IMPROVING PREDICTIONS OF OPERATIONAL ENERGY PERFORMANCE OF BUILDINGS

Dr. Anna Carolina Menezes
EngD MEng (Hons) LEED AP, Research Engineer
Group Energy Manager, Tesco

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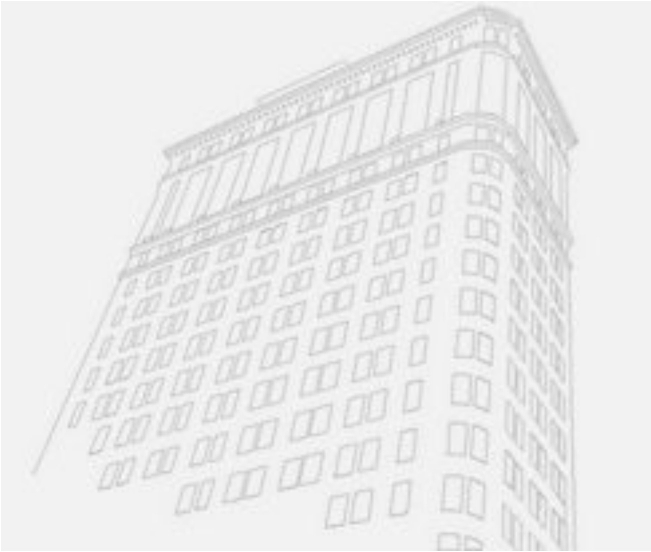
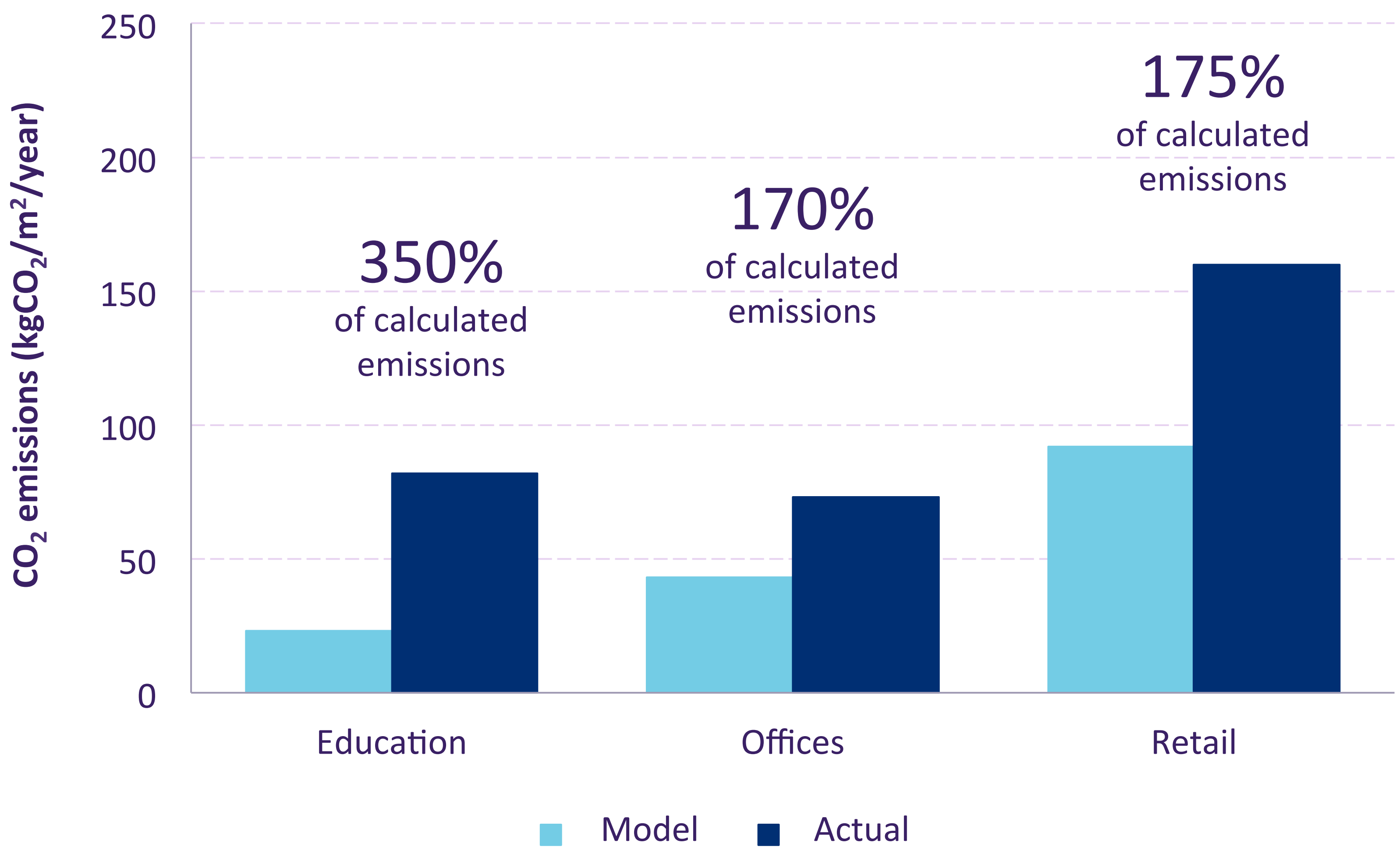
Presentation Overview

- Introduction to the “Performance Gap”
- My research focus and key findings
- CIBSE’s new guide on how to evaluate operational energy use at design stage
- Conclusions



