TM54 2022

Julie Godefroy
CIBSE Head of Sustainability
08.03.2022

CIBSE

The team

Working Group members

Esfandiar Burman, UCL IEDE
David Cheshire, AECOM
Darren Coppins, Built Physics
Susie Diamond, Inkling
Mark Dowson, Buro Happold
Jennifer Elias, Cundall then AECOM
Julie Godefroy, CIBSE
Nishesh Jain, UCL IEDE
Dejan Mumovic, UCL IEDE

Contributors

Laura Barrett-Affleck, AECOM
Sophie Parry, Zumtobel Group
Gina Barney, Gina Barney Associates

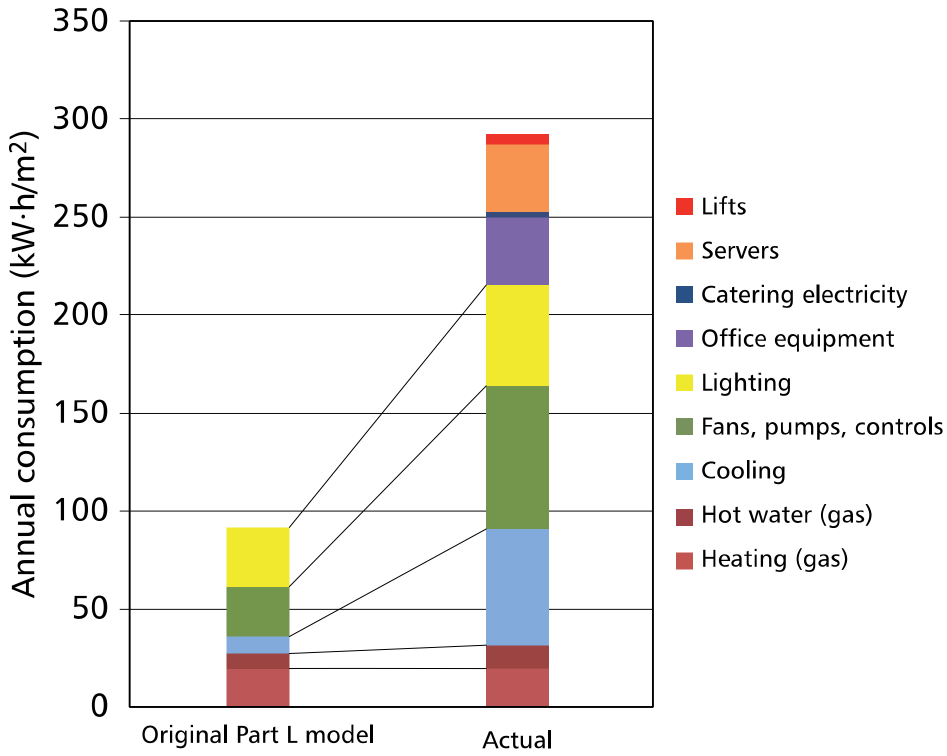
Peer reviewers

Ben Abel, Hilson Moran
Robert Cohen, Verco
Ed Cremin, Etude
Annie Marston, Hydrock
Leon Tatlock, Etude

+ Authors and contributors of 2013 edition

TM54, 2013

Evaluating operational energy performance of buildings at the design stage
CIBSE
TM54: 2013



Annual consumption (kW·h/m²)
0
50
100
150
200
250
300
350
Original Part L model
Actual
Lifts
Servers
Catering electricity
Office equipment
Lighting
Fans, pumps, controls
Cooling
Hot water (gas)
Heating (gas)

Why a revision?

Net Zero

Contractual performance targets

Advances in modelling

Approved Document (during the revision)

Approved Document L2, 2021

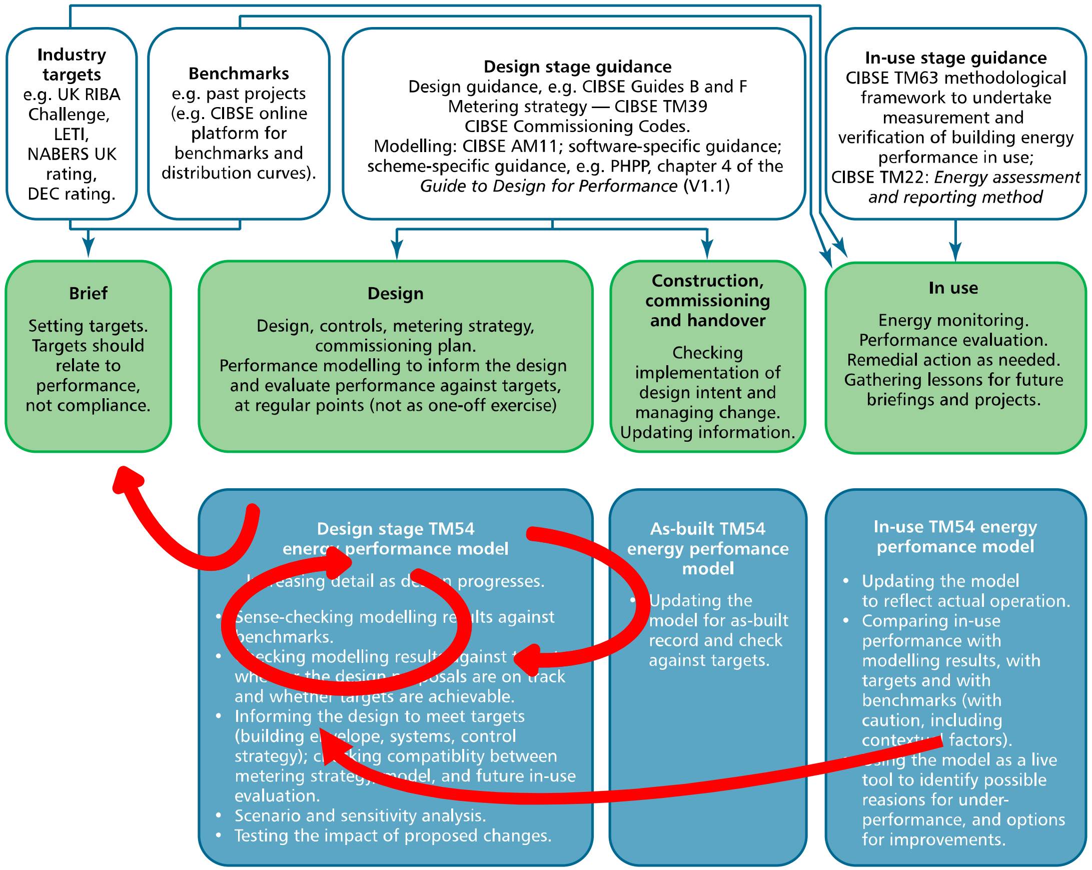
9.4 For new buildings with a total useful floor area over 1000m², the information to be handed over to the building owner should include a ***forecast of the actual energy use of the building in kWh/year broken down by fuel type****. The energy forecast should include all metered energy uses, including unregulated loads.*

This may be determined using any of the following methods, and should be recorded in the building log book:

- *design calculations*
- *energy benchmarks*
- ***an energy forecasting methodology such as CIBSE's TM54***
- *other building modelling or spreadsheet tools*
- *any combination of (a) to (d).*

NOTE: The compliance outputs of SBEM or other Building Regulations compliance tools are not suitable for direct use as energy forecasting estimates for any size of building.

