Net Zero Public Sector Buildings Standard

Dynamic Simulation Modelling Guide

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The Scottish Government
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NZPSB 2G5 Dynamic Simulation Modelling Guide v1

Contents

I. Executive Summary

This Dynamic Simulation Modelling Guide was commissioned by Scottish Futures Trust and Health Facilities Scotland to support Procuring Authorities to meet the modelling requirements of the Net Zero Public Sector Buildings (NZPSB) standard (“the Standard”) for newbuild and major refurbishment projects.

It is an overall objective of the Standard that Public Sector Bodies should demonstrably achieve significantly improved Operational Energy (OE) performance through construction projects, ensuring a balance with the delivery of ‘healthy buildings’ which deliver on Internal Environmental Quality (IEQ) criteria.

A step change improvement is needed in the application of robust dynamic simulation modelling and analysis and this Dynamic Simulation Modelling (Dynamic Simulation Modelling) Guide sets out how to achieve this.

The guide describes requirements for dynamic simulation modelling and reporting to be performed across each of the eight Royal Institute of British Architects (RIBA) plan of Work Stages. These guidelines range from the early concept stage of design right through to the ‘post-occupancy’ operational stage.

The guide, whilst primarily aimed at Dynamic Simulation Modelling modellers, is also written to help all other project stakeholders understand how to obtain the right level of dynamic simulation modelling to make evidence-based decisions to meet the Operational Energy Target (OET) and Indoor Environmental Quality criteria for their project.

Dynamic Simulation Modelling alignment with project Building Information Modelling (BIM) planning is described along with recommendations on suggested naming conventions within the data management framework. A checklist of reporting deliverables is described within the Dynamic Simulation Modelling Guide, include sharing all electronic models used throughout the process, to produce reported results at each delivered stage across common BIM platforms.

The primary energy simulation modelling challenge is meeting the ambitious Operational Energy Target, set in line with the Standard’s Requirements and Objectives Guidance.

Dynamic Simulation Modelling within the Scottish Construction sector has historically been focused on plant sizing for mechanical building services, and achieving compliance with Section 6 of Scottish Building Standards, using relatively simple simulation approaches, such as heat loss/heat gains calculations using a steady state model and the ‘Simplified Building Energy Model’.

This approach has contributed to a perceived ‘performance gap’ between the predictions of energy made at the design stage of a building when compared to its performance in use. The energy simulation modelling methodology specified in this guide should take a significant step forward in closing this performance gap by adopting a much more comprehensive and detailed approach to building systems analysis, known as ‘HVAC’ modelling, to calculate annual energy simulation and Operational Energy Target predictions.

This Dynamic Simulation Modelling Guide sets out the methodology through each RIBA stage. The requirement for model reporting should focus on evidencing key performance indicators to ensure design decisions are accurately justified and provide clarity to all participating stakeholders.

The Dynamic Simulation Modelling Guide sets out to assist project teams in designing to ensure occupant comfort conditions in Public Sector buildings and to avoid overheating, with the minimum impact on energy consumption. This should be achieved by promoting collaborative design, where each team member contributes as required at each stage.

The Dynamic Simulation Modelling Guide sets out approaches to a range of building analysis including energy and carbon predictions, and solar and daylighting studies. These studies are often performed iteratively to support members of the design team to determine the impact of their design suggestions and decisions upon performance. Reference is also made to detailed Computational Fluid Dynamics airflow analysis, which can be a powerful analytical tool for bespoke situations that warrant it.

At each design stage, the energy model is refined and the Operational Energy Target is predicted and is then verified at project completion after the first 12 months of representative operation. Indoor Environmental Quality criteria is also expected to be appropriately modelled and appraised, as part of ‘risk based’ analysis to achieve such criteria in use.

