A progressive approach to TM54 Design Stage Operation Energy Assessment

Phil O'Loughlin, Michael Pollock & Colin Rees

July 28th 2020

Presentation Overview

IES

- Opportunities to improve the accuracy of energy prediction based on the CIBSE TM54 methodology.
- The importance of a connected approach to energy modelling from the outset.
- The advantages of detailed HVAC Modelling.
- Post occupancy options and continued review and improvement for newly developed buildings.
- Q&A.

Presentation Overview

- Outside of this scope:
  - Initial Setup and how to re-task a compliance model for operational energy assessments.
  - The Performance Gap.
  - Legislation surrounding Building energy consumption.

Operational Energy Assessments

- A brief history
  - October 1973, the Arab members of the Organization of the Petroleum Exporting Countries (OPEC) raised their benchmark oil price by 70% and agreed to reduce production. The UK government was forced to introduce fast, severe measures to ensure the economy did not grind to a halt.

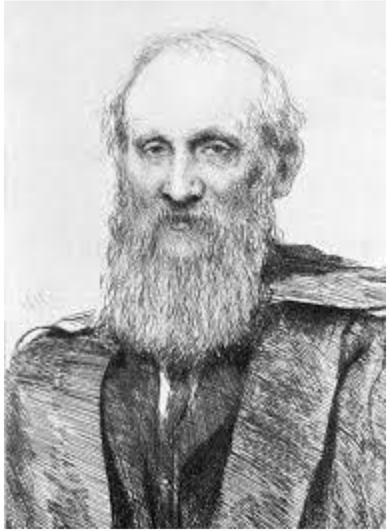
  - The Government have been trying to encourage the Country to reduce its energy consumption ever since but now with an emphasis on reducing CO_2 emissions.

Operational Energy Assessments

The Right Honorable Lord Kelvin (1824 – 1895) is famously quoted as professing:

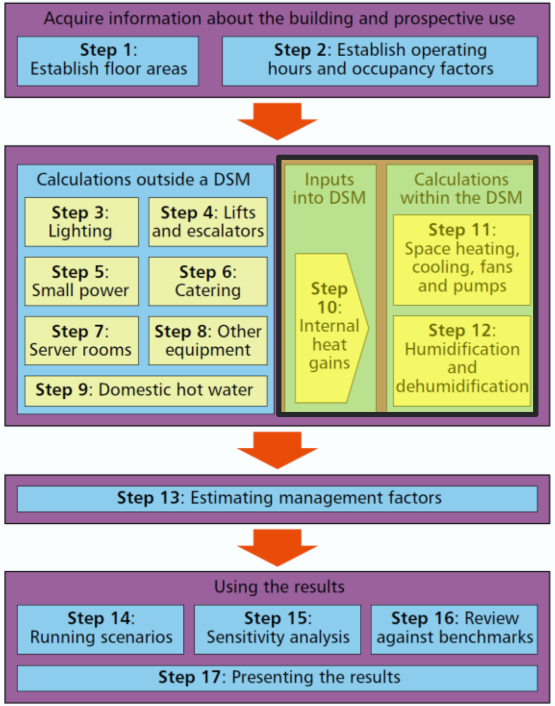
"To measure is to know. If you cannot measure it, you cannot improve it".

This is the mantra we follow at IES and clearly illustrates the need to better understand the Operational Energy of our Built Environment right from the design stage.



Current Approach

- The current TM54 provides a clear stepped methodology.
- This methodology proposes that the energy use of heating, cooling, humidification, ventilation systems are assessed in DSM.
- Energy consumption by all other loads is based on steady state calculations.



Progressive Approach

- Why should we take a progressive approach?
  - Reduce the width of the variance whisker from the median to improve the certainty actual realisation of the modelled predictions.
  - Reduce time spent on ad-hoc manual calculations.
  - Quickly make comparative assessments of variable amendment.

