

TM61-64: Operational performance of buildings

TM63: Modelling and calibration for evaluation of energy in-use

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CIBSE TM61-64 series on operational performance

CONTEXT

TM61 Operational performance of buildings

TOOLS

TM62 Operational performance: Surveying occupant satisfaction

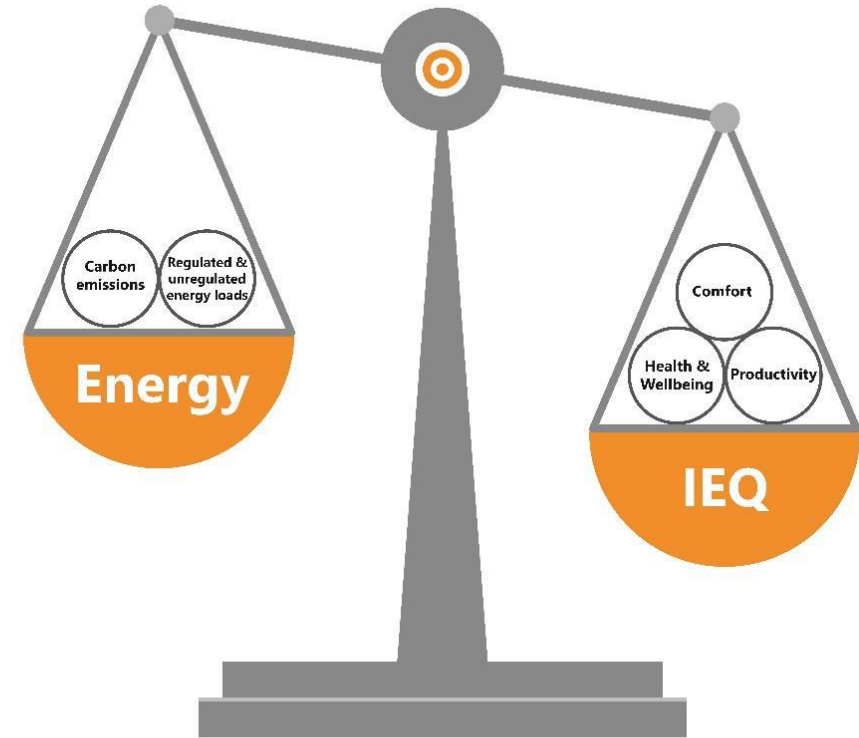
TM63 Operational performance: Modelling and calibration for evaluation of energy in-use

TM64 Operational performance: Indoor air quality – Emissions sources and mitigation measures



