iBECOME

Automation of building energy model calibration for improving operational efficiency in buildings

Dimitris Ntimos, IES R&D project manager, coordinator of iBECOME

Agenda

Intro to IES

Intro to IBECOME project

Our main role in iBECOME

Focus on Calibration

Applied Calibration and findings

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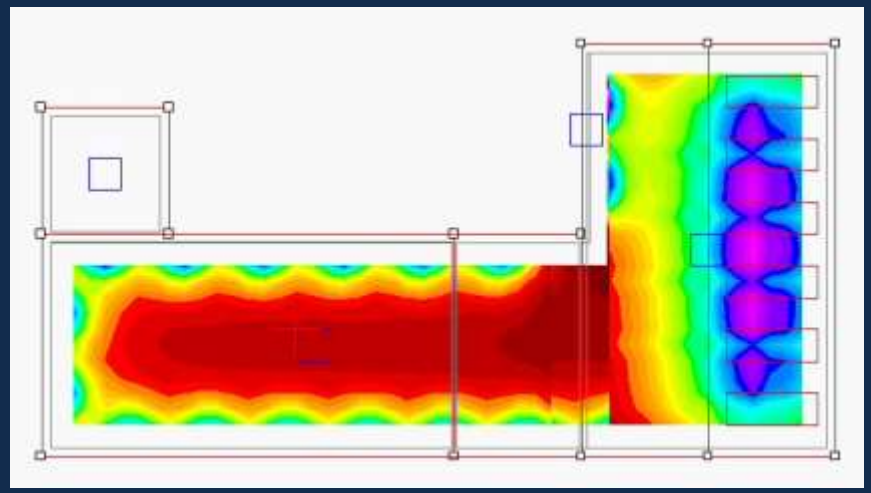

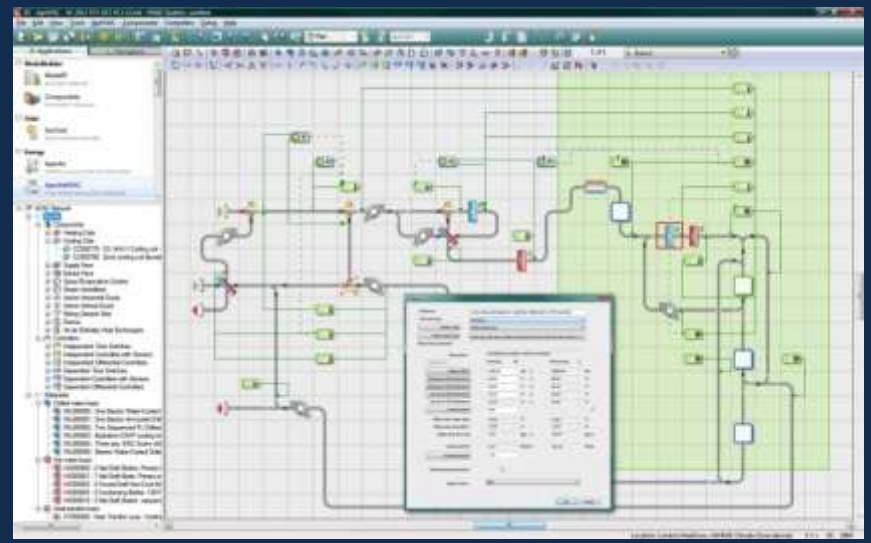

27
Years of building analysis

20,000+
Software users

75,000+
Projects per year

Home to the largest building physics analytics team in the world
Developers of the Intelligent Communities Lifecycle (ICL) digital twin

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ICL Digital Twins for Buildings and Communities

IES' ICL Digital Twins can be used for **monitoring and management** and for **predictive modelling**

Tackles Uncertainty

- Buildings are used by humans
- Every building is a 'prototype'

Use of Legacy Systems & Control Technology

- Multiple Buildings, Systems & interfaces

Harness the power of physics-Based Simulation

- Traditionally done only in design
- Not integrated in Building Lifecycle
- Need for multi-year modelling

Use of AI / ML Algorithms

- Useful for data analysis, but predictive capacity is diminished in novel situations

iBECOME wants to demonstrate a combination of novel technologies for:

Reducing bills in a building or facility through energy savings and demand response while…

…improving occupant wellbeing and optimising comfort…

…by leveraging IoT, data analytics and the efficient control of a building…

…while enabling additional services such as EV charging optimisation…

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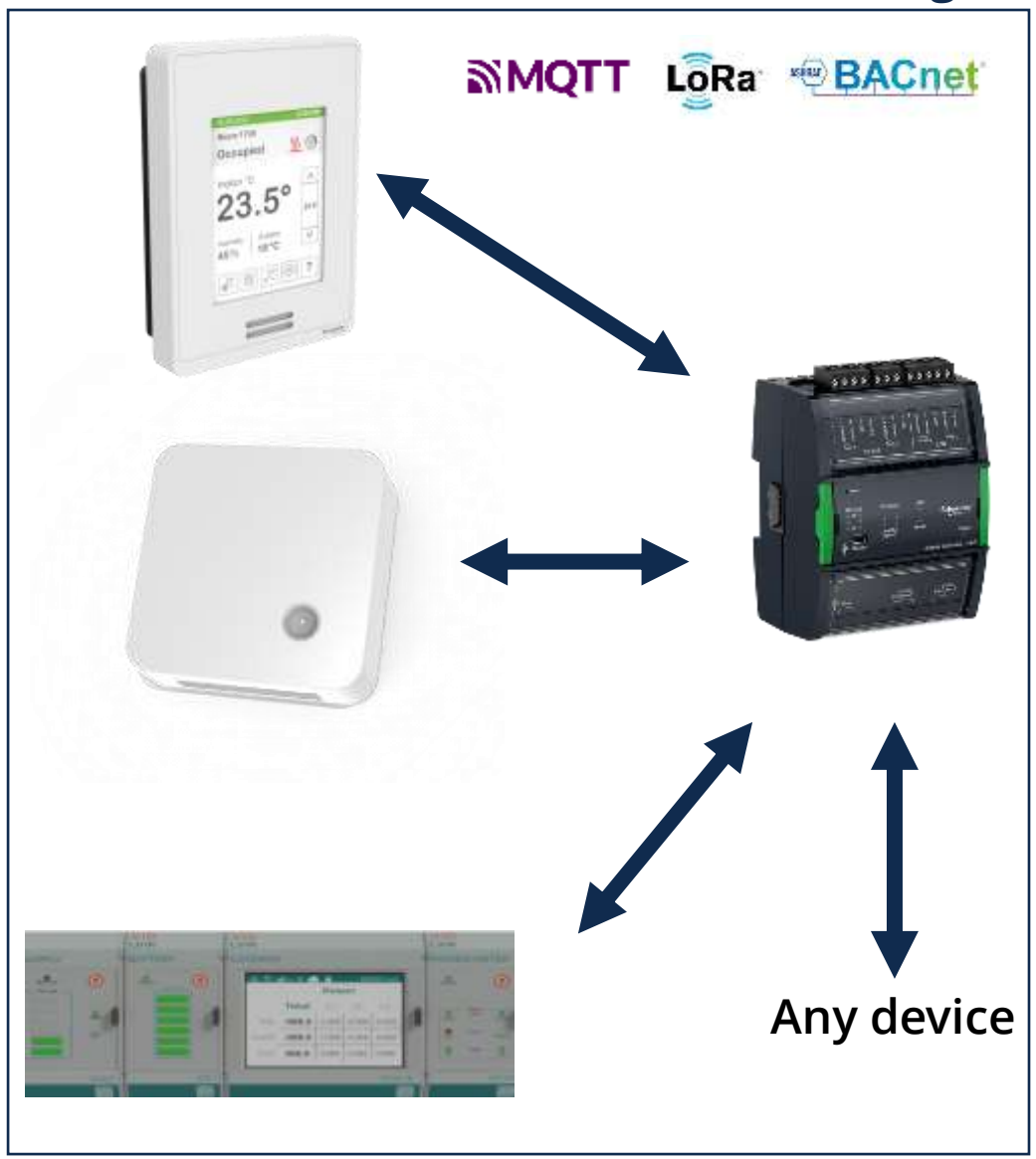
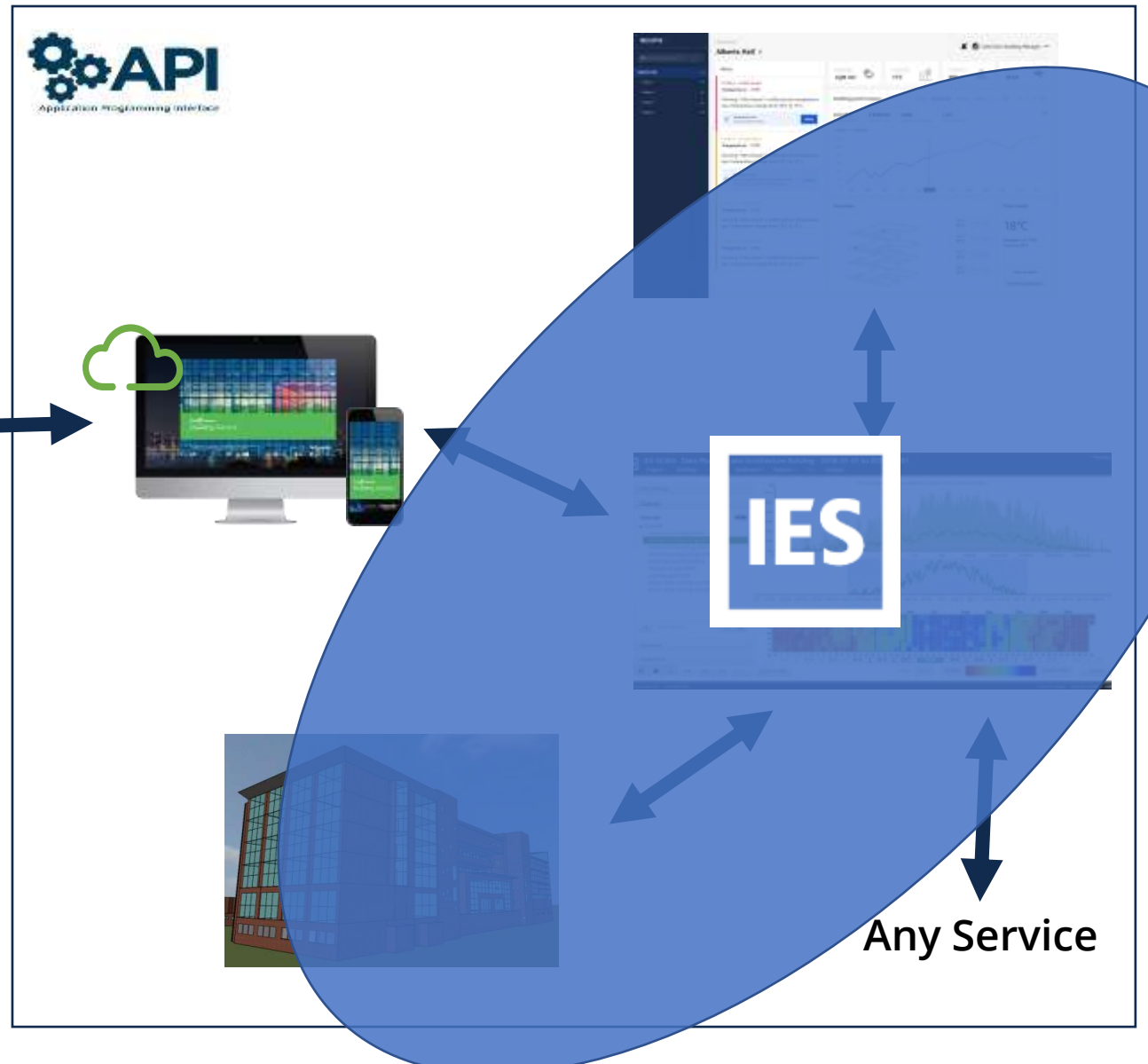
iBECOME virtual BMS