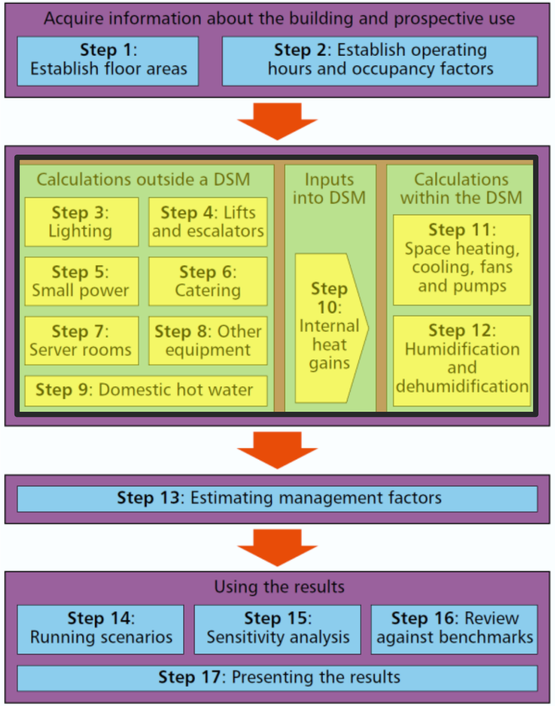
- When should we take a progressive approach?
  - Only when energy being assessed is initially shown to be significant.
  - Consider why the forecasted Operational Energy is required.
  - The end client is intent on embarking on a continued monitoring and improvement process post occupancy such as creating a Digital Twin.

Progressive Approach

1. Bring Steps 3 through 9 into the DSM Model.

2. Improve the accuracy of assessment of artificial lighting.

3. Improve the system modelling of HVAC systems.



Progressive Options

- Steps 3 to 9: Normally outside of the DSM model.

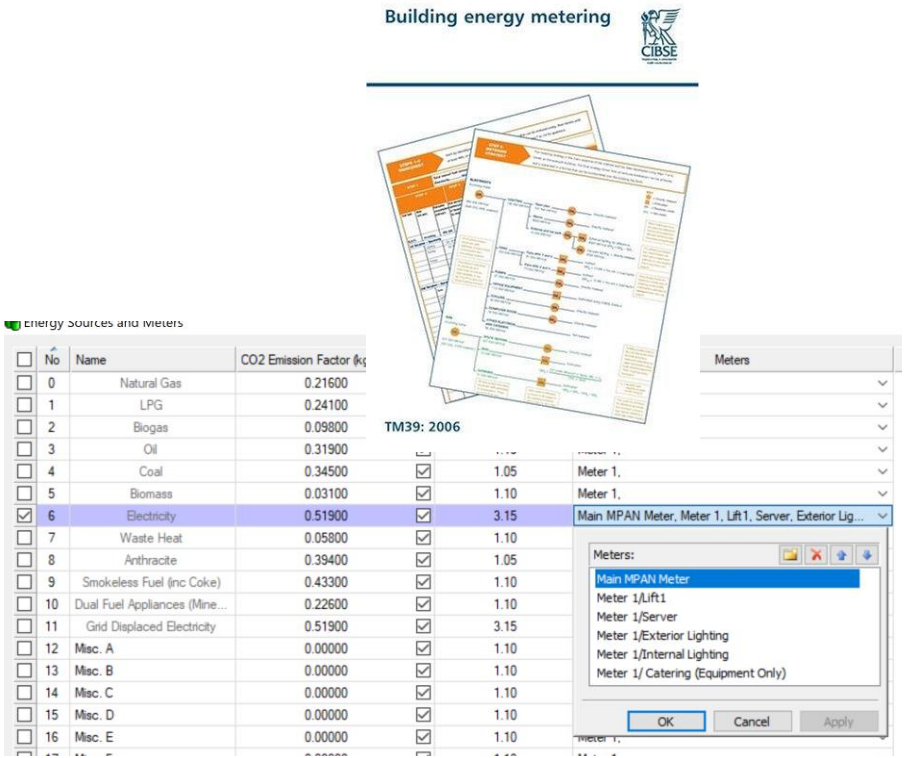
- With planning these loads can be decanted down and added to the DSM model and profiled accordingly.

