SUSTAINABLE PLACES 2025

IES

Energy Modelling & Data Analytics for Net Zero Retrofit

Giulia Barbano

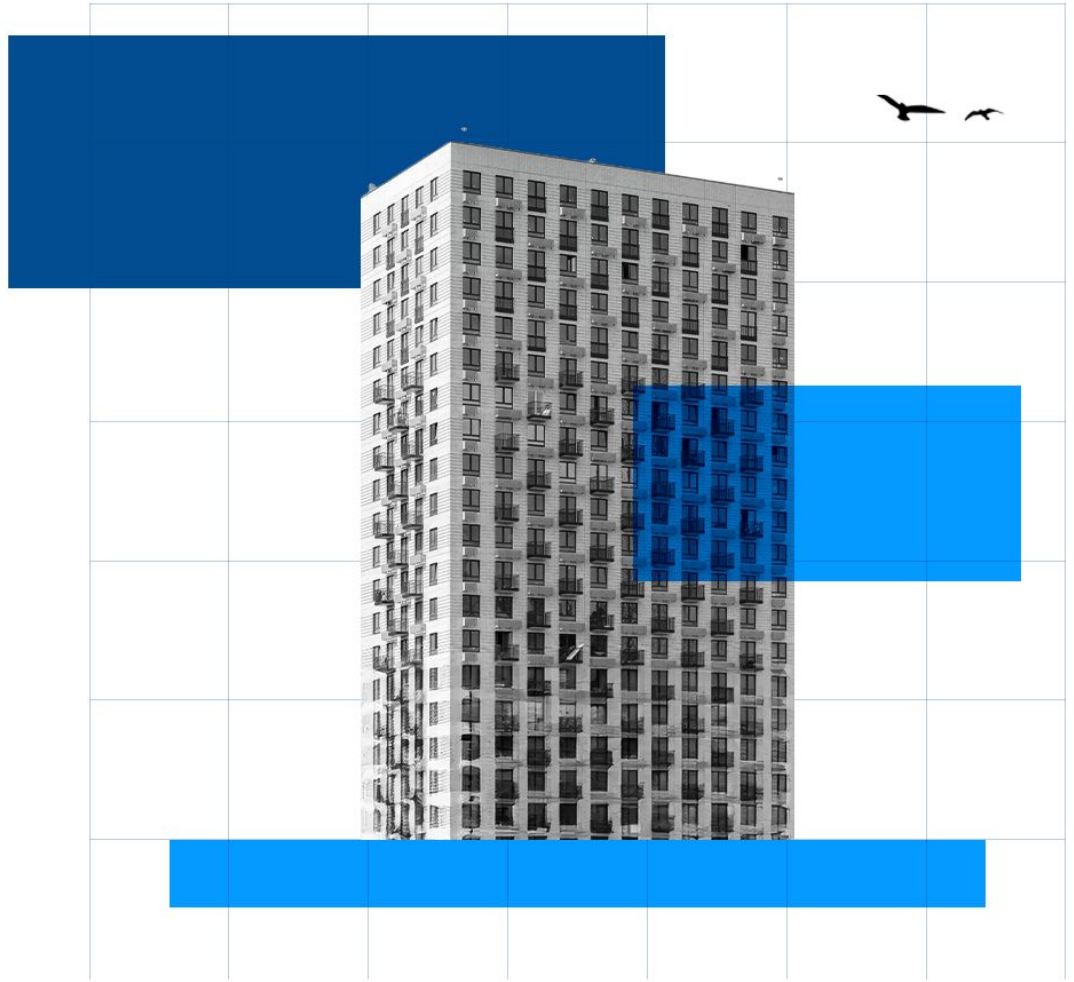
R&I Operations Manager

Johan Haeberle

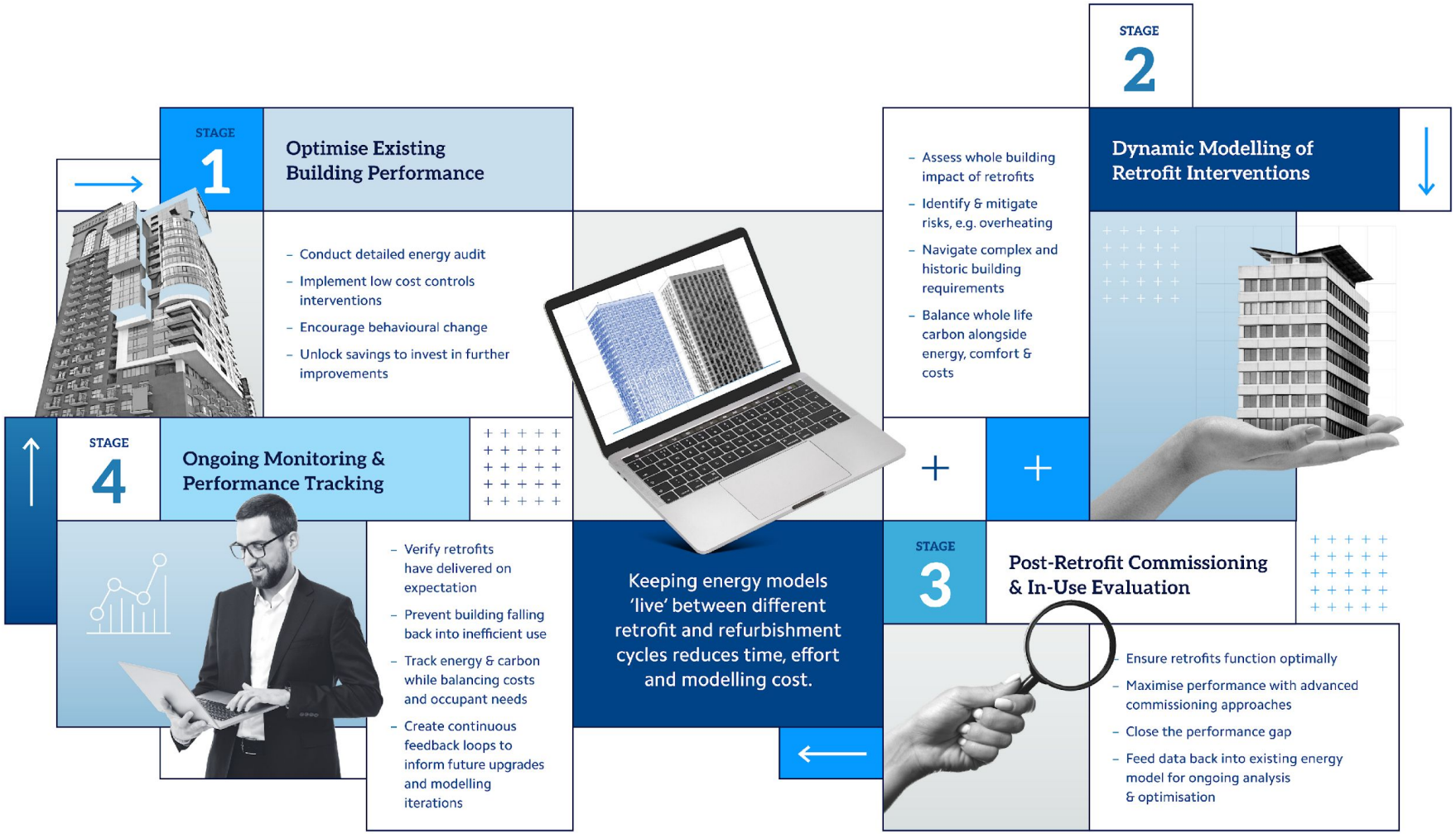
Head of Sales: Europe

Retrofitting for a Zero-Carbon Future

- **80% of the 2050 building stock** already exists
- More challenging than new builds to decarbonise
- Current retrofit rates must triple to **at least 3% of global stock** each year
- How can you be sure of deploying the right strategies?
- Energy modelling & dynamic tools can de-risk retrofit decisions
- Ongoing digital asset to ensure projects deliver across energy, carbon, comfort & costs



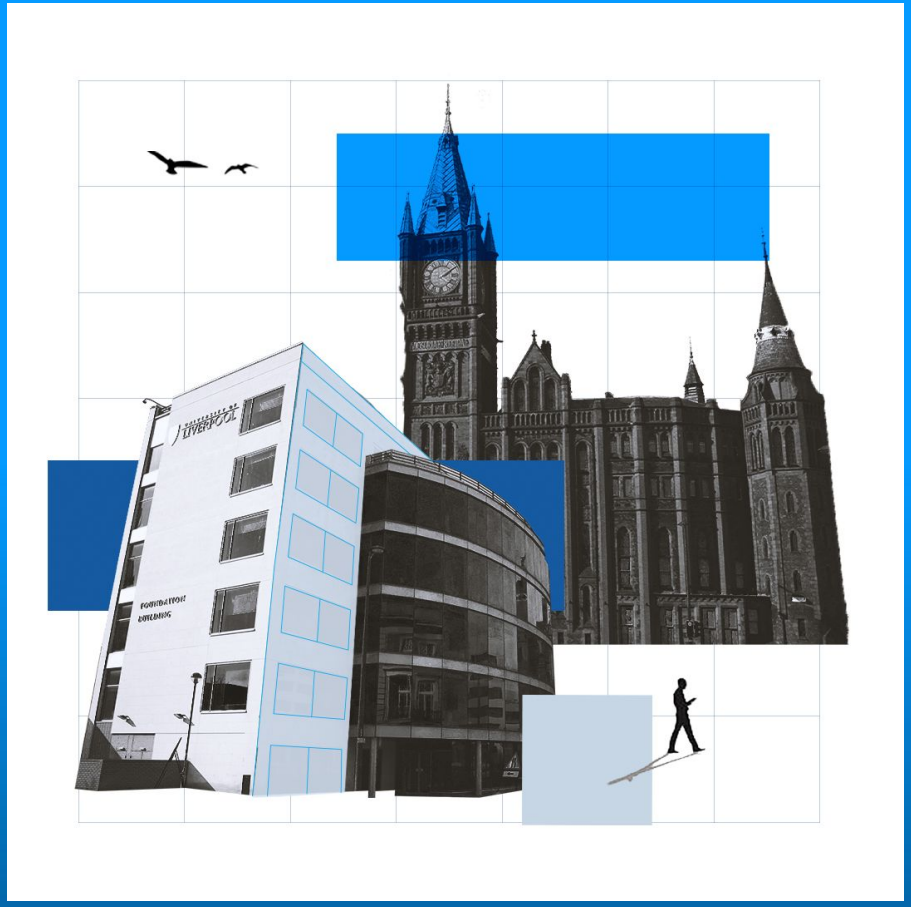
A Whole Lifecycle Performance-Based Approach to Existing Building Decarbonisation



SUSTAINABLE PLACES 2025

AUDIENCE POLL

What do you think is the greatest barrier to decarbonising existing buildings?



Optimising Existing Building Performance

Understanding the Building

Why?

- While each building is different (occupants, building fabric, controls, and technologies), buildings commonly fall short of performance expectations – optimisation quick wins can lead to 26% savings on average in commercial building types (UKGBC).
- Accurate data helps understand a building's energy consumption, essential to establishing baselines and patterns and comparing them to Energy Use Intensity (EUI) benchmarks.
- Low and zero cost controls interventions can unlock savings to reinvest in subsequent retrofit measures & can maximise their impact (i.e. ensures retrofit upgrades are not fighting against an inefficient building).
- IES' iSCAN is the data analytics tool we use due to its features:

One login to central platform

Organise & tag multiple data sources, formats & time intervals

Cross analyse data from different data sets

Smart tools to review data and fill data gaps

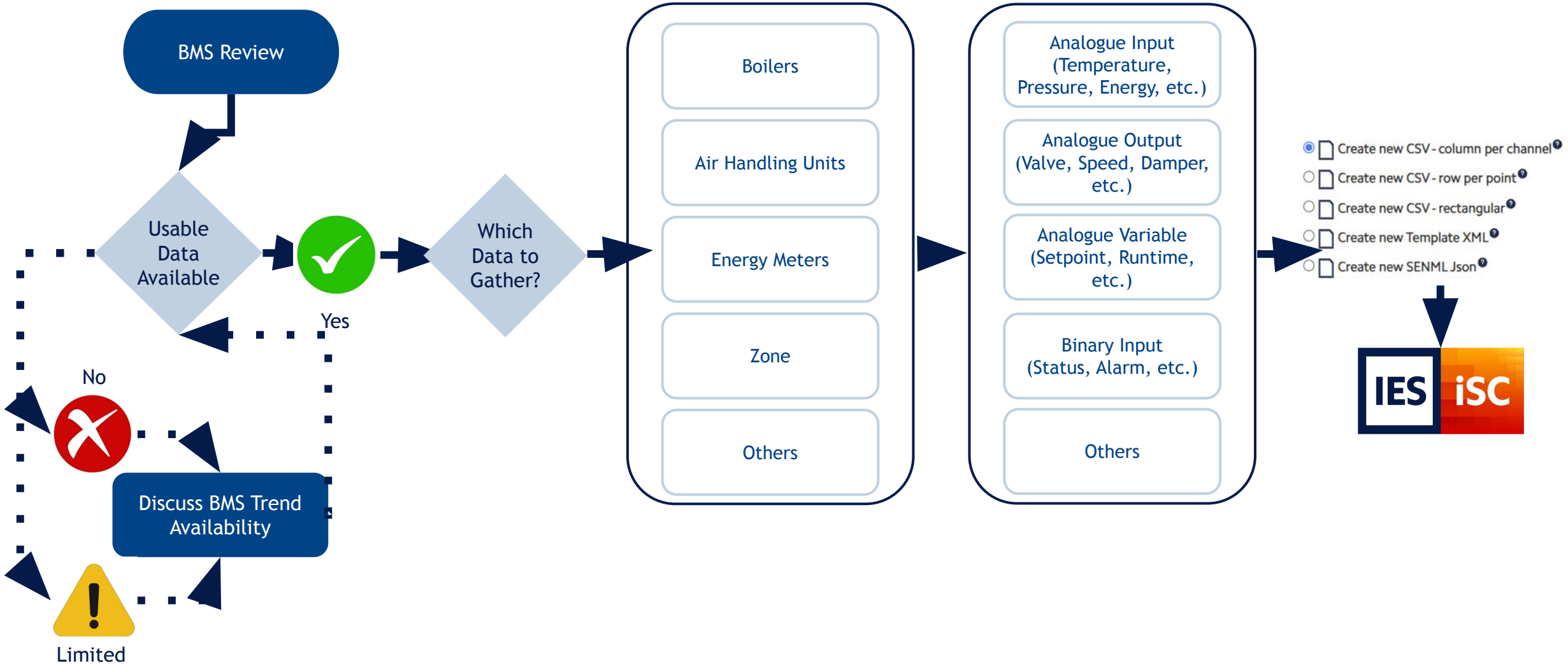
Unlimited bespoke data rules, alerts & dashboards

Common Data Challenges

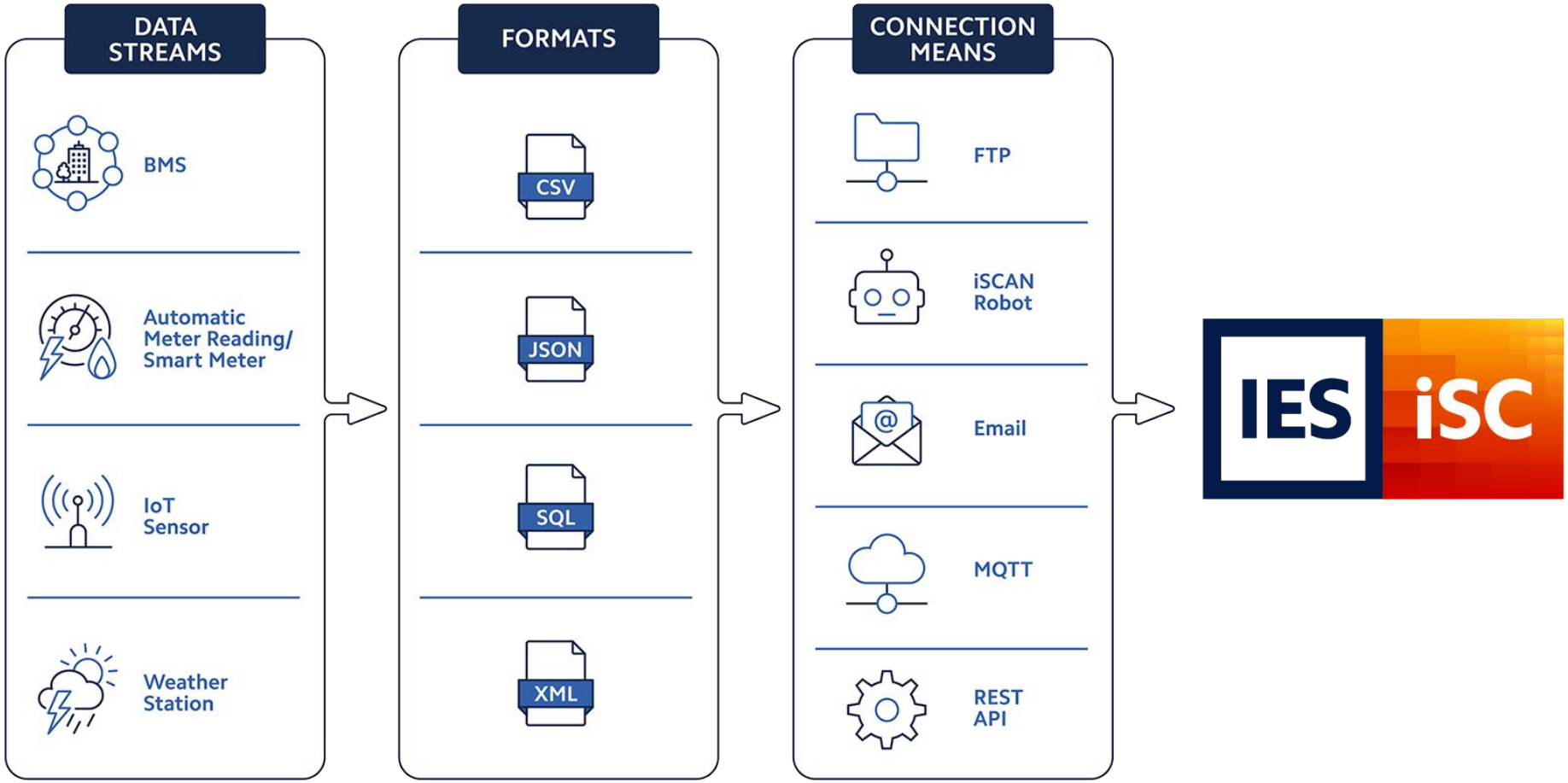
Old vs. New Buildings

Older Buildings	Newer Buildings
Limited building information: + Paper copies of schematics + Missing/outdated O&M Documents + Limited BMS data trend duration + None of Poor BMS Naming Conventions	**Design information typically digitized:** + CAD Drawings typically available + Digital O&M records that can be searched + Typically long duration of BMS data trends + Better BMS Naming Conventions
Energy Meters: + **Lack of data granularity (e.g. monthly for whole building)** + **Meters not connected to BMS**	**Energy Meters:** + **Typically more frequent (e.g. half hourly data)** + **Sub-metered data with granular energy use information**

BMS Manual Data Gathering



Automatic Data Gathering



Supporting Documentation

Description of Operation

+ The BMS contractor should make this available to describe how the building should be designed to operate.

As-Installed Mechanical & Electrical Schematics

+ As-installed mechanical and electrical schematics should be used when analysing buildings to help to understand energy flow.

Commissioning & Maintenance Sheets

+ The Mechanical/HVAC commissioning and Maintenance Sheets can help to identify known issues.

iSCAN Building Analytics

The Basics

Identify Faults

+ The issues or faults which effect the building operation efficiency should be highlighted, e.g. fault points, mismatches, sensors out of range etc.

Compare Schedules

+ This simple procedure is to compare the schedule, HVAC operation and building occupied hours against each other. ***The cheapest and greenest energy is the energy we don't use!***

Check Setpoints

+ Check if setpoints are reasonable and observe trends to see if they are modulating or static. Static or local zone temperature adjustment setpoints should be checked to understand daily and seasonal changes.

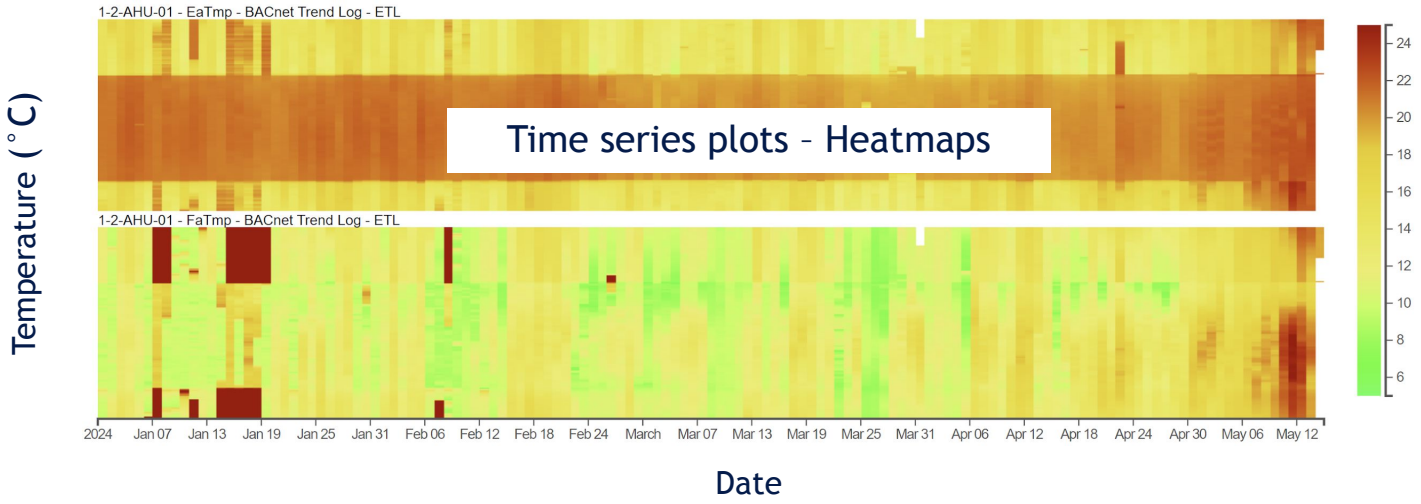
iSCAN Building Analytics

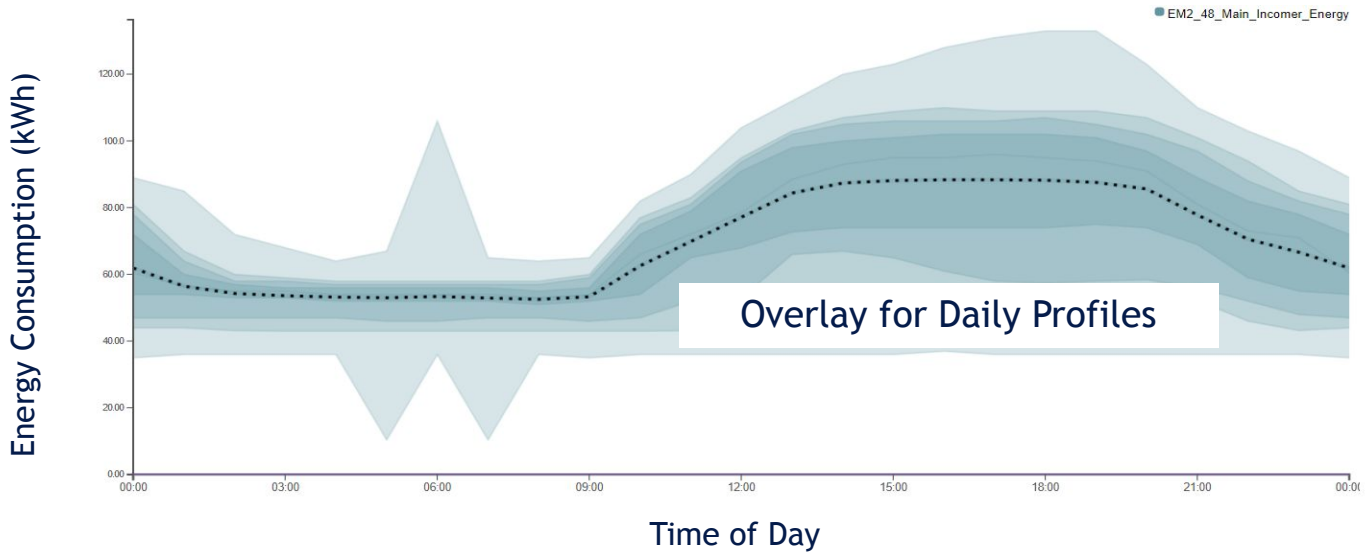
Data Interrogation

Range of Visuals

+ iSCAN has a wide range of different types of graphs which enable data interrogation for example summary chart, distribution charts, time series plots such as daily overlay or heatmaps.

+ This charts can then be based on value (max, min, average, running total, range, etc.) and period (hourly, daily, monthly, etc.)