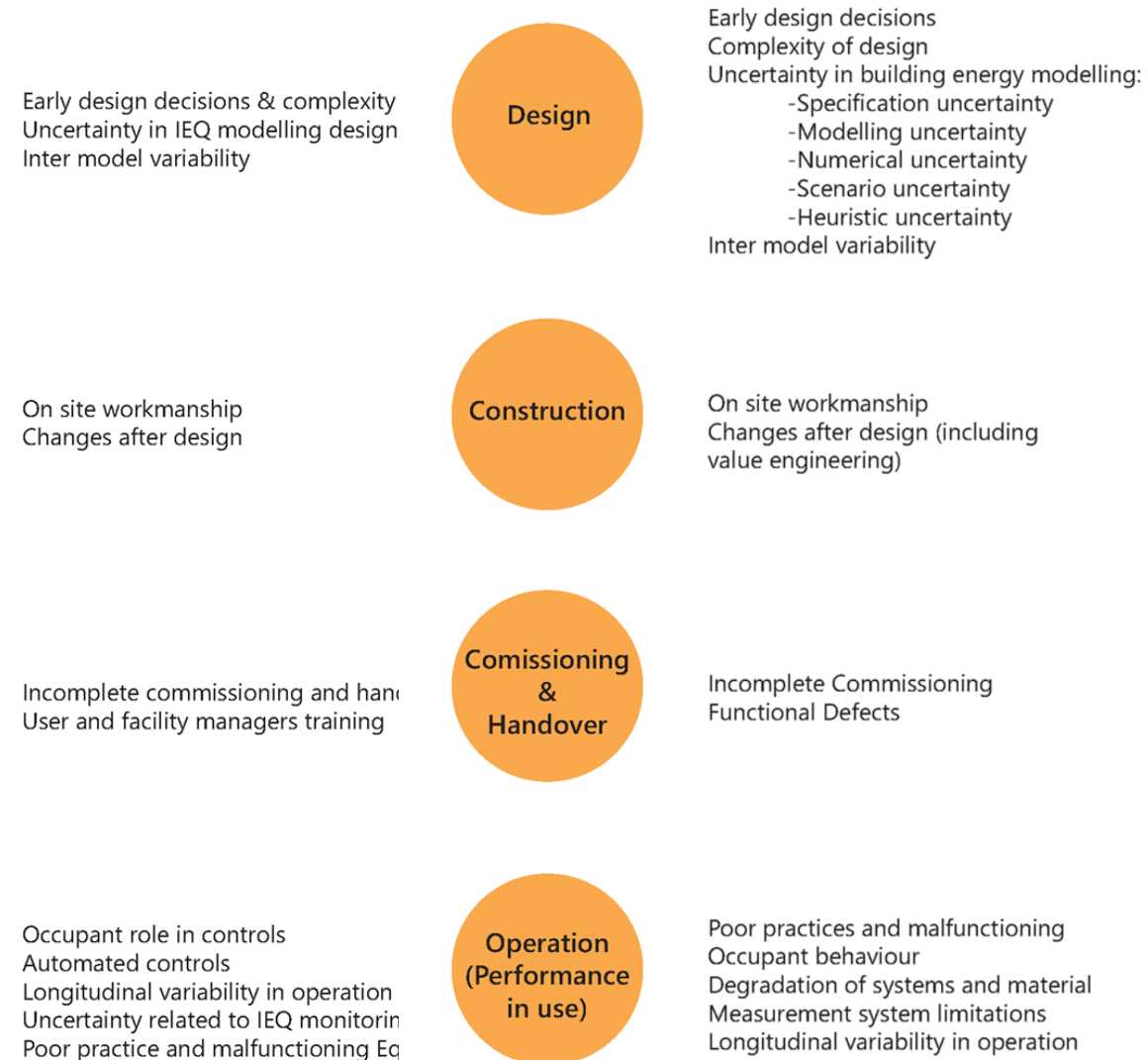
CIBSE TM61: Aims & Scope

- Energy performance gap and IEQ performance evaluation



CIBSE TM61: Aims & Scope

- Energy performance gap and IEQ performance evaluation
- Key factors at different stages: Design; Construction; Commissioning & Handover; and Operation



CIBSE TM61: Aims & Scope

- Energy performance gap and IEQ performance evaluation
- Key factors at different stages: Design; Construction; Commissioning & Handover; and Operation
- Four case studies on holistic evaluation of operational building performance



Office



Hospital



School



Apartment Block

CIBSE TM63

- Methodology to evaluate energy performance in-use.

How to use Digital Twins for Energy POE

- Compliments and extends *CIBSE TM54: Evaluating Operational Energy Performance of Buildings at the Design Stage*

TM54
Design Stage

TM63
Operation Stage

*See Chapter 8: Post occupancy evaluation of TM54: 2022 for links between TM54 and TM63

Operational performance:
Building performance modelling and
calibration for evaluation of energy in-use



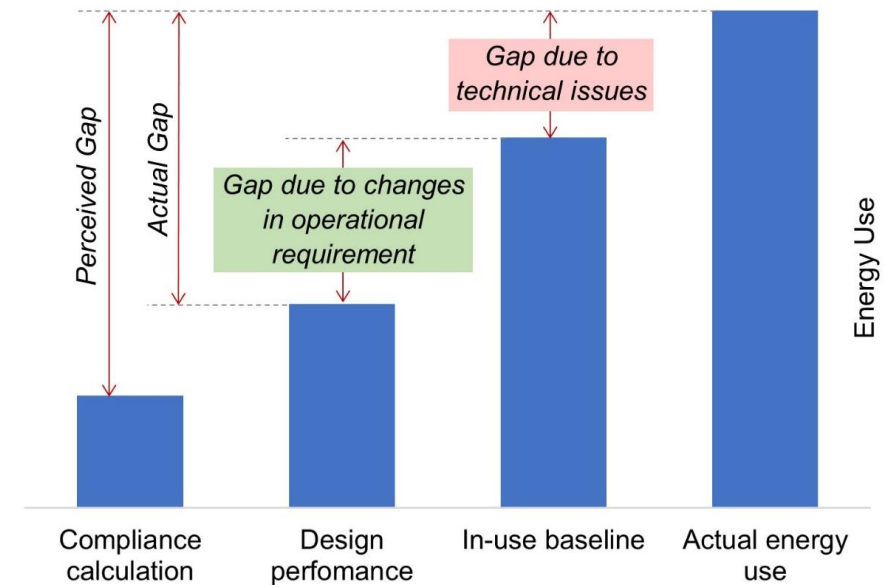
TM63: 2020



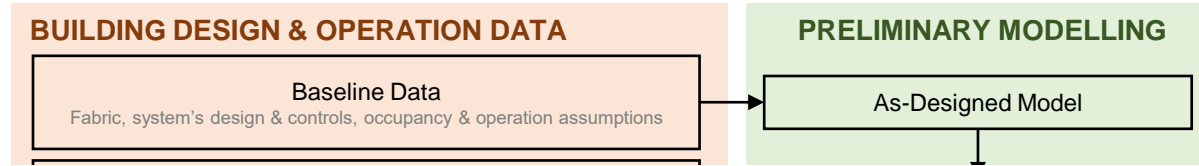
CIBSE TM63: Aims & Scope

Framework for M&V of in-use building energy performance:

- Guidance for creating **calibrated models (Digital Twins)**
- Determine performance gap accurately and **identify its root causes**
- Separate underperformance due to **changes made to meet functional needs** and **technical shortcomings**