Building IoT

Cloud





Services

Core

Energy-Comfort Optimisation

Measurement & Verification

Demand Response

Fault Detection & Diagnosis

Predictive Maintenance

What-if scenarios

Additional

Healthcare Management

EV Charging Optimisation

Car sharing

Can you think more?

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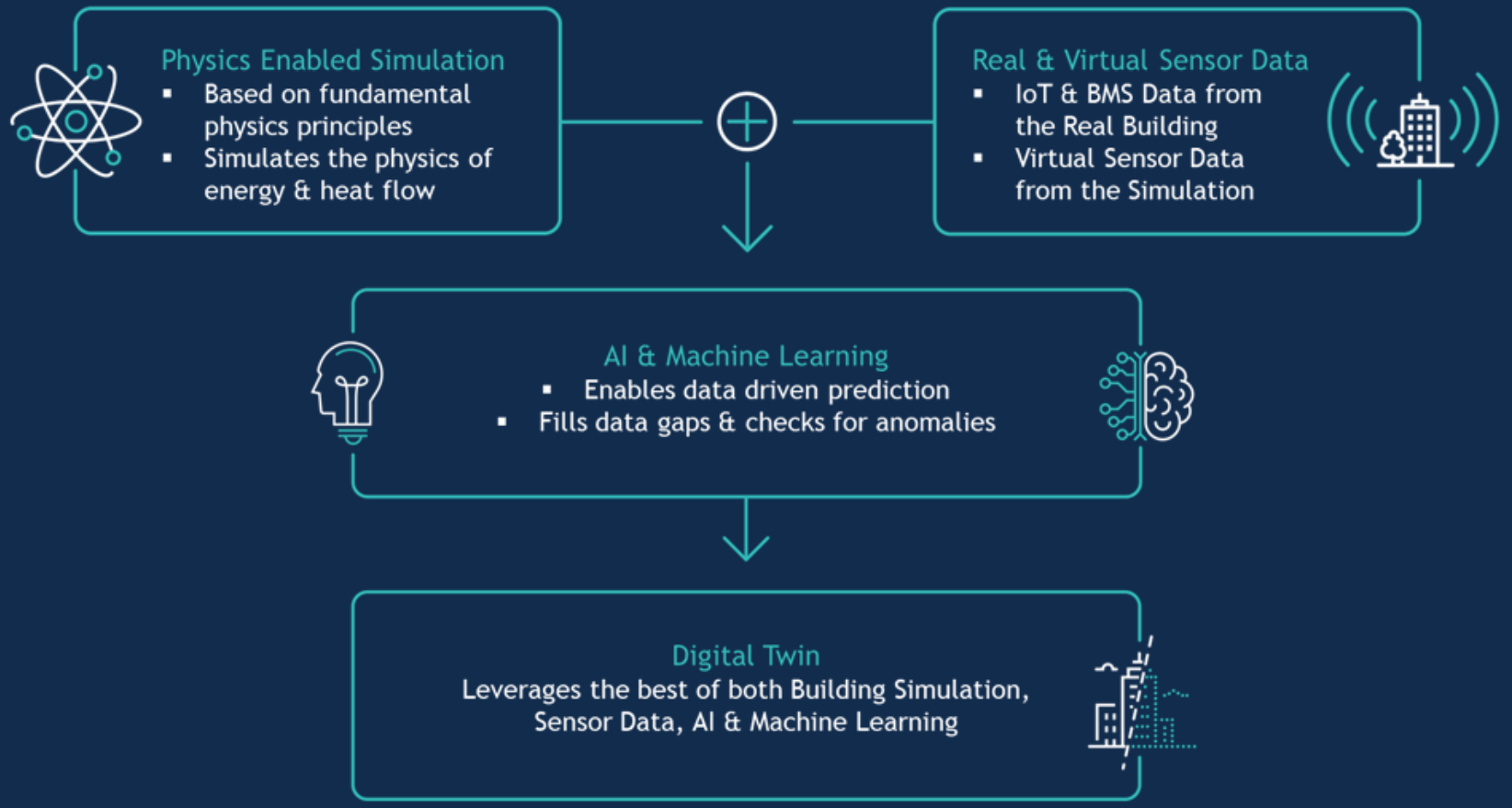
How we enable those services?