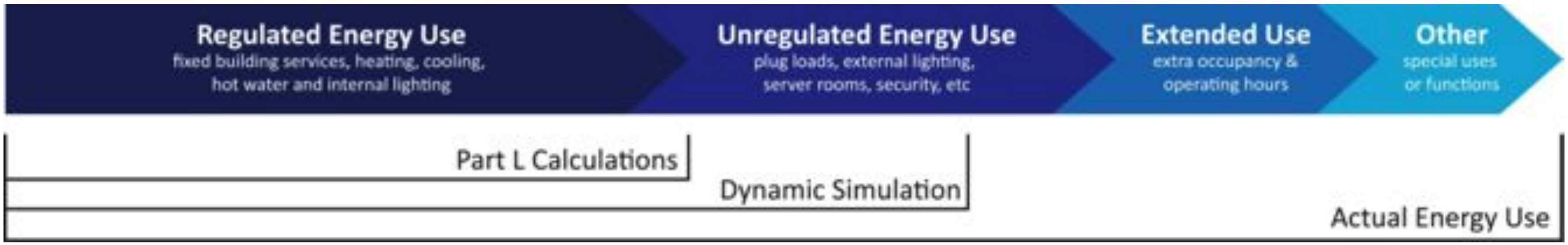
THE "PERFORMANCE GAP"



Source: www.carbonbuzz.org

BUT IS THERE A REALLY A GAP?

- When referring to 'The Performance Gap' we usually compare the results from simplified energy models generated at design stage against operational performance
- Yet compliance calculations for Part L are not intended to 'predict' energy consumption – they are simply a compliance method
- As a result they focus only on 'regulated' energy uses (i.e.: fixed building services such as heating, cooling, hot water and internal lighting)
- Small power equipment, servers, external lighting, vertical transportation as well as other 'unregulated' loads are not considered in Part L models

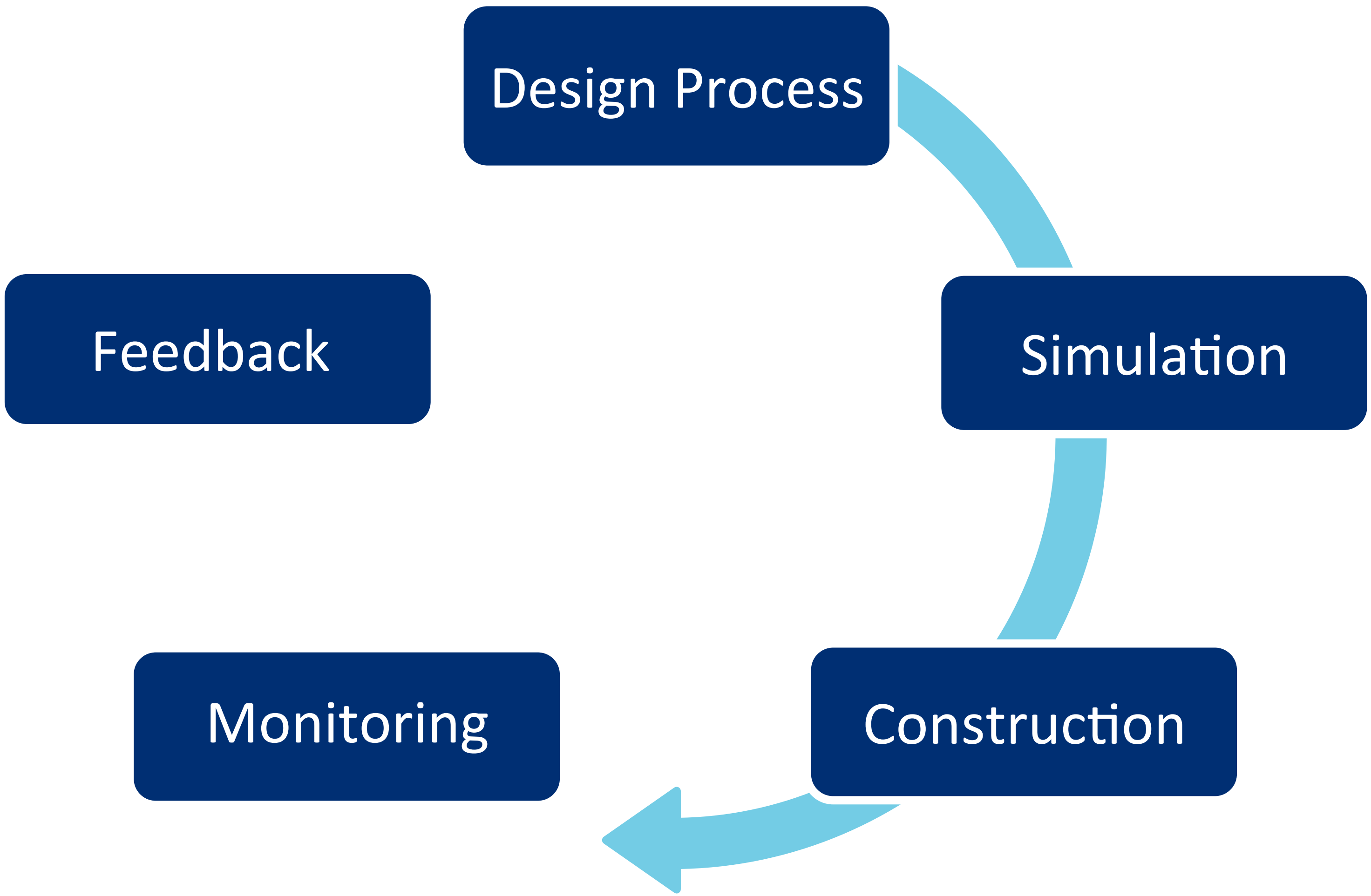


A GAP IN PERCEPTIONS

- The 'gap' we should really be worried about is the one between what we THINK we are doing and what we are ACTUALLY doing when it comes to energy predictions

- As an industry we currently do not predict operational energy use – certainly not routinely

A GAP IN COMMINUCATION



SO WHAT SHOULD WE DO?

