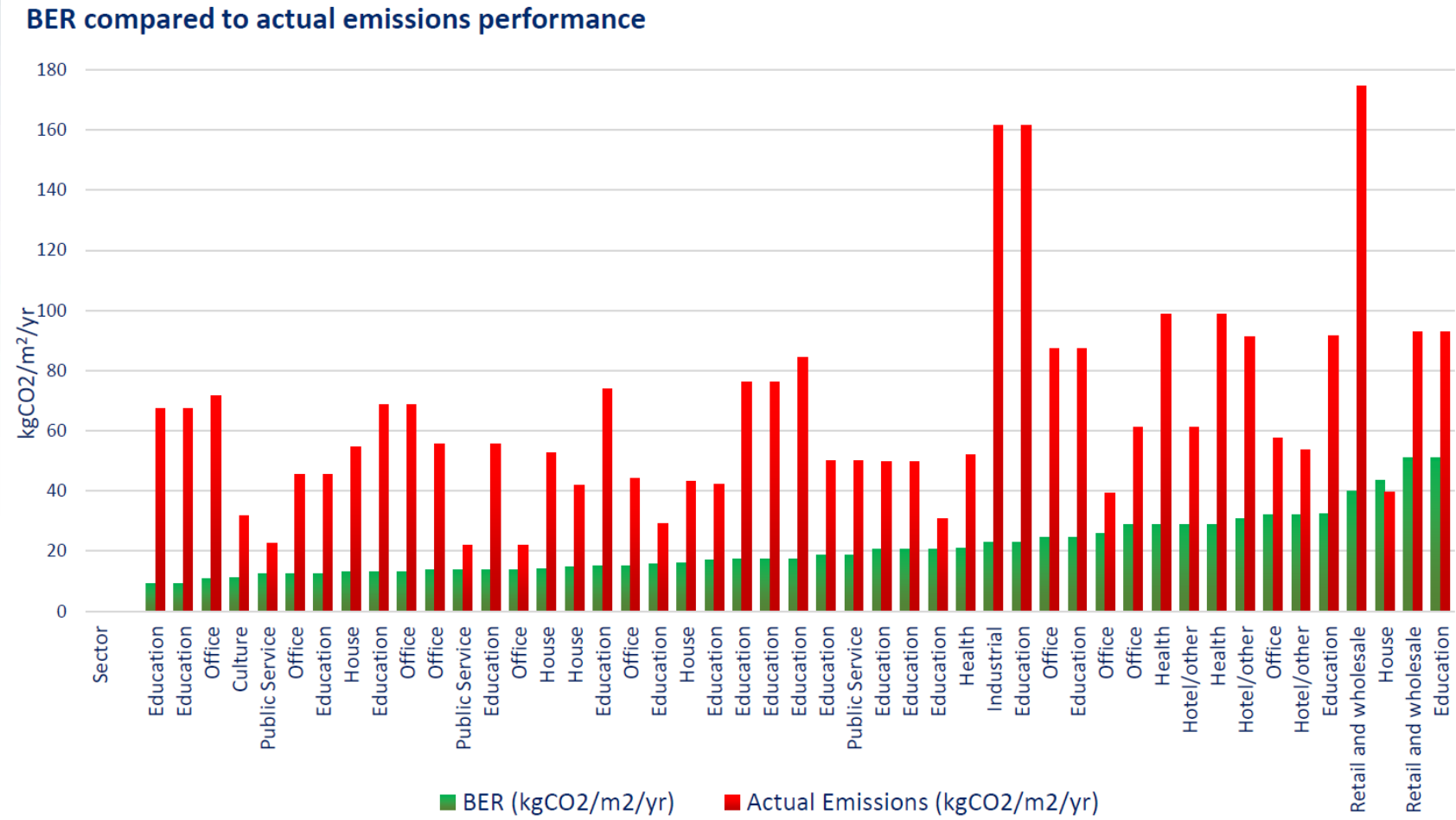
Building Performance



Building Performance



Building Performance



Innovate UK Building Performance Evaluation Programme

Performance Gap

Performance Gap

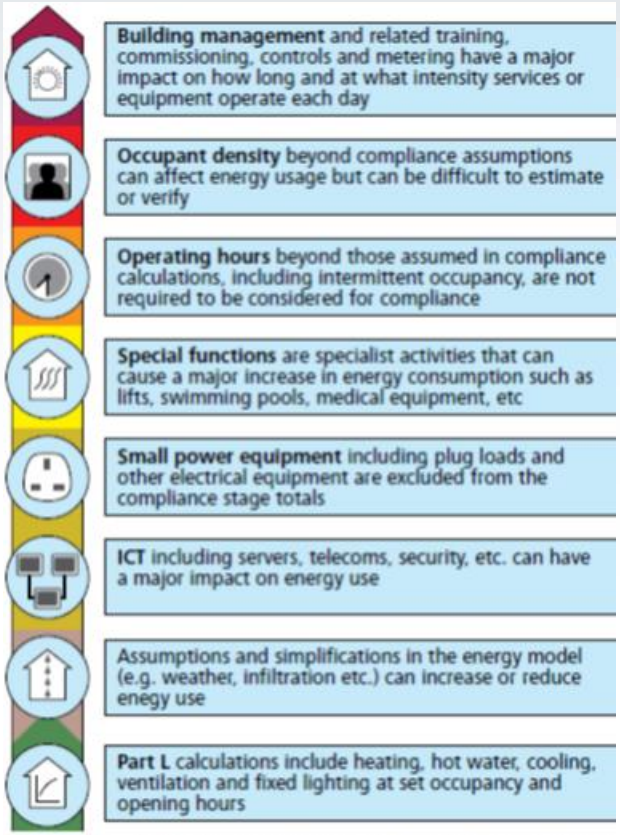


Figure 2 Reasons why Approved Document L2A compliance calculations differ from operation energy use (based on a CarbonBuzz diagram (http://www.carbonbuzz.org))