During the post occupancy operational stage, there should be the opportunity for the energy simulation modeller to use measured data to create a ‘calibrated model’, covering the energy, carbon and indoor environmental quality aspects of what has also become known as a ‘Digital Twin’ to verify performance against targets and core objectives. The digital twin energy model of a physical building responds and behaves like their real-world counterpart to function as problem-solvers and provide decision support information needed to improve performance, influence future building design and reduce risk.

Once the procedures set out in the guide are implemented, building owners and their facilities managers can take advantage of more detailed Dynamic Simulation Modelling models to help them to more assuredly design, manage and improve their building operations.

1 Introduction

1.1 Using this Guidance

This Net Zero Public Sector Building Standard ('the Standard') Dynamic Simulation Modelling Guide should be read in connection with wider Standard documentation and Guidance, including, but not limited to:

- The Standard's Requirements
- The Standard's Objectives Guidance

The Scottish Government's Standard Resource page should also be consulted for all supporting Standard documentation referred to in this Guidance document. Links within the documentation shall take Participants to this page. Standard resources, tools and templates can be navigated from the landing page[1]. A separate supporting external document, policy and guidance page has also been established, providing a centralised set of external website references, which will be updated from time to time to reflect changes and development in policy and industry[2].

Defined terms and abbreviations utilised in this document are detailed within the Standard's standalone Glossary and Abbreviations documentation.

1.2 Dynamic Simulation Modelling in the Context of the Standard

The Scottish Government has established the Standard to assist public bodies to act in the development, design and delivery of infrastructure to achieve net zero carbon in operation in advance of 2045.

This Guidance supports public bodies to articulate and achieve ambitious 'Operational Energy Targets' and 'Carbon Strategies' to reach Net Zero emissions by their own specified target date (the Net Zero Deadline), which must be in advance of Scottish Government's legally binding target date of 2045.

The Standard sets the following challenges for new build and Major Refurbishment projects:

- Achieving a world class Operational Energy Target (OET)
- Having a resourced strategy to achieve Net Zero energy supplies by a Participant set date in advance of 2045.

A Project is required to balance the above with the provision of Indoor Environmental Quality (IEQ) criteria which supports the provision of 'healthy buildings', and satisfies Good Industry Practice related top operational environmental performance.

In order to facilitate delivery of the Standard, the scope and depth of building dynamic simulation modelling needs to increase beyond pre-existing expectations. An appropriate level of building analysis is required at every stage in the building lifecycle. Responsibilities for the accuracy and the decisions drawn from the results of the modelling need to be shared across the project stakeholders, and maintained through the development of the building lifecycle.

[1] Text highlighted in green through this document
[2] Text highlighted in blue through this document

This ‘Dynamic Simulation Modelling Guide’ is intended to support public bodies deliver the modelling required to meet the Standard, and to articulate the modelling needed in their Participant brief.

A Participant’s Project Team, inclusive of their building simulation modellers, also need to ensure the needs of building users and Participants’ requirements are understood, agreed and incorporated at each project stage. For instance, this could mean considering a range of potential occupancy scenarios and determining their impact upon forecast energy use. This could lead to a need to review and revise the Operational Energy Target during the design stage by agreement with the Participant. This is dependent on particular building use and subject to procurement and delivery routes, and conditions of funding and contracts.

1.3 Roles and Responsibilities

Dynamic Simulation Modelling should evolve throughout the design process up to, and in some instance, post-Handover, into operation. The data used in models needs to be agreed through a collaboration of Project design team and project stakeholders. In particular, Participants need to be mindful of the benefit to project outcomes of providing comprehensive data relating to how the building should be used. The data entered into Dynamic Simulation Modelling models directly impacts the output results and the ensuing decision making.

Participants should nominate a technical specialist to act on their behalf. The duties of this specialist are described in this guide as the ‘Inclusive Net Zero (INZ) Champion’, who is independent of the Participant’s design team. The INZ Champion does not need to be an individual appointed solely to perform these duties and instead may be included within the duties of a designated member of the Participant’s team, such as an appointed information manager or others, to suit the need of each individual project.