Evaluate operational performance:

- Regular monitoring and feedback
- Ensure conscious use of the building by occupants
- Better control & management of services
- Better designer/client communication

Make realistic predictions of performance

- Representative of real building operation
- Include unregulated loads in modelling
- More accurate modelling of system controls
- Better understanding of occupant behaviour

MY RESEARCH FOCUS

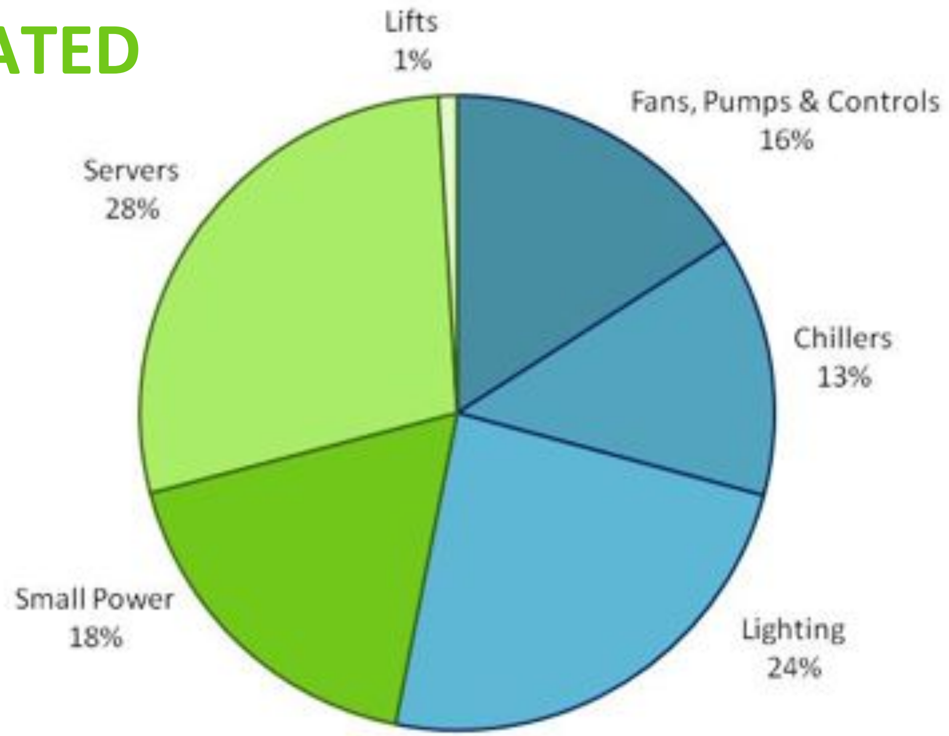
- My research project aimed to use monitoring data from occupied building to inform better predictions.
- Over 4 years (2009-2013) I monitored a number of multi-tenanted office buildings to get a better understanding of their in-use performance.
- Key areas of interest included :
  - ✓ Unregulated energy consumption
  - ✓ Variations in energy use by different tenants occupying the same building
  - ✓ Small power demand
  - ✓ Ways of representing realistic operation patterns in energy models

UNREGULATED ELECTRICTY CONSUMPTION

- According to monitored data from a multi-tenanted office building in Central London, unregulated loads account for almost 50% of total electricity consumption
- Most of these are used/controlled by the tenants