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Physics enabled simulation

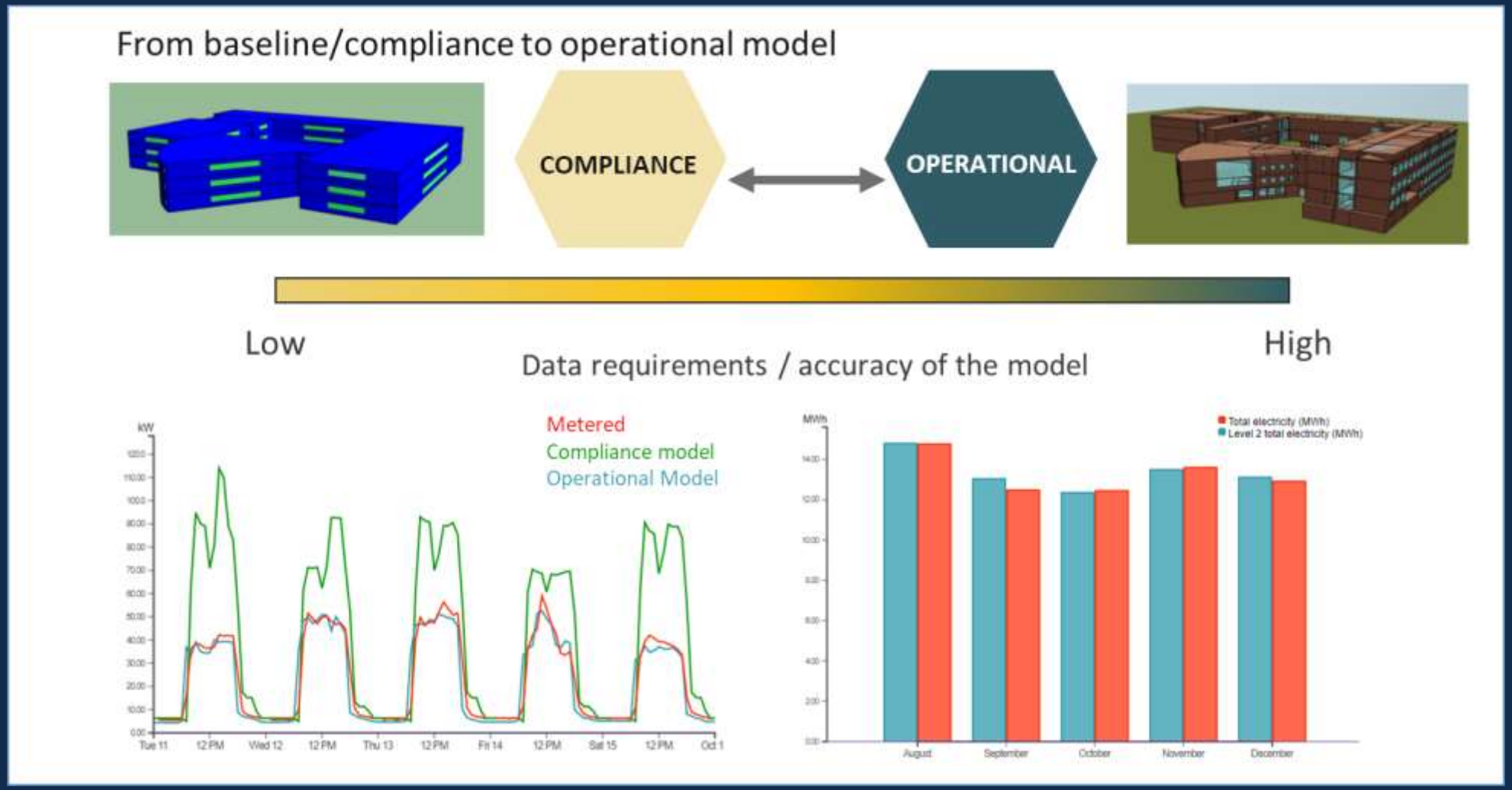
Prediction of future savings
prediction of impact of potential ECMs before their installation, fault detections and Measurement and Targeting (M&T) – Using existing/past data to set future targets of energy reduction.

Estimation of achieved savings
Energy savings cannot be measured directly. Energy savings are the absence of energy

Optimisation of energy use and comfort
We generate virtual datasets, simulate operational ECMs and push the best control strategy to a device to satisfy specific conditions

ASP de la Carnia building energy model in IESVE software

Why is calibration important?



The performance gap

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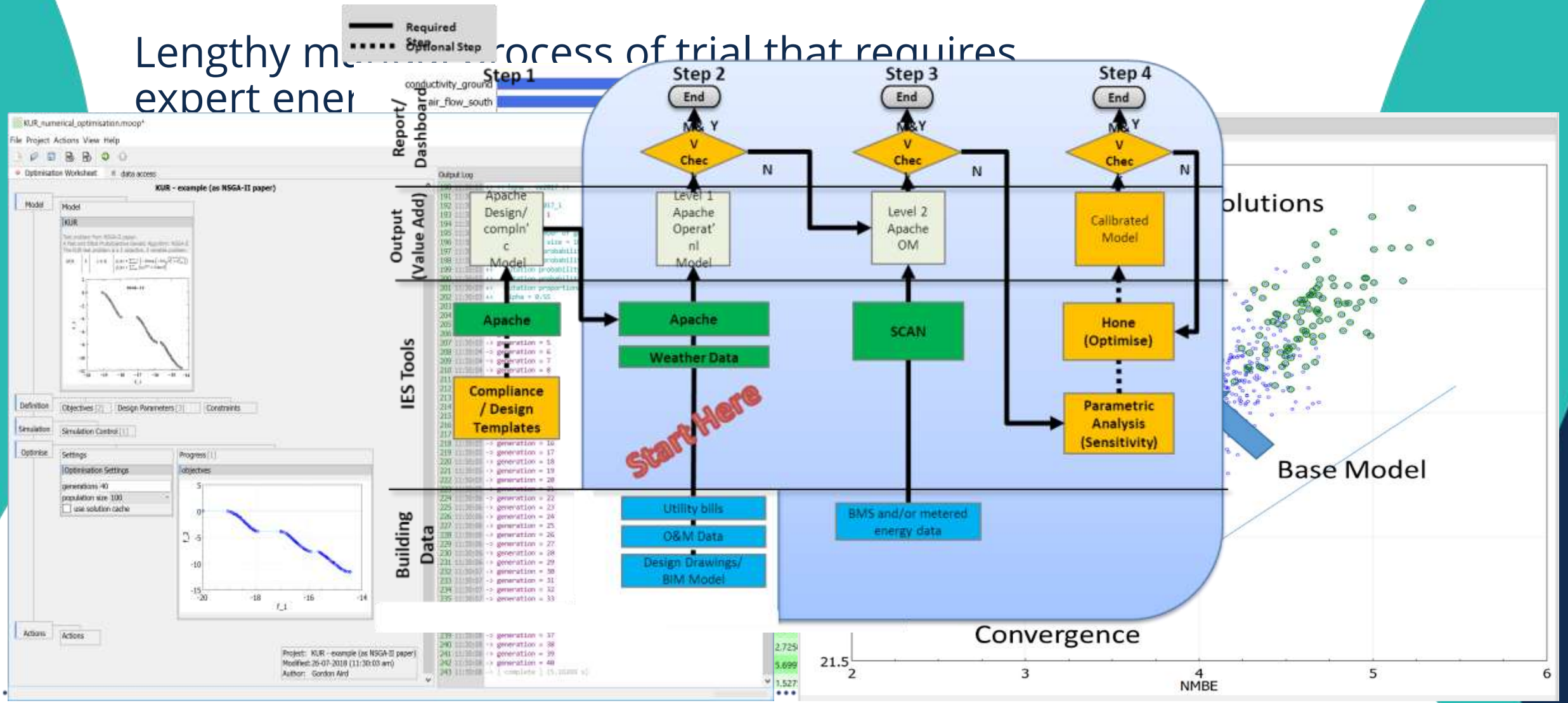
How we achieve calibration?

Lengthy manual process of trial that requires expert ener



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Literature Review of Calibration Methodologies

Automated Calibration Method	Accuracy	Complexity	Computational Effort
Bayesian	High	High	High
Metamodel	Medium	Low	High
Profile Optimisation	Low	Low	Low
Whole Building Optimisation	High	Medium	Medium

- Whole building optimisation was selected as it produces the highest accuracy at least computational effort

- Although profile optimisation is lower in computational effort, the accuracy of these models are not sufficient for the needs for optimising building control

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Key problems to solve

To be able to use calibrated models for operational efficiency we had to solve two main problems:

Calibration is a complex problem.

“Historically, the calibration process has been a form of art that inevitably relies on user knowledge, past experience, statistical expertise, engineering judgment, and an abundance of trial and error. [1]”

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Key problems to solve

To be able to use calibrated models for operational efficiency we had to solve two main problems:

IESVE is a desktop suite of interconnected tools. It is not efficient to run the whole platform on the cloud (yet ☺) as it consumes many resources. Apache is the dynamic simulation engine.

We had to decouple the Apache from the IESVE platform and cloudify it in a lightweight version OR use a Reduced Order Model.