The INZ Champion should take primary responsibility to ensure the Operational Energy Target and Indoor Environmental Quality targets remains a key focus of the design team in accordance with this Guidance and should monitor at each stage that the design team (and the Modellers in particular) provide sufficient evidence to demonstrate the design is on track to meet such Requirements.

Prior to commencing design, the INZ Champion should assist the Project’s information manager(s) to record roles and responsibilities in relation to the Objectives of the Standard for each Project Team member at each project stage and how parties should communicate with each other. BSRIA’s BG 6 Design Framework for Building Services is an example that may assist with allocating these activities.

The Modeller(s) has a responsibility to clearly describe the information required in order to perform the various modelling tasks. Each project stakeholder has an obligation to contribute the information under their individual control at each stage in the project. For instance, this can include building fabric properties, and information to define ranges of operation for specialist medical equipment.

This Guidance also describes the skillsets required by Modellers.

1.4 The Standard for Net Zero Carbon Public Sector Buildings

The Standard supports public sector bodies participating in publicly funded construction programmes to develop buildings that are highly energy efficient; have plans in place to meet their energy needs from net zero carbon sources and to progress other relevant organisational sustainability priorities.

It should be noted the scope of this Dynamic Simulation Modelling Guide is concerned with all on-site building related energy and carbon used, as metered by utility meters. Strategies to develop Net Zero energy supplies through off-site solutions, e.g. electricity grid decarbonisation and energy/heat networks serving groups of buildings are essential elements of the Standard, but are outside the scope of this Dynamic Simulation Modelling Guide. The Standard comprises six stages:

1. Application
2. Concept Design
3. Detailed Design
4. Delivery
5. Verify Performance
6. Continuous Improvement

These stages align with individual or grouped Royal Institute of British Architects (RIBA) stages and with Soft Landings. The Standard Stage milestones conclude at each of the following RIBA stages or align with RIBA in Stage 7 'use':

Scottish Capital Investment Manual (SCIM)	Assurance Review Framework Gateways	RIBA Plan of Works	Government Soft Landings (*Adjusted for Energy Focus*)	NZPSB Standard
Service Change Planning				
Strategic Assessment	0 Strategic review of a programme	0 Strategic Definition	Draft Energy Management Plan	Application
Initial Agreement	1 Business Justification before IA Approval	1 Preparation & Briefing		
Outline Business Case	2 Delivery Strategy & readiness to proceed to procurement	2 Concept Design		Concept Design
Full Business Case		3 Spatial Coordination	Energy Management Plan	Detailed Design
	3 Investment decision review before contracts are placed	4 Technical Design	Draft handover and aftercare strategy plan	
Construction & Commissioning	4 Readiness of service to use the facility	5 Manufacturing and Construction	Final handover and aftercare strategy plan	Delivery
Project Monitoring & Evaluation		6 Handover		
	5 Operations review & benefits realisation	7 Use	Qualitative health check and seasonal commissioning	Verify Performance
				Continuous Improvement

NHS Design Assessment Process (NDAP)

Dynamic Simulation Modelling activities should be regarded as an ‘organic’ process that develops at each project stage from design into operation, as an integral component of the ‘Soft Landings’ planning for a Project.

Appropriate Energy Modelling needs to be reported, including compliance with Operational Energy Targets and appropriate Indoor Environmental Quality targets, at the end of each stage defined within the Standard, agreed by design team members; verified by a Third Part Verifier where appropriate and signed off by the Participant prior to proceeding to the next stage.

Please refer to the Standard and its Requirements and Objective Guidance documents for specific reporting requirements.

The level of detail in Dynamic Simulation Modelling models needs to reflect the level and detail of analysis and reporting requirements at each project stage (e.g. overheating predictions for hours over a target maximum temperature).