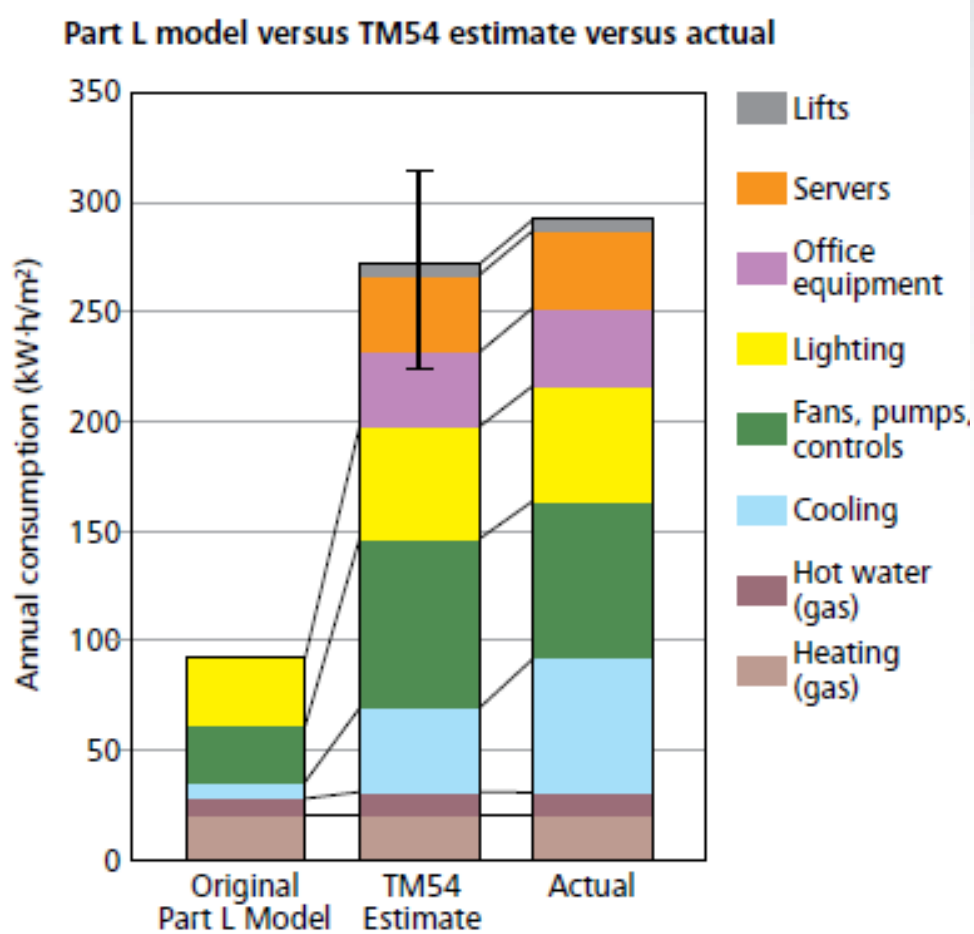
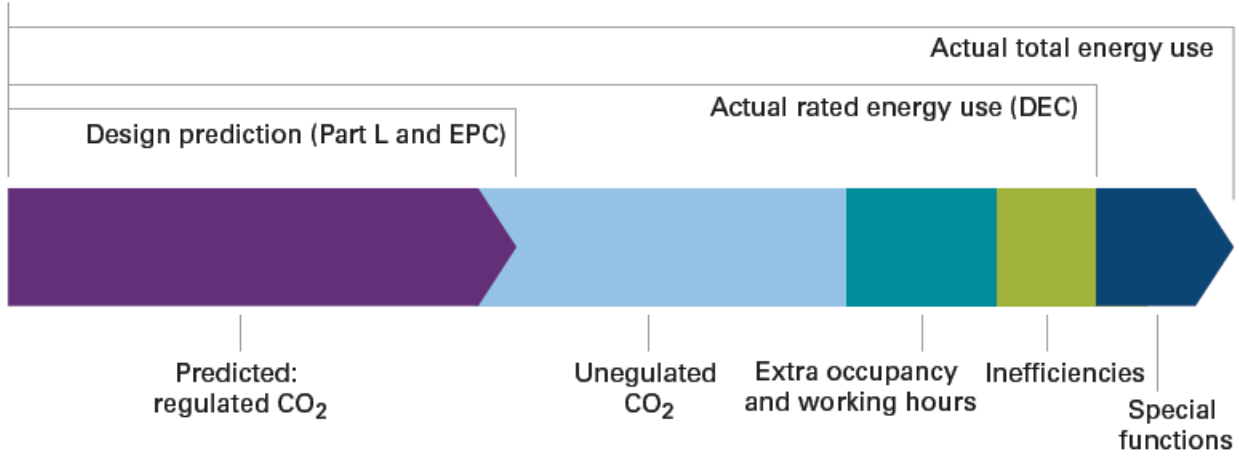


Figure 3 Results of applying the methodology to the case study building

Performance Gap

Figure 1 Design predictions for regulatory compliance don't account for all energy used in a building (adapted from Carbon Buzz)