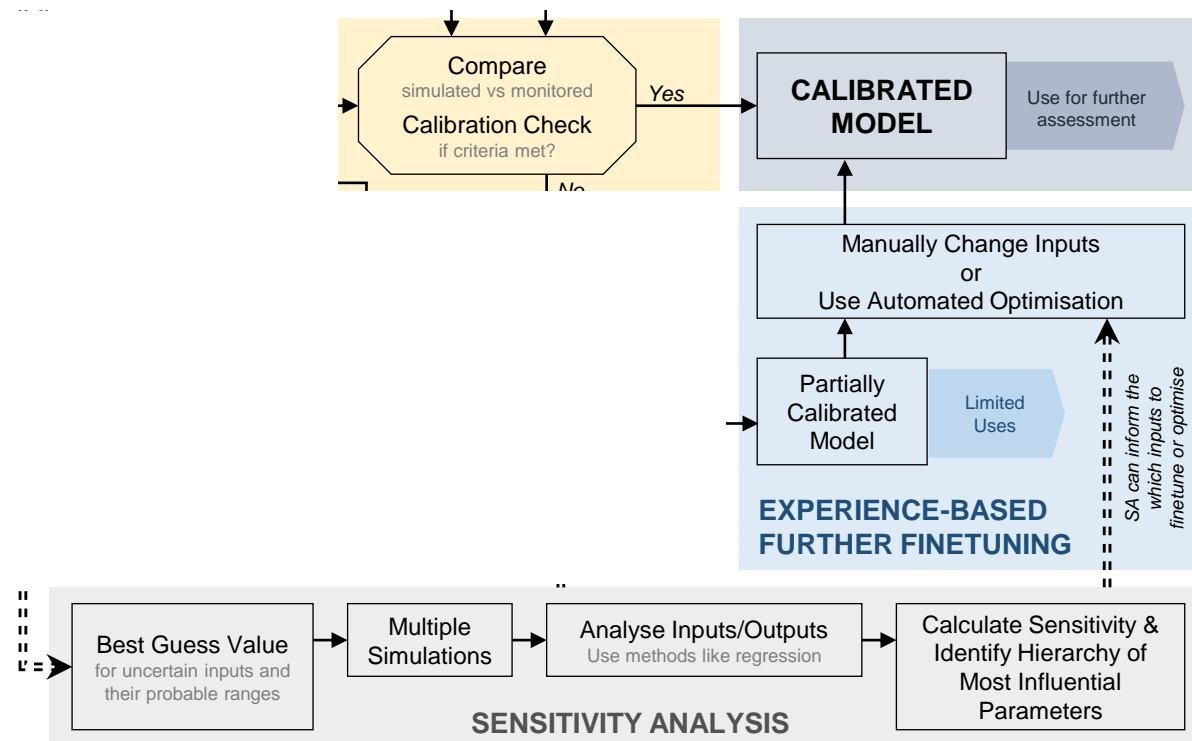


TM63: Model Calibration

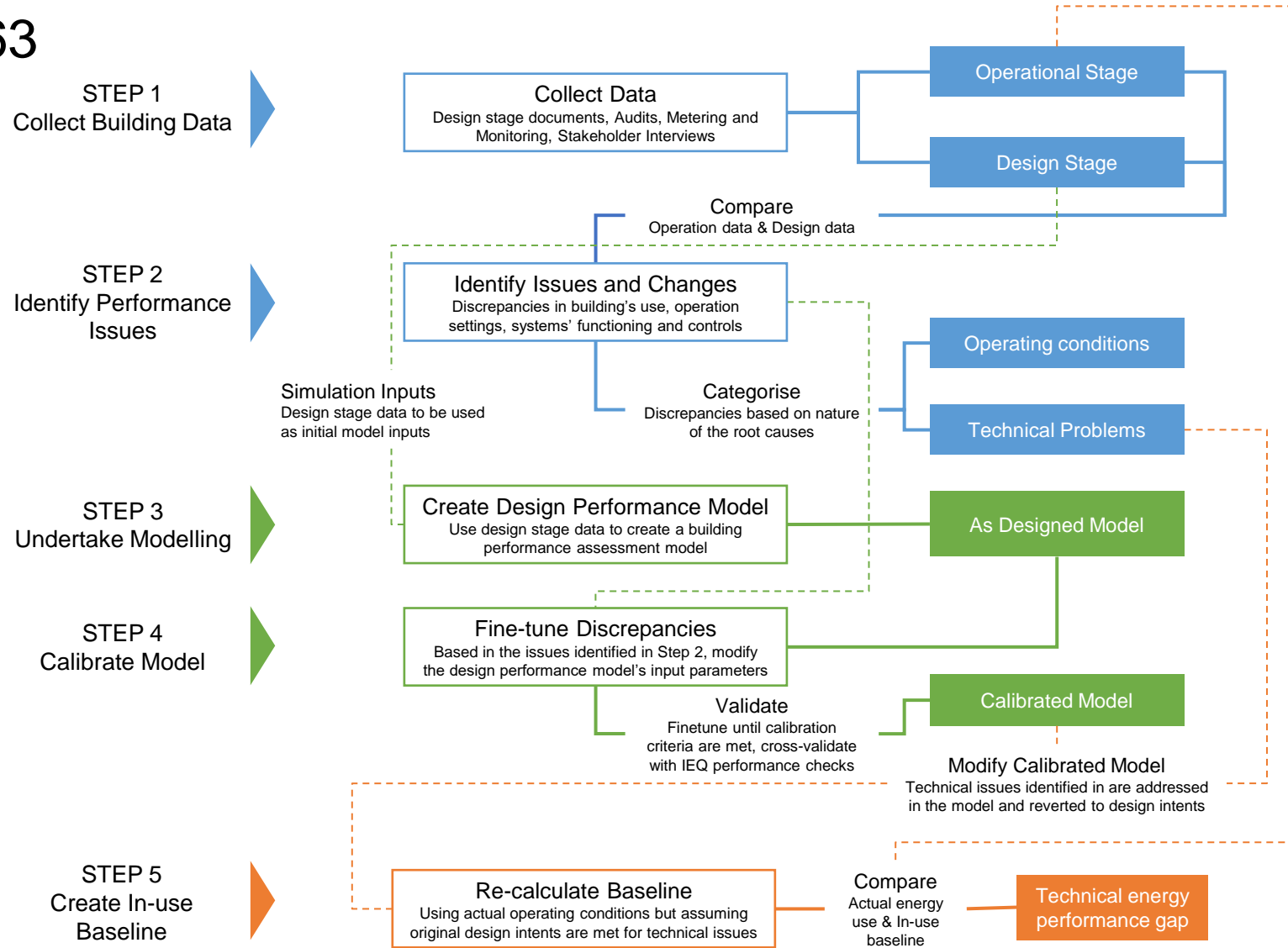


Evidence based calibration process

1. As-designed model
2. Intermediate model and initial run
3. Iterative improvement final model calibration and validation
4. Partially calibrated model
5. Sensitivity analysis