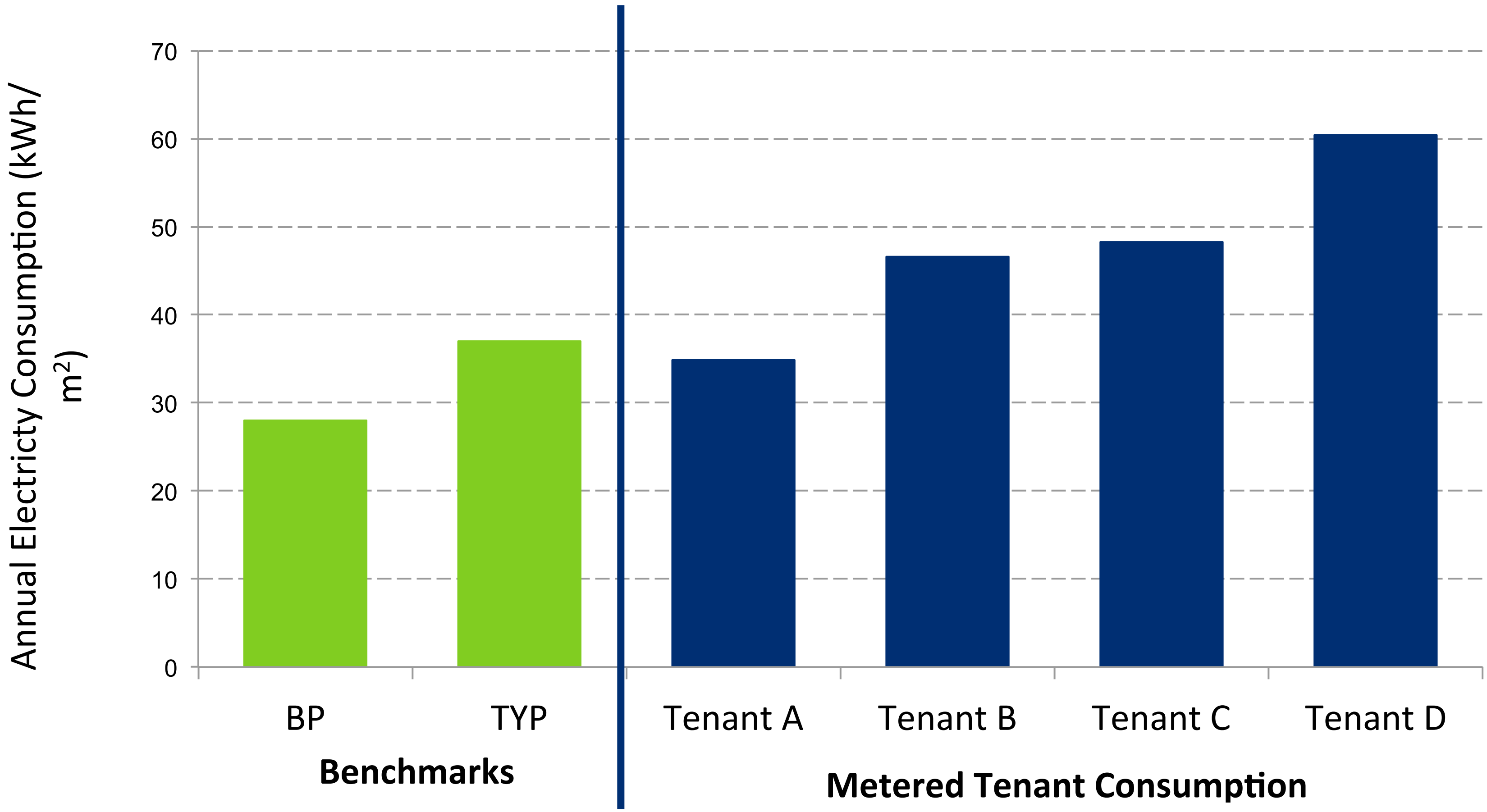
UNREGULATED LOADS

REGULATED LOADS



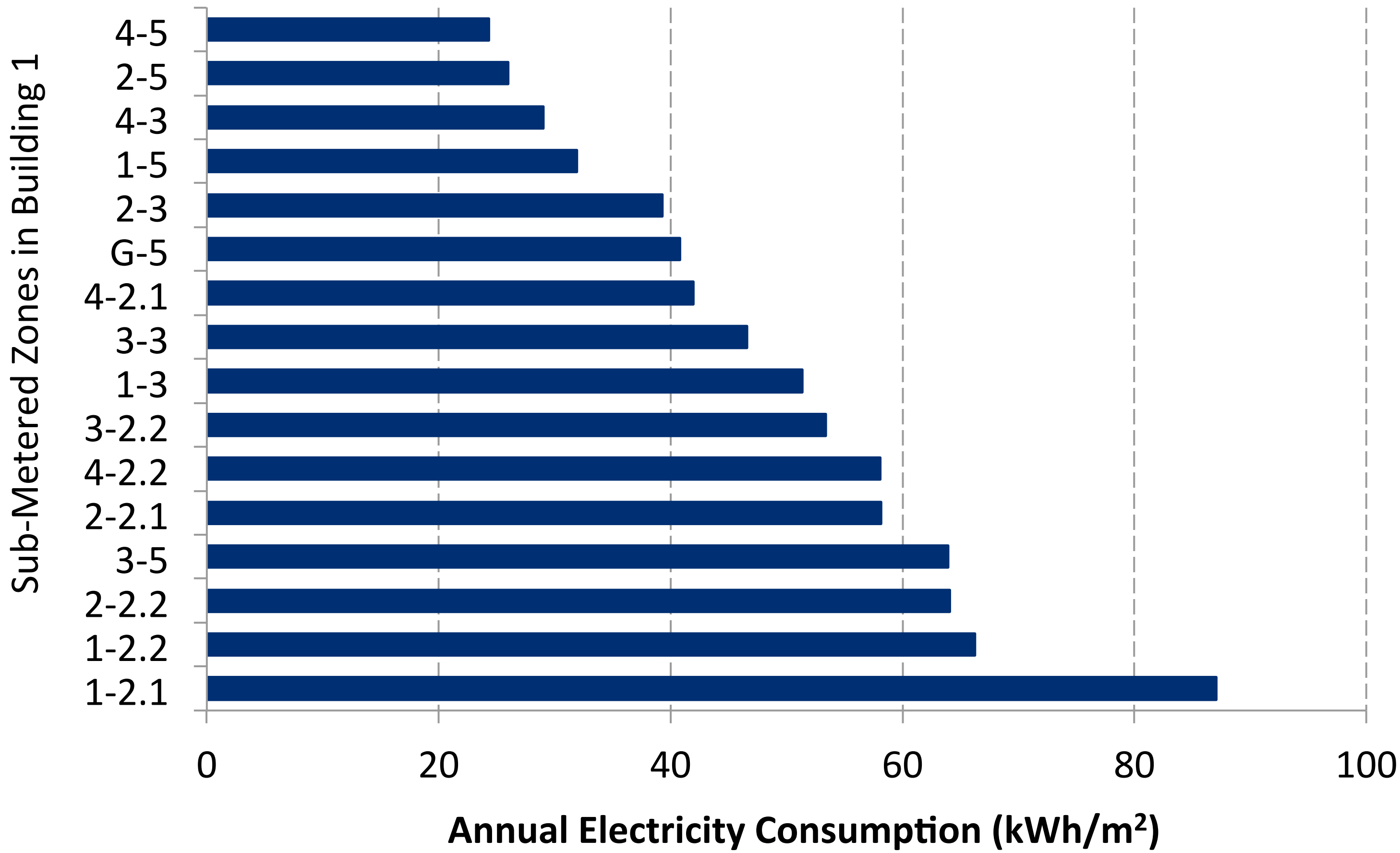
VARIATIONS IN SMALL POWER CONSUMPTION

- In the same multi-tenanted office building, significant variations in small power consumption can be observed amongst different tenants.