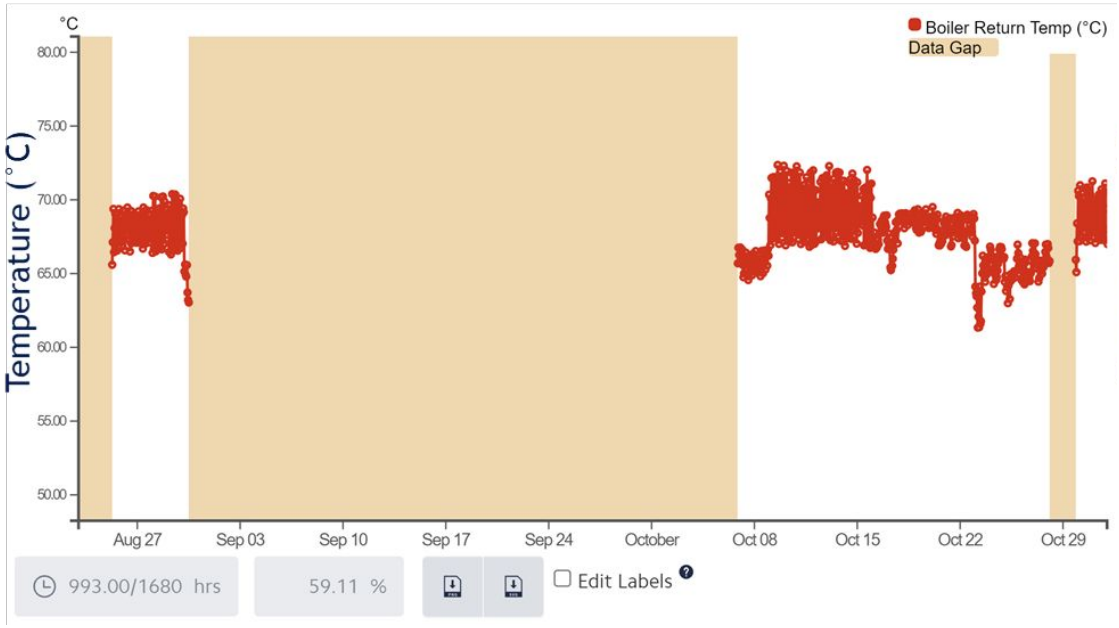


iSCAN Building Analytics

Insights

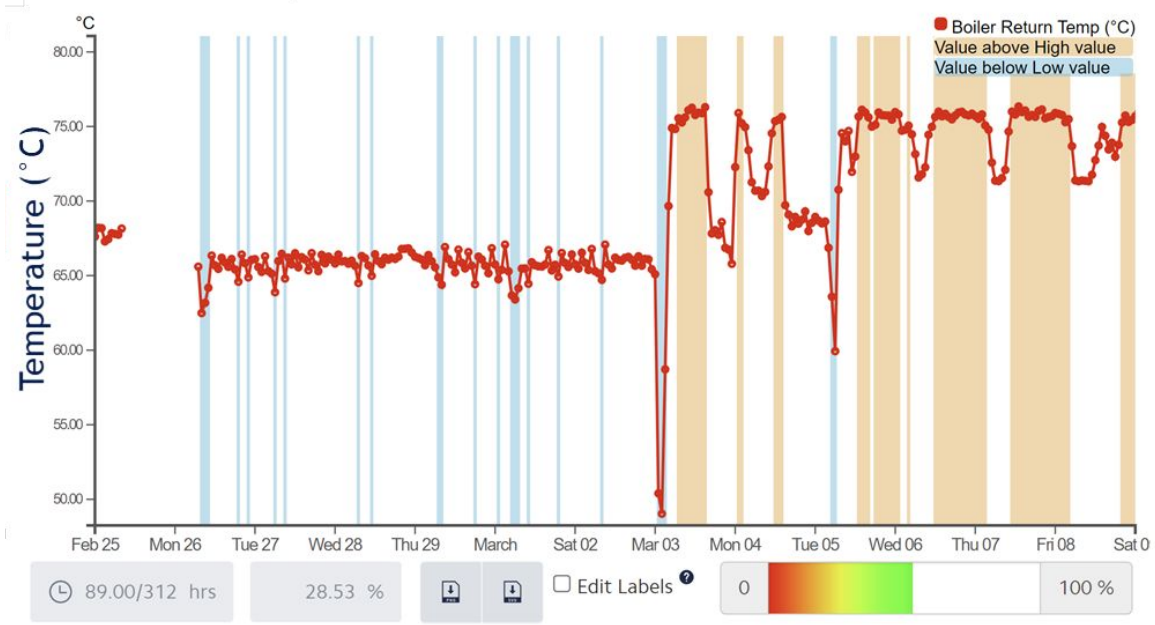
Data Gaps

+ Quickly identified and quantified



Out of Range/Setpoint Tracking

+ Finds when values are out of range when occupied



Reporting & Data Storytelling

- Building decarbonisation is an iterative process requiring discussion and engagement from all.
- Data, visuals, and narrative tell the building's story in an understandable, relatable way that allows for better decision-making .

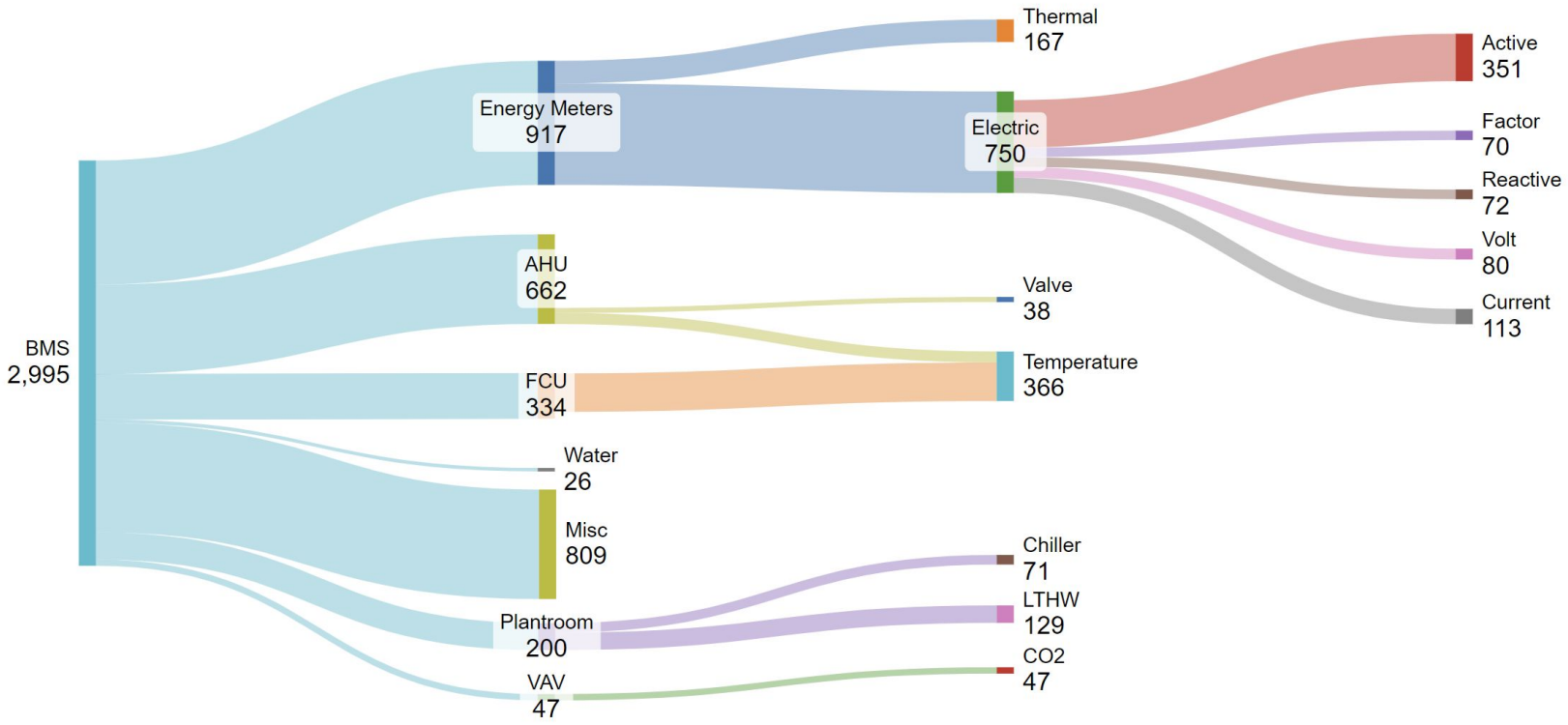
University of Glasgow

Case Study

University of Glasgow

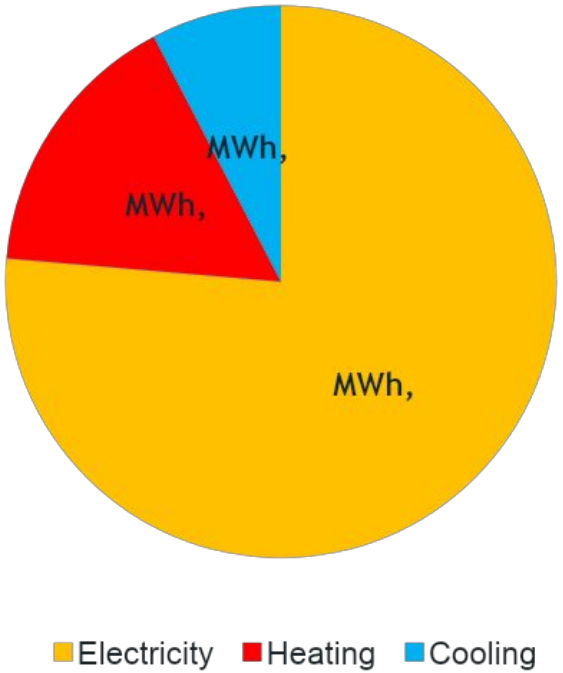
Data Coverage

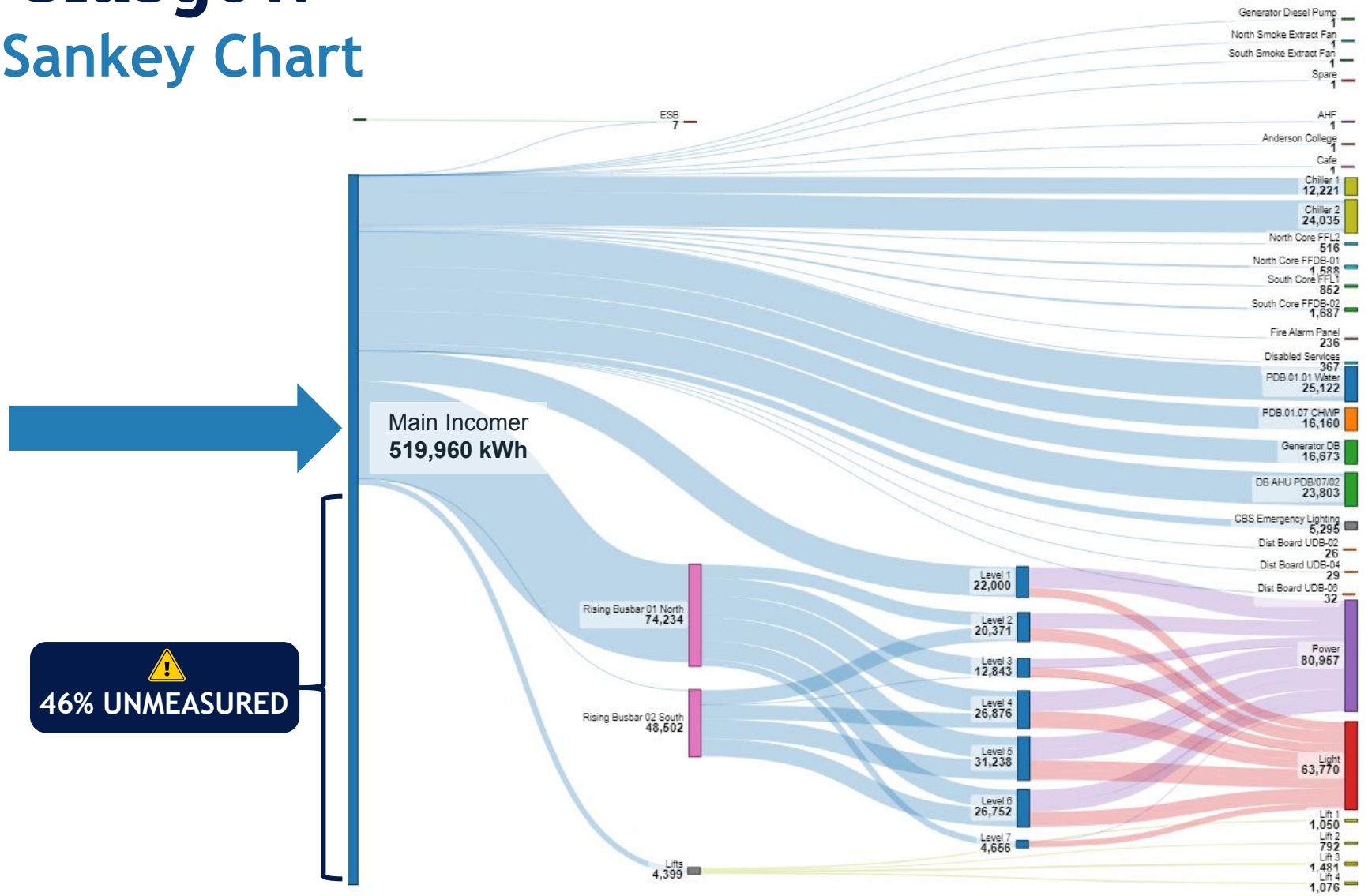
+ Displaying all available data points and categories provides an overview and guides the insights in the report.