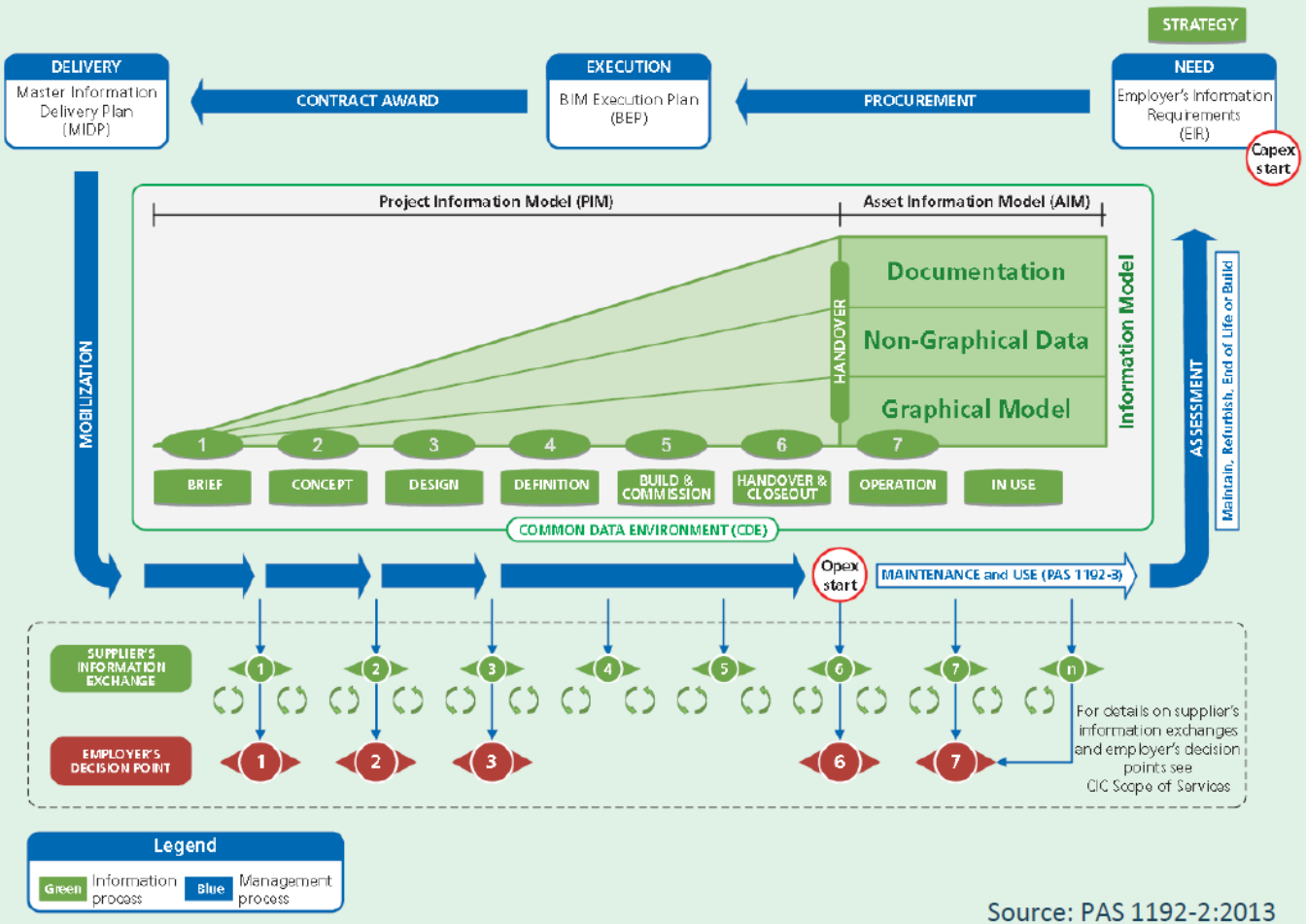


- Regulated energy use includes modelled heating, hot water, cooling, ventilation and lighting
- Unregulated energy use includes plugload, server rooms, security, external lighting, lifts, etc
- Extra occupancy and equipment and extra operating hours (e.g. evening/weekend working)
- Inefficiencies from poor control, bad commissioning, bad maintenance, etc
- Special functions (separable energy uses) include trading floors, servers rooms, cafeteria, etc

- Compliance vs Design or Actual Energy End Uses
- Better energy prediction at design stage is fundamental to understanding and therefore closing the Performance Gap.

BIM & Soft Landings

Figure 2 – The information delivery cycle



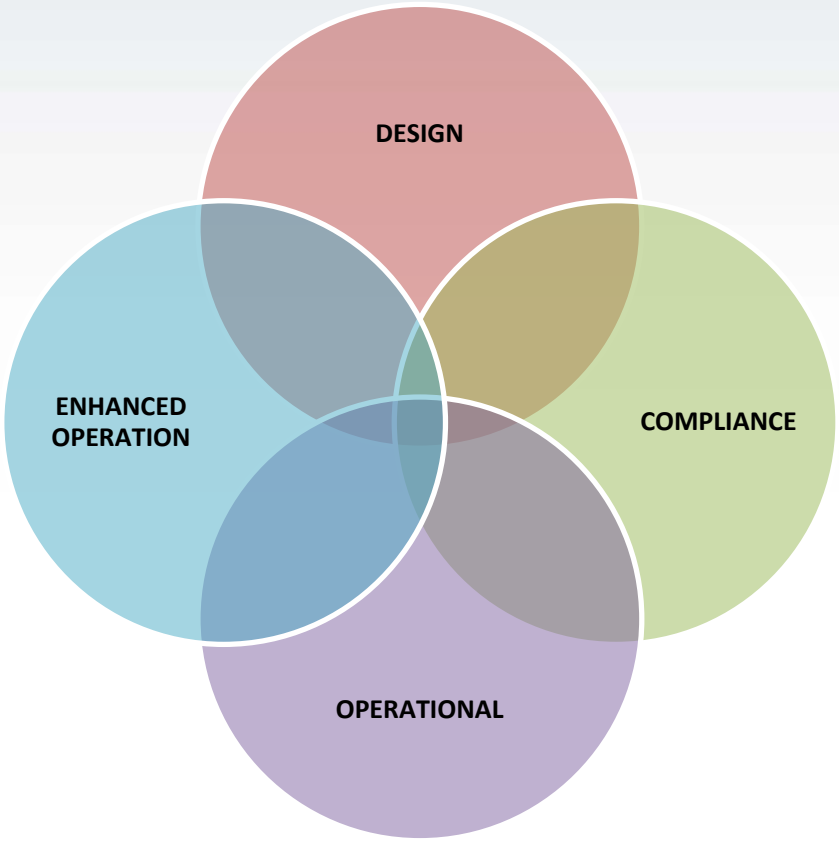
Source: PAS 1192-2:2013

BIM & Soft Landings

"A process for the graduated handover of a new or refurbished building, where a period of professional aftercare by the project team is a client requirement – planned for and carried out from project inception onwards – and lasting for up to three years post-completion"

Building Models

Building Energy Simulation Tools are used to analyse buildings for a range of purposes. Some of these purposes require a specific type of model that is specific to its purpose. However, the differences between these model types is poorly defined which causes confusion to the marketplace.