VARIATIONS IN SMALL POWER CONSUMPTION

- Looking into the individual building zones, variations are even more prominent

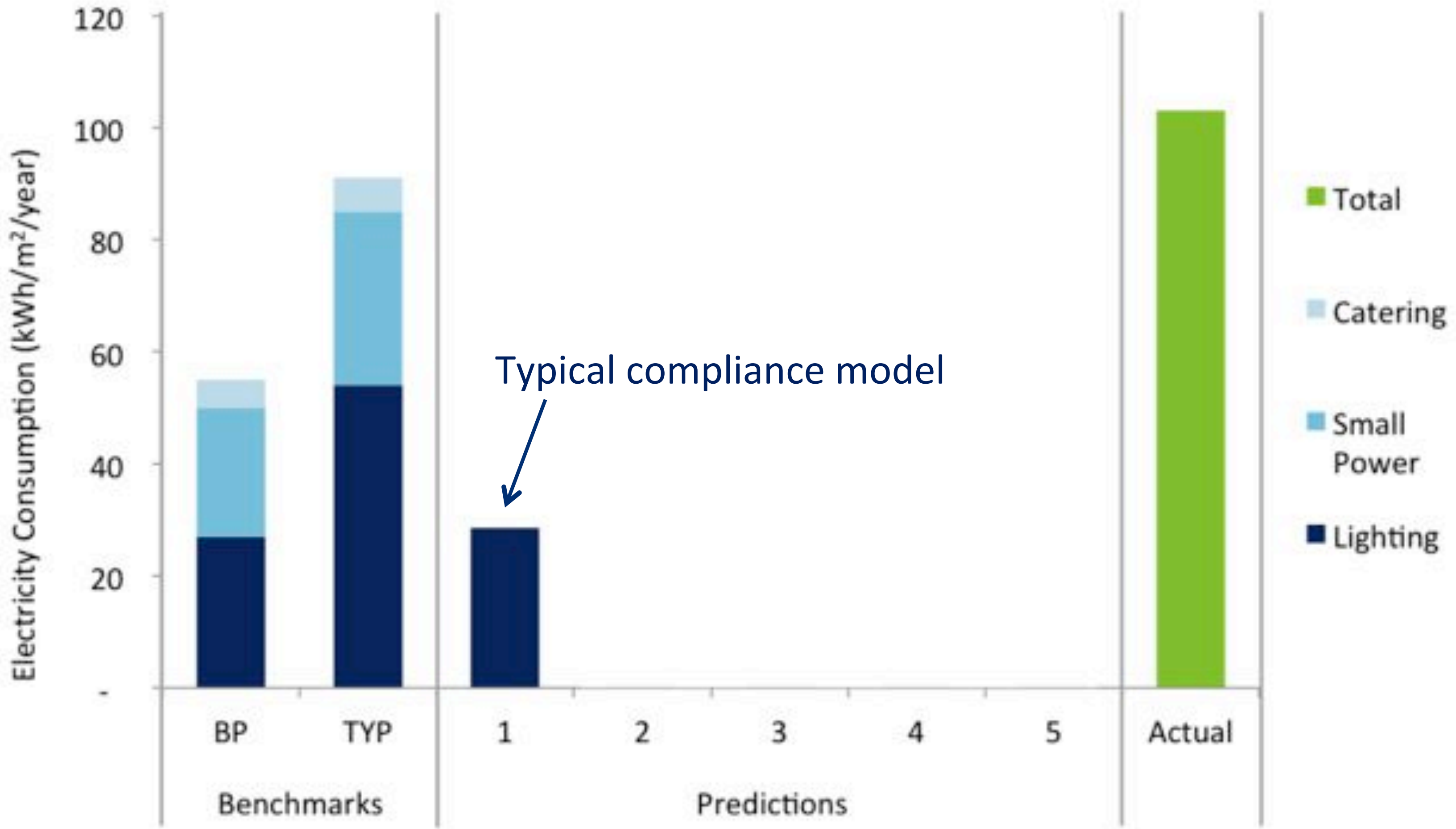


PREDICTING TENANT ELECTRICITY CONSUMPTION

- Driven by the significant variations in electricity consumption monitored, an attempt was made at predicting the consumption for lighting and small power by an individual tenant in the case study building
- The proposed approach utilised monitoring data to inform the predictions
- This was undertaken in five steps with increasing levels of detail being added incrementally

	Brief description	Lighting	Small Power	Catering
1	Typical compliance model	11 W/m^2 (design load) SBEM occupancy	Not considered	Not considered
2	'Enhanced' compliance model	11 W/m^2 (design load) SBEM occupancy	15 W/m^2 (design load) SBEM occupancy	Not considered
3	Initial bespoke model	13 W/m^2 (installed load) SBEM occupancy	11 W/m^2 (basic equipment) SBEM occupancy	0.3 W/m^2 (basic equipment) SBEM occupancy
4	Intermediate bespoke model	13 W/m^2 (installed load) SBEM occupancy	11.5 W/m^2 (installed load) SBEM occupancy	1 W/m^2 (installed load) SBEM occupancy
5	Advanced bespoke model	13 W/m^2 (installed load) Monitored occupancy	11.5 W/m^2 (installed load) Monitored occupancy	1 W/m^2 (installed load) Monitored occupancy