University of Glasgow

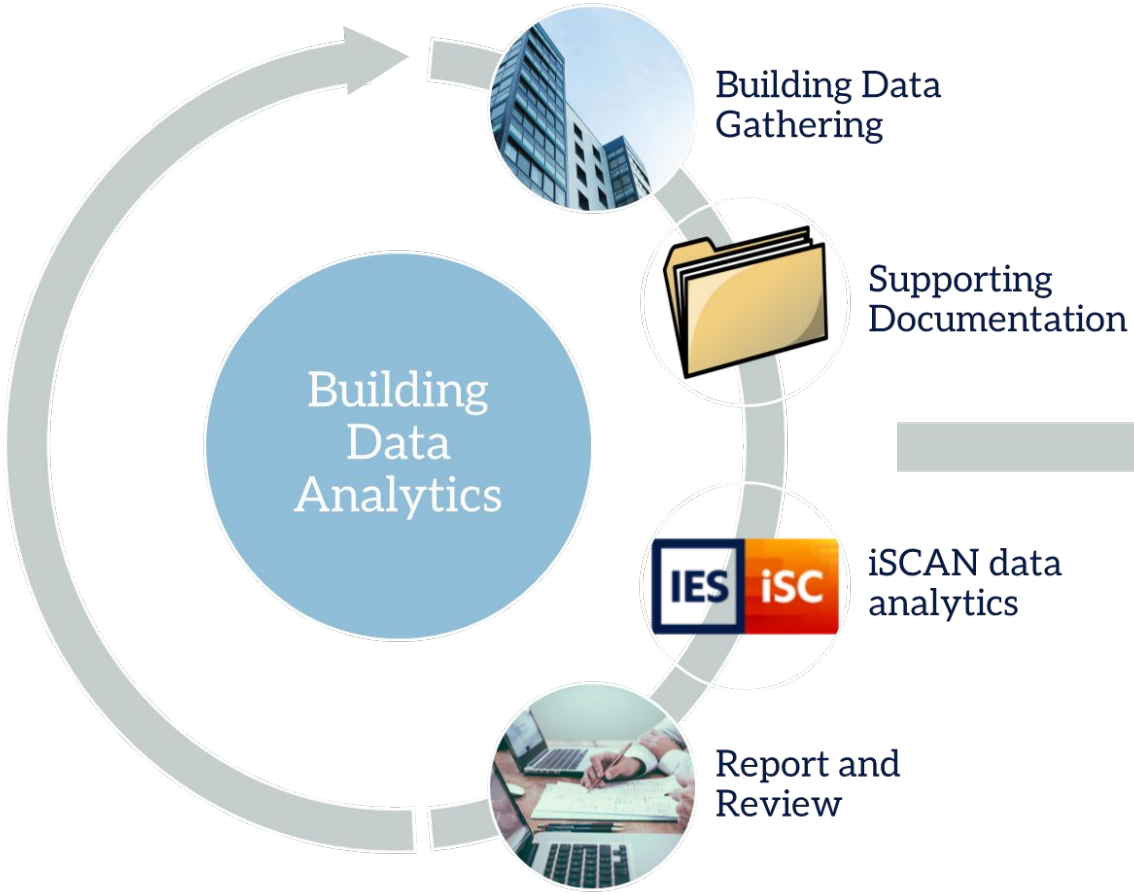
Electrical Energy Sankey Chart





Key Takeaways

Optimising Existing Building Performance



Stage 2: Dynamic Modelling of Retrofitting Interventions

Increase Confidence in Retrofit Decisions with Dynamic Modelling

Energy Modelling of Existing Buildings

Increase Confidence in Retrofit Decisions

+ Dynamic simulation modelling is an invaluable tool to assess and compare the whole building impact of retrofit measures.

+ Upgrading basic compliance models to a detailed HVAC, operational (e.g. TM54) or calibrated model will offer increased accuracy and confidence when it comes to predicting the impact of different retrofit strategies.

+ Predict and mitigate the risk of any potential negative consequences arising from retrofit upgrades, e.g. poor ventilation, overheating.

+ Navigate projects with complex requirements or limitations (e.g. historic/listed buildings or those with high energy demands).

+ Holistic assessment of embodied and operational carbon impacts alongside comfort and costs, aligned to project/client goals.

University of Edinburgh

Case Study

Calibrating Energy Models for Retrofit Predictions







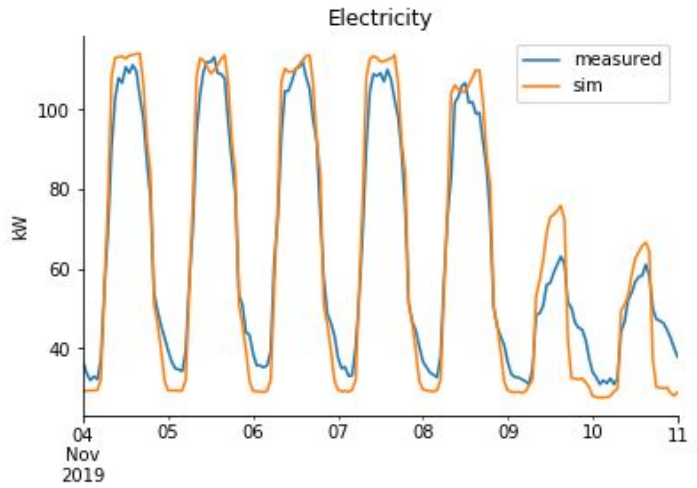
Energy Modelling

Existing Building Model

- Calibrated against available metered information
- Minimise Performance Gap
  - Real Building Model vs Compliance Model
- Benchmark for further ECM scenarios
- Identify dominant energy demands and key opportunities for savings

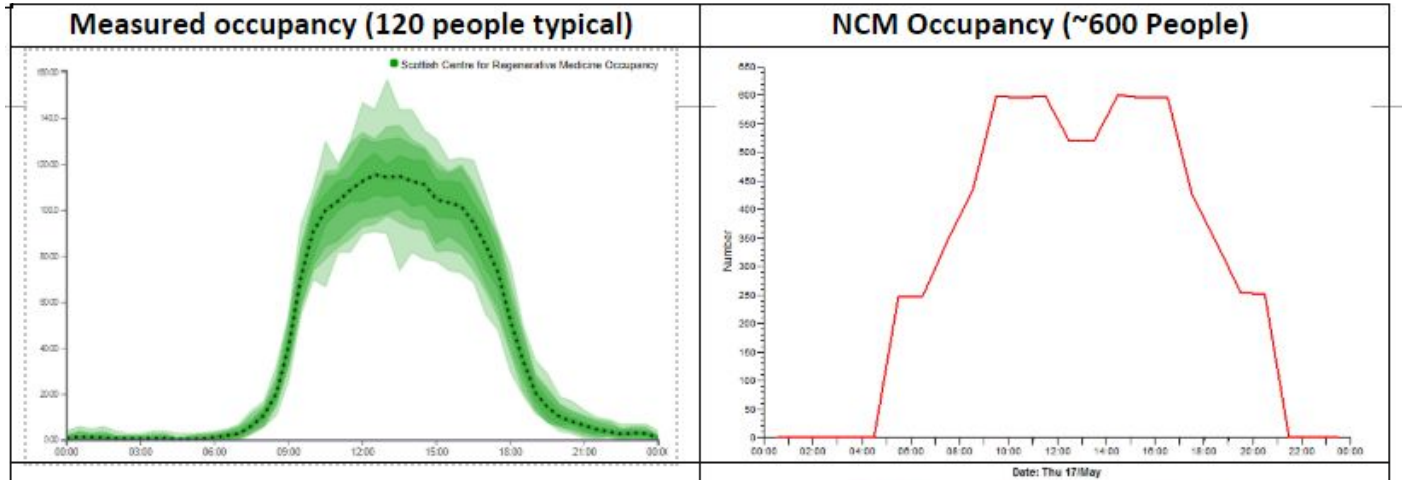
Real

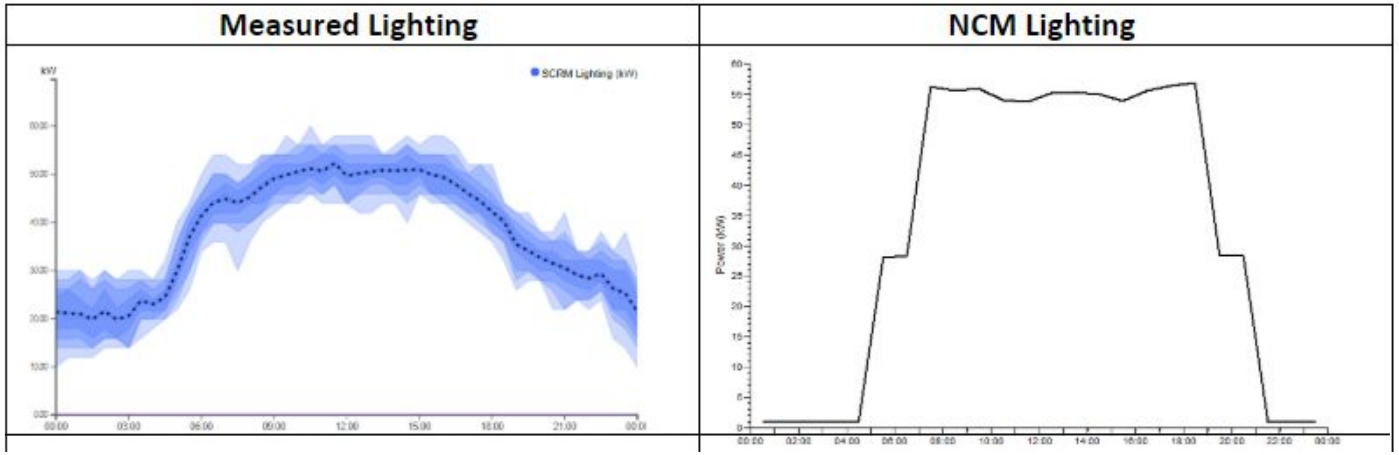
Digital Twin



Utilising Operational Building Data

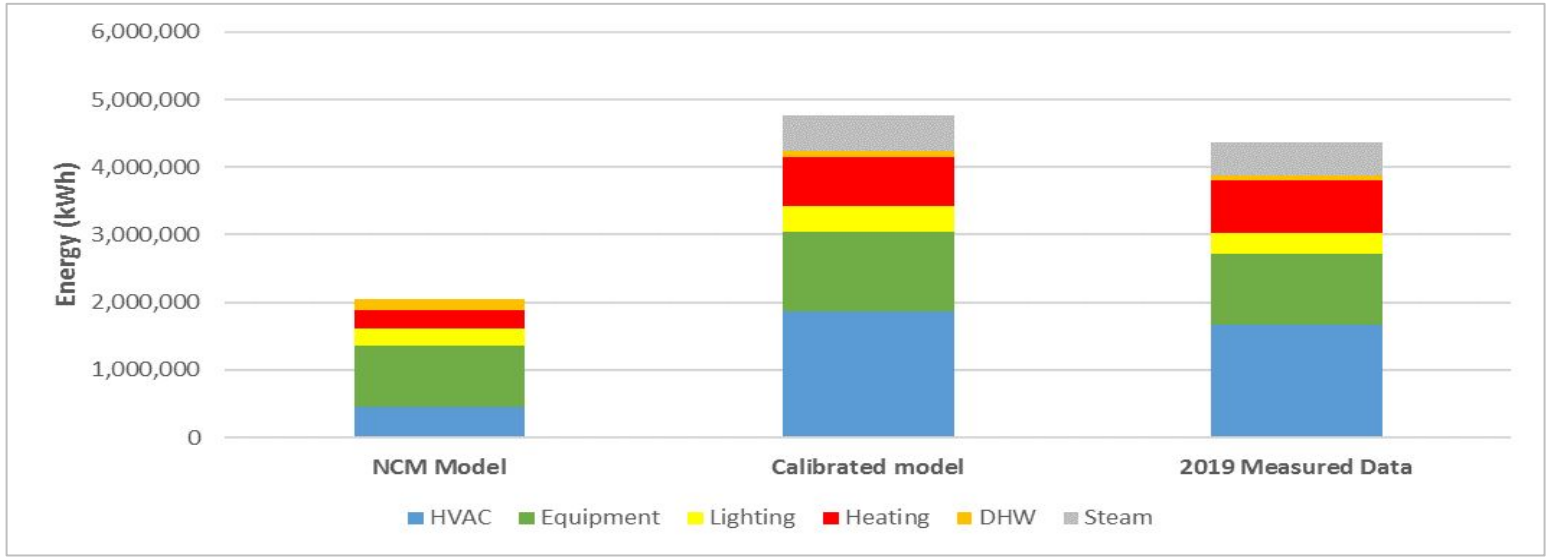
- NCM occupancy 3x greater than actual
- Space heating demand 2.5x greater than compliance model prediction
- Domestic hot water prediction 10x greater than actual
- Evening and weekend electrical baseloads understated by a factor of 3