- This forward planning will assist in scenario exploration and simplify reporting.

Metering

- Primary thoughts should be around an informative metering strategy for all energy consumers.

- Well laid out within the model will aid in understanding, reporting and latter stages of the project development.



Progressive Options

- Bringing in the Steps normally outside of the DSM model.
- Example – Step 6 Catering:

Take the 'Operation' estimates from TM50 (kW.h/meal)

→

Create suitable template and profile based on these estimates

→

Set up an independent meter in the model to enable separate assessment and reporting

→

Allocate to Space

Evaluating Lighting Energy

- TM54 directs to use the equations based on the *SLL Code for Lighting* (SLL, 2010) referred to as Lighting Energy Numeric Indicator (LENI)

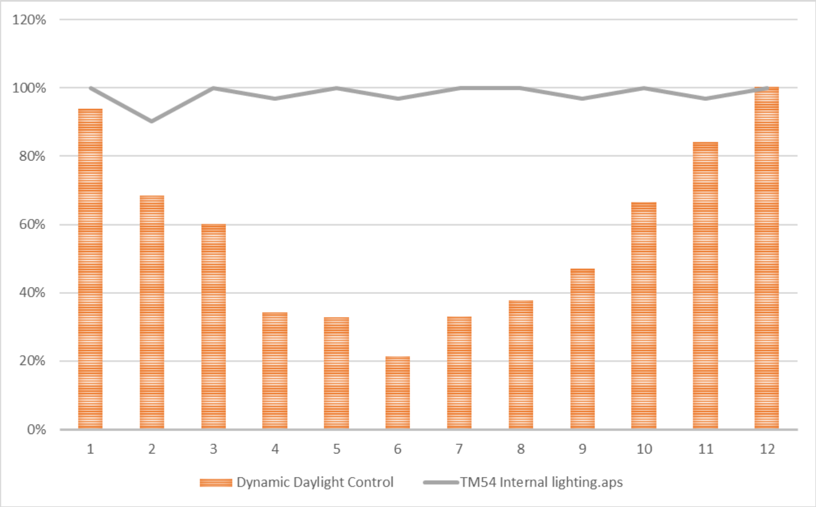
Annual energy use for internal lighting (MWh) = ((energy used for illumination (W_l)*) + (parasitic energy consumption (W_p) †))

*W_l is factored to account for occupancy and daylighting

† W_p accounts for lighting control and emergency lighting

Progressive Options

- Ensuring we had the correct Light Transmission Value for the glazing, we profiled the full internal lighting load coupled to a ray-tracing tool (IES RadianceIES) to simulate the effect of daylight dimming controls on the artificial lighting.



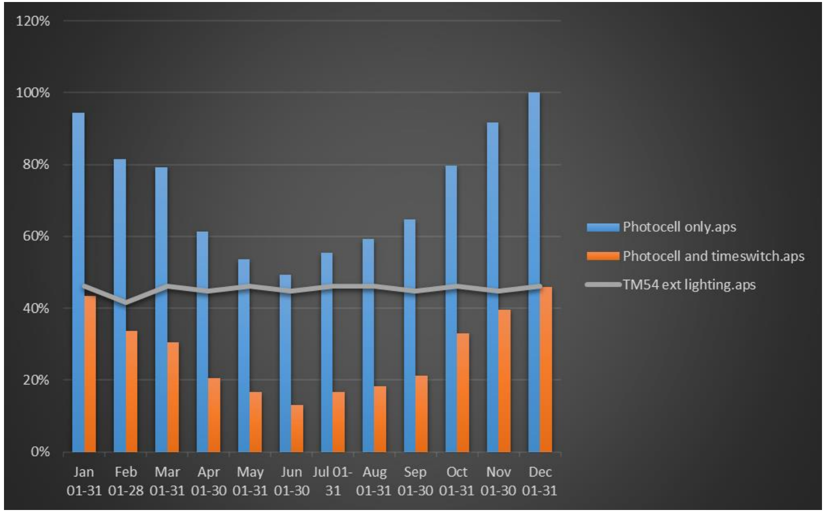
- The LENI method, indicated with the grey line, is steady other than account for the number of days in the month.