TM54 modelling within a project lifecycle



Key updates

Same spirit as original TM54: performance, not compliance

More emphasis on targets, informing the design and testing the results

Guidance on different types of modelling, from steady state to dynamic with “detailed HVAC modelling”

Regulatory model not necessarily the starting point: more on building and set-up the model

More on HVAC and controls

No “blanket” approach to management factors

QA & Implementation matrix

+ General updates e.g. gains in/out of the model; lift & hot water calcs

TM54 Methodology

Step 0: Choosing the modelling approach

Step 1: Constructing and building the model

- Constructing and zoning the model
- Establishing floor areas
- Weather file

Step 2: Estimating operating hours and occupancy factors

- Operating hours
- Occupancy factors

Internal gains and associated energy uses

These may be calculated inside or outside the model, depending on the modelling approach and context

- Step 3: Lighting
- Step 4: Lifts and escalators
- Step 5: Small power
- Step 6: Catering
- Step 7: Server rooms
- Step 8: Additional plant and equipment
- Step 9: Domestic hot water

Step 10: Adding internal heat gains to the model, for energy uses calculated outside the model

Step 11: Modelling HVAC systems and their controls

This should include domestic hot water unless calculated separately outside the model in Step 9. This may entail detailed HVAC modelling, depending on the approach selected in Step 0.

Step 12: Taking management considerations into account

Producing, analysing, reporting and checking the results

- Step 13: Sensitivity analysis
- Step 14: Scenario testing
- Step 15: Review against targets and benchmarks
- Step 16: Reporting and implementation matrix
- Step 17: Quality assurance (QA)

Step 16 – Reporting and Implementation matrix

Table 13 Example TM54 implementation matrix

TM54 steps	Recommendation	Modelling approach (summary)	Probable range	Confidence level (L/M/H)	QA check
Simplifications and assumptions (see section 5.2)	They should be used appropriately and judiciously, and detailed in the report	*See report entitled 'xxx_TM54 modelling report' dated 12/2/22, sections x and y.*	*n/a*	*n/a*	*Yes*
Use of benchmarks and targets (see section 6.2)	Benchmarks should not replace a dedicated calculation of energy use. Targets that can be verified in use are recommended to be set for the project from the early stages, and should be reported alongside the modelling results. The aim of the modelling will be to test whether the targets are achievable, and inform the design proposals to meet the targets.	*Project has targeted LETI Energy Use Intensity target of 65 kW·h/m^2 (GIA/year) and space heating targets for schools. The report references these and reports results against these targets.*	*n/a*	*n/a*	*Yes*
Step 0: Choosing the right level of modelling	The project team should establish early on in the project, in discussion with the client, the right level of modelling for the project. This should consider multiple factors including	*The building is a large secondary school which is largely naturally ventilated but with significant mechanical ventilation using centralised AHUs. The building is controlled by a BMS system.*	*n/a*	*n/a*	*Yes*

Call for case studies!

UCL to produce an illustrative case study

Get in touch to showcase your project:

- TM54 modelling
- Comparison with in-use data

Thank you

Full details of the key relevant policy positions and guidance from CIBSE relating to the headings in the one pager above can be found below. This page is updated as our guidance develops, so please check it regularly. Much of CIBSE guidance is dedicated to designing, operating and maintaining energy efficient and low-carbon buildings. It is therefore not possible to list all relevant guidance here.

- LOW ENERGY USE AND DEMAND MANAGEMENT
- LOW CARBON ENERGY SUPPLY
- MEASUREMENT AND VERIFICATION
- REDUCING CONSTRUCTION IMPACTS
- ZERO CARBON BALANCE

Net Zero guidance page

https://www.cibse.org/News-and-Policy/Policy/Technical-Themes/Net-Zero/CIBSE-guidance-to-deliver-net-zero-carbon-new-buil

Julie Godefroy
Head of Sustainability
jgodefroy@cibse.org

CIBSE TM54:2022

Using modelling to meet operational energy targets

Step 0: Choosing the right approach

Jennifer Elias
jennifer.elias@aecom.com

3 key themes running throughout the update

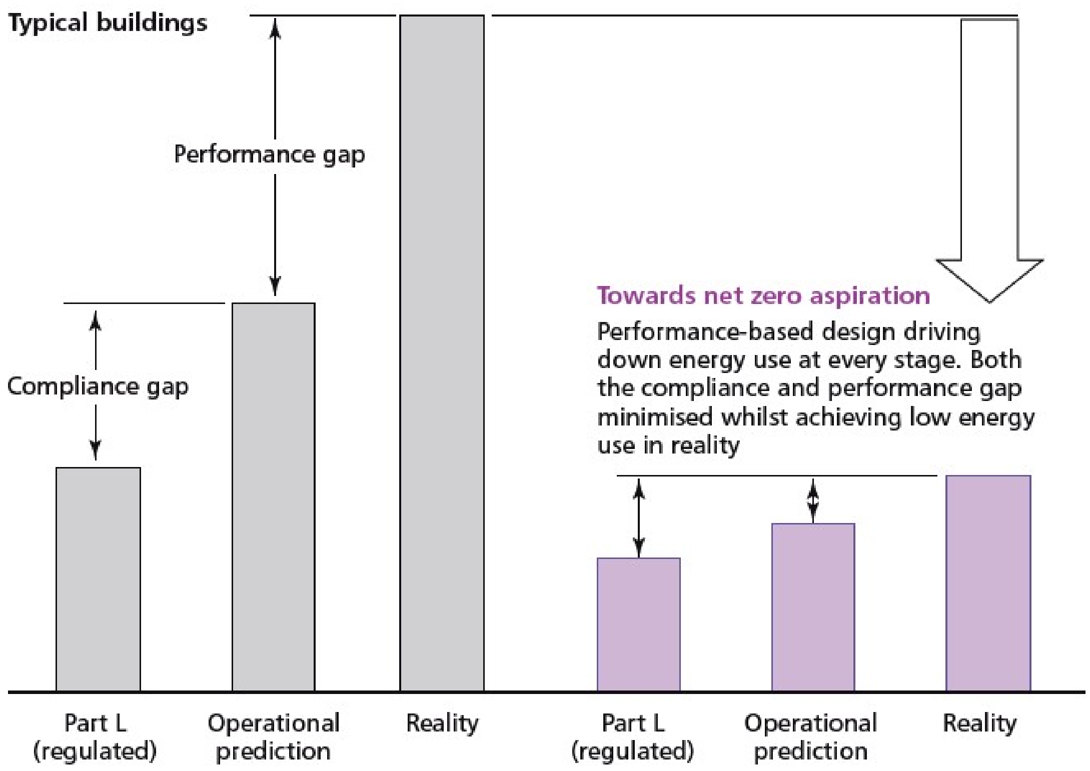


Figure 1.1 Energy performance modelling can help with dual aims: reducing the performance gap, and producing better, lower energy use buildings (image courtesy of Buro Happold)