MODELLING RESULTS



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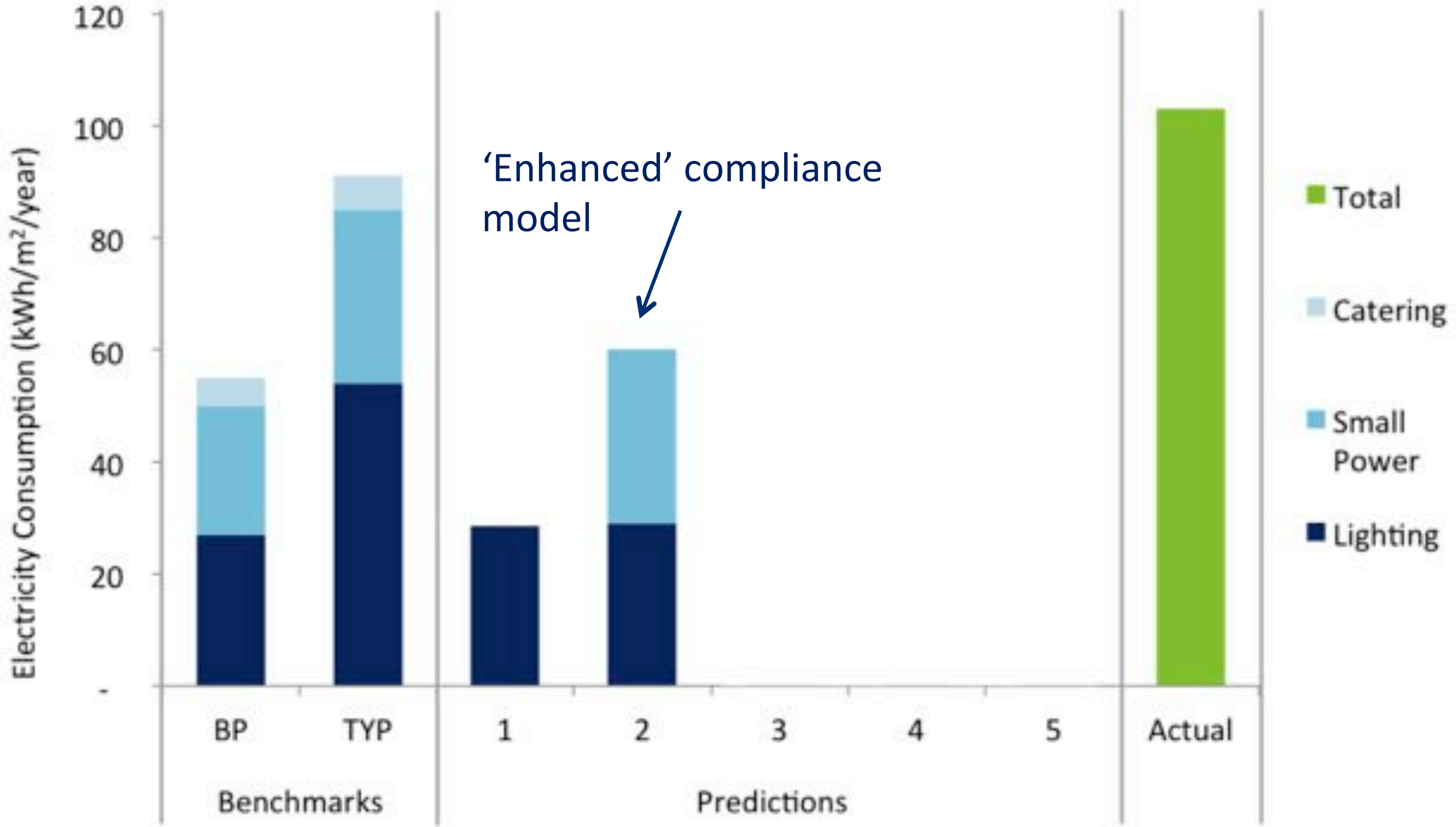

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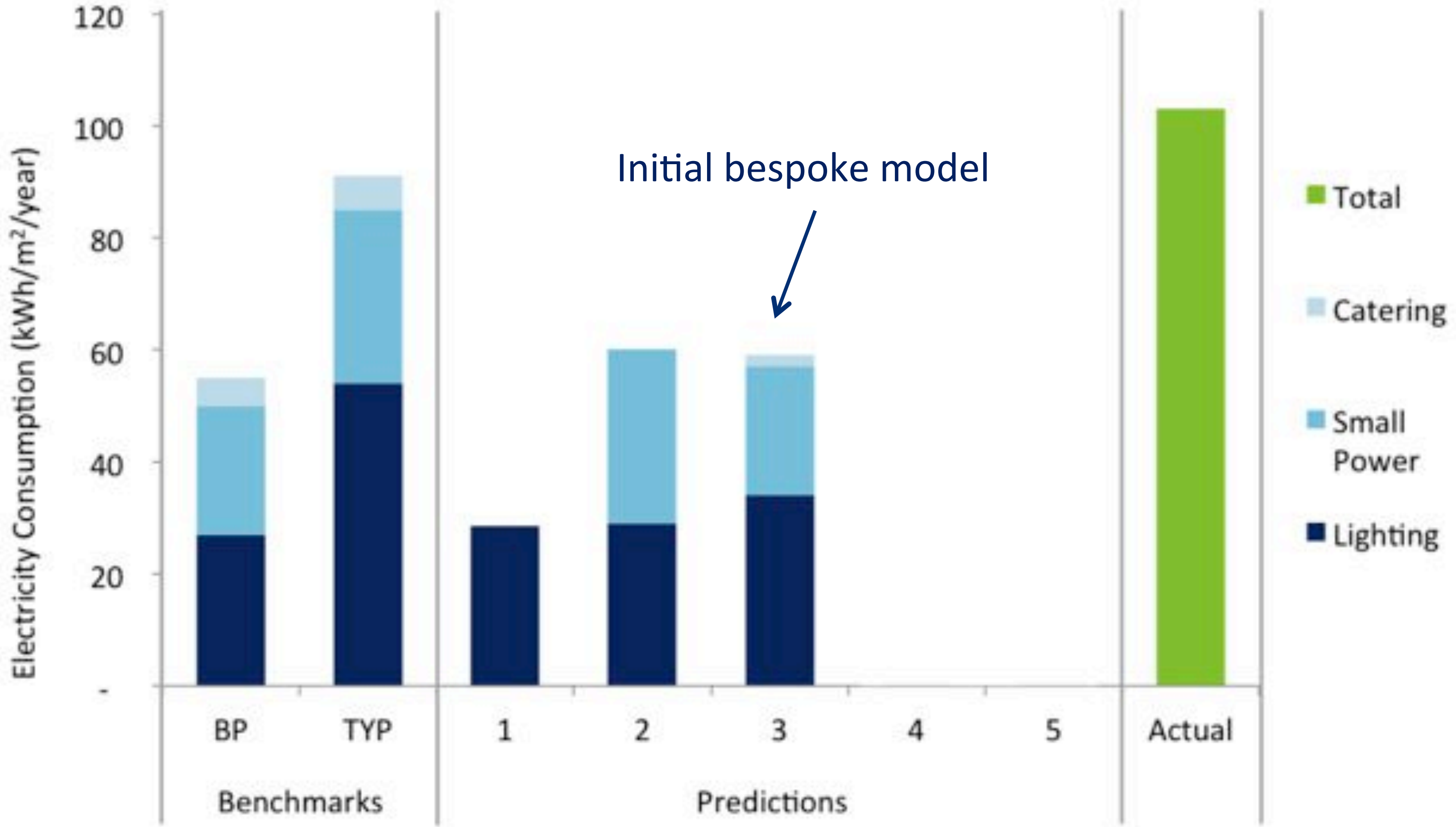