Step-by-step TM63 framework

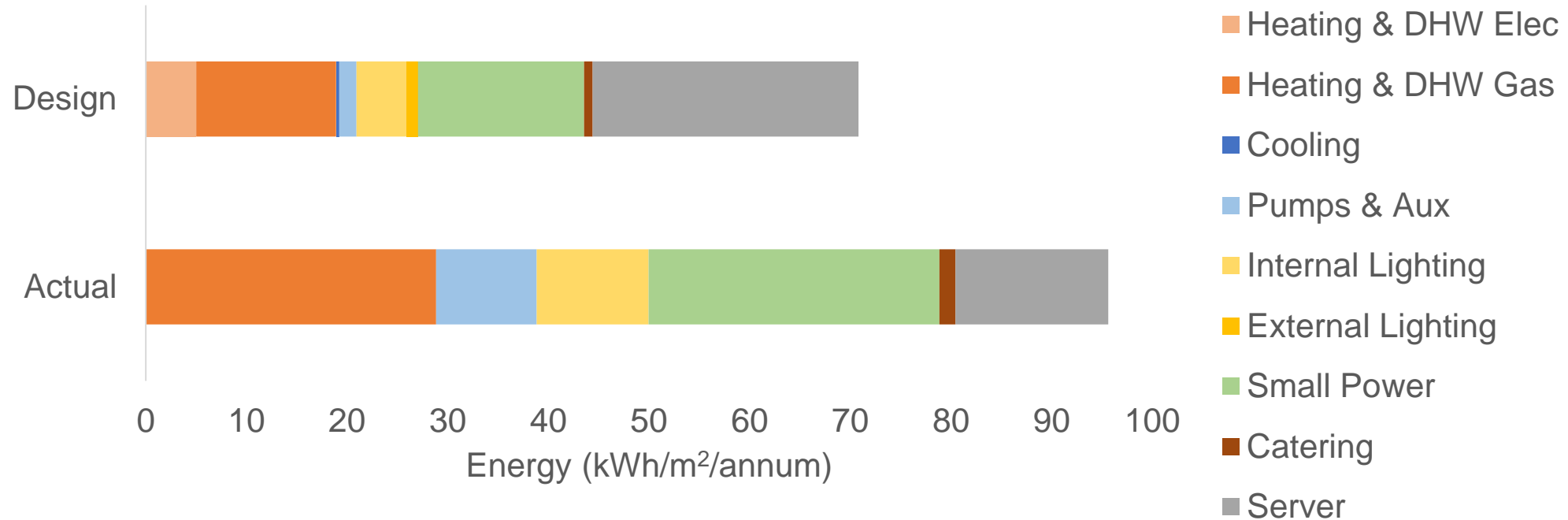


TM63: Modelling and Calibration case study

- Four storey newly built office building with about 6500 m² floor area
- Located in South-West England
- Mainly has open plan offices and meeting rooms
- Designed to high energy efficiency standards