As we move towards net zero carbon:

- ✓ Designs need to be more innovative
- ✓ Modelling needs to be more accurate
- ✓ Modelling needs to better inform post occupancy evaluation

Targets and Benchmarks

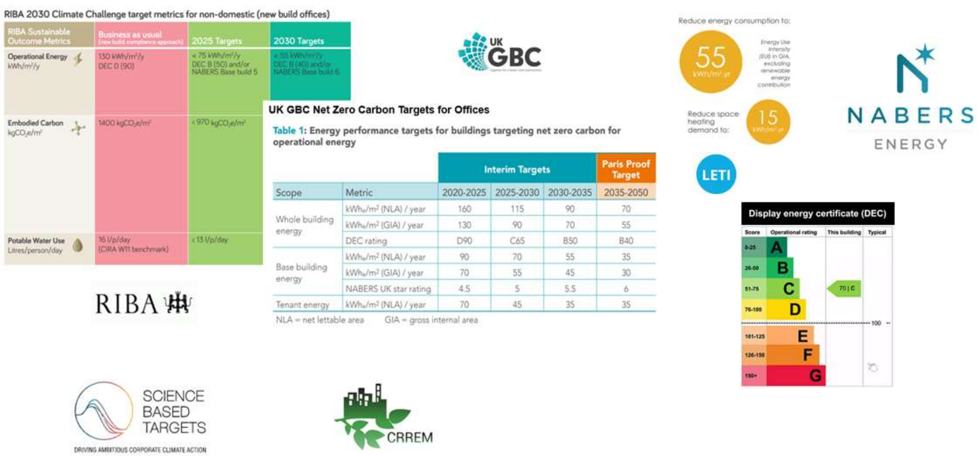
Targets:

Set by the project owner, e.g.

- Net zero carbon Energy Use Intensity target
- NABERS UK, DEC
- Improvement on a precedent project

Benchmarks:

- Can inform targets
- Can act as a ‘sanity check’ for TM54 results
- Inform specific components of the TM54 model
- Support in use performance monitoring


RIBA 2030 Climate Challenge target metrics for non-domestic (new build offices)

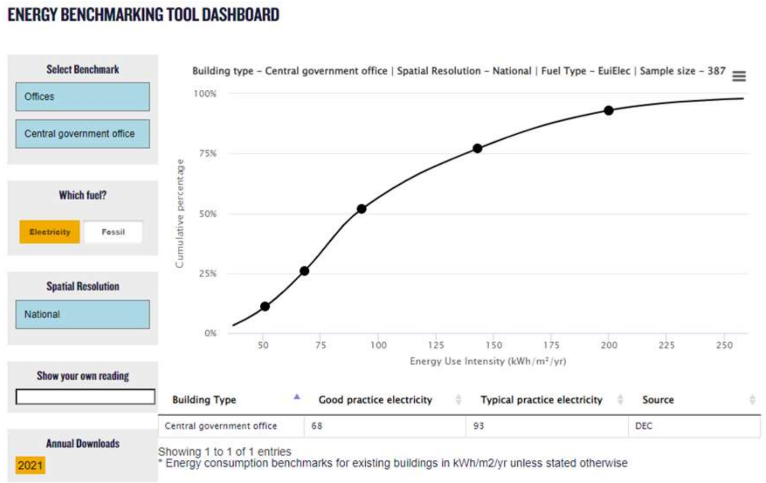
RIBA Sustainable Outcome Metrics	Business as usual (new build, compliance approach)	2025 Targets	2030 Targets
Operational Energy kWh/m²/y	130 kWh/m²/y DEC D (90)	< 75 kWh/m²/y DEC B (50) and/or NABERS Base build 5	< 55 kWh/m²/y DEC B (40) and/or NABERS Base build 6
Embodied Carbon kgCO₂e/m²	1400 kgCO₂e/m²	< 970 kgCO₂e/m²	
Potable Water Use Litres/person/day	16 l/p/day (CIRA W11 benchmark)	< 13 l/p/day	

UK GBC Net Zero Carbon Targets for Offices

Table 1: Energy performance targets for buildings targeting net zero carbon for operational energy

		Interim Targets			Paris Proof Target
Scope	Metric	2020-2025	2025-2030	2030-2035	2035-2050
Whole building energy	kWhₑ/m² (NLA) / year	160	115	90	70
	kWhₑ/m² (GIA) / year	130	90	70	55
	DEC rating	D90	C65	B50	B40
Base building energy	kWhₑ/m² (NLA) / year	90	70	55	35
	kWhₑ/m² (GIA) / year	70	55	45	30
	NABERS UK star rating	4.5	5	5.5	6
Tenant energy	kWhₑ/m² (NLA) / year	70	45	35	35

NLA = net lettable area GIA = gross internal area



Step 0: Choosing the Right Approach

TM54
Steady State

- ✓ Simple systems, limited interaction with each other & hourly weather conditions
- ✓ HVAC energy doesn't drive results or design decisions