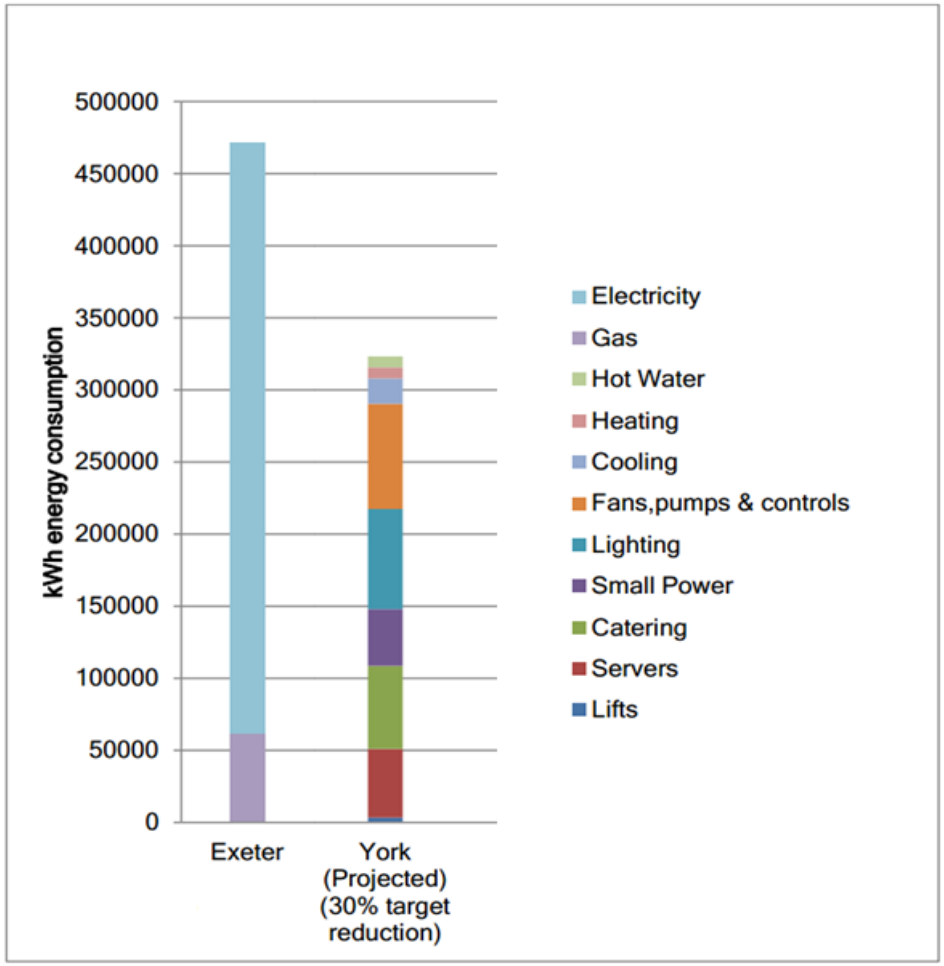
Case Studies

John Lewis York, UK

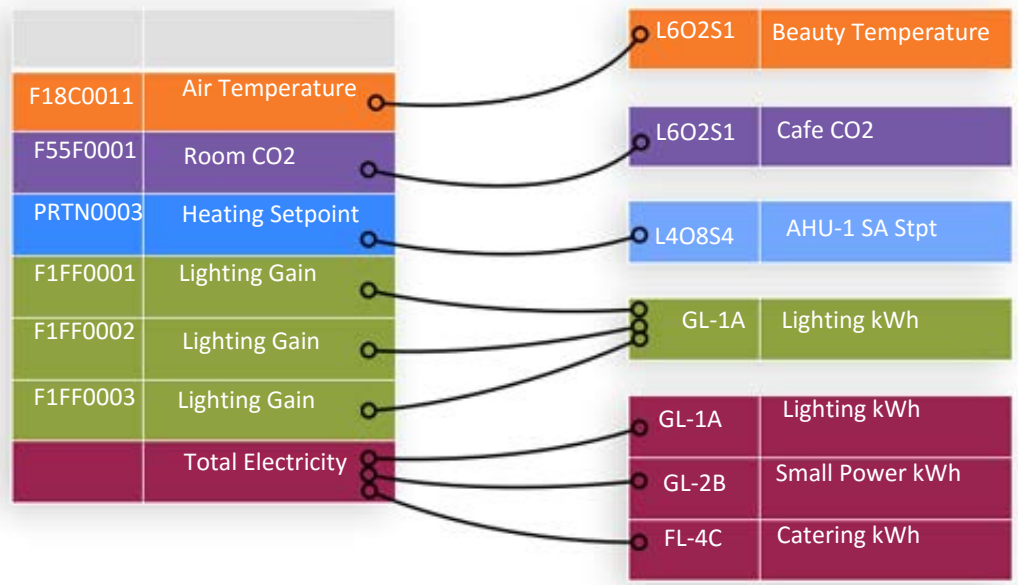
Key Points

- Lateral Technologies tasked with designing JLP's lowest energy store
- Lateral Tech extensive users of IES-VE technology
- Utilise ApHVAC on each project to right-size plant & save CapEx
- IES Commissioned by Lateral to support efforts on JLP York LZC Design
- IES R&D technology used to deliver enhanced monitoring solution
- M&T platform with a difference – allows overlay of Design vs Real datastreams
- Support Commissioning, M&V, Soft Landing