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Solution

ROM (i.e. simplified model)	Apache on Cloud (i.e. full physics model)
Cost effective	Cost effective
Highly scalable	Highly scalable
Fast simulations as models are not complex	Speeds up complex workflows
Significant loss in accuracy	No loss in accuracy

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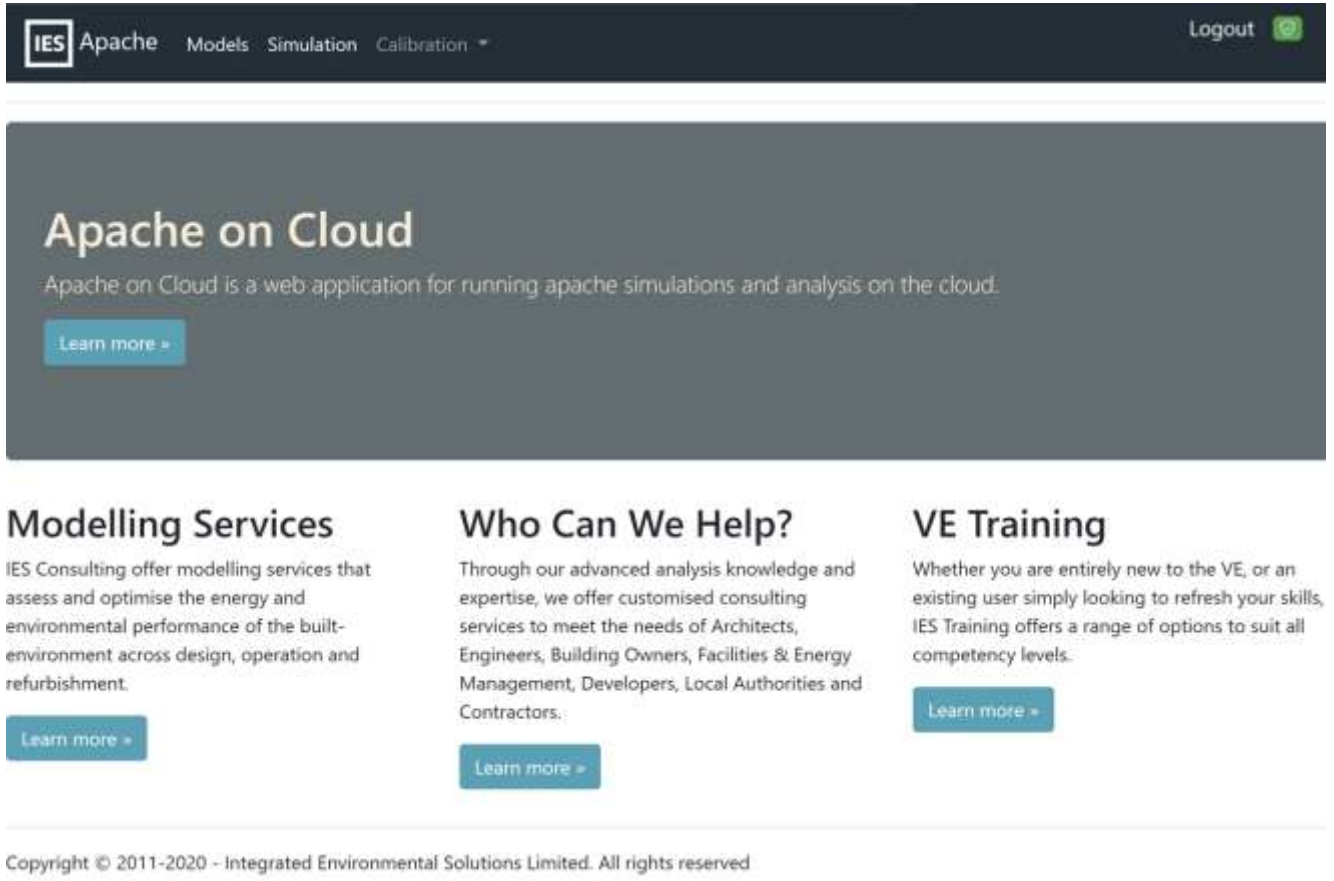
Solution

We developed a UI and API to allow humans and machines run physics-based simulations on the cloud

We automated many manual steps in calibration process that reduce time and improve calibration accuracy



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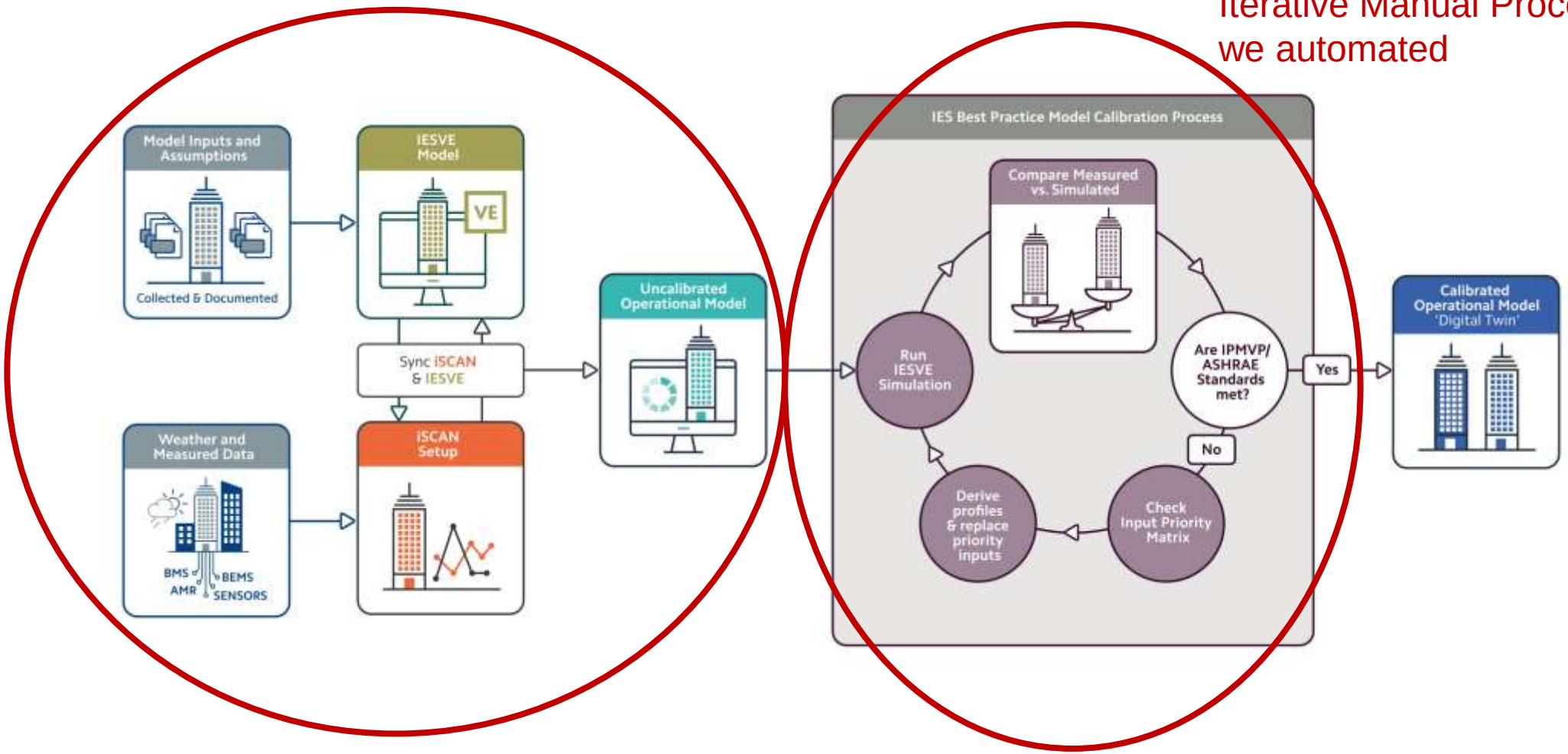
Current Calibration Process