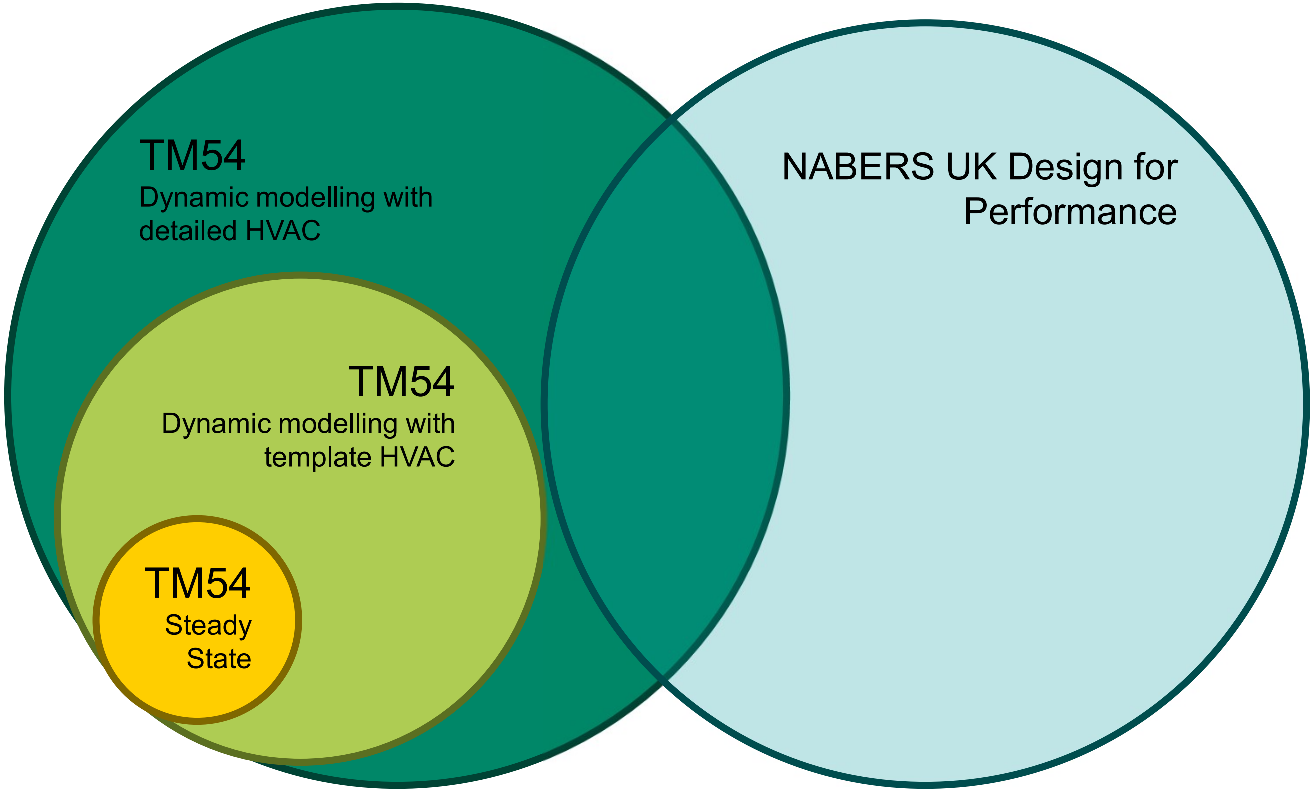
TM54
Dynamic modelling with template HVAC

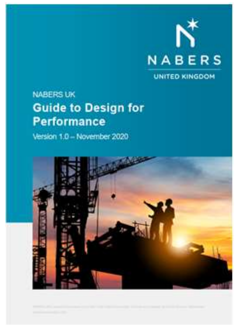
- ✓ More complex buildings
- ✓ Significant detail and certainty are not paramount
- ✓ HVAC system is typical
- ✓ HVAC component level detail is not required

TM54
Dynamic modelling with detailed HVAC

- ✓ Contractual performance targets (Net Zero Carbon, DEC etc)
- ✓ Complex or innovative HVAC system
- ✓ Selection / Optimisation of HVAC system
- ✓ Centralised (de)humidification systems
- ✓ Component-level HVAC results comparison
- ✓ Expertise is available

Step 0: Choosing the Right Approach





Choosing HVAC modelling

DesignBuilder

Template HVAC Modelling

Select **Simple HVAC** in model options and all HVAC settings are described in the HVAC model data tab

Detailed Component Level HVAC Modelling

Select **Detailed HVAC** in model options and HVAC model is created graphically and settings are defined for individual components separately

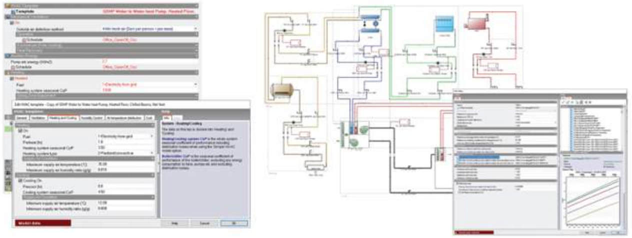


Figure 4.5 Illustration of 'template' and 'detailed' HVAC system modelling in DesignBuilder software (courtesy of DesignBuilder Software)

IES INTEGRATED ENVIRONMENTAL SOLUTIONS

Template HVAC Modelling

Use **Apache Systems** to set up the key HVAC system input parameters.

Detailed Component Level HVAC Modelling

Create a schematic model in **Apache HVAC** and describe the system configuration in detail, component by component.

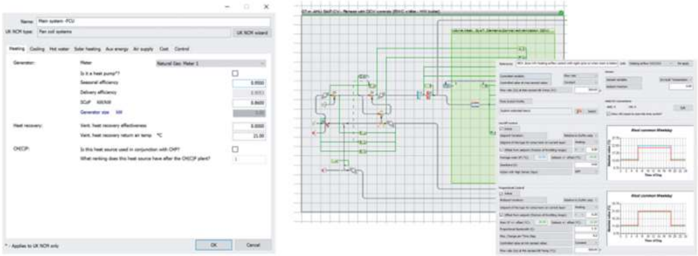


Figure 4.6 Illustration of 'template' and 'detailed' HVAC system modelling in IES software (courtesy of IES)

EDSL Tas

Template HVAC Modelling

Use **Tas System Project Wizard** to set up the HVAC system from templates.

Detailed Component Level HVAC Modelling

Use the HVAC system model created in **TAS Systems** and describe the system configuration and controls in detail, component by component.

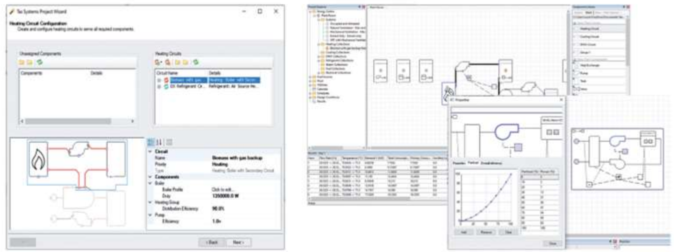


Figure 4.7 Illustration of 'template' and 'detailed' HVAC system modelling in TAS software (courtesy of EDSL)

Choosing HVAC modelling

Template Systems:

- A better match for constant volume systems than for variable volume systems
- Less accurate where systems provide heating and cooling at the central AHU and at the terminal unit
- Less accurate than detailed models for systems with (de)humidification

Template HVAC Modelling

Use Apache Systems to set up the key HVAC system input parameters.