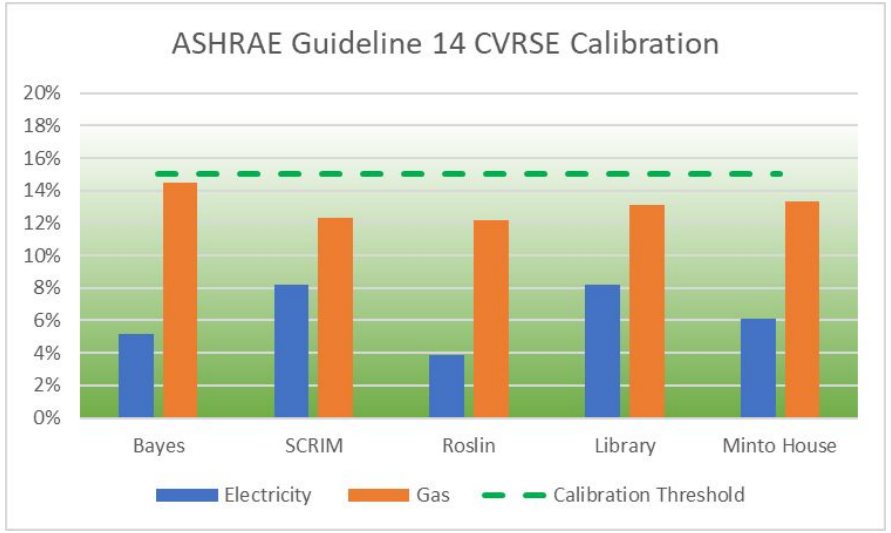
Minimising the Performance Gap

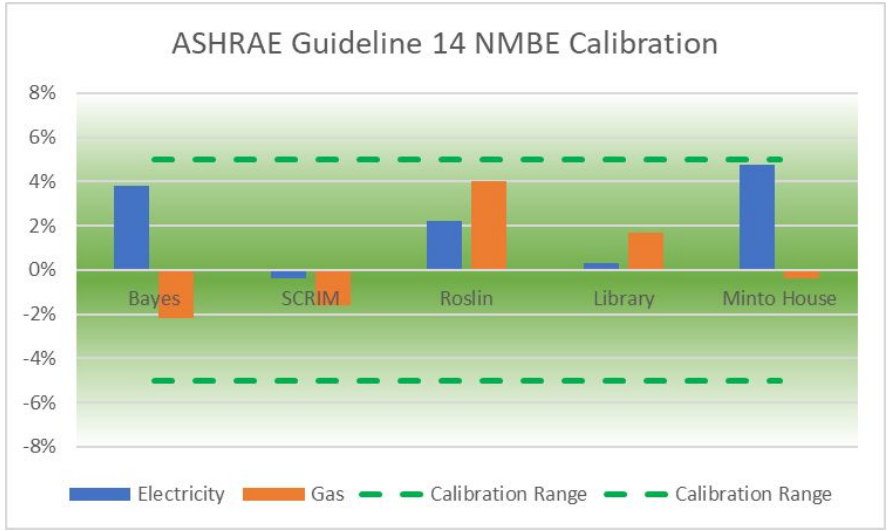
- Predicting potential energy savings and ensuring appropriate retrofit measures are perused
- Models that don't reflect Real usage can lead to Performance gap



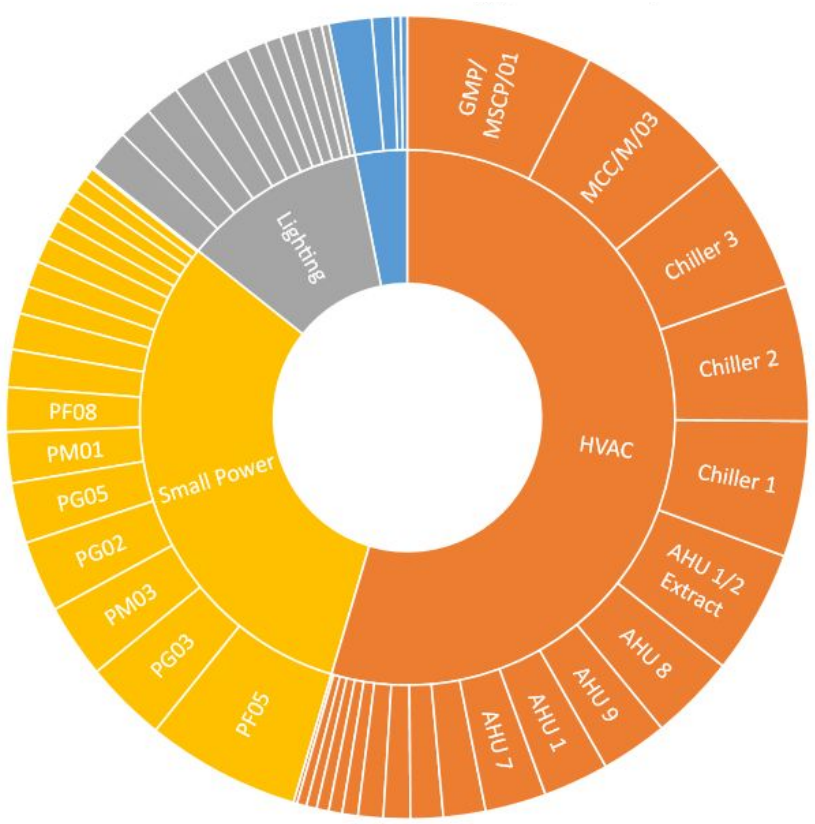
Model Calibration

- When a model is Calibrated it means that it can make realistic and reliable predictions for Future Energy Consumption.
- ASHARAE Guideline 14 provides metrics to determine whether a model can be considered as Calibrated by comparing simulated data against measured data.
- This uses the metrics ‘Coefficient of Variation of the Root Mean Square Error’ (CVRMSE) and ‘Normalized Mean Bias Error’ (NMBE) at Monthly or Hourly timesteps depending on available data.





Identifying Key Opportunities



- When we have an accurate representation of the Buildings energy demands and end uses we can identify where the key opportunities lie to make the greatest impact.
- This can help target ECM's and retrofit options towards these biggest opportunities.

Energy Modelling

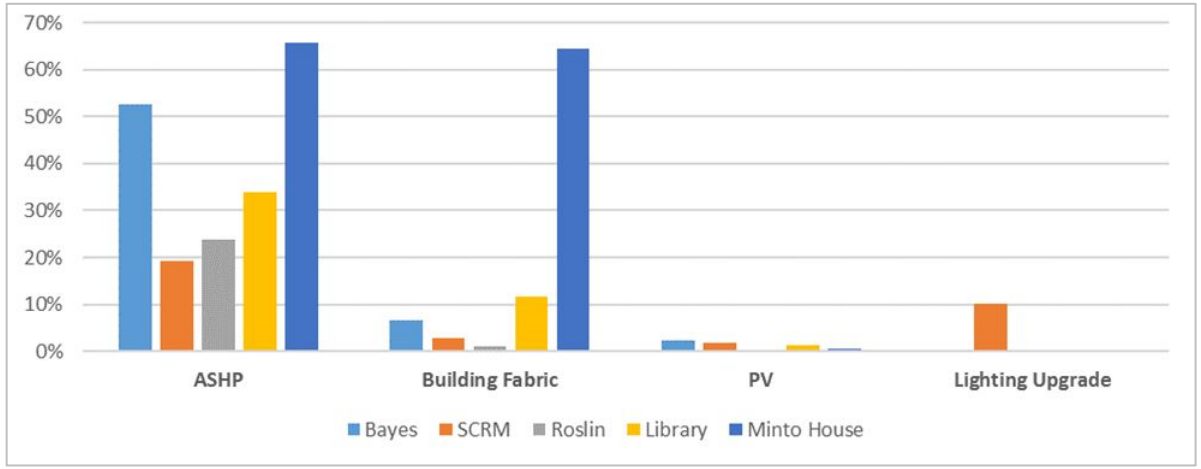
Energy Conservation Methods

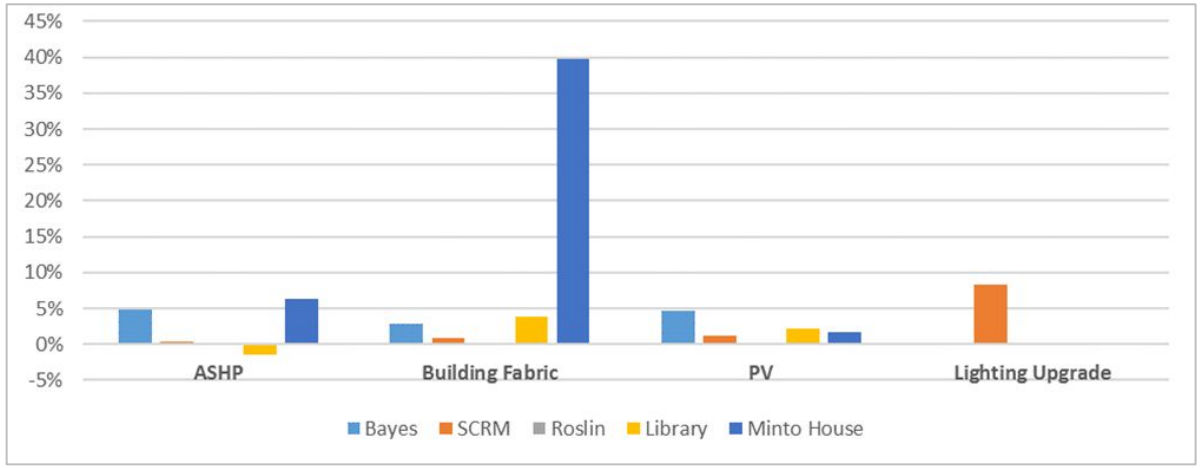
- Fabric Improvements
- Lighting Systems
  - High Efficiency LED Fixtures
  - Occupancy Sensing Controls
  - Daylight sensing
- HVAC upgrades
  - Reduced SFP’s
  - VAV Controls
  - Demand Controlled Ventilation
  - Heat Recovery
- Low Carbon Heat Sources
  - Heat Pumps
  - Consideration for loop temperatures and emitter sizes
  - Performance Curves
- Renewable Technologies
  - PVs
  - Wind Turbines

Energy Modelling

Assess Energy and CO2 Emission Reductions

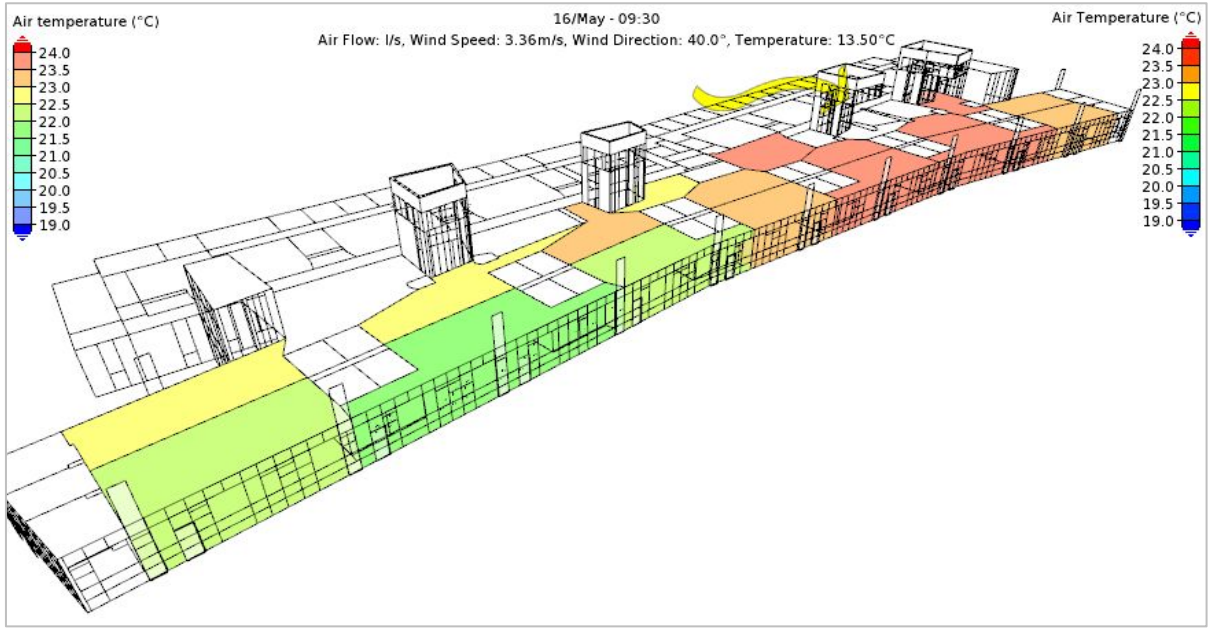
- Determine retrofit targets
- Identify most impactful Energy Saving Measures
- Ensure changes have not introduced any unexpected negative effects
  - Improving U-values can keep heat trapped in the building and lead to overheating issues
  - Reducing internal heat gains can leave the heating plant undersized to meet peak loads
  - Operating at a lower hot water temperature may cause existing heat emitters to be undersized





Energy Modelling

Assessing the Impact on Space Conditions and Avoiding Negative Impacts



+ Increasing the air tightness and fabric U-values can effectively trap heat within the building and lead to overheating particularly in areas that do not include mechanical cooling.