Manual Process

Iterative Manual Process that we automated



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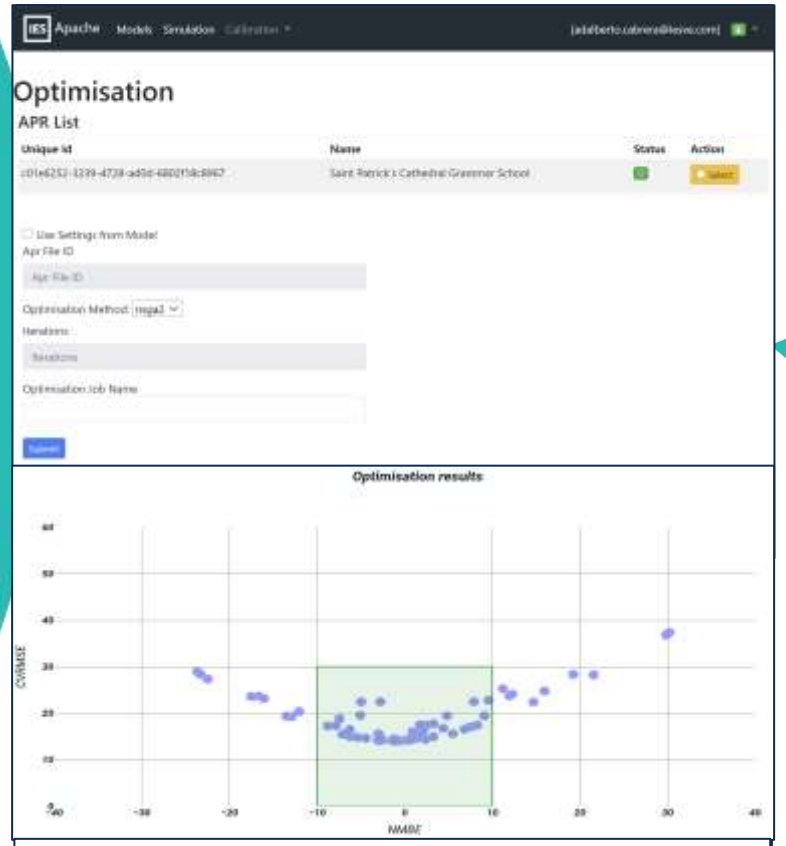
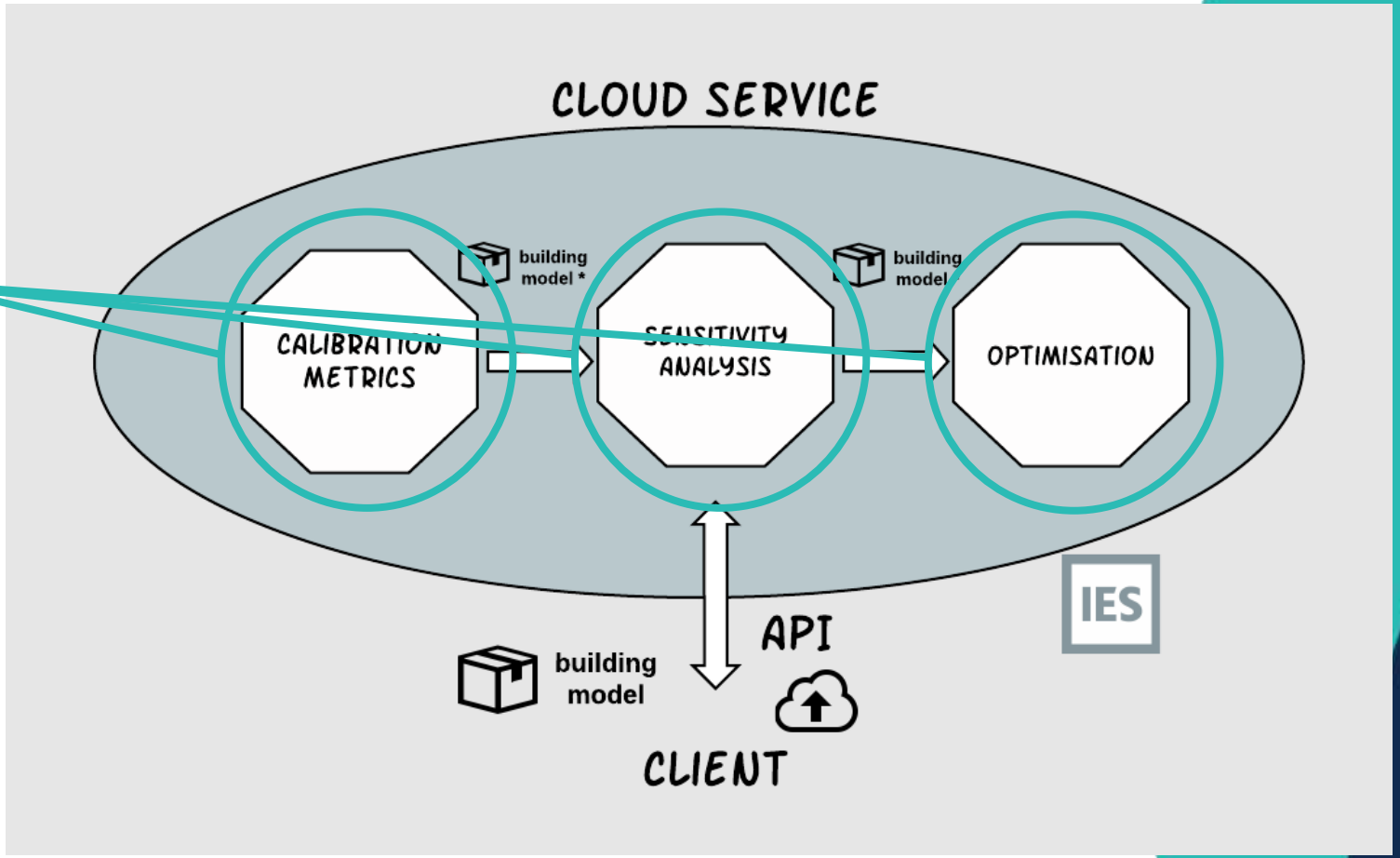
Apache on Cloud



Find optimal parameter inputs & generate a new model with best parameters



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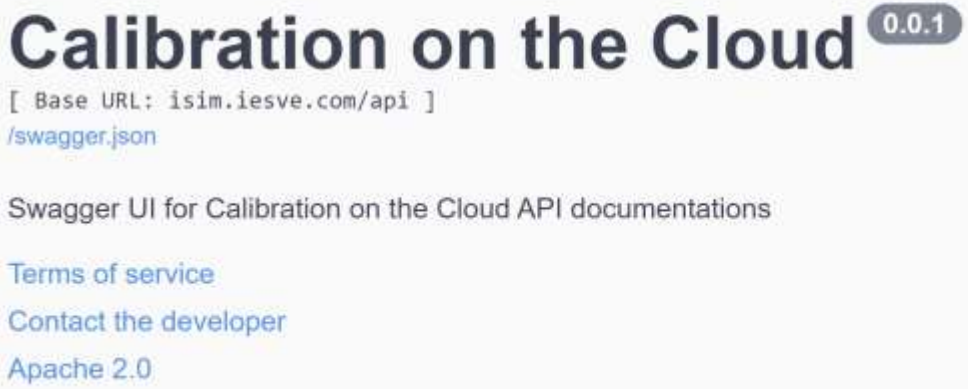
AoC Outputs

Output Type	Application
Export to .CSV file	Defined model outputs may be exported to a .CSV file for further analysis / integration with third party tools.



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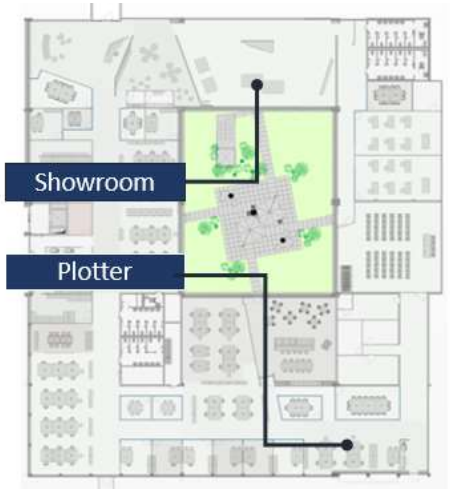
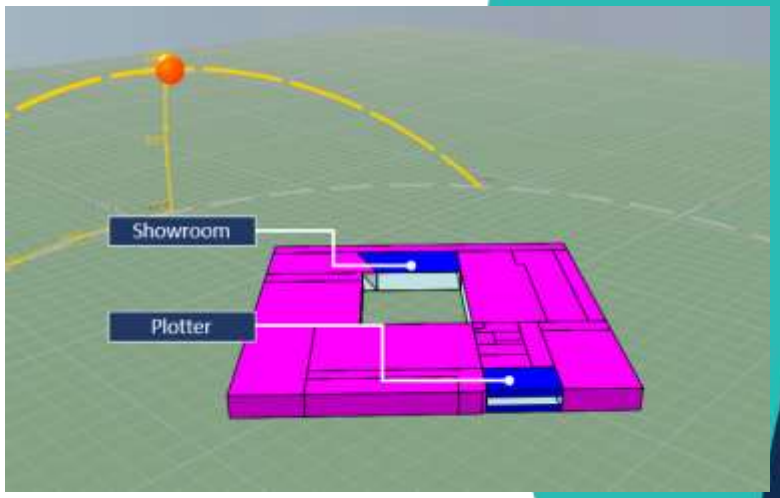
Case study