Detailed Component Level HVAC Modelling

Create a schematic model in Apache HVAC and describe the system configuration in detail, component by component.

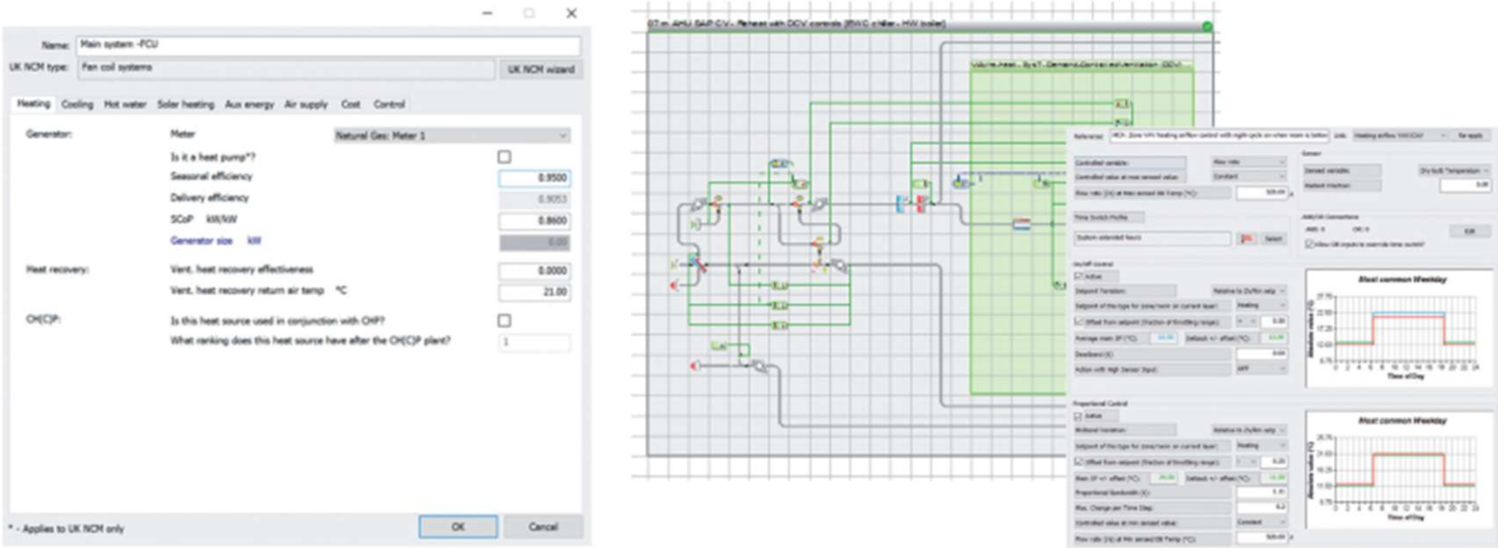
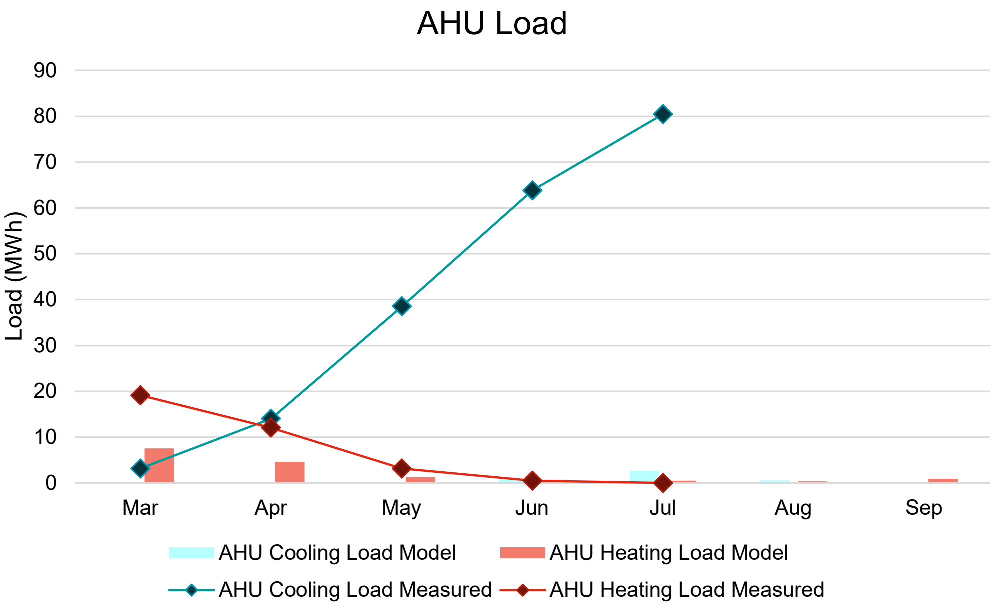
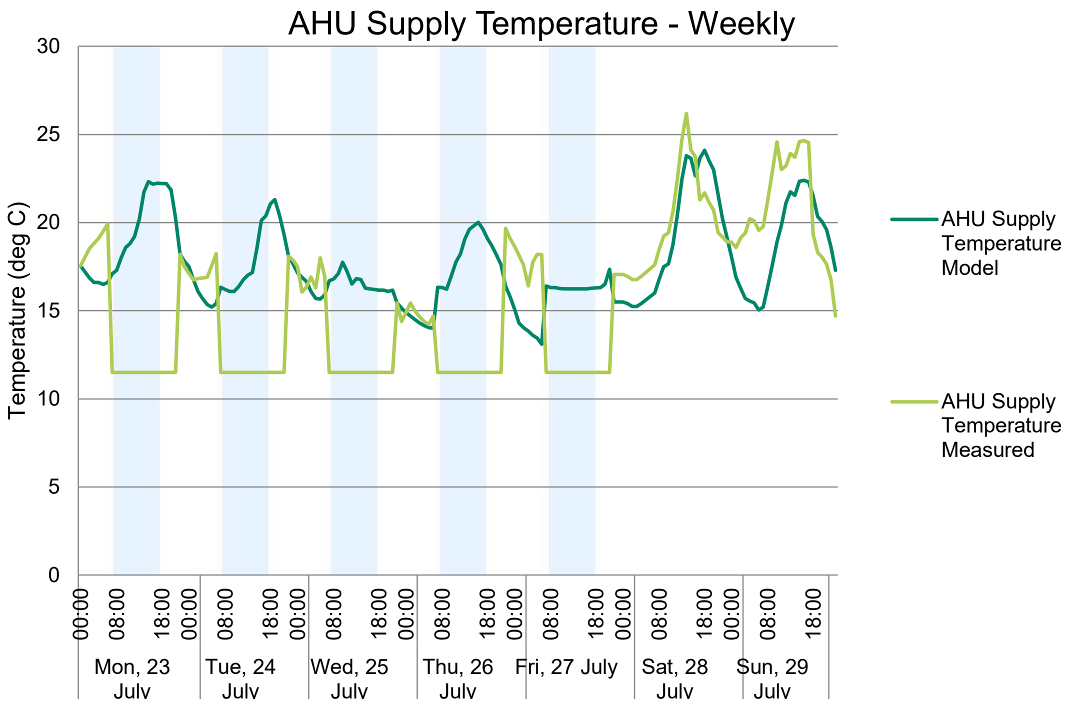