Reports on modelling performance at the end of each stage, where appropriate, could also include:

- Weather analysis
- Solar impact analysis and shading
- Thermal loads analysis and overheating risk

- Prediction and the breakdown of total building energy usage (regulated and non-regulated)
- Energy efficiency measures including passive design and controls strategies

1.5 Scottish Capital Investment Manual (SCIM)

The Scottish Capital Investment Manual (SCIM) provides guidance on the processes and techniques to be applied in the development of infrastructure and investment programmes and projects within NHS Scotland and other parts of the public sector in Scotland.

This Dynamic Simulation Modelling Guide should be read in conjunction with SCIM and other relevant public sector project governance, briefing and verification frameworks and where appropriate, project teams should perform modelling to suit the needs of each stage of the processes and outcomes.

2 Dynamic Simulation Modelling Guide - Overview Requirements

2.1 Stage by Stage Modelling Requirements

Appendices 1 and 2 describe the energy modelling steps required at each RIBA 2020 stage. These steps are intended to guide the project team through the energy modelling related aspects of their project and define the expected methodology with illustrations at each stage.

A high level of Energy Modelling sophistication is needed to meet the requirements of this Guidance beyond those requirements for demonstrating compliance with the Scottish Building Standard Section 6. Modellers provide the analysis required to make a wide range of decisions as projects evolve and therefore need to allocate sufficient resource to satisfy the deliverables required at each project stage.

The scope and timing of modelling activity is significant and the impact to project programme should be carefully considered with adequate time planned and scheduled to undertake modelling, analysis and iterations.

Where all required actions are not complete at the end of an individual project stage the Project Team should flag up a lack of completeness and propose a course of action to be approved by the INZ Champion prior to starting the next stage.

2.2 Operational Energy Target (kWh/m^2)

Guidance on applicable benchmarks and setting Operational Energy Target's is provided in the Standard's Requirements and Objective Guidance documents.

This Dynamic Simulation Modelling Guide provides supplementary Guidance on the modelling input to assist project teams to ensure Operational Energy Targets and Indoor Environmental Quality criteria is met at design, delivery and operational stages of their projects.

2.3 Net Zero Deadlines

Whilst the primary objective of this Dynamic Simulation Modelling Guide is to inform realisation of the Operational Energy Target and Indoor Environmental Quality criteria, design teams also need to develop carbon strategies to meet energy needs by Net Zero sources by 2045, or by the public sector body's specified date (the Net Zero Deadline). Dynamic Simulation Modelling to support this should be performed at each Project stage. Where permitted by the Project Team, this can include 'allowable solutions' which can be used to offset carbon emissions through remote measures if on-site methods are deemed unsuitable. Typically, the latest Department for Business Energy and Industrial Strategy's (BEIS) carbon emission conversion factors and associated forecasts should be applied. However, design teams should agree with the Participant whether there are any variations from this requirement, e.g. to take account of variations relating to location, season, time of day and tariff.

2.4 Performance Gap

As part of these guidelines, the so-called 'performance gap' between energy use predictions at design stage and operational energy use needs to be closed and potentially eliminated. In order to close the performance gap it is important to use as accurate data as possible when modelling at each stage in the design and construction lifecycle.

For instance, National Calculation Methodology (NCM) data, which is used as the basis of Section 6 and Energy Performance Certificates (EPC), via SBEM & Dynamic Simulation Modelling (Dynamic Simulation Modelling) calculations should be avoided for any other purpose (6). Furthermore, the NCM data is intended, and is appropriate for comparative compliance calculations, but not for design analysis. The NCM data is not site specific and does not include energy associated with processes, plug loads, ceiling voids, etc.

The approach in this Dynamic Simulation Modelling Guide defines where an energy simulation model coupled with the more detailed 'HVAC' analysis (based on system component part-load performance curves) is needed, rather than an energy simulation model based only on seasonal efficiencies. The use of seasonal efficiencies and specific fan powers should be insufficiently sophisticated to meet an ambitious Operational Energy Target, although may be appropriate in some cases to provide indicative and comparative results at early design stages, (e.g. RIBA stage 1).