+ Models can be tested using future weather files to ensure Thermal comfort should still be achieved in the future.

Key Takeaways

Dynamic Modelling for Retrofit

- In Existing Buildings there is the opportunity to accurately model the building usage as there is generally information available on the Real operation.
- Information on the Real usage can allow a Calibrated model to be created of the existing building. Metrics such as CVRMSE and NMBE can be used to verify calibration.
- A Calibrated model of the Existing building can help Target ECMs that are likely to be most impactful.
- Dynamic simulation can help minimise risk of Retrofit solutions introducing unexpected issues such as problems with thermal comfort.

SUSTAINABLE PLACES 2025

AUDIENCE POLL

Which measures do you think will have the greatest impact in decarbonising our existing buildings?

Ongoing Monitoring & Performance Tracking: Ensuring Retrofit ROI

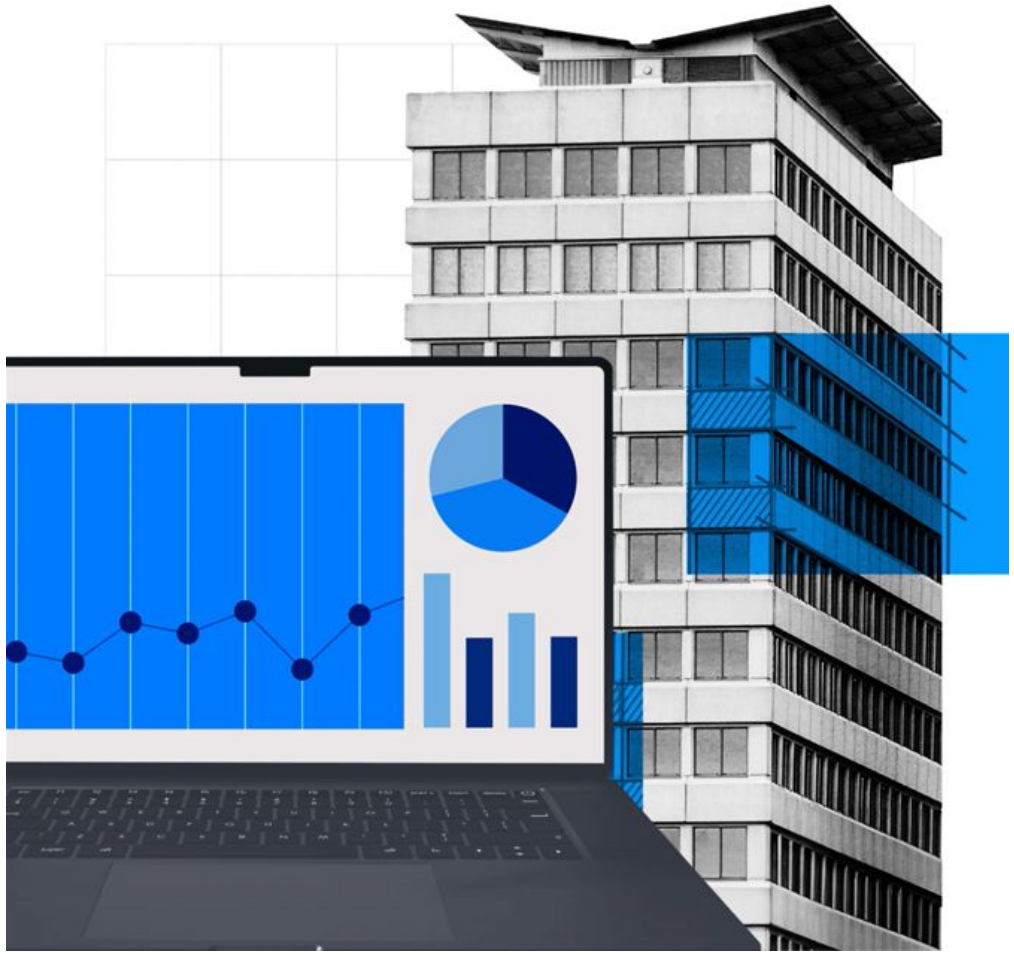
Energy Models After Retrofit Implementation

Key questions

+ How well is your renovated building performing against the optimal scenario?
+ Have you achieved the expected savings?
+ Was your decarbonisation investment ensuring the right return?
+ Where do you invest next?

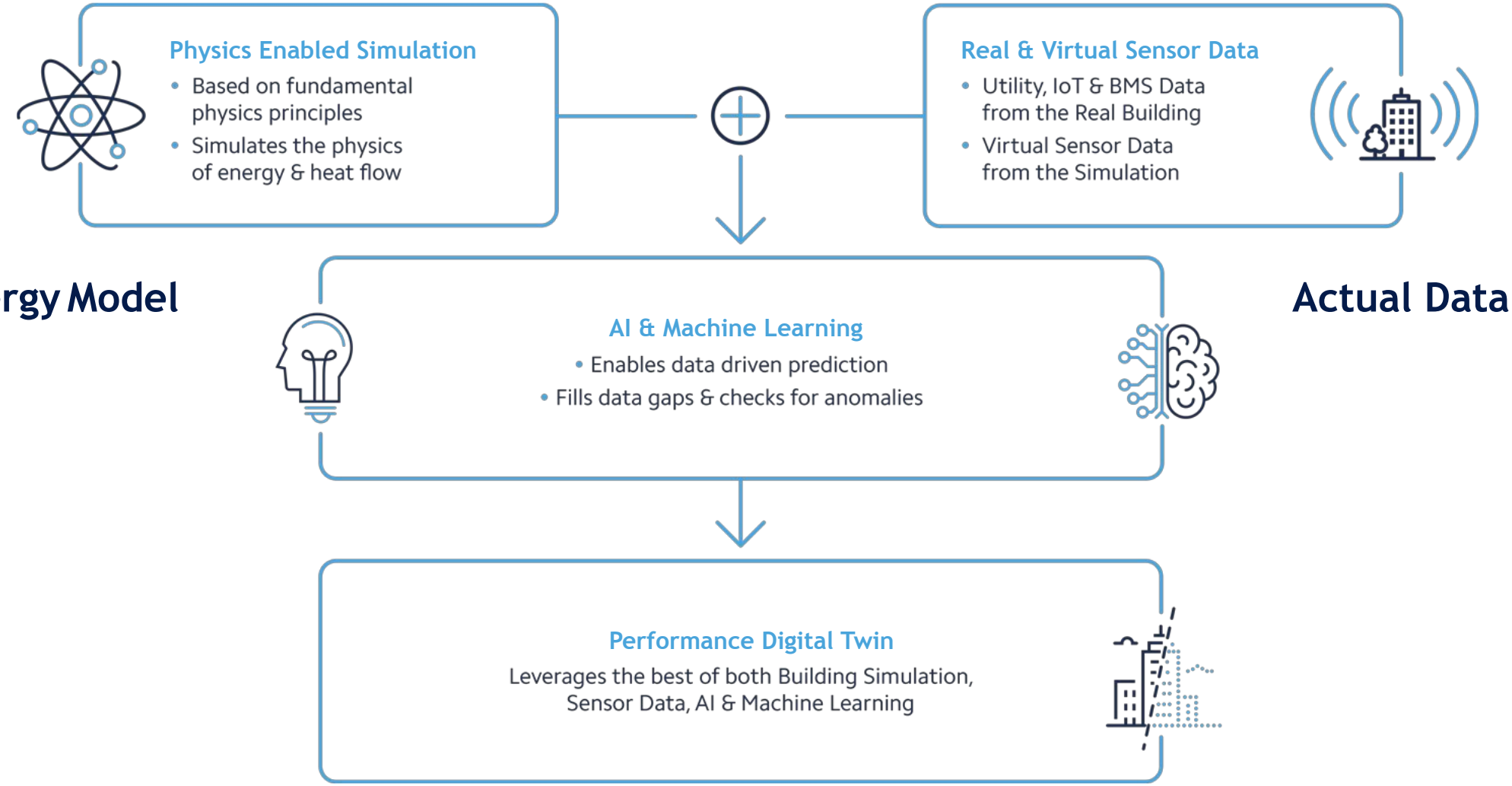
How energy models can help

+ Feed model with measured data to improve fidelity
+ Energy model becomes a Digital Twin representing optimal behaviour of your building
+ Compare simulated and actual data to track savings
+ Support auditing and reporting of verified savings