Figure 4.6 Illustration of 'template' and 'detailed' HVAC system modelling in IES software (courtesy of IES)

Component Level Comparison to actual





aecom.com

Using the Implementation Matrix at Step 0

TM54 steps	Recommendation	Modelling approach (summary)	Probable range	Confidence level (L/M/H)	QA check
Step 0: Choosing the right level of modelling	The project team should establish early on in the project, in discussion with the client, the right level of modelling for the project. This should consider multiple factors including the complexity of the building and its systems, the resources available for the modelling, and the level of accuracy and certainty needed from the results. The discussions should also determine whether some steps in this methodology should be carried out within or outside the model, e.g. Step 3 (Lighting), Step 9 (Domestic hot water).	*The building is a large secondary school which is largely naturally ventilated but with significant mechanical ventilation using centralised AHUs. The building is controlled by a BMS system.* *A dynamic thermal modelling approach has been chosen as this enables the model to be used for additional tasks such as thermal comfort analysis and building regulations compliance. HVAC will be modelled starting from templates and tuned to more accurately reflect the design proposals.* *Energy use associated with hot water and lighting will be calculated within the DSM. DHW volumes based on anticipated usage data provided by the client.*	*n/a*	*n/a*	*Yes*

Key takeaways and Next Steps

1. CIBSE Advanced simulation model training

CIBSE Training

2. Review modelling scopes and ensure they're clear on:

- Applicable energy performance targets (NZC EUI, NABERS UK, DEC etc)
- Significant and complexity of HVAC System and controls, whether the model will guide HVAC system selection
- Whether the model is required for component level end use comparisons in the future

Thank you

& onto Nishesh to talk through sensitivity analysis and scenario testing

UCL Institute for Environmental Design and Engineering

TM54: 2022

Sensitivity Analysis & Scenario Testing

(Steps 13 and 14)

Nishesh Jain
PhD, MSc, BArch

Research Fellow, IEDE, University College London
KTP Associate, DesignBuilder Software Ltd.

n.jain@ucl.ac.uk

8th March 2022

Sensitivity Analysis & Scenario Testing

What is Sensitivity Analysis & Scenario Testing?

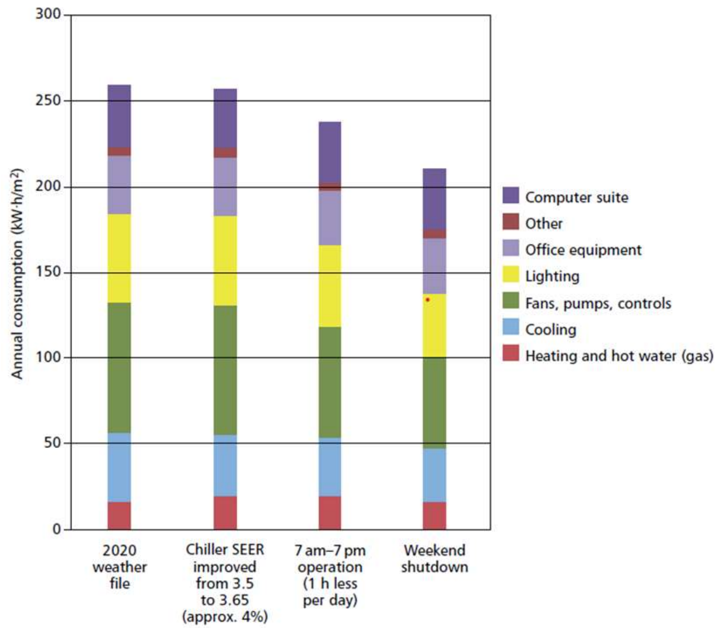
Why do we need these analysis and tests?

How can these be done for a design as per TM54?

Sensitivity Analysis

What

- Process where impact of various design variables on calculation results are analysed
- Helps to identify most important and influential variables that can affect the design's performance.

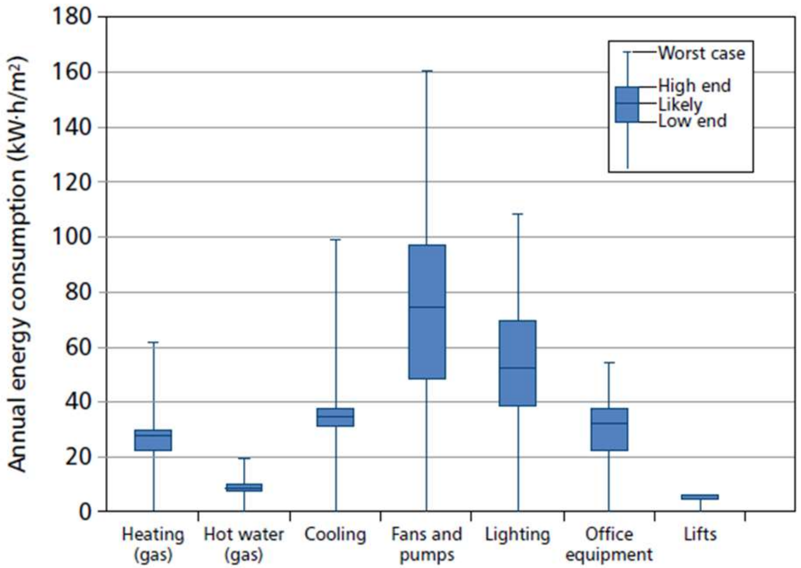


Scenario Testing

What

- Quantification of total variability in the calculation results due to uncertainties in the model inputs

- Can be called as Uncertainty analysis.



Sensitivity Analysis and Scenario Testing

Why

These are necessary because

- assumptions used in models during design stage are uncertain.
- there is difference between buildings ideal performance and how it is likely to operate.
- designs often go through changes (specification change, value engineering, late determination of the control strategy etc.)
- it is important to know how design changes can impact performance so that safeguards can be put in place.