Step 1: Design vs actual performance



Step 2: Performance gap issues

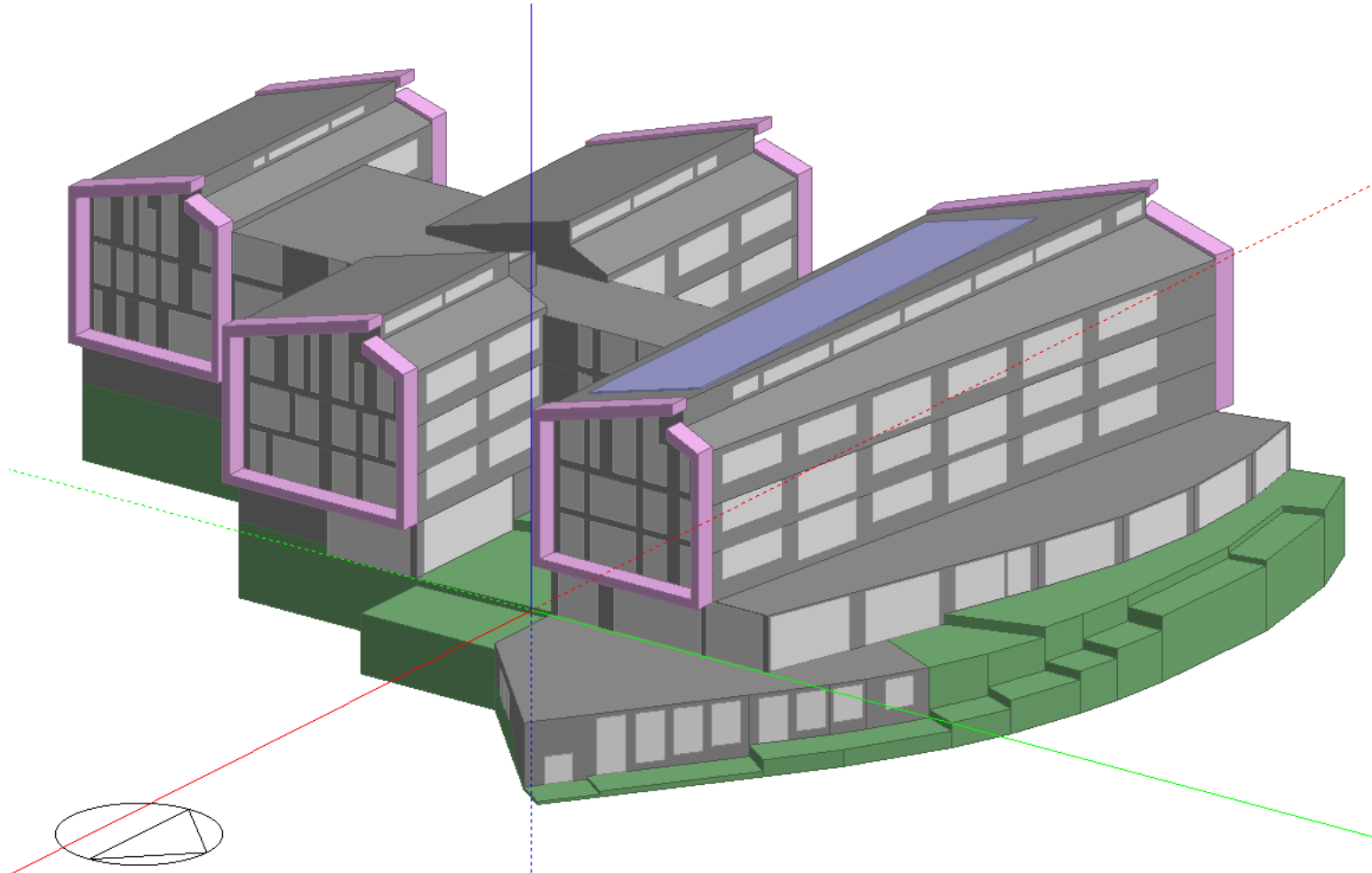
Changes in Operating Conditions

- There were extended operation hours along with some weekend use
- The total occupancy was about 25-30% higher
- Heating set-point was maintained at about 2-4°C, higher than the design intent
- Limited use of hot-desking and use of 'kill-switches' to shut off systems in unoccupied areas.

Technical Issues

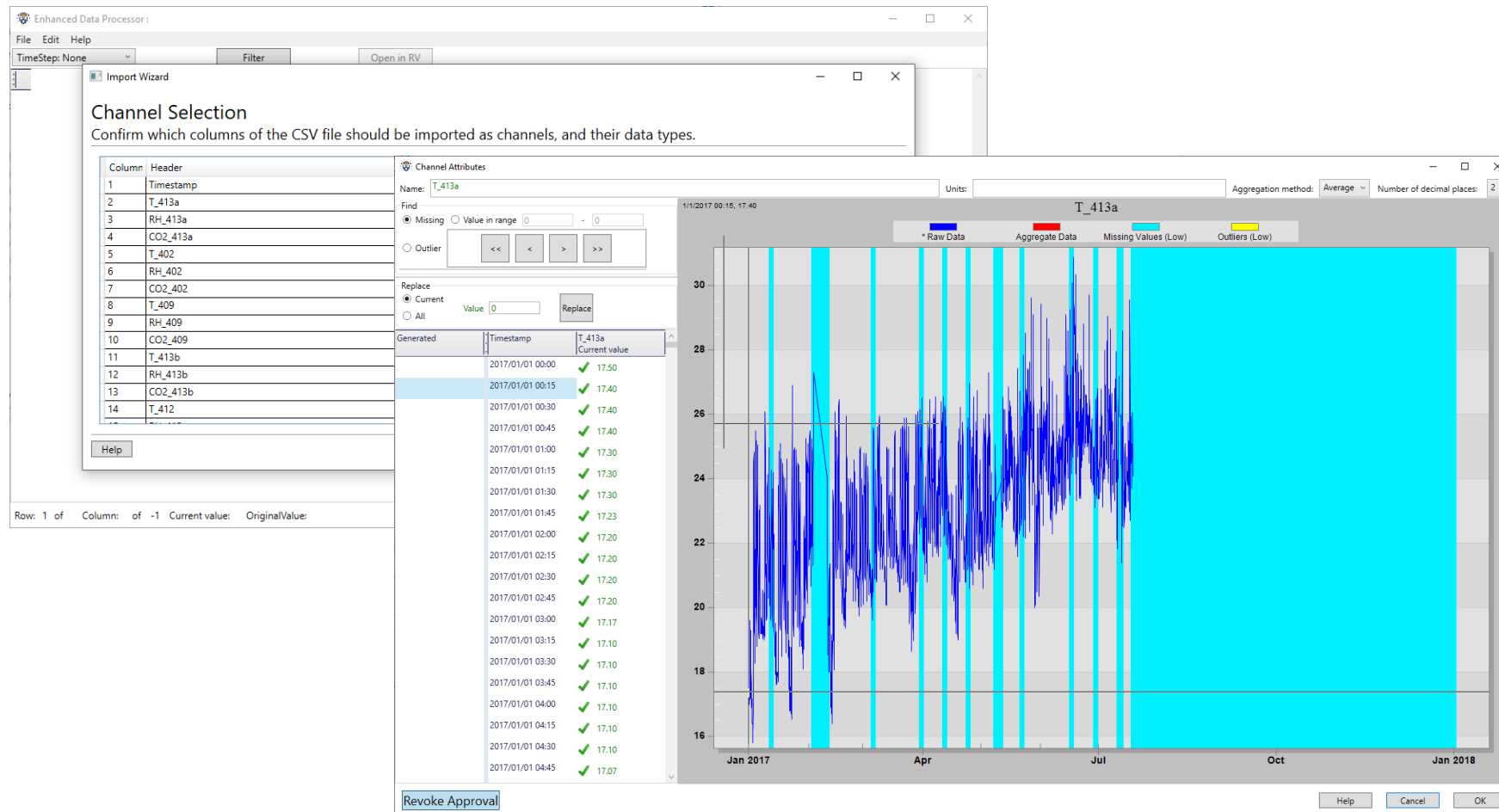
- Malfunctioning of heat pumps due to issues with heat exchangers and flow rates specifications
- Heating terminals sizing was not consistent with the LTHW requirements
- Server loads were overestimated leading to less free heat available for the heat pumps
- Some ventilation control sensor malfunctioned and there were high parasitic loads during unoccupied times