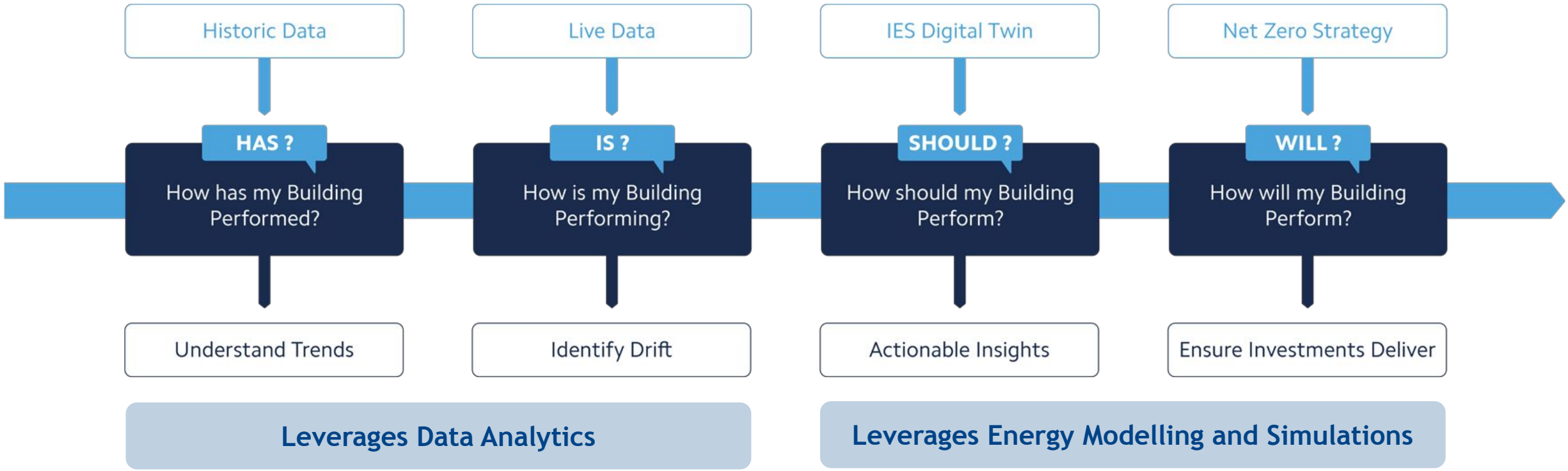


The Best of Physics, Data and AI/ML

SUSTAINABLE PLACES 2025



Keep your Finger on the Pulse of Operational Performance After Retrofit



IES Live: Investment Grade Intelligence

Energy & Carbon Performance

+ EUI, KWh, Cost, tCO2e

Actionable Intelligence

+ Impact of improvements
+ Energy, cost & carbon savings

Net-Zero Investment Performance

+ Verify energy, cost, carbon savings

Energy tracked against Occupancy

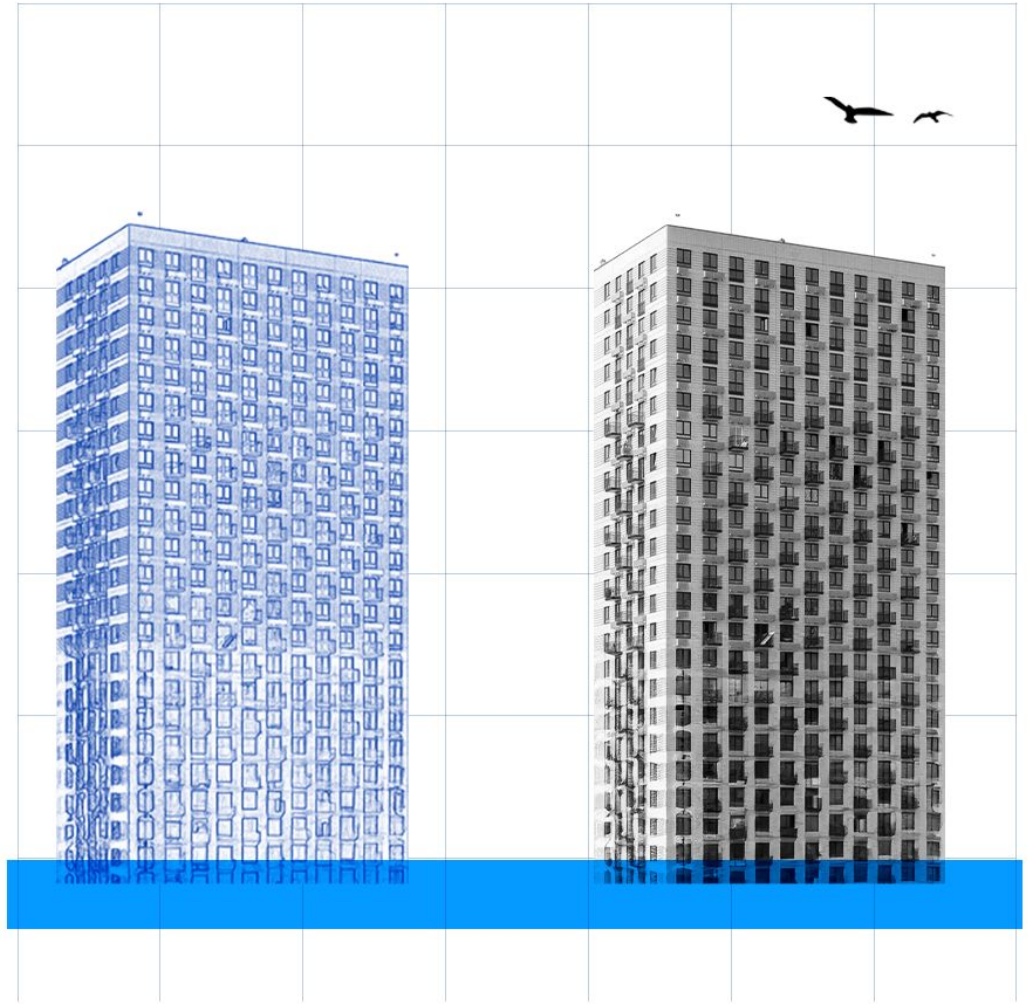
+ Use/Cost per Occupant

Indoor Air Quality (IEQ) Tracking

+ CO2, temperature, humidity

Value Case for Performance Digital Twins

- + Investment Grade Intelligence
- + Inform Risk Management
- + Enable Financial Planning
- + Deliver Operational Efficiency
- + Reach ESG Goals
- + Achieve Regulatory Compliance
- + Modernise and Digitise your Assets
- + Preserve, Bolster and Create Value
- + Unlock Year-on-Year Savings



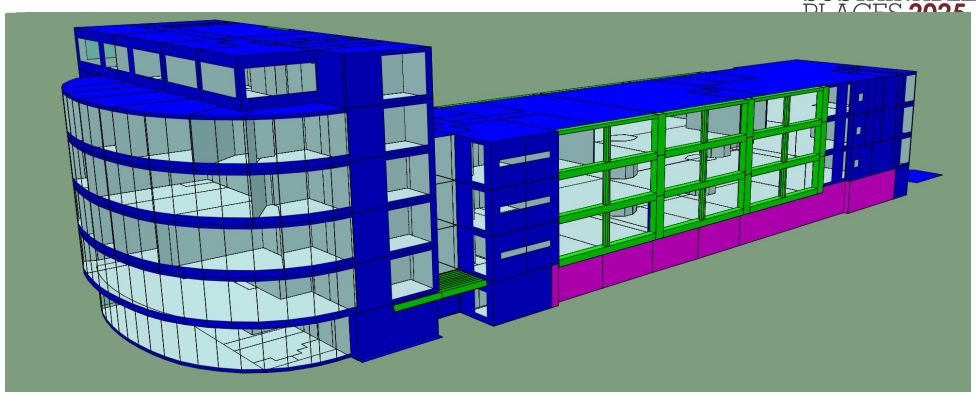
University of Liverpool

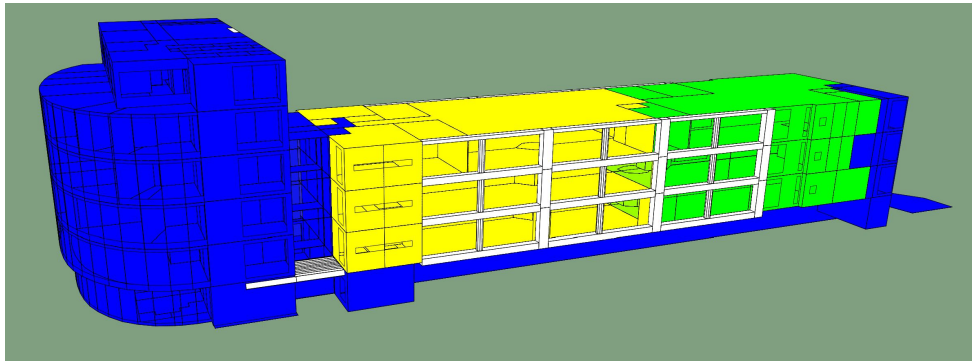
Case Study

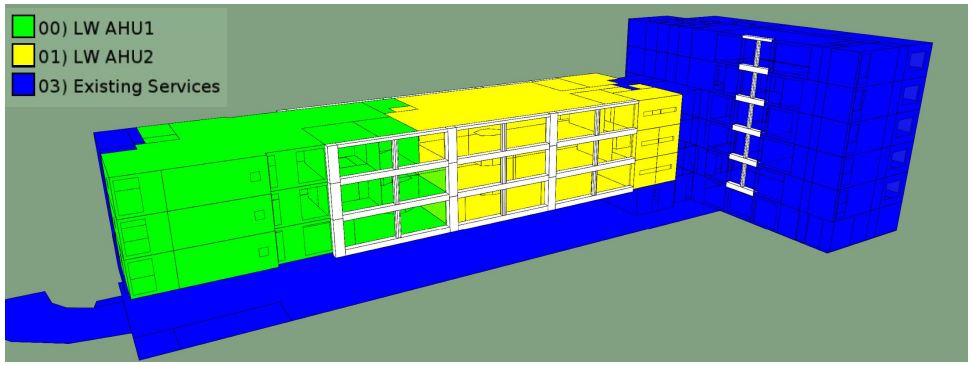
HVAC Refurbishment Evaluation

- University wanted to assess the impact of an HVAC refurbishment on one of their buildings (Foundation Building)
- Initial energy model created in 2022
- Used to evaluate HVAC refurbishment
- Existing singular air handling unit to be replaced by 2 new units
- Demand control ventilation implemented
- LED lighting installed

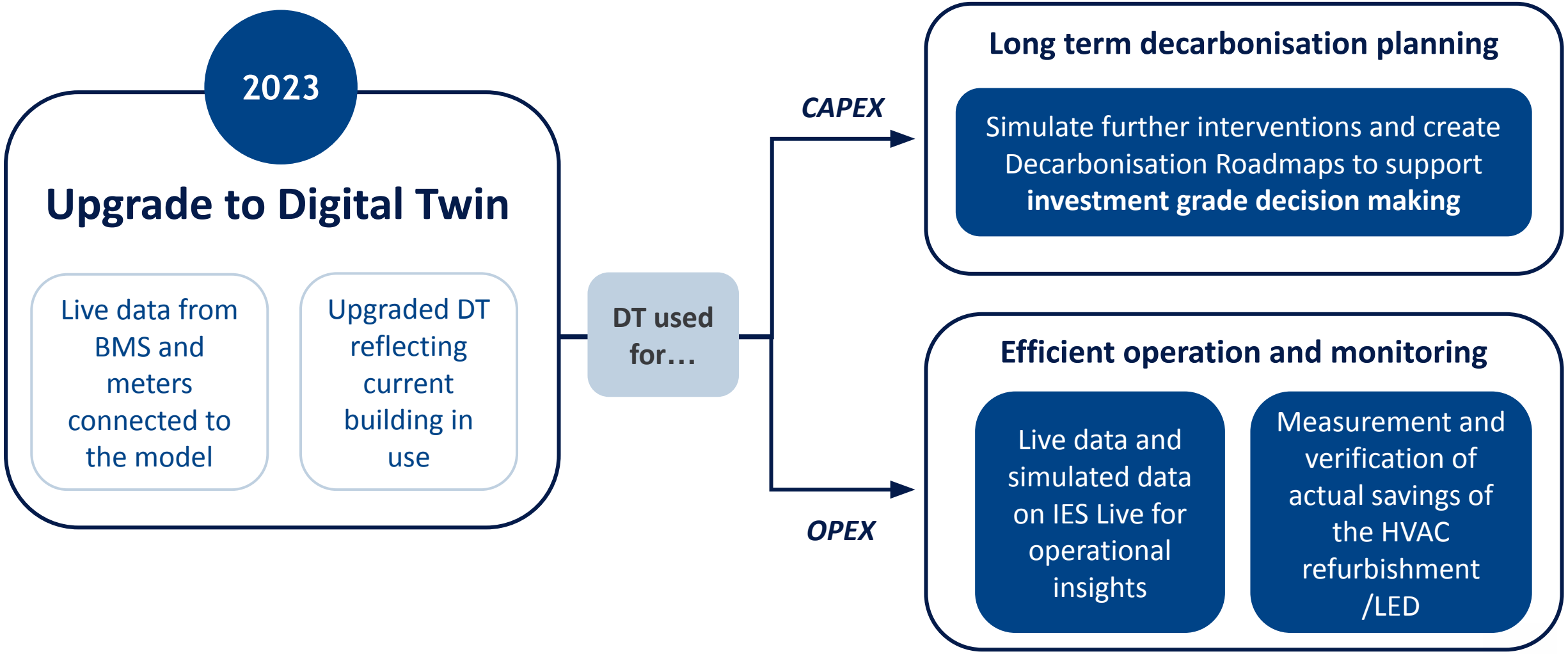
14% **estimated energy savings** from the energy model