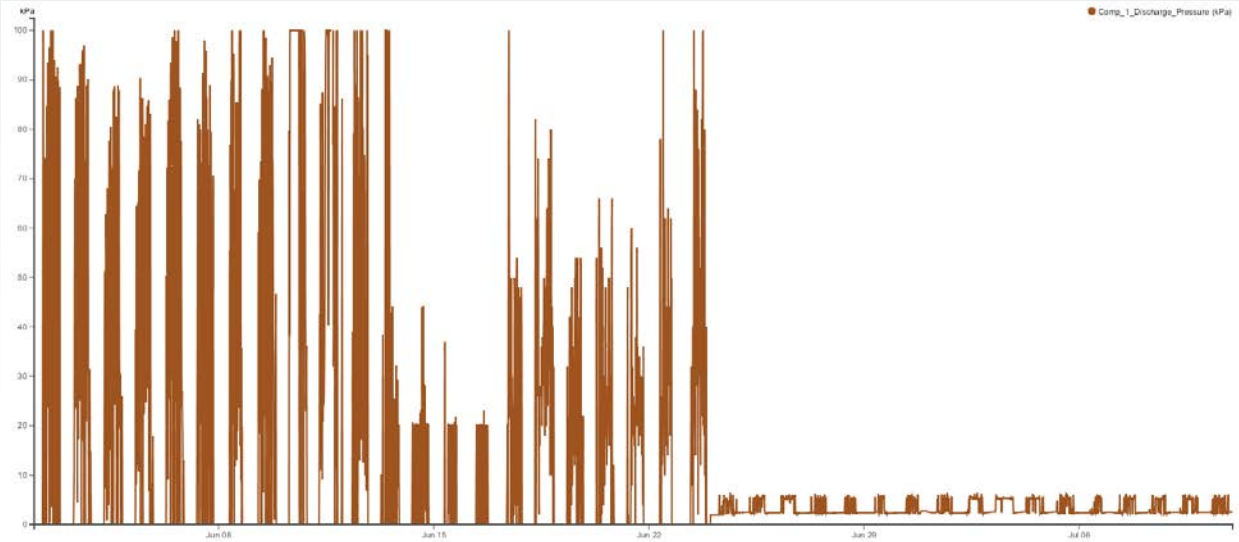
The Target – innovation required!