Schneider Electric Building in Bologna





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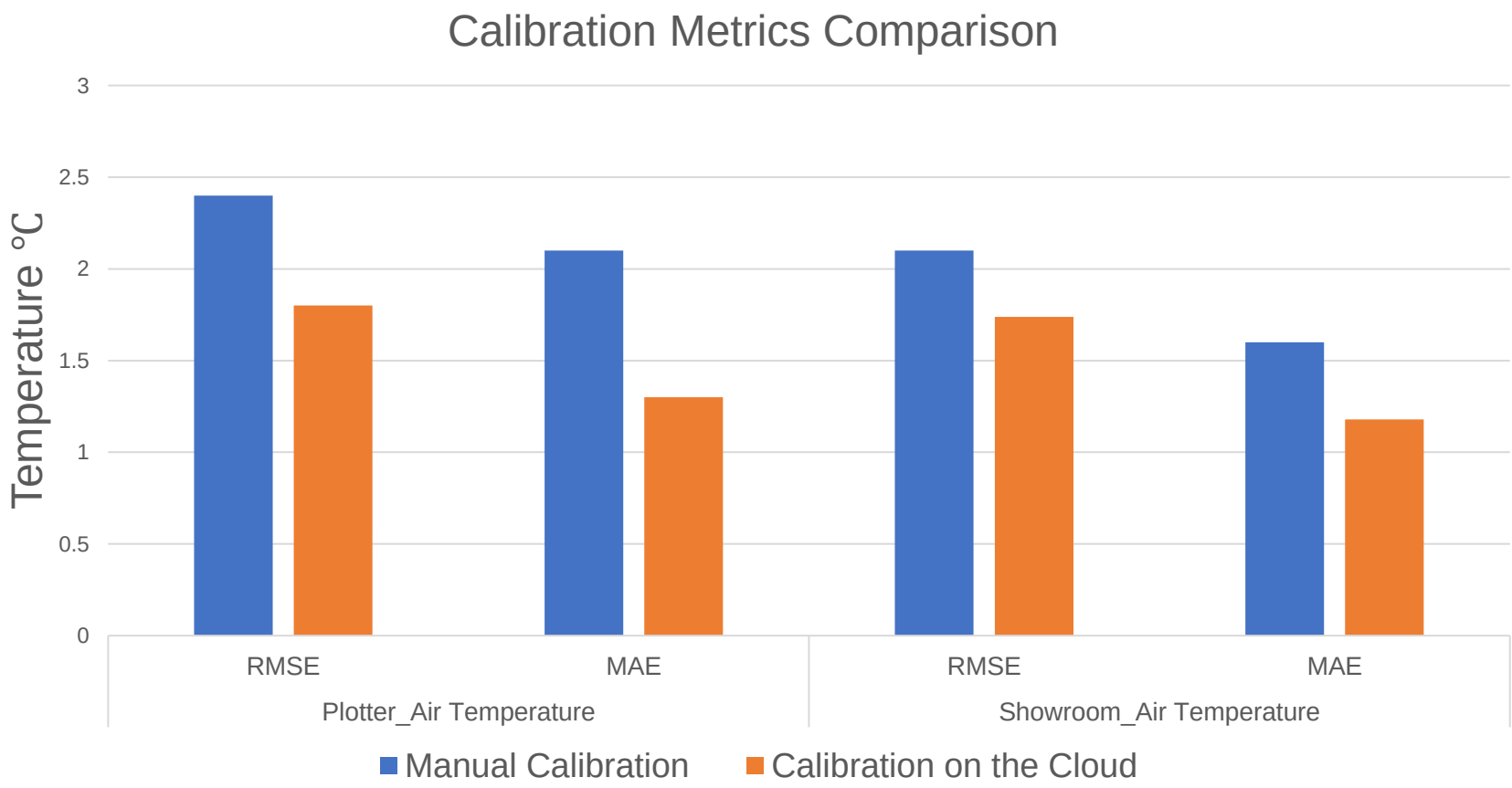
Results Comparison: Manual vs. Automated Calibration

Automated Calibration resulted in 27% improvement in model accuracy



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Results Comparison: Manual vs. Automated Calibration

Challenges of Manual Calibration	Addressing the Challenges with AoC
Lack of standardisation	Defined workflow developed
High costs associated with time intensity	Time taken to calibrate a model has been reduced significantly. **Manual Calibration = 2 days** **Automated Calibration < 20 minutes** (The timings are dependant on model complexity)
Lack of clarity on which datasets to collect	SA module identifies the most important datasets
Deterministic approach used to improve accuracy, which relies on user expertise	SA module identifies which variables have biggest impact on model accuracy and optimization helps find best fit.
Lack of automation	Apache on the Cloud provides an automated process for calibration which **reduces the reliance on the expertise of the modeller.**

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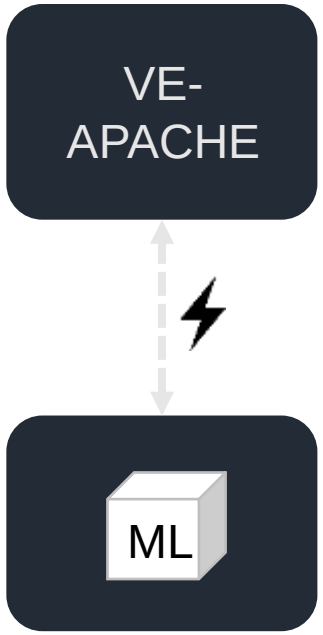
Integration between physics based engine and data driven models

- A prediction algorithm can now interact with the physics simulations engine in every time step

- This way we can combine the best of two methods, including IoT data collection to enable data driven predictions and control optimisation (e.g. optimise heating to maximise comfort and minimise energy savings simultaneously)

Hybrid model
co-simulation Apache/VE-ML



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iBECOME virtual BMS – sample workflow

Building IoT

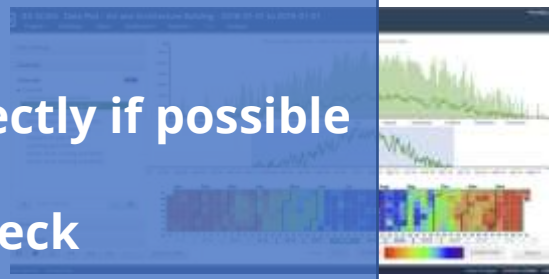
Cloud

MQTT LoRa BACnet

API

Application Programming Interface

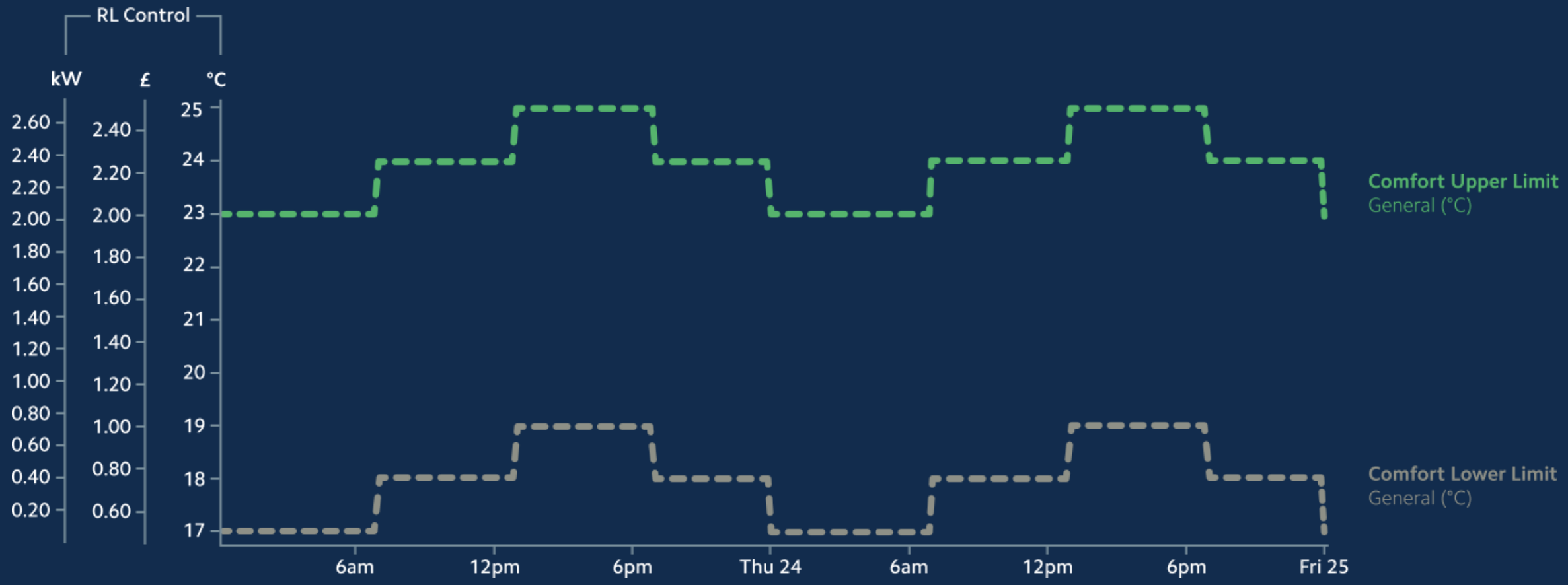
Collect static data manually (drawings-patterns etc.)
Collect data from IoT and BMS automatically
Develop baseline energy model
Develop initial calibration semi-automatically
Schedule co-simulations daily/hourly to inform services
Run control algorithms and send to dashboard or device directly if possible
App to regularly check if the model is calibrated
Perform auto-calibration on the cloud or nudge expect to check