Eliminating the performance gap, by performing more accurate energy modelling, should enable project teams to deliver lower energy consuming environments that are more comfortable for building users.

2.5 Dynamic Simulation Modelling Software

This Dynamic Simulation Modelling Guide is intended to be used across a range of software tools employing Dynamic Simulation engines. Some software tools can perform all or most of the analyses described in this document, whereas some tools may be able to provide answers to particular types of analysis. It is for the project team to decide which tools are most suitable for their individual project and agree this with their Participant.

The modelling software used should be capable of Dynamic Simulation, where required for detailed and operational modelling using sub-hourly time-steps (at least every 10 minutes) with coupled analysis of detailed HVAC plant systems, bulk airflow movement, illuminance respondent control and solar shading tracking.

Within this Dynamic Simulation Modelling Guide, any illustrated examples use IES's Virtual Environment (VE) as a guide to assist in understanding the requirements, rather than being prescriptive in terms of delivery.

2.6 Modeller Training and Competency

Modellers and Verifiers should be able to demonstrate sufficient skill and expertise in performing the required range of modelling tasks at each project stage.

Evidence to support this may include:

- Building physics higher education qualifications (including Thermodynamics, Heat Transfer, Controls, lighting etc)
- Records of training in the software modules being used (e.g. HVAC system and controls)

- Documentation to demonstrate successfully working on a number of projects of similar complexity (e.g. 6 similar projects) in the preceding 3 years.

It should be acceptable for the modelling to be performed by a team of modellers, drawn from members of the design team whose combined experience is sufficient to demonstrate the skills and expertise required.

2.7 Modelling Quality Management

Modellers should be able to demonstrate that they have acceptable Management Systems in place at all stages in the project. Accreditation to ISO 9001, including management of modelling activities is an example of how this could be demonstrated.

Evidence of Quality Management should involve checking and verification of input data and output results by suitably qualified and experienced independent Third-Party Verifiers at all Participant specified milestones and otherwise as agreed where Dynamic Simulation Modelling has been performed. During the design stages of a project, this should be performed as a minimum at the end of RIBA Stage 2 and 4 to confirm the Operational Energy Target and Indoor Environmental Quality criteria are being met, prior to progressing to the next project stage.

2.8 BIM Process and Delivery

The Dynamic Simulation Modelling activities and outputs require detailed planning and collaboration across all project stages and should therefore be managed through a robust BIM execution plan and integrated delivery process. The overall project stage outputs should be aligned with the Participant information requirements, and in accordance with industry BIM standards and best practice. The choice and adoption of BIM standards may be dependent on the Participant organisation, the size and value of the project, and the project procurement route e.g. *existing framework.* Further details on the Project's BIM requirements related to Standard compliance can be found in the Standard's Requirements and Objective Guidance documents.

2.8.1 Project BIM requirements

There are several key BIM requirements which interact with Dynamic Simulation Modelling and should be considered for adoption on projects at the outset. These include: -

- A clear set of Participant objectives and information requirements for all project stages (via Employers Information Requirements (EIR)and Project Information Requirements (PIR) documentation,
- Clear tasks, roles, and responsibilities to deliver the correct project services, models and information at the correct stage and time,
- Agreed project BIM strategy including standards, processes and procedures for model development, collaboration, coordination, and information delivery (*verification and validation*) (via BIM Protocol & BIM Execution Plans (BEP) documentation),
- A Participant established common data environment (CDE) process & technology solution for all project stages,
- Agreed classification naming of project model systems, elements and associated information deliverables using Uniclass 2015 tables

- Agreed naming conventions for project files, models, and associated layers,
- Participant agreed naming protocols for project spaces, volumes, assets etc.