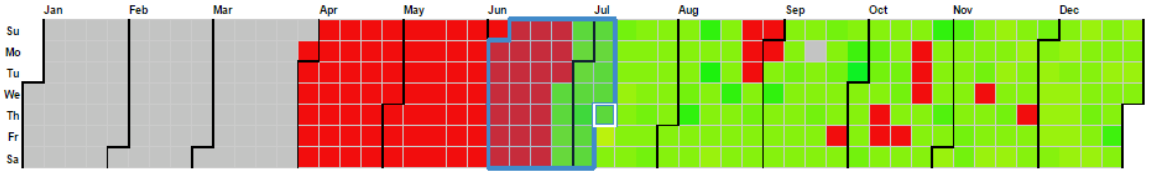


Mapping Virtual to Real Data Points

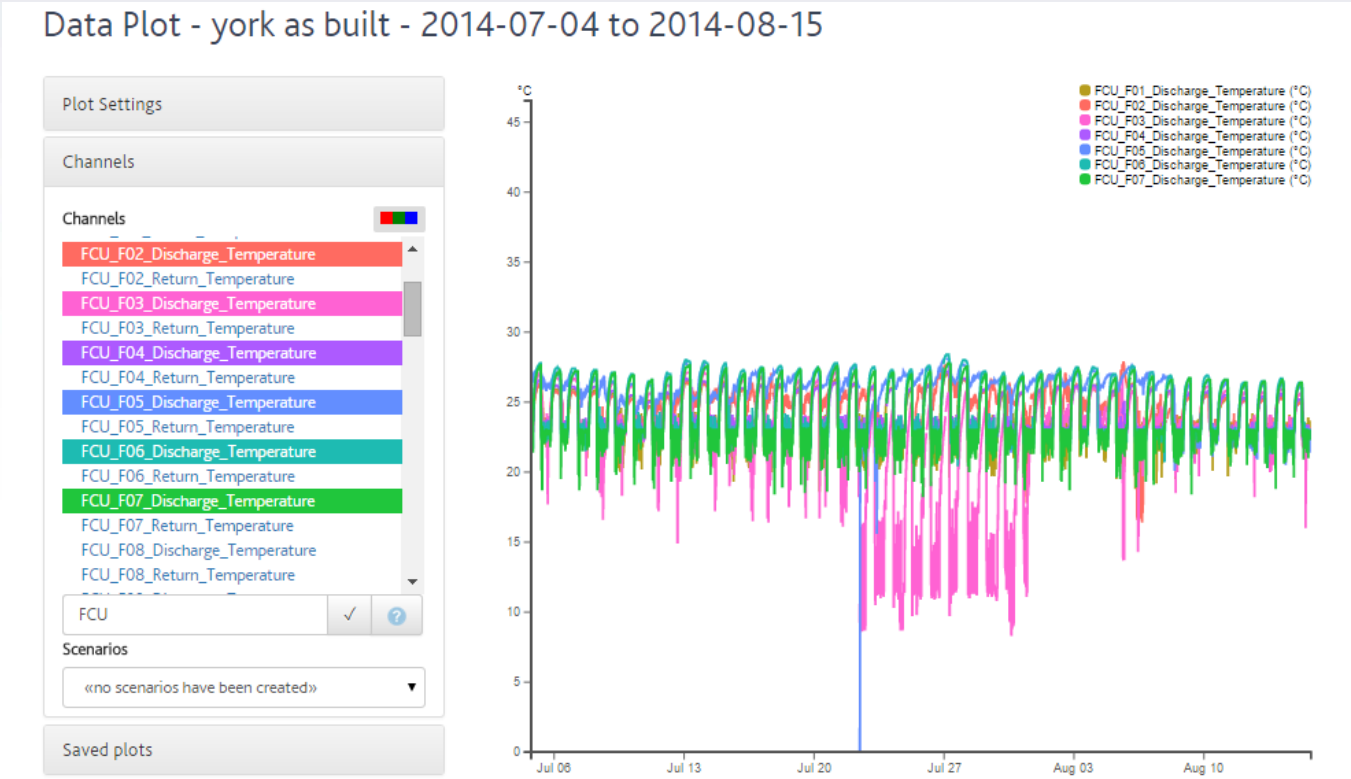


Commissioning Support – Chiller Operation

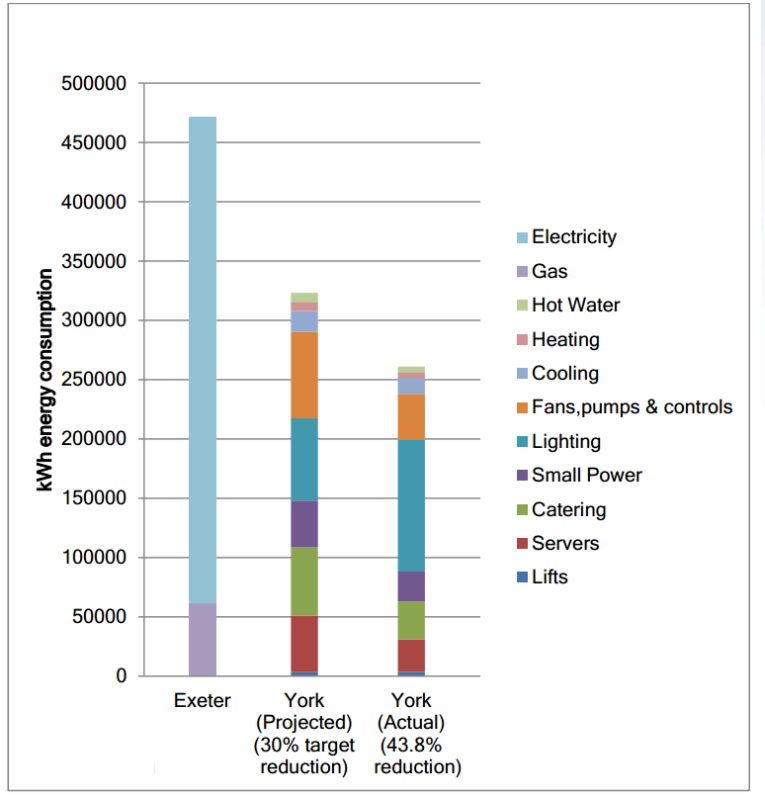




Commissioning Support – FCU Operation



The End Result

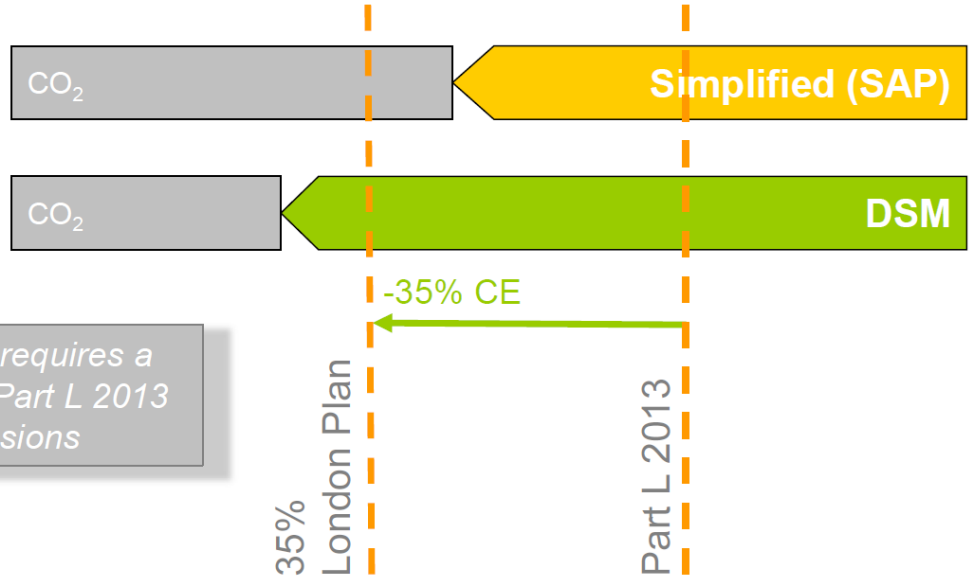


HLM Architects

Key Points

Simplified vs Detailed

- New targets pose a special challenge in the residential sector:
  - Higher performance requires a strong integrated design
    - But integrated design is not measured through simplified methods



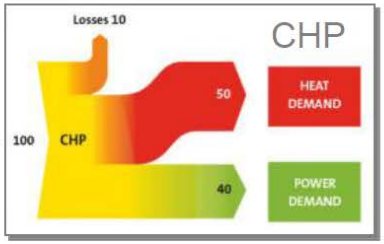
The London Plan requires a 35% reduction on Part L 2013 Carbon Emissions

Compliance with London Plan targets is only demonstrated via DSM.

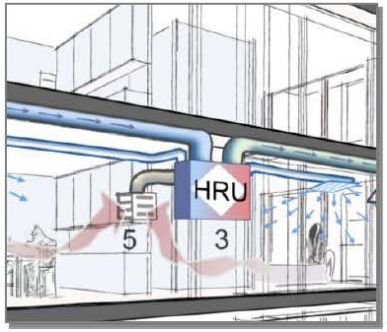
Key Points

Integrated design strategy

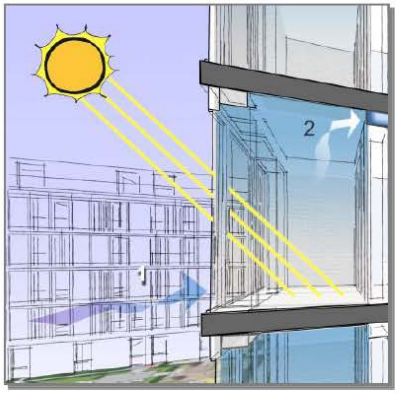
1. Passive design
   - Solar access
   - Daylighting
   - etc
2. Whole house Mech Vent w/ Heat Recovery
3. Integrated Winter Gardens
4. Indoor Environmental Quality / Controls
5. District System - CHP