Step 3: As Designed Model



CIBSE TM54
Model

Step 4: Model Calibration



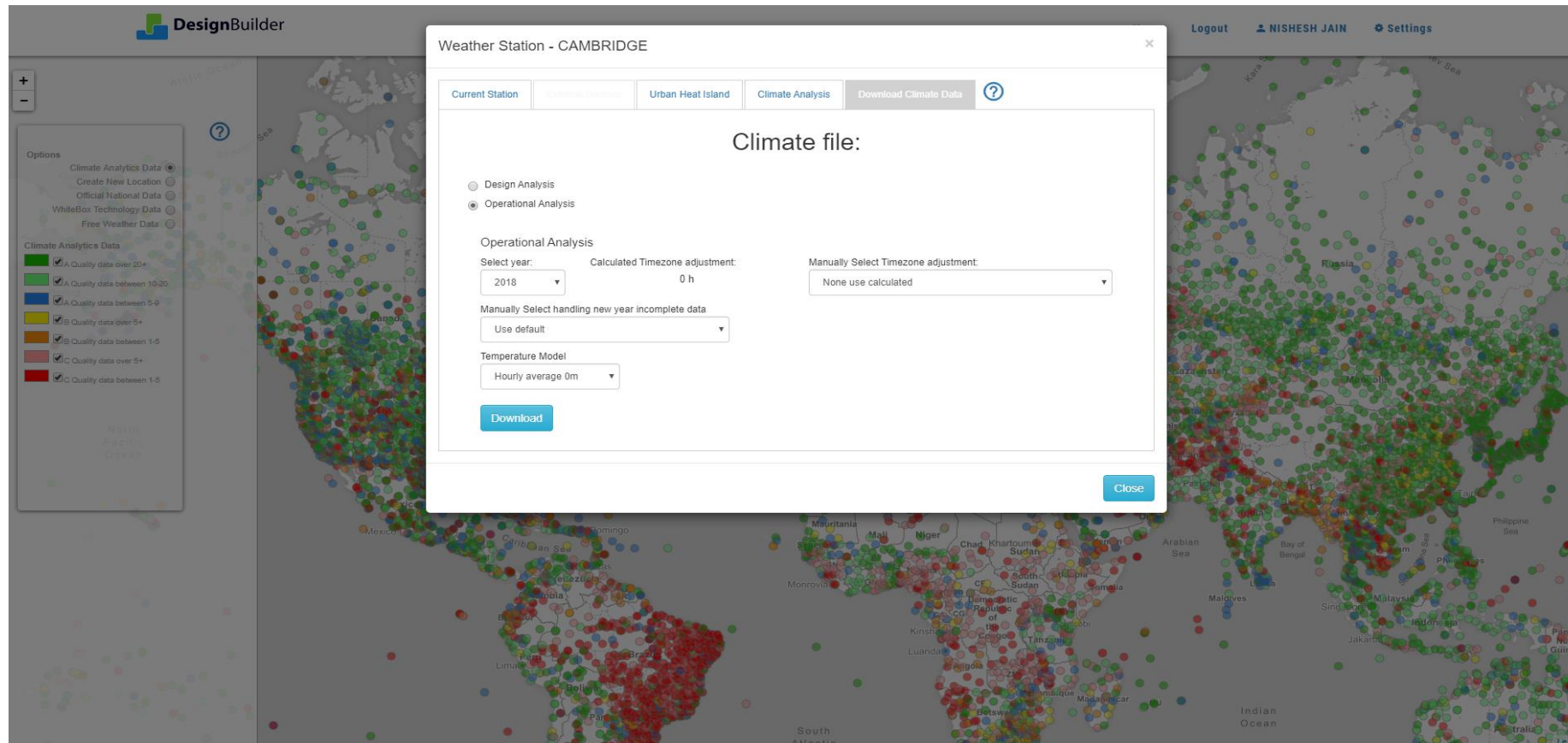
The screenshot displays the 'Enhanced Data Processor' interface. An 'Import Wizard' dialog is open, showing a 'Channel Selection' step. The wizard lists columns from a CSV file and allows for channel attribute configuration. The 'Channel Attributes' section for 'T_413a' shows 'Find' options (Missing, Value in range, Outlier) and 'Replace' options (Current, All). A table of generated data points is visible, showing timestamps and values for 'T_413a' with green checkmarks indicating successful processing.

Generated	Timestamp	T_413a Current value
	2017/01/01 00:00	✓ 17.50
	2017/01/01 00:15	✓ 17.40
	2017/01/01 00:30	✓ 17.40
	2017/01/01 00:45	✓ 17.40
	2017/01/01 01:00	✓ 17.30
	2017/01/01 01:15	✓ 17.30
	2017/01/01 01:30	✓ 17.30
	2017/01/01 01:45	✓ 17.23
	2017/01/01 02:00	✓ 17.20
	2017/01/01 02:15	✓ 17.20
	2017/01/01 02:30	✓ 17.20
	2017/01/01 02:45	✓ 17.20
	2017/01/01 03:00	✓ 17.17
	2017/01/01 03:15	✓ 17.10
	2017/01/01 03:30	✓ 17.10
	2017/01/01 03:45	✓ 17.10
	2017/01/01 04:00	✓ 17.10
	2017/01/01 04:15	✓ 17.10
	2017/01/01 04:30	✓ 17.10
	2017/01/01 04:45	✓ 17.07

Overlaid on the wizard is a time-series plot for channel 'T_413a' from 1/1/2017 00:15 to 17:40. The plot shows a blue line representing the data, with vertical cyan bars indicating missing values. The y-axis ranges from 16 to 30. The plot includes a legend for 'Raw Data', 'Aggregate Data', 'Missing Values (Low)', and 'Outliers (Low)'. The x-axis is labeled with months: Jan 2017, Apr, Jul, Oct, Jan 2018.