- The dynamically linked lighting (orange bars) is 42% lower over the year.

Progressive Options

- A similar approach to external lighting is suggested in the TM for all other lighting, such as external car park lighting.

- Using a profile based on global radiation (igh),we found this to be circa 60% under estimated (blue bars).



- However we found that with a time-switch to terminate the lighting of at midnight the energy consumed reduced to 58% of that estimated by the TM54 method (orange bars).

Connected Approach

- Project teams including building client, architects, M&E designer, contractor all have different viewpoints and therefore expectations.

- Imperative to align these with the project objectives to achieve a successful building outcome.

- Risk to energy / carbon / cost and related sustainability objectives.

- Design is fluid so team collaboration in the stages is fundamental to maintain consistency and quality.

Connected Approach

- Team roles and responsibilities should be specified to support high quality energy modelling.
- Ensure modellers have the required competency to perform the analysis.
- Define a modelling process (TM54 basis) to map ahead for the project team.
- Adapt this map as the design and modelling require it.
- Learn from previous projects.
- Gather data from these and define further data where required.
- Plan to add data layers to evolve the model through the design stages.
- Repeat this process for the design stages where modelling is active.

Connected Approach

- Focus on planned deliverables that can be tracked consistently to measure the performance.
- Agree on the results format to ensure the project team – both designers and client can talk the same language on the reportage.
- Track the stage outputs for continued reference.

Connected Approach

IES

- Examples of a connected approach for example at RIBA stage 2:
  - A map for the modelling analysis to evolve the design
  - Climate data
  - Identifying the model inputs
  - Modelling concept forms
  - Quick win sensitivity modelling on light models
  - Energy model
  - Developed energy model with HVAC
  - Recorded stage findings

Connected Approach

IES

- Puts the focus on the building needs.
- Outlines early on the key design considerations needing answers.
- Project team are united on the objectives and working together for that common goal.
- High quality data is sourced to the modeller to include.
- The correct modelling methodologies are implemented, peer reviews undertaken and quality held up to a high standard.
- Clearer definition on modelling time and managed expectations for delivery.
- Greater potential for achieving more analysis with the reward of lower energy use and a higher performance building.

Detailed HVAC Modelling

- Simple systems modelling, such as used in the NCM, cannot model the energy associated with HVAC systems as accurately as a Detailed HVAC model.

- Using simplified models, system performance is expressed as an Auxiliary Energy value for the system with static seasonal efficiencies employed for heating and cooling systems.

Detailed HVAC Modelling

- TM54 notes that the use of detailed simulation of the HVAC design will provide a better representation of how the building will perform in reality.

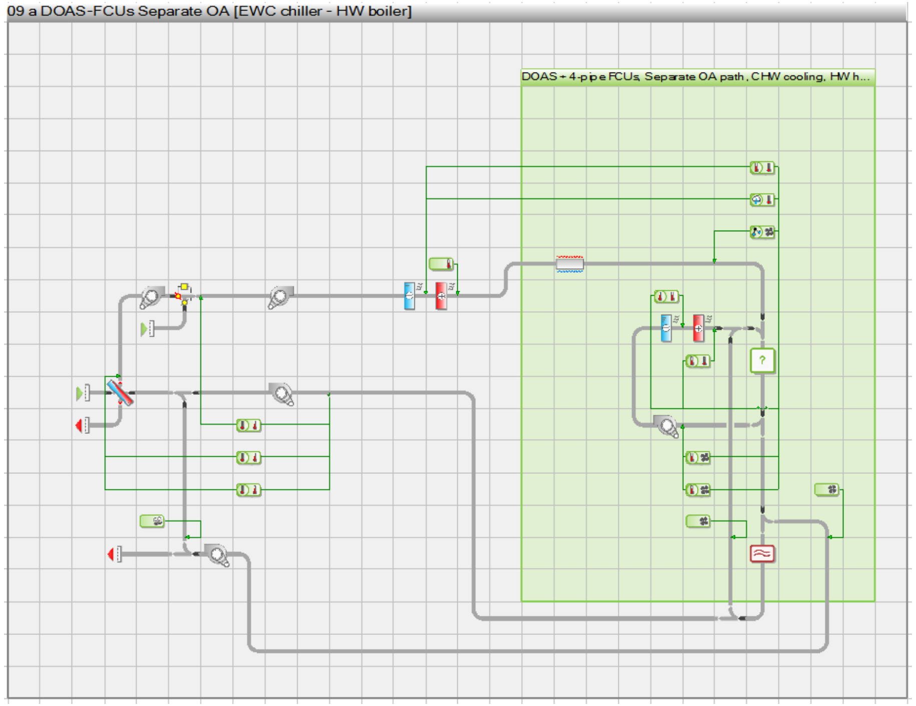
- Where humidity control is required there can be a significant load associated dehumidifying the air and the associated reheating loads.