2.9 Modelling Techniques

Appendices 1 and 2 of this Guidance describe Energy Modelling steps required at each RIBA stage. It is important to set over-arching modelling requirements, and guidance for building energy simulation models, which are described below.

Using appropriate input data is critical to success of Dynamic Simulation Modelling models and being able to achieve the Operational Energy Target and Indoor Environmental Quality criteria. As energy targets become increasingly stringent, and projects target Net Zero emissions, the models used to assist with design and decision making need to become more accurate.

The Operational Energy Target energy predictions include all building delivered energy. The range of energy uses to consider within the Operational Energy Target is generally as described in the Chartered Institute of Building Services Engineers (CIBSE) Technical Memorandum 54 (TM54) (1).

Teams should consider and reflect recent industry guidance to enhance the modelling performance where available. This includes but is not limited to CIBSE TM61-64: Operational Performance (2020) (2, 3, 4, 5) which builds on the experience of building performance evaluations, and any other best practice guidance on Dynamic Simulation Modelling through organisations such as LETI, UKGBC, etc.

2.9.1 Operational Energy Modelling

Predicting peak and annual energy loads can be approached in a number of ways. Traditionally within the UK, this has frequently involved 'steady-state' energy analysis, also known as 'CIBSE Loads'. This approach has been shown frequently to overstate loads and is not considered accurate enough when designing to meet stringent Operational Energy Targets.

The use of steady-state modelling should not be acceptable at any stage of the design process for the calculation of the Operational Energy Target.

It is therefore a requirement of the Standard's Dynamic Simulation Modelling Guide that all Energy Models are constructed using a 'Dynamic Thermal' calculation approach, as opposed to 'Steady State'. This is described further in Appendix 2. All Dynamic Simulation Modelling from RIBA Stage 3 and onwards should be performed using a more detailed 'HVAC modelling approach'. HVAC component performance data (performance curves and part load efficiencies) should be used to inform and validate plant sizing selections, system controls and plant sequencing for optimum operation.

Energy models shall also include where possible detailed Solar Analysis and Daylighting, including illuminance-based daylighting control where daylight sensors can control lighting energy in the model based on sunlight intensity.

Energy models shall be able to study both natural ventilation, including window and louvre opening controls, as well as mixed-mode, hybrid, mechanical ventilation and air conditioning systems. Such activities should support with the relevant activities and analysis expected of the Standard's Indoor Environmental Quality criteria.

Advances in simulation technology are always being developed and modellers are encouraged to use the latest technology available in software to maximum effect. This could involve the ability to improve modelling of new building technologies or improved simulation techniques, e.g. to run simulation batches, parametric analysis, optimisation algorithms, scripted profiles etc.

An important consideration is to study viable design scenarios both in isolation and in parallel in order to identify optimum arrangements.

2.9.2 BIM / Model Geometry

3D models and BIM processes are used to help design, construct, and operate buildings and are configured in many guises to deliver the project needs. An energy simulation model is one of these and is used to perform energy analysis.

Modelling in an energy simulation requires a focus on ensuring a space is represented by a complete bounded volume, whereas architectural BIM models have an initial focus on surfaces. Therefore, when transferring model geometry from the 3D architectural model into the analysis model the software provider's guidance steps need to be considered and followed to ensure the best transfer is completed. This process can be defined as 'interoperability' where importing from 2D/3D CAD packages. As spaces and volumes are defined, then adjacent surfaces should automatically be configured to identify room relationships.

Model geometry is used to define the volumetric space configuration of a room on to which layers of thermal attributes can be linked. This process is used to represent the 3D form of the building to reflect its architectural form for capturing and transferring energy processes.

Model geometry for analysis does not require a fully developed design model to be in place beforehand. Instead, energy modellers can analyse various options to inform the design team in developing design solutions from simple mass forms developed from the Concept Stage. These can start as simple shapes and develop into more complex forms. They can be targeted at key components expected to be included with the building design such as windows/doors, and local shading features attached to the building façade. In addition where known, geometry for surrounding obstructions including local buildings and topography should be included with reasonable application of shape and height so that their influences are included.