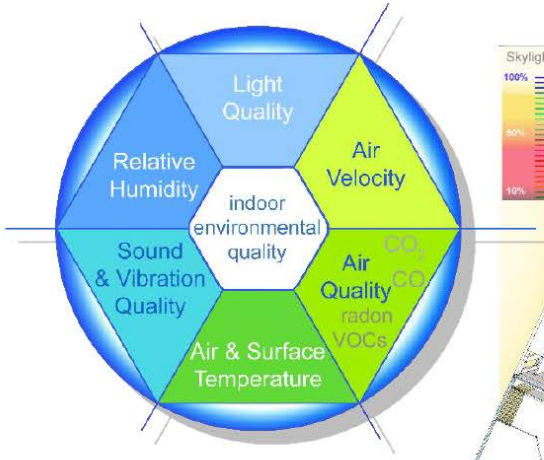
5. District System



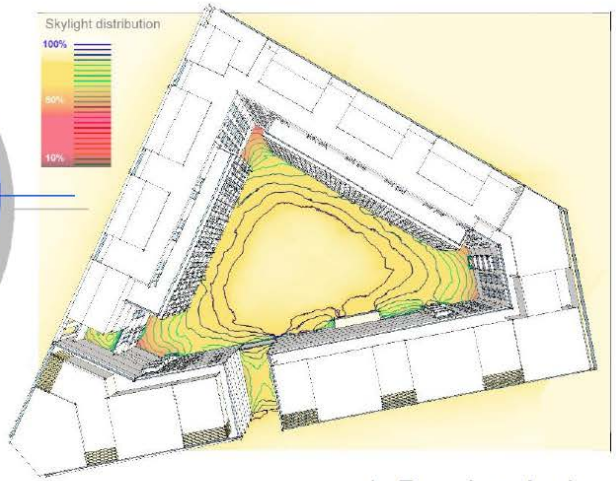
2. Whole house MVHR



3. Winter Gardens

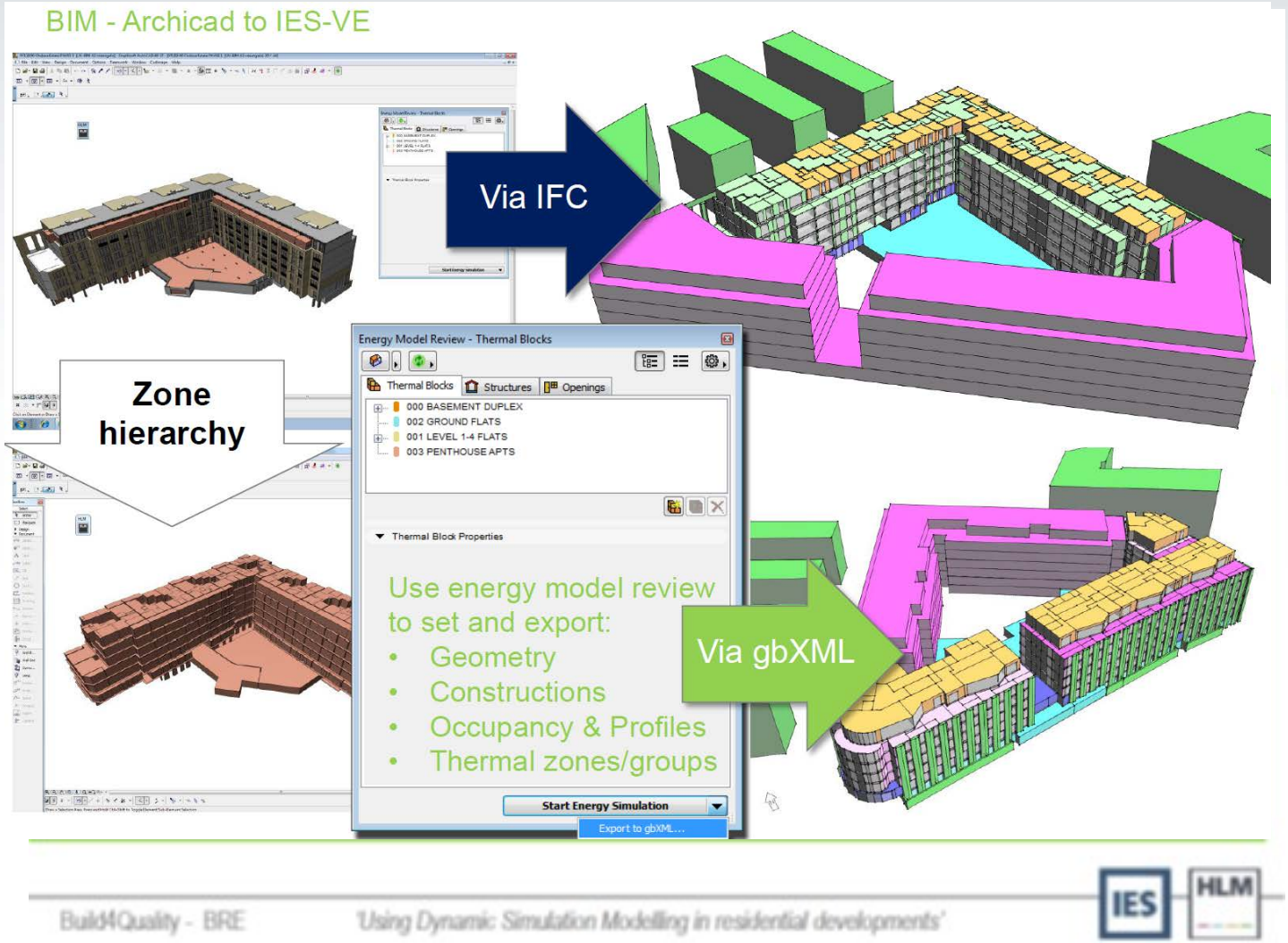


4. Indoor Environmental Quality Control



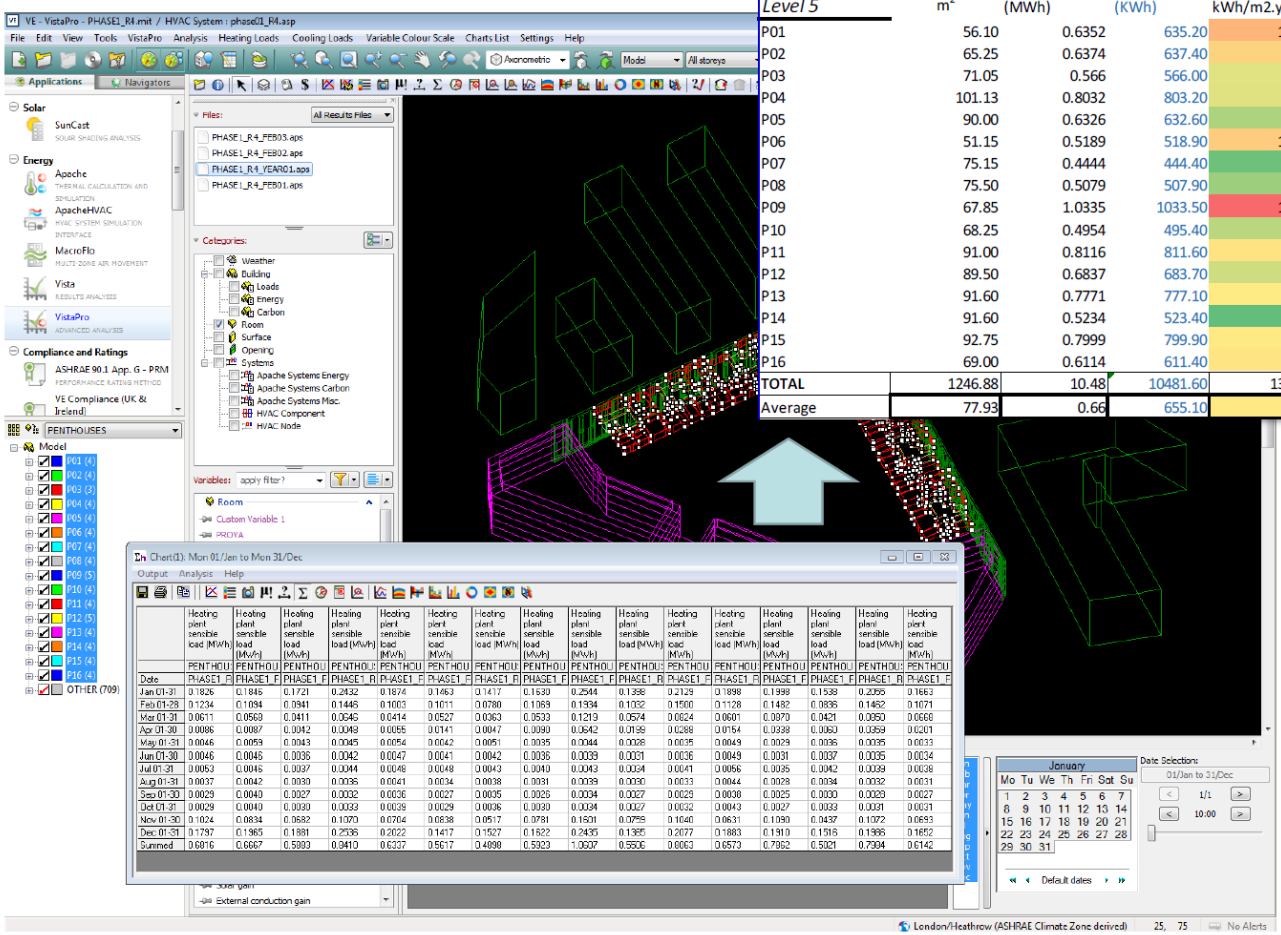
1. Passive design

Key Points


BIM - Archicad to IES-VE
Via IFC
Zone hierarchy
Energy Model Review - Thermal Blocks
Thermal Blocks
Structures
Openings
000 BASEMENT DUPLEX
002 GROUND FLATS
001 LEVEL 1-4 FLATS
003 PENTHOUSE APTS
Thermal Block Properties
Use energy model review to set and export:
• Geometry
• Constructions
• Occupancy & Profiles
• Thermal zones/groups
Start Energy Simulation
Export to gbXML...
Via gbXML

Key Points

Exporting results data back to BIM



PENTHOUSE flats	Floor area (*)	Annual plant load	Annual plant load	Unitary plant load	CO2
Level 5	m^2	(MWh)	(KWh)	kWh/m2.yr	kg/m2.yr
P01	56.10	0.6352	635.20	11.32	2.45
P02	65.25	0.6374	637.40	9.77	2.11
P03	71.05	0.566	566.00	7.97	1.72
P04	101.13	0.8032	803.20	7.94	1.72
P05	90.00	0.6326	632.60	7.03	1.52