- TM54 advises the use of a detailed HVAC simulations especially in buildings where relative humidity is closely controlled.

Detailed HVAC Modelling

- In a detailed HVAC model each component of the network is explicitly modelled and controlled.

- This allows the performance of each component to be simulated at each time step of the analysis.

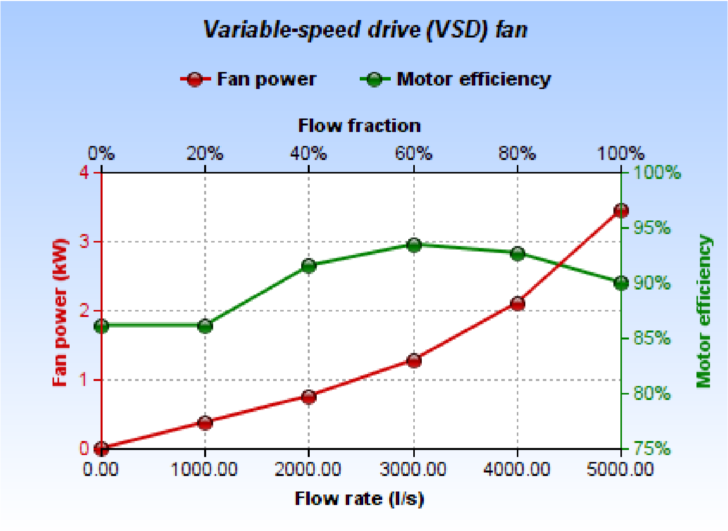


Detailed HVAC Modelling

IES

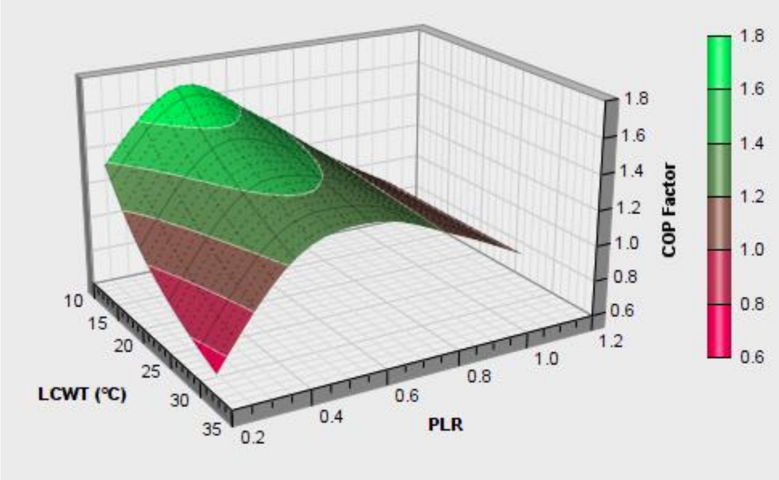
- Each component within a HVAC system can be modelled with dynamic performance details.

- Performance curves for pumps and fans allow power consumption to adjust with volume flow rates.



Detailed HVAC Modelling

- Heating and cooling system performance is influenced by temperatures and part load operation.



