November 2021

Vision for 2050

How can building modelling change to deliver to the needs of a sustainable future.

A vision to inspire further research, development and education.

Prepared by CIBSE BSG Group Vice Chair Darren Coppins with contribution from David Cocking, Darren Woolf, Hasim Awbi, Rokia Raslan, Enrico Crobu, Vasiliki Kourgiozou.

Context

Now more than ever, buildings are being scrutinised for their sustainable contribution to the built environment. Their claimed failure to perform to design predictions has cast doubt on ability of modelling to accurately predict building performance.

To limit the impact of global warming, we need to limit the rise in temperature to 1.5^{O}C. To achieve this, net zero carbon needs to be achieved by 2050.

In 2019, the IPCC identified that we were not on target to achieve this, unless significant improvements can be made in reducing carbon emissions by 2030. Many local authorities and corporations have made commitments to be net zero by 2030 in response to this.

Comfort, air quality and infection control are equally important to ensure that buildings can perform as designed and provide sustainable, high quality indoor environments that support wellbeing in extreme climate conditions without risking additional unpredicted carbon emissions.

As project briefs move towards Net Zero performance, the practice of building simulation and analysis needs to adapt to accurately guide design and deliver buildings that perform.

Aims

This vision for the Building Simulation Group is to determine a path for how the practice of building simulation needs to change and how the Building Simulation Group can lead the change.

Vision 2050 is a no limits view on the ideals of building simulation. The group is encouraged to think without restriction on what the ideal building modelling tools, skills and methods would be to meet the deliverables required.

In addition, understanding what is possible and how to achieve it can follow.

Definitions

For the purpose of this note, Modelling and Simulation are not used interchangeably. Simulation relates to undertaking a simulation to provide results as to performance. Modelling relates to a wider definition of considering the methodology and processes to achieve the required brief.

Modelling for 2050

<u>Deliverables</u>

What basic building performance expectations do we have that models can/should influence?

- Energy & Carbon (Net zero)
- Comfort (Thermal, Visual and Acoustic)

- Health & wellbeing (including daylighting and productivity)
- Ventilation systems (mechanical and natural)
- Building envelope including shades
- Operational performance
- Indoor air quality

Ultimate Modelling

What would be the ultimate model? A model that accurately predicts and optimises every aspect of building performance combining all deliverables noted above, aiding design teams and clients to make informed decisions from concept to end of life:

- Thermal
    - Annual thermal simulation
    - Modelling of thermal bridging
    - How the building interacts with its surroundings
        - Air and radiant temperatures
        - Humidity
        - Wind
        - Solar
        - Site-specific weather
        - Peak / simultaneous heating and cooling loads
    - Prediction of user activity, demand and internal loads
- Comfort
    - Our interaction with buildings
    - Predicting our perception of comfort
    - Maintaining and promoting healthy indoor environments
- HVAC
    - Full representation of the environmental conditioning methods and their controls
    - Prediction of user interaction with manual comfort methods such as opening windows. This is especially important with mixed mode buildings.
    - Prediction of failure scenarios
    - Estimating airflow distribution in a space, for the purpose of improving air quality (mean age of air).
- Embodied Carbon
    - Integration of embodied carbon with thermal performance to enable parametric analysis of the optimum balance between comfort, thermal performance, embodied energy & operational energy.
- Lighting
    - Do we need the same lighting levels throughout the day?
    - Is Circadian important? Can it influence perceived comfort?
- Interoperability - perhaps the biggest issue facing many firms? Fast industry evolution as more progressive firms are modelling in a much wider range of tools like Grasshopper and need to exchange data with mainstream tools for compliance.

What do we need to do to make models more accurate, integrated and have greater impact on the design process?

Not Modelling

There is a growing movement that suggests modelling cannot predict building performance any better than a rule of thumb calculation. Are they justified? Is this due to the state of our ability to understand and model buildings, the abilities of the software or other factors? Bringing together some research in this area can help to understand such claims.

Modelling and Construction Quality

Modellers rarely have the opportunity to investigate actual and modelled building data to understand and refine models. It is essential that we obtain an understanding of how the actual building differs from the simulation.

Construction, installation, commissioning and control errors can cause a deviation from a modelled result as much as poor or inaccurate modelling.

How can we influence modellers to learn from the buildings they have been involved with?

How can modellers influence construction quality with prediction via modelling of potential failure scenario's so construction teams can understand the importance of such failures. Is it possible to optimise a buildings energy systems to minimise the impact of known construction issues and failures?

Software capability

Integrated analysis including Wind & indoor-outdoor coupling (infiltration avoidable and unavoidable, natural ventilation, control of pollutants) thermal transfer (including FEM Bridging – dynamic + Moisture analysis?) Control systems reactions, automated failure analysis, automated consideration of a group of weather files, ability to predict construction quality scenarios to categorise risk, embodied carbon vs performance analysis. Incorporating more multi-physics leading to more chemistry and biology supporting a building science led approach to design. Use of metrics for better targeting / position of design (along with climate).

Better visuals that are quicker to produce will aid communications amongst the teams. Integration with gaming software to produce visually appealing graphics to aid understanding?

Interconnectivity of software & data – enabling models and results to move between packages, from lighting calculation to an energy model.

Stakeholder Collaboration

What are the influences of good and poor stakeholder collaboration and how can the modelling process be enhanced to encompass collaboration to optimise the outcome

Smart control with smart grids

Efficiencies from a smart energy management system are being quoted upwards of 15% energy use reduction.

How can our buildings predict energy consumption in real time and work with smart grids to optimise source generation allocation within local energy systems and take advantage of smart tariffs. How can we capture and optimise energy consumption through smart metering and controls at building scale to allow for flexible building operation and building communication.

The need exists for better links between local and grid scale energy generation at high temporal resolutions, spatial neighbourhood scale representation and modelling of energy systems with building scale modelling to allow for bi-directional communication between the energy supply and demand side. Data integration software can work with multiple file formats and aggregate and manipulate big data linked to real-time modelling results – example of data integration platform is FME (Feature Manipulation Software). Digital dynamic data reporting format, can allow for a better exploration and interpretation of data (example interactive PowerBI reports).

Programming skills and growing energy systems knowledge is required from building simulation experts.

Digital twins

Automatic simulation of building operation with forecast weather patterns with real time comparison with building performance to aid refinement of complex systems.

Self-learning simulation software to monitor the buildings performance and understand differences from the model. This will be with two aims, to identify areas that require rectification and for the software to adapt to differing building characteristics than assumptions in the model to calibrate.

Daily models can predict building performance over short term with out of range values flagged for investigation.

Level of information required will increase to include occupancy and usage patterns, monitoring on floor live energy loads, prediction of occupancy based on historical information, air quality & comfort influences.

Potential to generate and learn from big data through implementation within truly intelligent buildings to refine software and modelling techniques. The feedback on the differences between modelled performance and actual will ultimately produce a better understanding of where gaps in performance are present and why.

What else would a building model without limits do for us?

Collaboration

Collaboration will be an essential part to a successful evolution of building simulation skills and modelling outcomes worldwide. The authors of the software, modellers, academia, industry groups, clients, developers and end users all represent important members of this process.

Implementation of the Vision

The CIBSE Building Simulation Group aims to bring together knowledge and experience to achieve the goals of this vision. Where working groups already exist, we will assist with knowledge and experience. Where we identify gaps, we will seek to prioritise and form working groups to tackle the gaps.

Our aims can only be realised through an open and collaborative approach