Models require accurate alignment to room naming conventions and include grouping schemes. These grouping schemes facilitate model management when applying thermal attributes, communication of model information to the project team, as well as assisting with interrogation of simulation outputs. This process should work to help create a calibrated energy model which can be constantly fed with live data for the 'Continuous Improvement' stage.

2.9.3 Model 'Metering'

Detailed HVAC Energy models need to have the facility to report their alignment with real building meters so to directly compare at the same intervals and on a sub-hourly basis. Ideally, all building energy meters, including heat meters and sub-meters should be directly reflected in the energy simulation model.

Energy meters include both energy consuming and energy generation meters (e.g. for solar photovoltaic panels). It is recommended that the design team create a 'meter map' to set out the metering strategy and to make sure that real and virtual models are aligned. Please refer to the Standard's Objective 3 Measurement and Verification Guide for further details.

2.9.4 Weather Files

Weather file selection is critically dependent on purpose of each analysis; e.g. annual average energy prediction, average warm summer comfort analysis, future weather files and real measured weather data for model calibration, etc.

The consideration and selection of appropriate weather files used as part of each stage therefore needs to be carefully considered and assessed in advance of simulation analysis. Weather file selection should be proposed by the project Dynamic Simulation Modelling modellers for agreement with the project team.

For example, weather files used to predict Operational Energy Targets and heating loads should be applicable to an appropriate 20-year average to suit the building location, elevation and exposure.

Weather files being considered need to be assessed for a number of factors including the suitability of temperature, wind speed, wind direction, cloud cover and solar data and their selection being made to avoid anomalies affecting predicted performance.

CIBSE offers a range of weather files that can be considered for use. It should be noted however these best represent Glasgow and Edinburgh in Scotland and careful consideration is required to select the most appropriate weather files to represent weather conditions in other locations.

Energy analysis is typically to be represented by a 'Test Reference Year' (TRY) or similar 'average year'. Overheating is typically to be represented by a 'Design Summer Year' (DSY) or similar 'typical warm summer year'. Simulations performed to compare model results with real measured building data, and for use with 'Calibrated Energy Models' should be represented by the nearest applicable site measured data for the specific period of operational measurement.

Future weather files are used to assess the range of potential risks to the building performance. It is recommended to use a range of future weather files to cover the potential spread of projections due to greenhouse gas emission scenarios and global warming impacts on thermal comfort. The process to create future weather files needs to be determined, particularly for specific locations, microclimates, etc.

Future weather files are particularly expected to be used for thermal comfort Indoor Environmental Quality appraisals, including use of DSY 2050 /2080 scenarios for 'future proofing' building performance, particularly where passive ventilation and cooling solutions are sought.

Links to weather files for use in Scotland are included within Appendix 2.

2.9.5 Design Analysis Considerations

The Participant's requirements should set out specific project objectives. Designs also need to comply with the relevant Building Regulations. Specifically, this includes Section 6 energy, which should be checked using model-based analysis at each project stage. Whilst there is an obligation to meet minimum building standards, any design decisions based on energy model outputs should be taken based primarily on the most realistic modelling rather than to meet compliance targets, such as Section 6 or other 'sustainability levels' based upon NCM model inputs.

The impact of the quality and extent of Participant briefing information is critical during the design stages. The Participant team have a responsibility to set out their needs clearly. For example, by including normal and extended operating hours; building activities; identifying separable energy uses that use significant amounts of energy, such as including catering facilities and server rooms [7, 8].

Subject to the above, the energy modelling performed at each stage should seek to compare the performance of passive and active design solutions, e.g. informing the scope for reducing the need for mechanical Heating, Ventilation and Cooling systems. .