Detailed HVAC Modelling

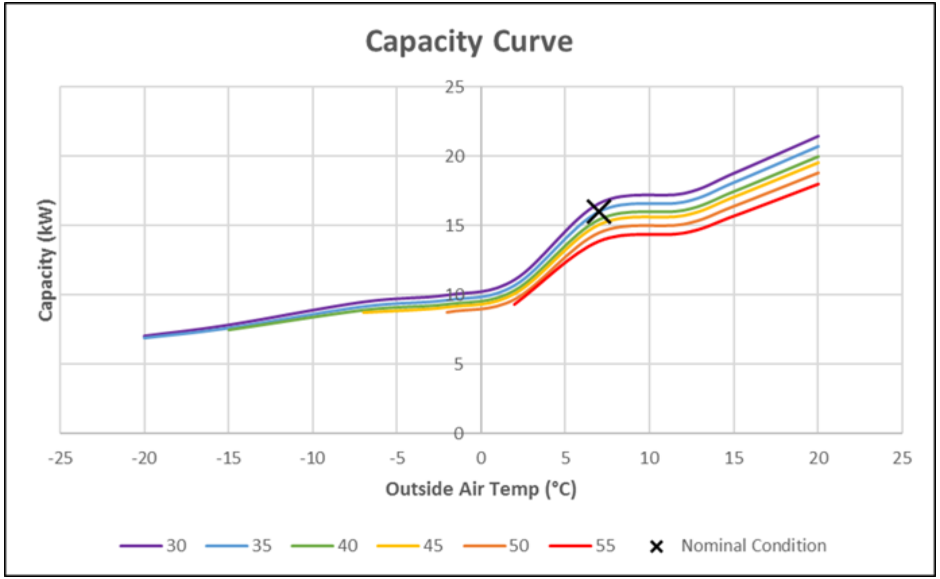
IES

- Various control strategies intended for the system can be modelled to identify how effective they are at maintaining the design conditions.

- As a detailed HVAC analysis allow Operational Models to reflect the capacity and intended operation of the system, design issues can be identified and rectified early before construction.

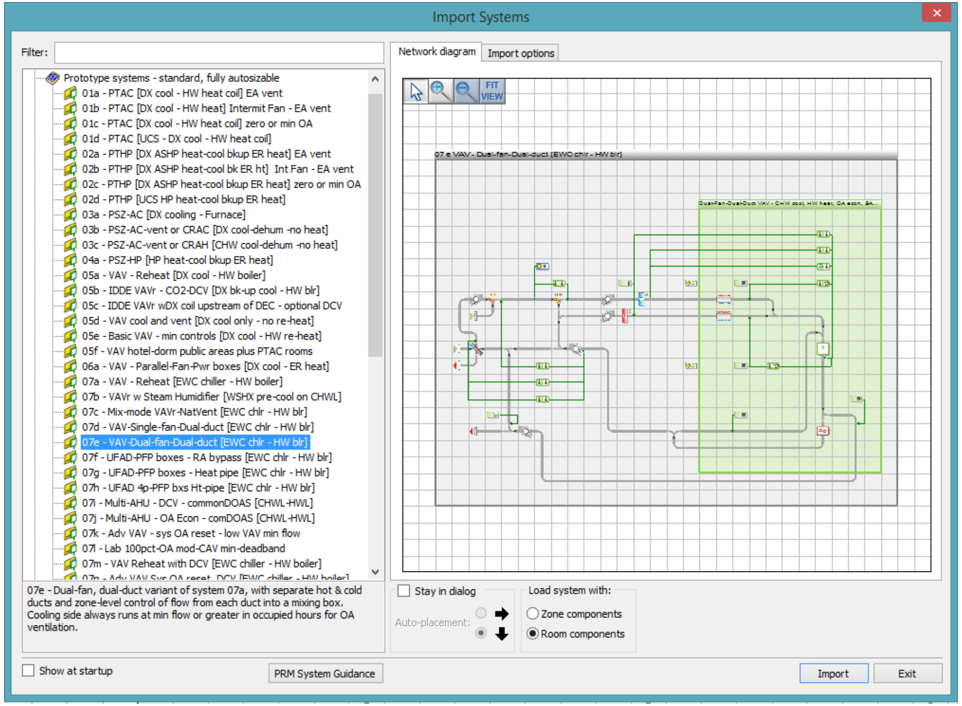
Detailed HVAC Modelling

- An example of this would be in a scenario where an Air Source Heat Pump has been designed and the operating temperatures are different to the rated conditions. This could lead to a potential scenario where the selected heat pump does not have sufficient capacity to meet demand.