Any device

Any Service

RL controller performance test in simulation



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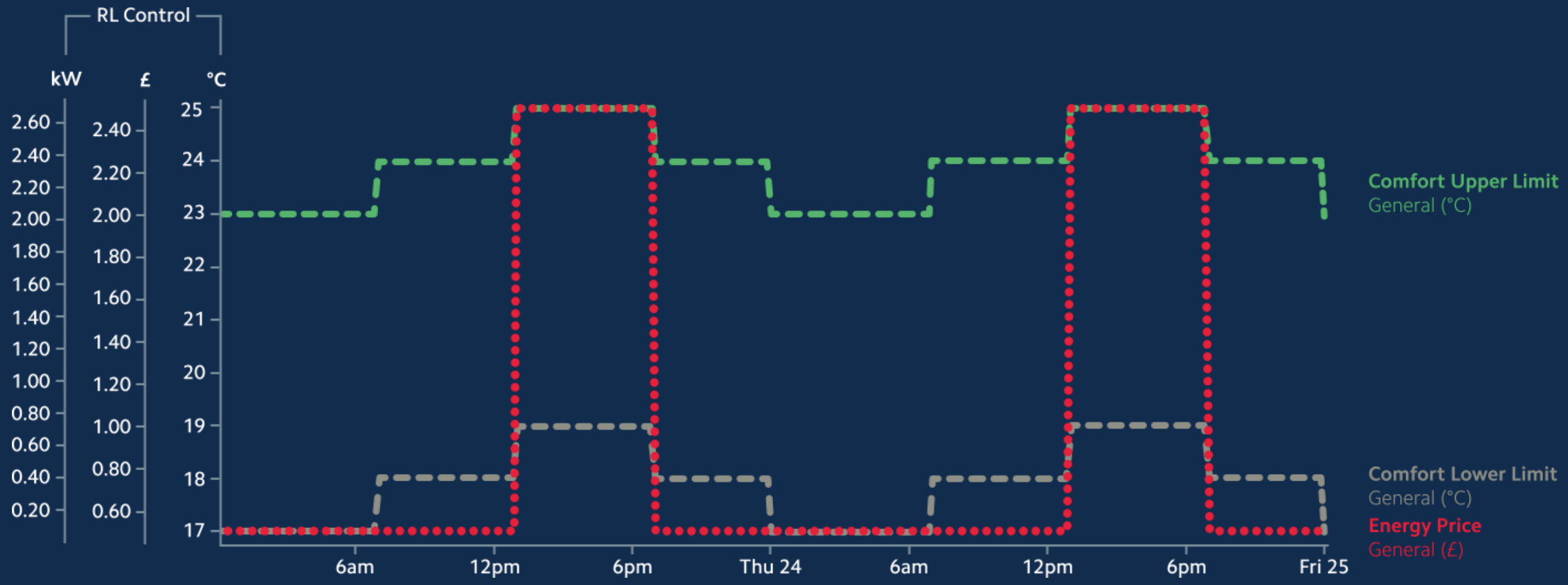

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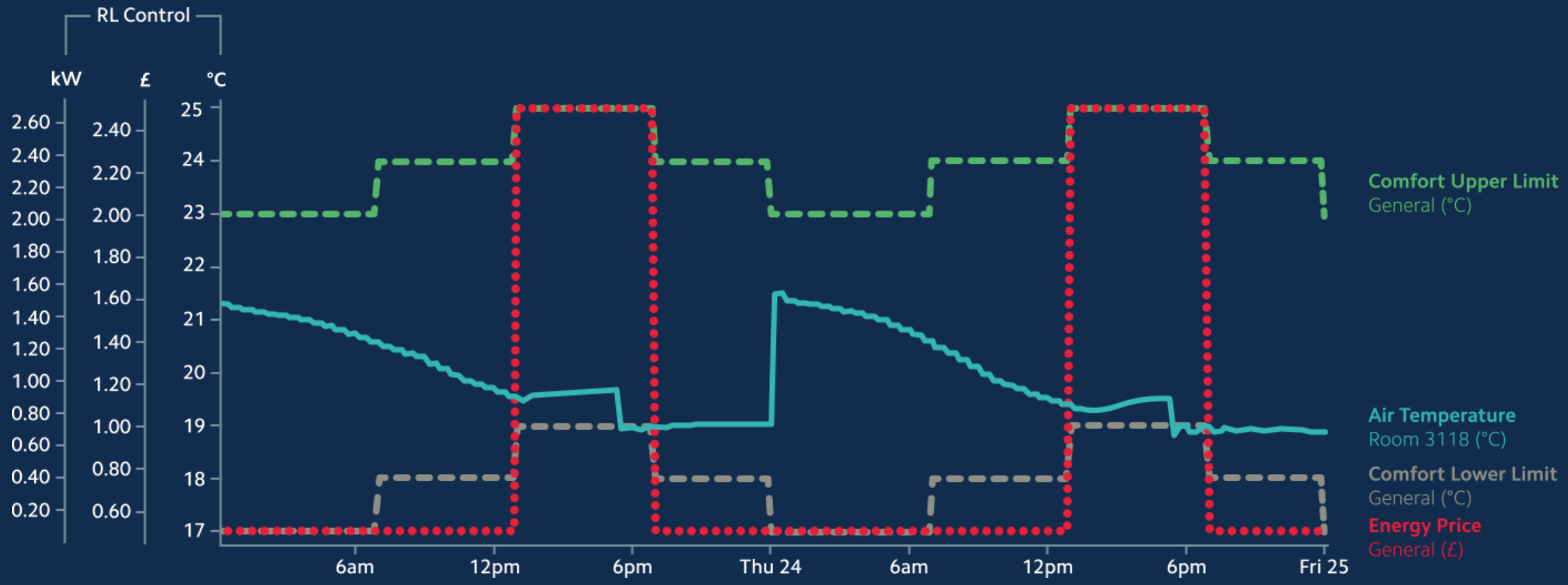

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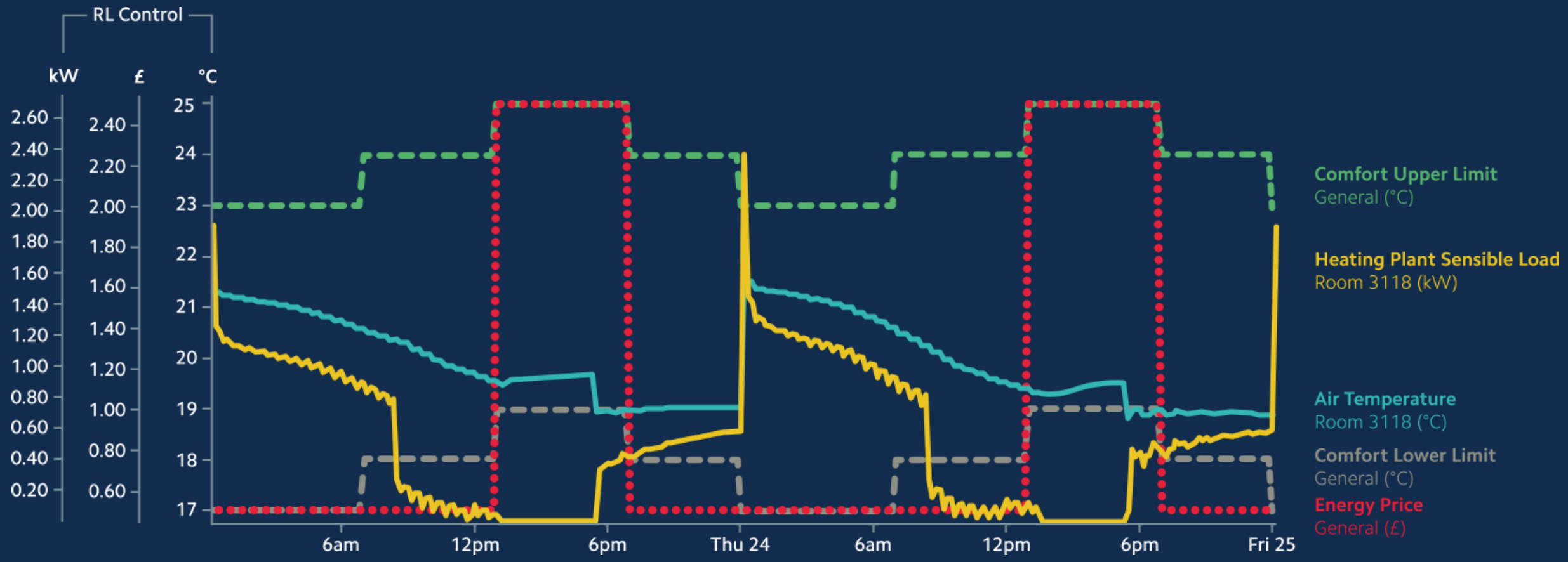