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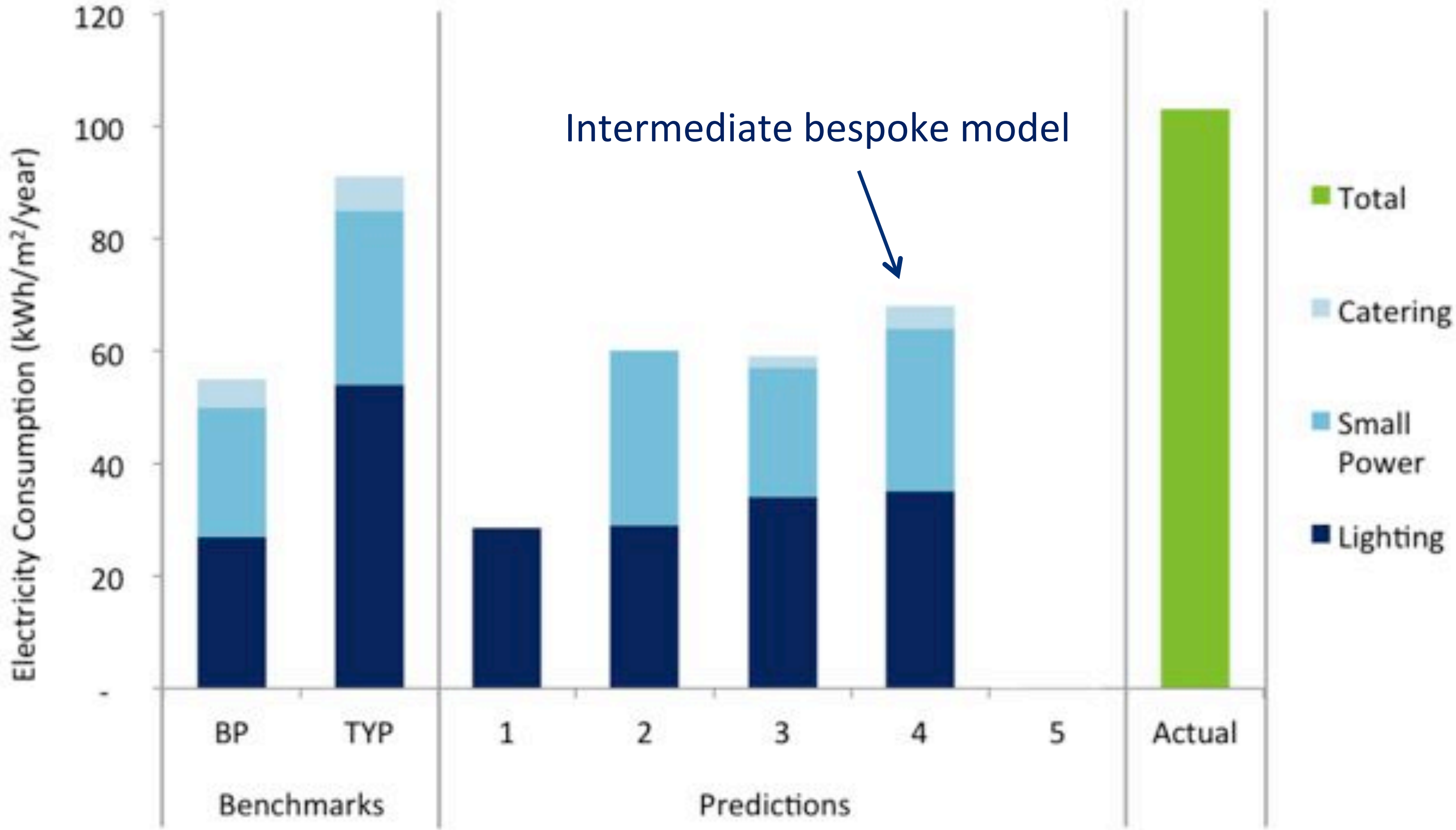