Detailed HVAC Modelling

- For early stage analysis template systems can be imported and autosized.
- Different systems will have their own advantages in different climates and operating conditions. Early analysis of these system types help designers to identify systems that are best suited to the building demands

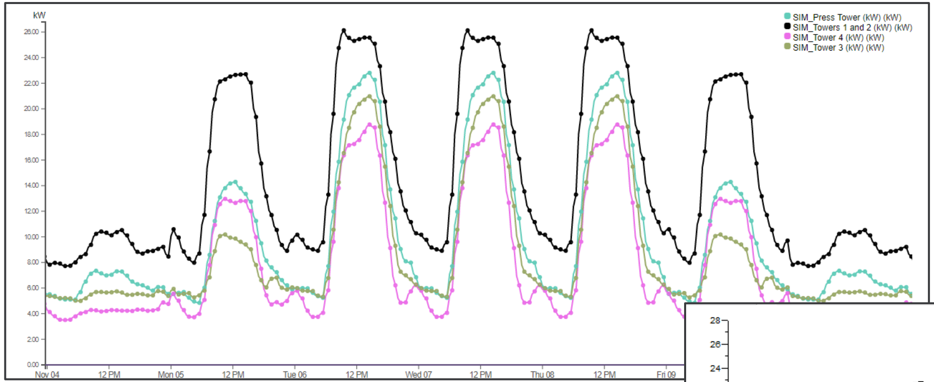


Operational Energy

- A fully aligned energy model including a HVAC network and metering strategy is the goal as the project enters the Use stage.
- This model can stand as a beacon to ensure the performance objectives are reached from doors open and onwards in the long life of the building.
- POE, continual review and forecasting building change, such as retrofit, or climate impacts can be fully assessed.

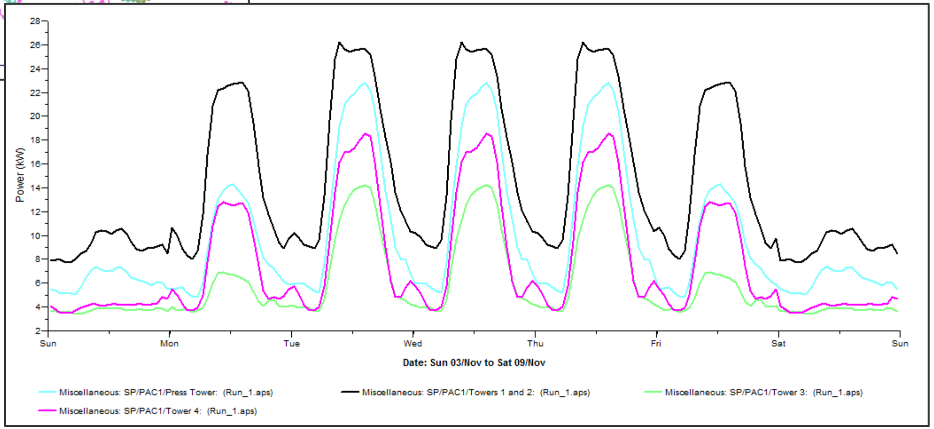
Operational Energy

- Data from the building meters can be validated and synced to a DSM model via a web based integrated data environment platform.



Measured Sub-meters

Simulated Sub-meters



Operational Energy

- Real climate data from a matching time period set as the external test conditions.
- Then begin the process of creating a *calibrated* energy model.
- With the model now mirroring the operational building then POE and seasonal commissioning can be performed.
- An certainty and reliability for the building's operation now exists on energy savings and running costs.
- This Digital Twin is now active for planning future considerations.

Discussion

IES

Any Questions?