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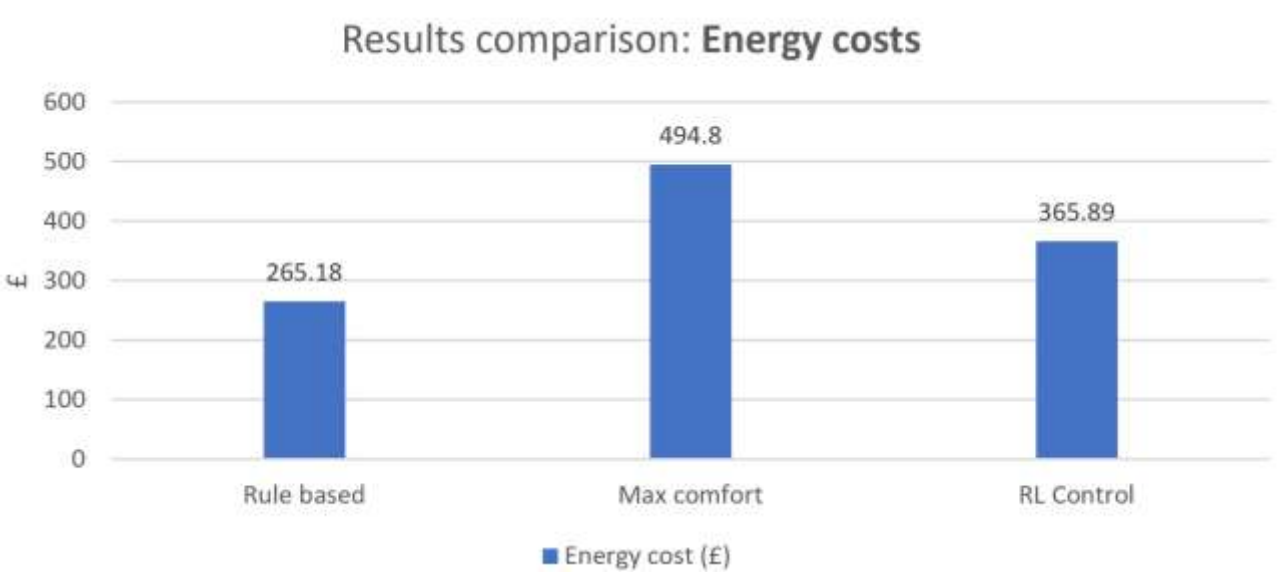
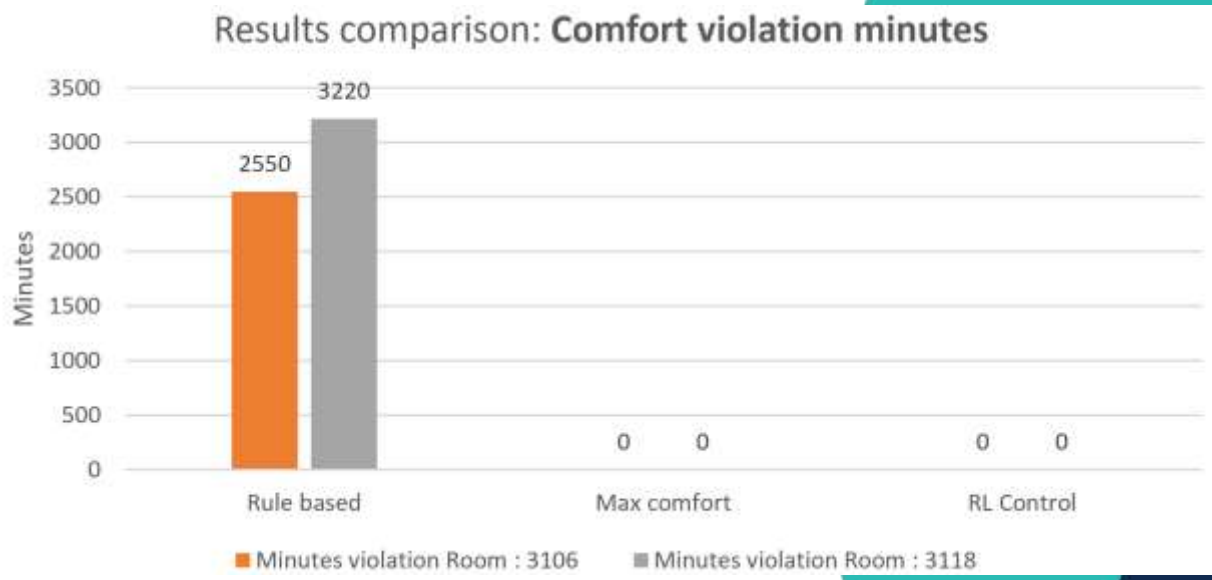
Comparison between iBECOME controller and standard methods tested in simulation





The intelligent controller (uses Reinforcement Learning algorithm) provides an optimal solution with 25% lower energy costs than the max comfort scenario without comfort disruption.

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Trial of the vBMS: Demonstration sites

Just vBMS installed, No BMS

vBMS Combined with retrofits and BMS

Country Crest, Ireland

Food Processing Facility

Helix Building, Glasgow

Office

ASP della Carnia, Italy

Care Home

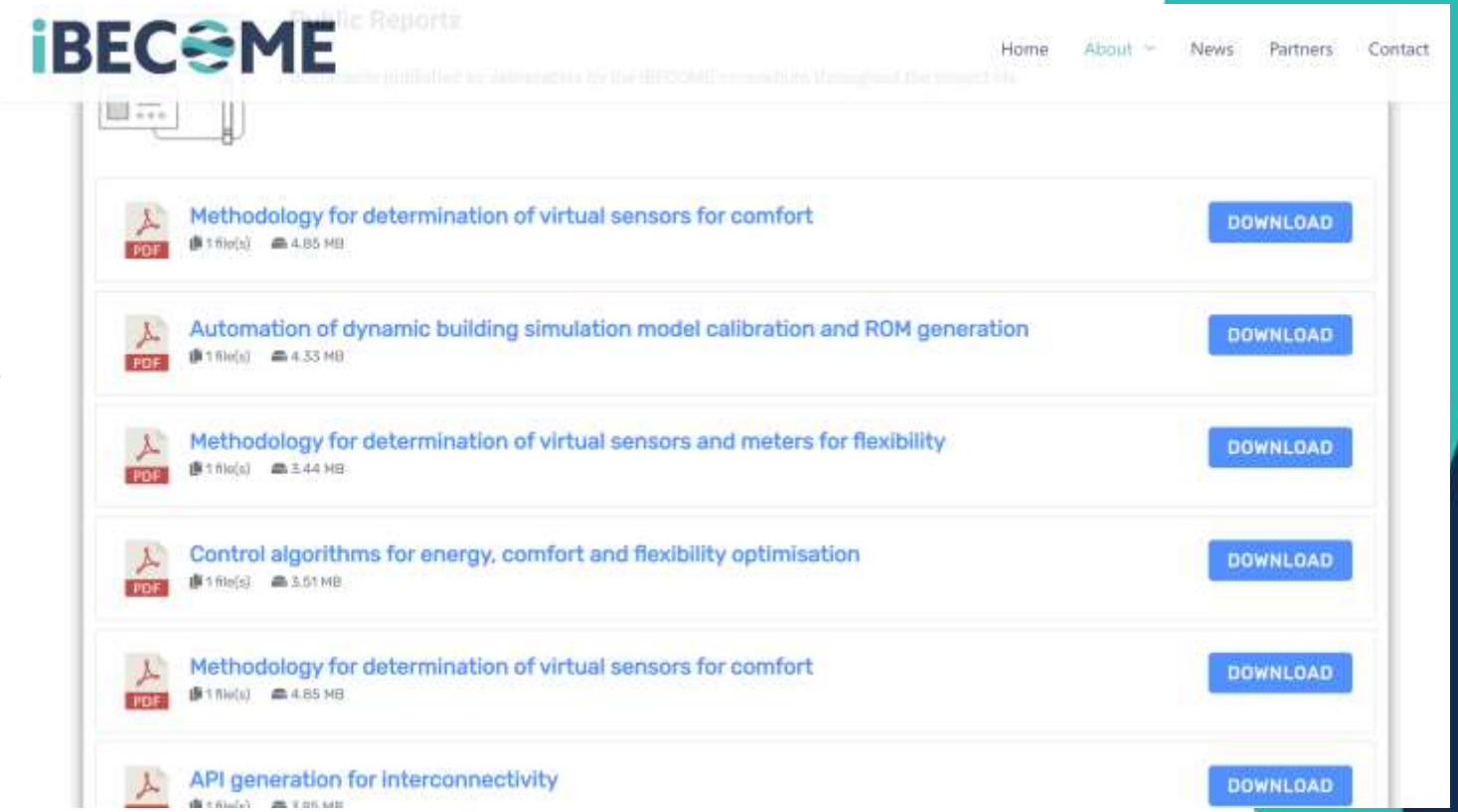
World Trade Center, Grenoble

Business Center

Summary and Next steps

- Calibration is a complex problem, we are trying to find solutions to simplify it and use it in operational phase
- We will trial our services in the demo sites and evaluate them

https://ibecome-project.eu/downloads/



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Stay Tuned!

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