P06	51.15	0.5189	518.90	10.14	2.19
P07	75.15	0.4444	444.40	5.91	1.28
P08	75.50	0.5079	507.90	6.73	1.45
P09	67.85	1.0335	1033.50	15.23	3.29
P10	68.25	0.4954	495.40	7.26	1.57
P11	91.00	0.8116	811.60	8.92	1.93
P12	89.50	0.6837	683.70	7.64	1.65
P13	91.60	0.7771	777.10	8.48	1.83
P14	91.60	0.5234	523.40	5.71	1.23
P15	92.75	0.7999	799.90	8.62	1.86
P16	69.00	0.6114	611.40	8.86	1.91
TOTAL	1246.88	10.48	10481.60	137.55	29.71
Average	77.93	0.66	655.10	8.60	1.86

Key Points

Comparing SAP and DSM - sample apartment in Phase 1

Total space heating requirement per year, per m^2

SAP worksheet

SAP 2012 worksheet for - calculation of fabric energy efficiency

433.01	366.26	346.95	251.35	159.40	-	-	-	-	20

Total space heating requirement per year (kWh/year) (October to May)
Space heating requirement per m² (kWh/m²/year)

DSM simulation

33.6 kWh/m^2.yr

DIFFERENCE

7.1 kWh/m^2.yr

78% better than SAP

Conclusions

Potential Benefits
Information Modelling

Golden Thread

Share

Digital Future

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