Sensitivity Analysis and Scenario Testing

Why

These will help to address model uncertainties and:

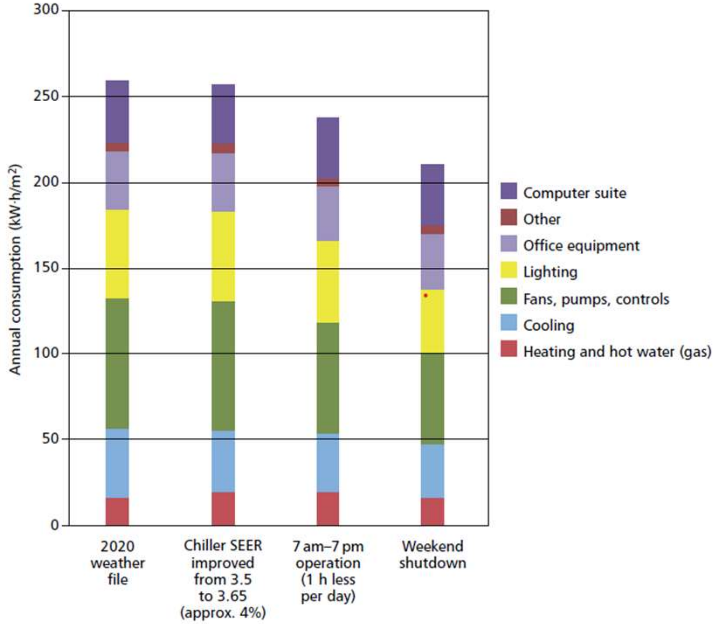
- find the factors that have the greatest impact on the end energy consumption
- understand the drivers for building's energy performance and potential risk factors
- highlight the importance of modelling assumptions (design, operational and occupancy)

Step 13: Sensitivity Analysis - Recommended TM54 Approach

How

Basic sensitivity tests

- A simple approach
- Iterative one at a time changes
  - Weather and climate
  - Occupancy and other loads
  - Operation hours
  - Impacts of management and occupancy behavior
- Identify important parameters to inform scenario testing



Parametric sensitivity and uncertainty analysis

How

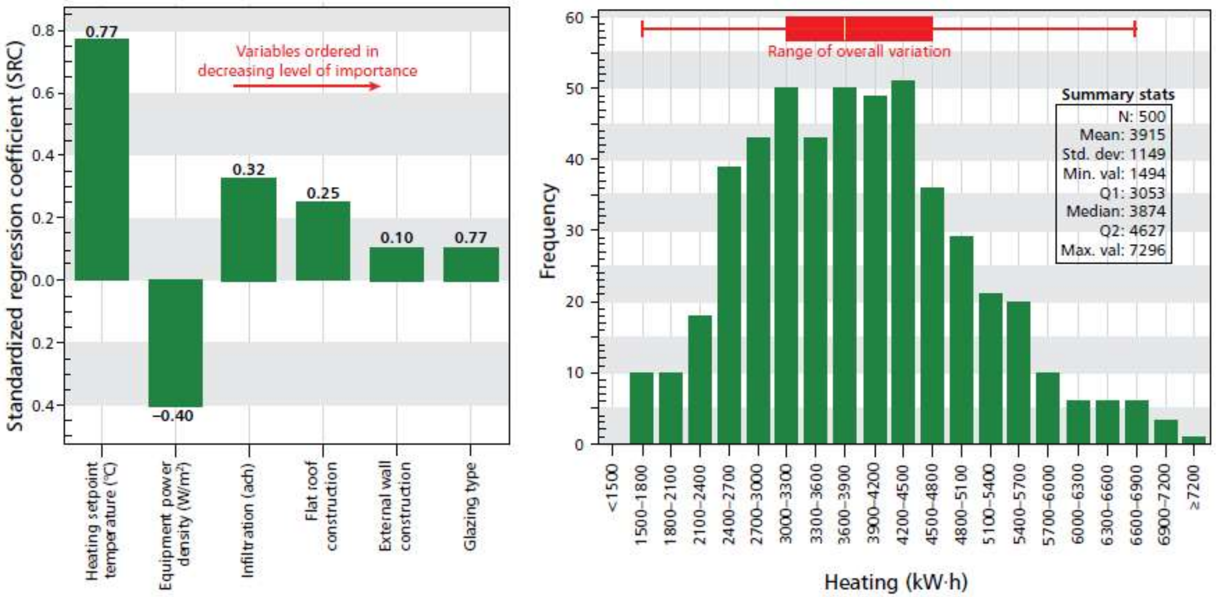


Figure 7.5 Example of parametric sensitivity and uncertainty analysis (courtesy of DesignBuilder Software)

- A holistic analysis
- Determine effects of multiple inputs changing at a time
- Accurately calculated ranking and uncertainty
- Useful in risk quantification (e.g., in performance contracts)

For typical projects basic sensitivity tests may be sufficient

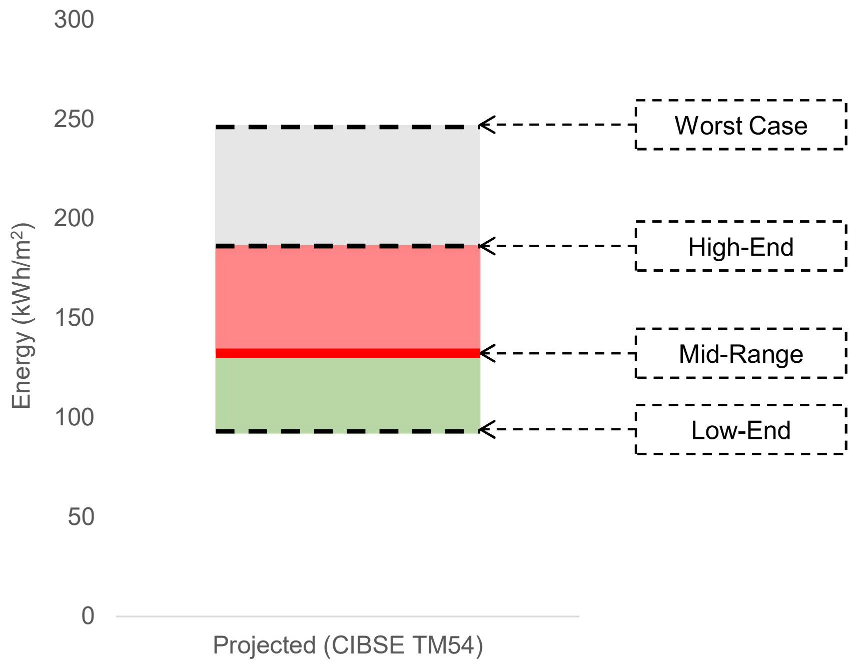
Step 14: Scenario testing - Recommended TM54 Approach

How

The modelling results demonstrate the level of uncertainty in results

4 Scenarios to be explored

- A mid-range scenario (baseline case)
- High-end and low-end scenarios
- 'Worst case' scenario



Step 14: Scenario testing - Recommended TM54 Approach

How

What variables to change and scenarios to consider?