Cleaning and processing of monitored data

Step 4: Model Calibration



Real Weather
Data for
Calibration
Period

Step 4: Model Calibration

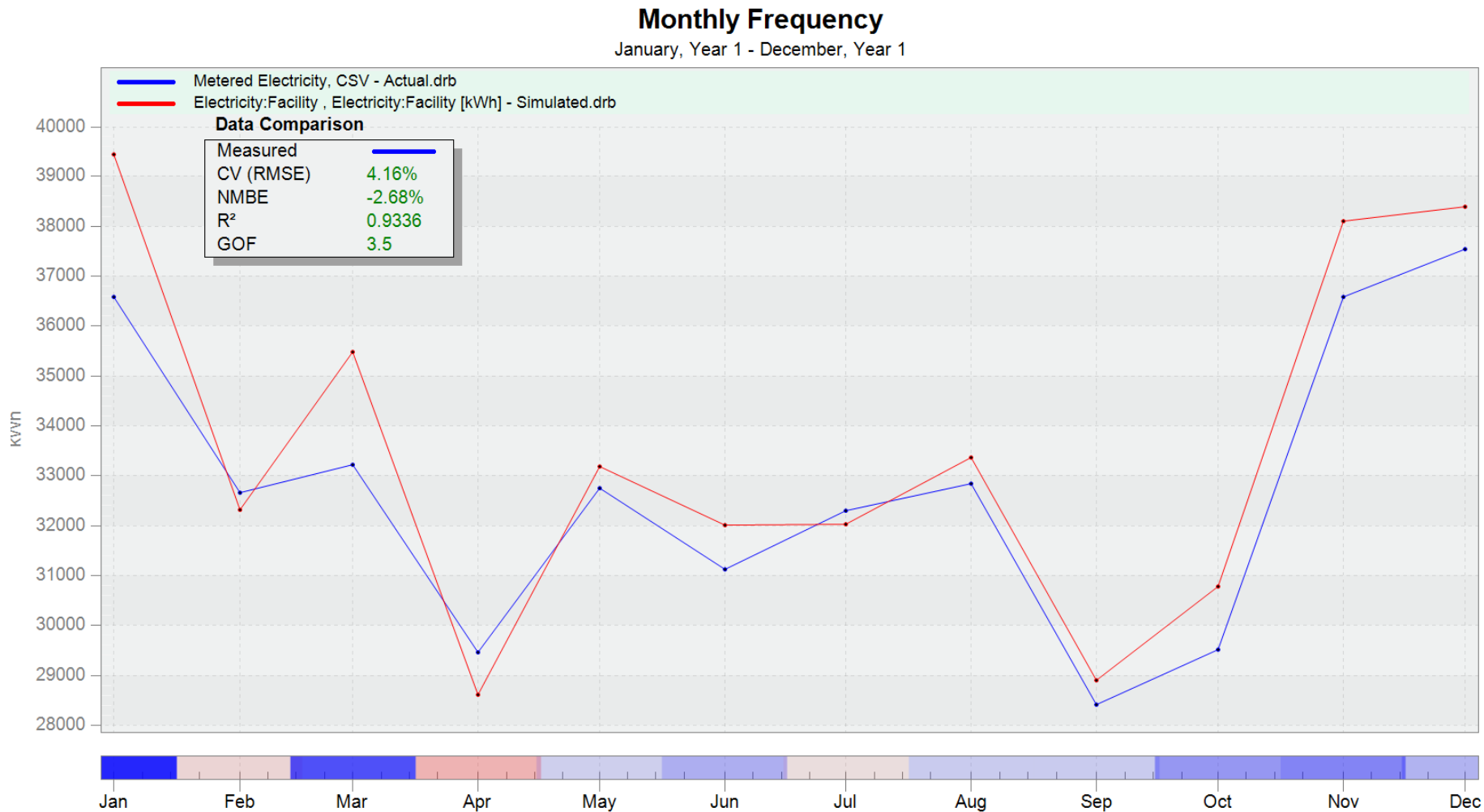


Table 1 Calibration criteria for energy defined in ASHRAE Guideline 14-2014

Index	Error range
NMBE (monthly)	±5%
C _v (RMSE) (monthly)	15%
NMBE (hourly)	±10%
C _v (RMSE) (hourly)	30%

NMBE: normalised mean bias error
 C_v(RMSE): coefficient of variation of the root mean square error