Modellers should always use the best available information at each project stage. Consider the ranges of data values if more definitive information is not available, e.g. how low or high could variables be? Should more accurate information not be available, modellers should consider initiating energy modelling by using generic templates, possibly from other similar models where appropriate.

Model input information needs to be considered to be appropriate to its intended purpose – i.e. average vs maximum design scenarios.

In all cases, the impact of the quality of input data on the accuracy of the outputs of the energy model should be clearly expressed to the Participant and the accuracy and confidence levels of outputs documented for them. Consideration should be given to advising that energy modelling be suspended where input data is of insufficient quality or quantity to allow time for this to be resolved.

2.9.6 Passive Design

Examples of features to consider and capitalise upon in energy modelling include:

- Building Orientation
- Floor Layout Planning
- Building Form
- Self-shading and external shading features
- Window to Wall Ratio
- Daylight Capture
- Whole Building Ventilation Strategies
- Natural Ventilation / Mixed Mode vs Mechanical Ventilation and cooling
- Thermal Mass

2.9.7 Sensitivity Analysis

- Some modelling aspects can be captured by considering representative models (e.g. single room types at RIBA stages 1 & 2), whereas some aspects do require a whole building approach (e.g. energy and carbon forecasts).
- Within public sector buildings, commonly occurring space types include offices, meeting rooms, kitchens, toilets, circulation spaces, plant rooms etc.

2.9.8 In-use Analysis

Following project handover, the use of modelling should be considered and used where of benefit as part of commissioning and Measurement and Verification (M&V) activities.

During the design stages, ‘model meters’ would be developed to align with real building meters, particularly for required Separable Uses and core hours analysis. This gives the Project Team the opportunity to compare model predictions with real data from automatic meter reading (AMR) systems and building management systems (BMS) by running real weather data simulations. Where appropriate the Project Team should consider using the International Performance Measurement & Verification Protocol (IPMVP), Option D. Option D involves the use of a Dynamic Simulation Model to predict energy use, and the energy simulation model should be "calibrated" so that it predicts an energy use and demand pattern that reasonably matches actual utility consumption and demand.

Please refer to the Standard's Objective 3 Measurement and Verification Guide for further details.

2.9.9 CFD Analysis

CFD analysis should be performed where appropriate during design stages (i.e. up to RIBA stage 4) in order to quantify and mitigate design risks, where these cannot be addressed adequately using energy modelling. The project energy model should be used where possible to create 'boundary conditions' for CFD analysis, and any decisions made resulting from CFD modelling should be reimported back into the energy modelling analysis.

Examples of CFD analysis that can be performed include the following:

External CFD Analysis:

- Air exchanges at entranceways to avoid draughts and large volume air exchange
- Reducing external wind influence, creating more sheltered environments
- Reduce turbulent flow / wind acceleration, especially around large and tall buildings. E.g. outside spaces analysis for patient amenity, including pedestrian comfort
- Fume and effluent dispersal, e.g. generators and laboratories

Internal CFD Analysis:

- Detailed airflow of mechanically served spaces with high level functions to ensure correct airflow distribution – e.g. clinical/surgical spaces
- Large volume spaces with many dependencies such as atria, large entranceways, and cafeterias.
- Spaces with multiple repetition where risk can be significantly minimised with minimal additional analysis for typical/peak scenarios
- Detailed analysis of spaces with very high internal heat loads, e.g. data centres etc

Appendix A. References

1. CIBSE (2013) – Evaluating operational energy performance of buildings at the design stage TM54:2013
2. TM61: Operational performance of buildings
3. TM62: Operational performance: Surveying occupant satisfaction
4. TM63: Operational performance: Building performance modelling and calibration for evaluation of energy in-use
5. TM64: Operational performance: Indoor air quality — emissions sources and mitigation measures
6. IES & Mabbett (2017) - Engineering Evaluation of Generic New Build Health Buildings
7. CIBSE (2008) - Energy benchmarks
8. BSRIA (2018) - Design Framework for Building Services