- Inputs identified as
  - important in Step 13: Sensitivity test/analysis
  - low or medium confidence in implementation matrix
- Controls
- Occupancy and hours of operation
- Internal gains (equip/lighting loads etc.)
- System efficiencies
- Weather (incl. future climate)
- Management considerations (Step 12)

Scenarios to test will differ per project.

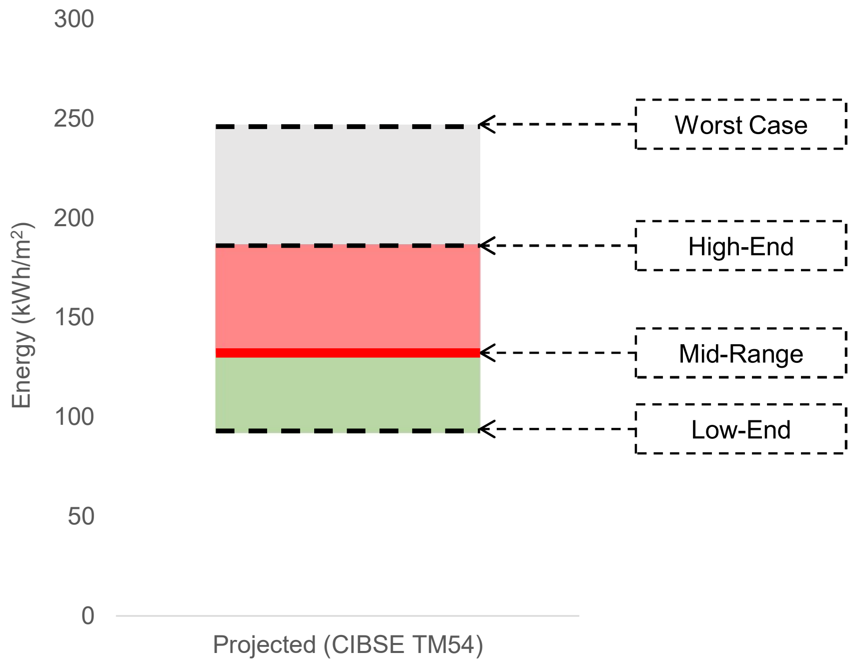
Avoid blanket approach of ±10% variation to all results or to all inputs.

Use the probable range from implementation matrix

Step 14: Scenario testing - Recommended TM54 Approach

How

Category	Low	Medium	High
Occupancy number	1	2	3
Occupancy hrs / schedules	8-10	12-14	16-18
Heating EER	3.5	3.5	2.5
Heating set-point (° C)	20	22	24
Lighting load (W)	800	1200	2500
Lighting operating hrs	6-8	6-10	10-12
Equipment Load (W)	2500	3200	6000
Equipment operating hrs	6-8	6-10	10-12
Parasitic Load (W)	1500	2000	4000
Weather (2050 CIBSE future emission scenarios)	Low	Medium	High



UCL Institute for Environmental Design and Engineering

TM54: 2022
Sensitivity Analysis & Scenario Testing

(Steps 13 and 14)

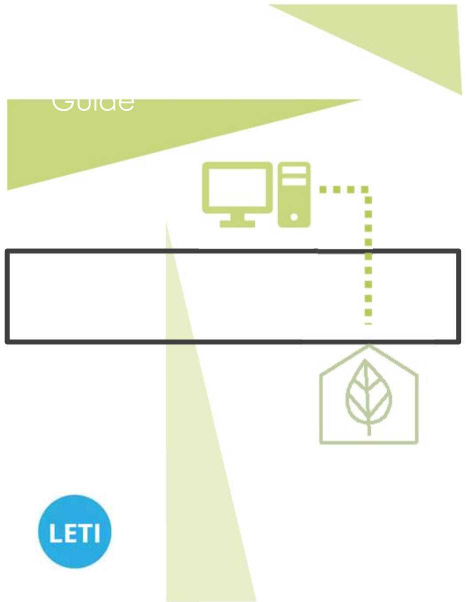
Thank You

Nishesh Jain (n.jain@ucl.ac.uk)

DesignBuilder SOFTWARE

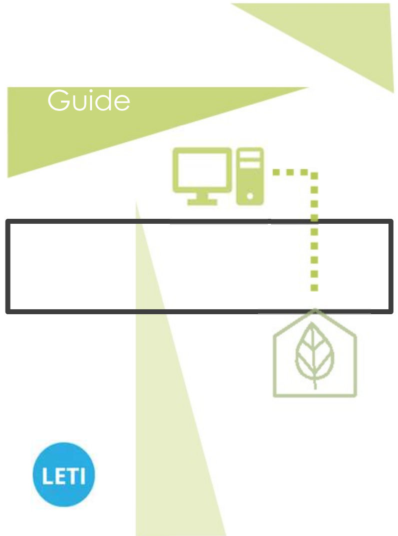
LETI Modelling Guide

Coming soon…



LETI Modelling Guide

Who is it for?



Clients

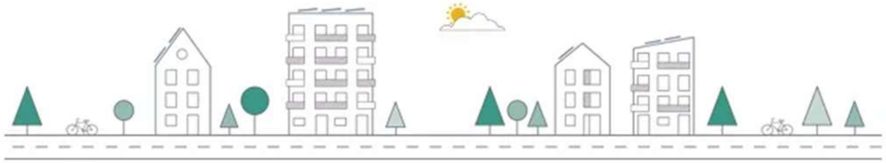
- Caution about compliance
- The modelling timeline
- Expectations of your modellers
- The risks of an EUI target

Design Teams

- What modellers will need from you
- Additional benefits of modelling

Modellers

- Modelling for an EUI
- What to be aware of
- Reporting the analysis and the risks



How does it relate to TM54?

All buildings

0		Choose the right tool for the job	✓
1		Get the basics right	✓
2		Consider the impact of occupants	✓
3	9	Include all the energy uses	✓
10		Assume realistic internal heat gains	✓
11		Model complicated systems in detail	✓
13	14	Stress test for robustness, and manage risk	✓
16	17	Report clearly and QA your work	✓

35

$kWh/m^2.yr$

EUI

Wider topics?

- How to meet the other LETI KPIs
- Overheating risk assessment against TM59/52 or GHA tool/PHPP
- Unmet hours check (ensuring comfort)
- EUI targets hit using ‘baseline’ (mid) estimate WITH risk management exercise
- By detailed design ‘high’ confidence level achieved for all the key modelling inputs, or included in risk management plan
- Modeller integrity and transparency – models should be replicable from reports

Thank you

Susie Diamond
LETI
susie@inklingllp.com