Calibration
 check for
 monthly
 electricity use

Step 4: Model Calibration

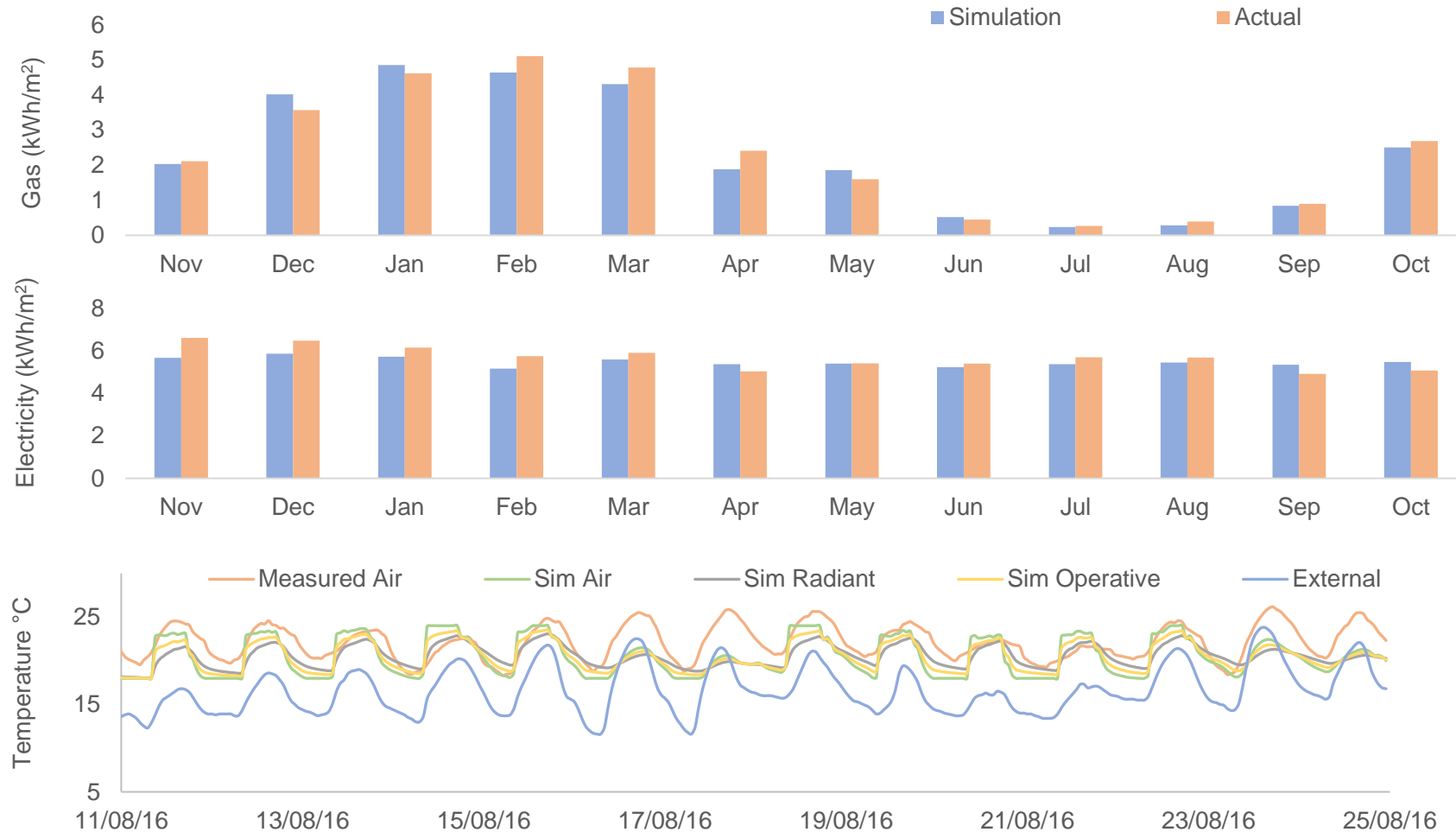


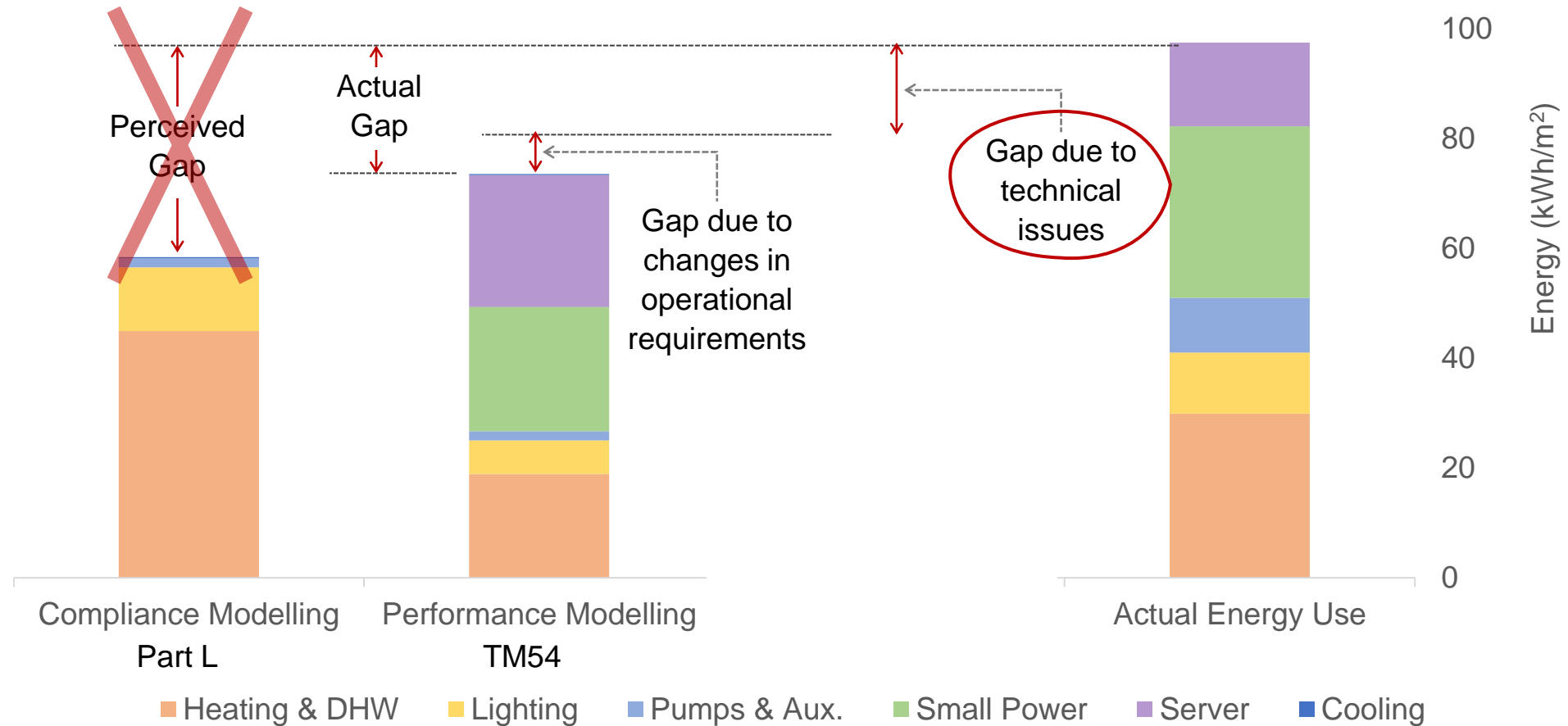
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Cross-Validation
for Dependent
Variables

Step 5: Operational baseline and the associated performance gap



TM63: Operational performance

*Modelling and calibration for evaluation
of energy in-use*

Thank You

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