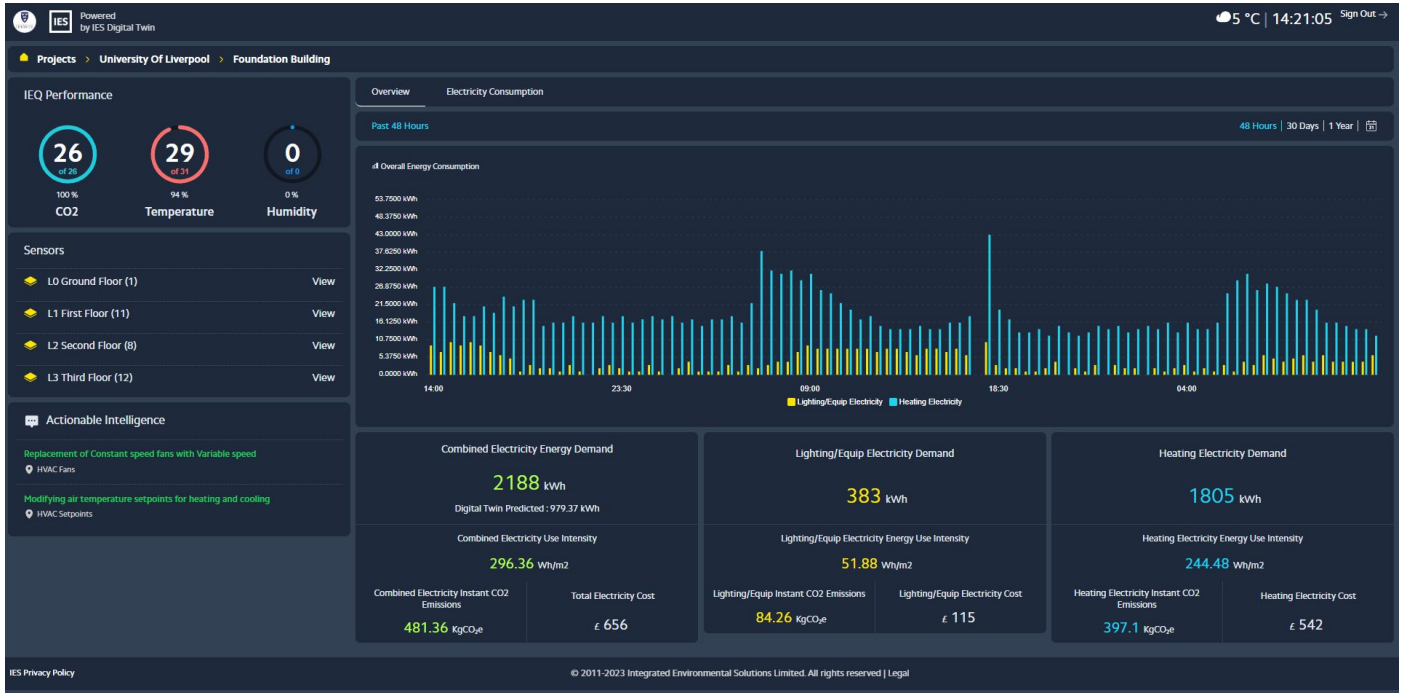


Phase 2: Upgrade to Operational Digital Twin



Live Data Connection

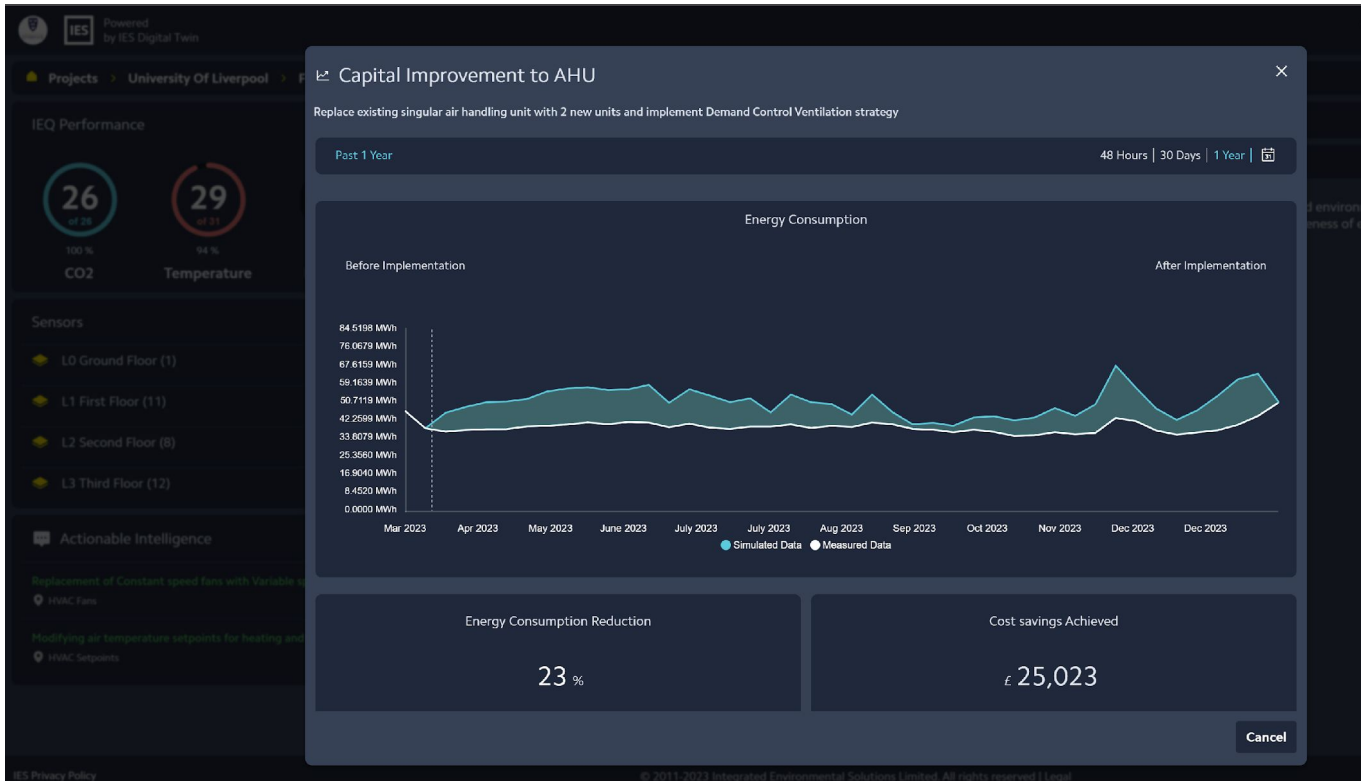
- Data from BMS, energy meters and sensors flowing live and connected to the digital twin
  - Temperature, CO2, humidity – status, range & map view
  - Energy data from meters
- Overview of energy use and KPIs in real time: total & breakdown of electricity consumption
- KPIs displayed and updated in real time: EUI, CO_2 Emissions, Cost, etc.



Live Data Environment - Efficient Operation

Project Tracking

+ Monitoring actual savings from the HVAC refurbishment and LED lighting upgrade since implementation using the Digital Twin



KEY FACTS

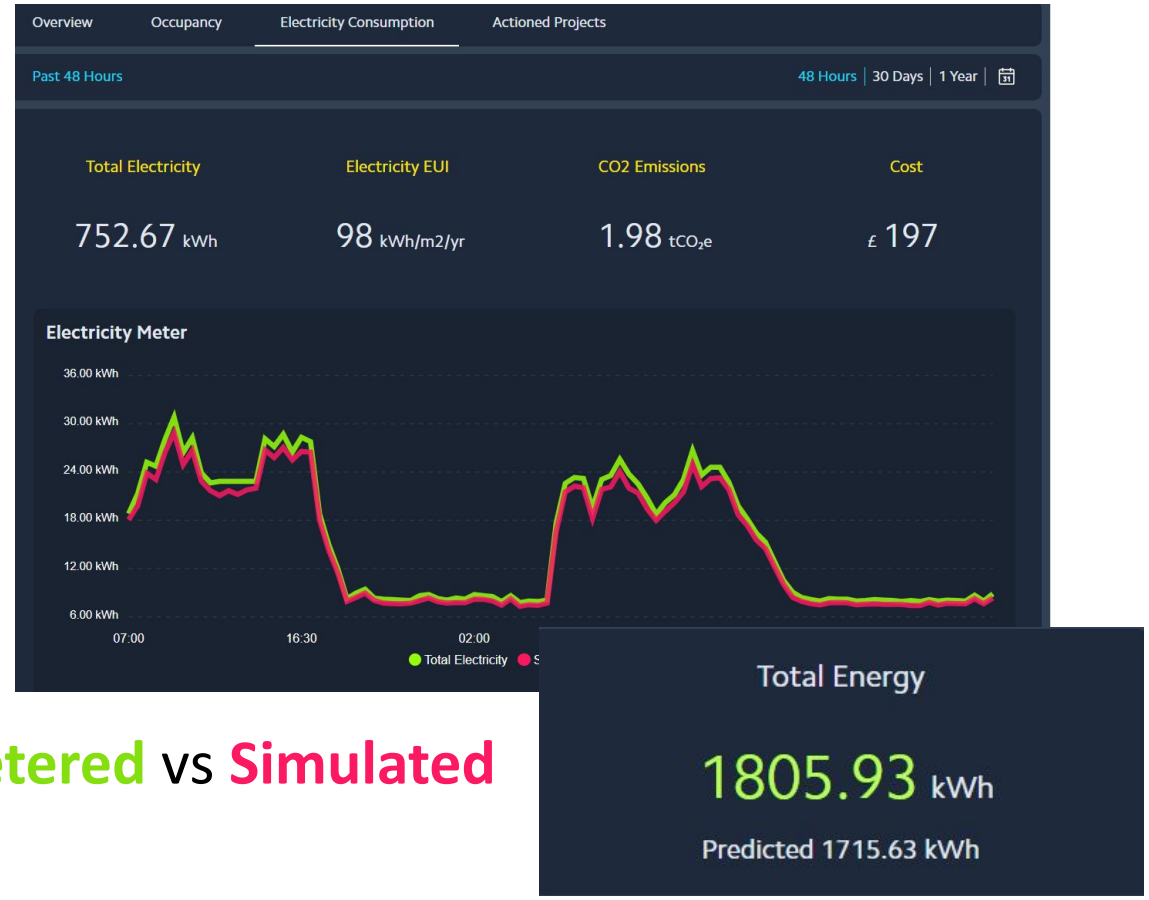
23%
Verified energy savings

£25k
Operational cost savings

9 Months
April-Dec 2023

Upgraded Digital Twin – Operational Insights

- DT simulated on the cloud daily- results displayed with live metered data
- Impact of operational scenarios evaluated on the DT (i.e. change of setpoints)



Metered vs Simulated

Baseline vs Proposed

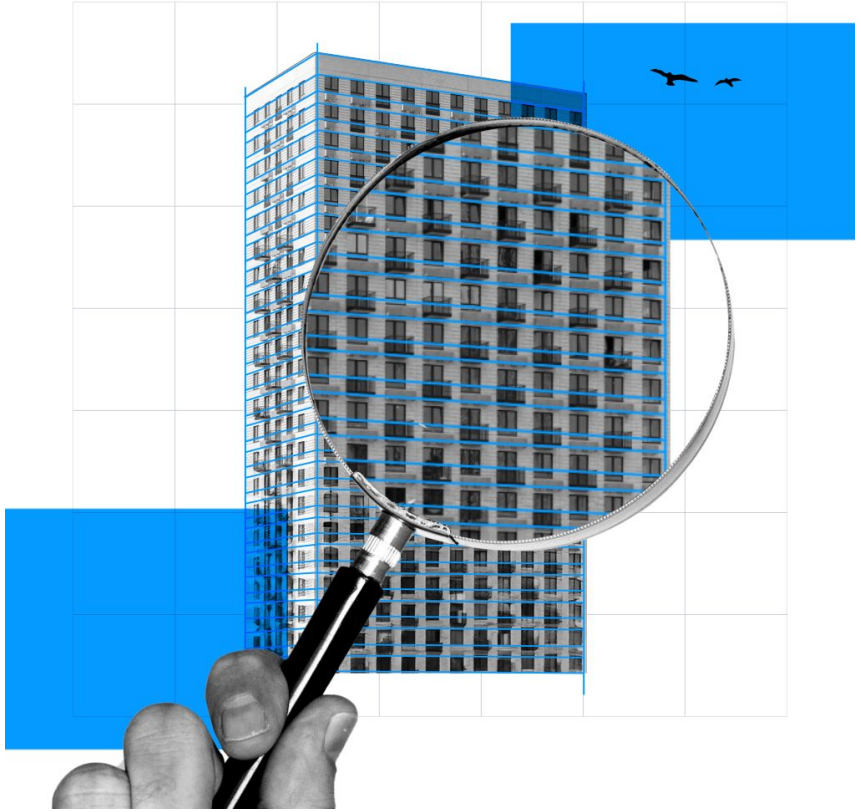
IES Live: Whole Life Performance Evaluation

The best from energy models and data analytics - together

Key Takeaways

Ongoing Monitoring & Performance Tracking

- Ongoing M&V is essential to verify that retrofits have delivered, justify your investments and prevent buildings from falling back into inefficient use.
- Advanced digital technologies can help leverage data insights to continuously track and verify the impact of implemented retrofits.
- Track energy and carbon metrics while balancing costs and occupant needs.
- Performance optimisation is a continuous process. Energy models and data should be used to create continuous feedback loops, informing future upgrades and modelling iterations.
- Keeping energy models ‘live’ between different retrofit and refurbishment cycles reduces time, effort and modelling cost.
- Unlocks the power of energy models in operation to deliver a whole lifecycle performance-based approach to building decarbonisation.



In Summary...

- Every building has energy savings that can be achieved.
- Data analytics and tools such as iSCAN can help you identify the quick wins and start the journey towards net zero.
- Dynamic simulation modelling in the VE, coupled with industry standards such as TM54, can increase confidence in retrofit decisions.
- The tools now exist to transform these models into Digital Twins in line with industry best practice standards and calibration guidelines.
- IES Live empowers building owners to make best use of their Digital Twin, even when they don't have the in-house skill sets for energy and physics modelling.

SUSTAINABLE PLACES 2025

FREE GUIDE

Energy Modelling for Retrofit

Best Practice Approach to Decarbonising Existing Buildings

https://www.iesve.com/net-zero-retrofit

SUSTAINABLE PLACES 2025

IES

Thank you

Questions?