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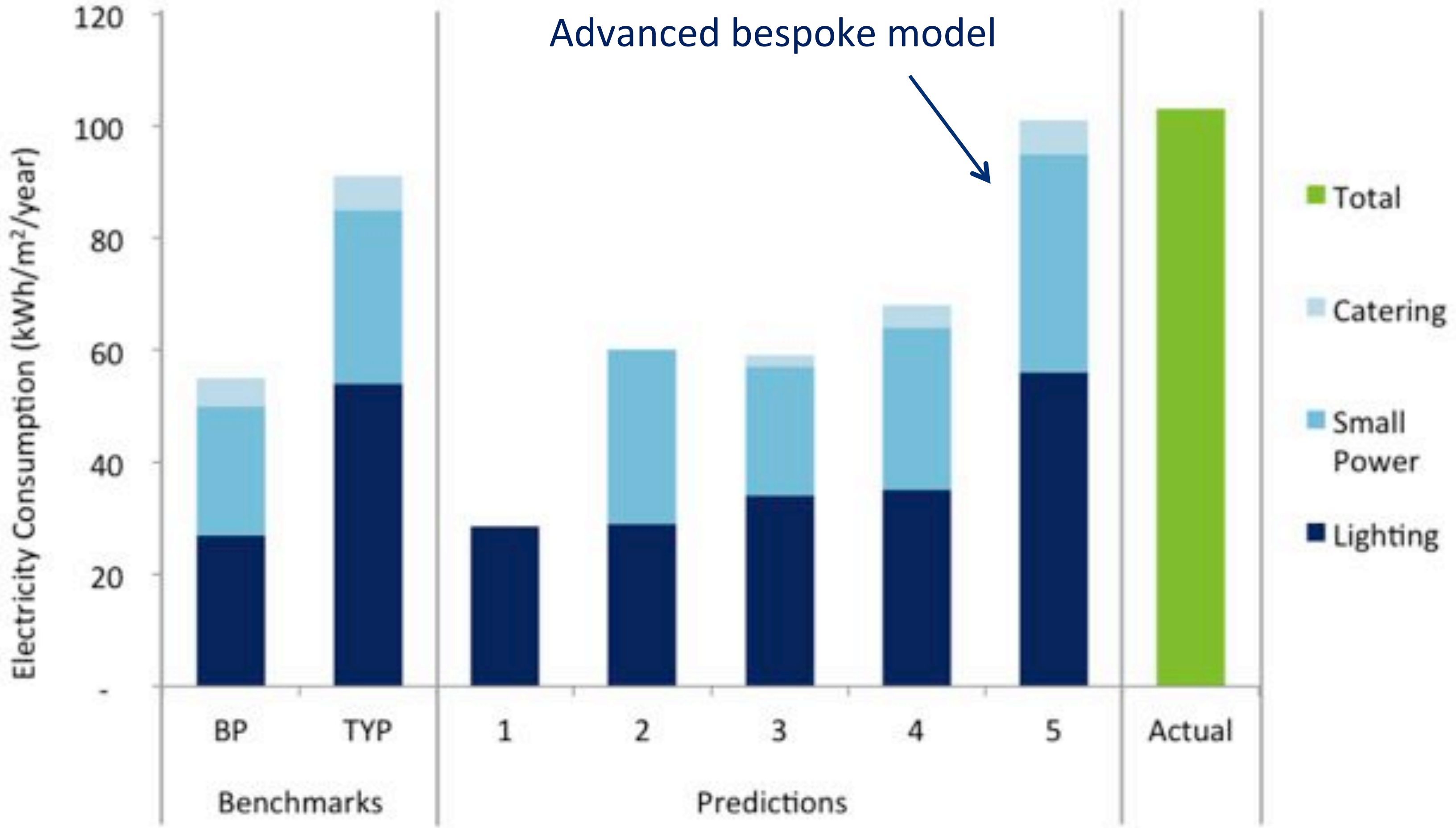

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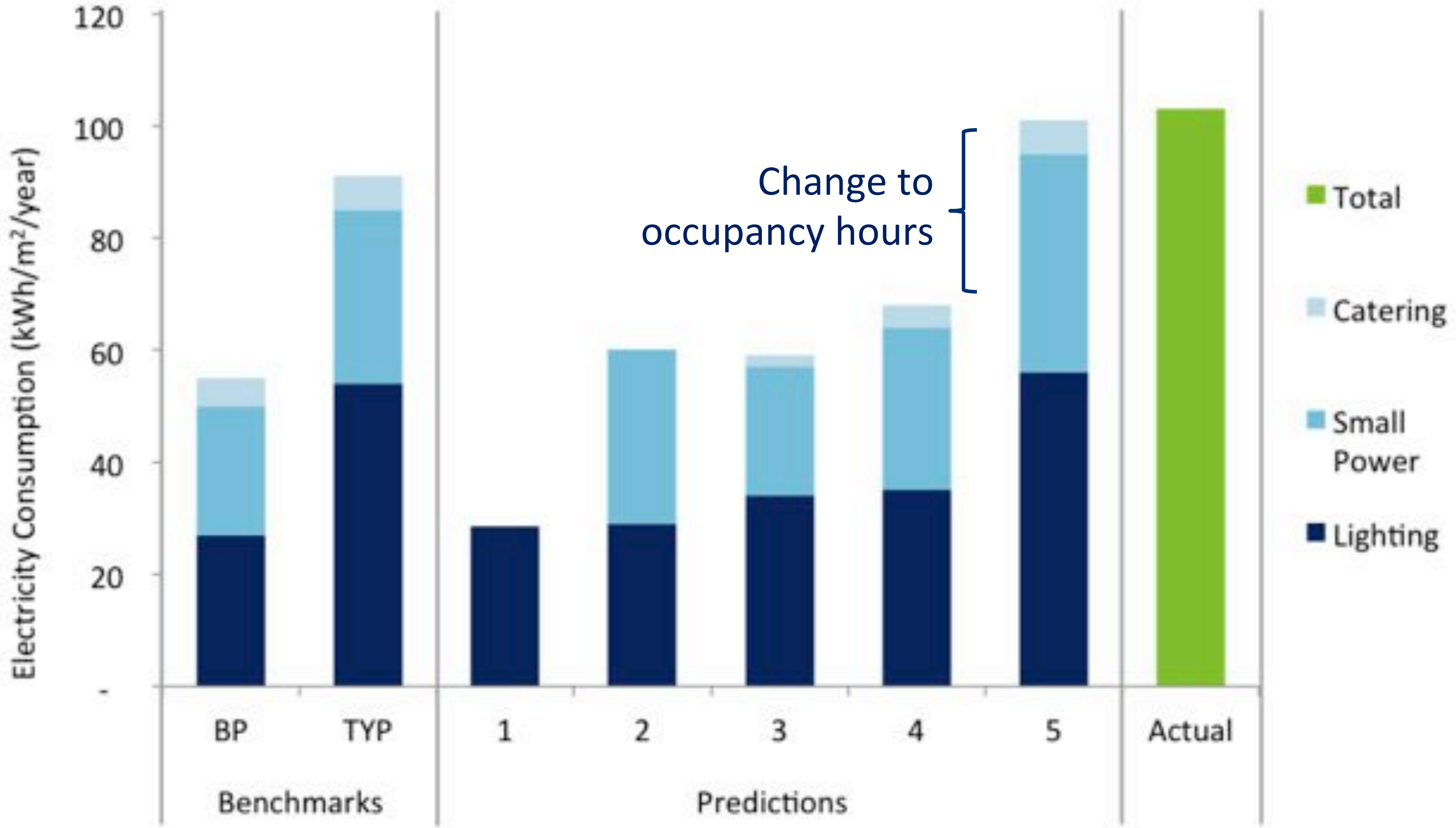
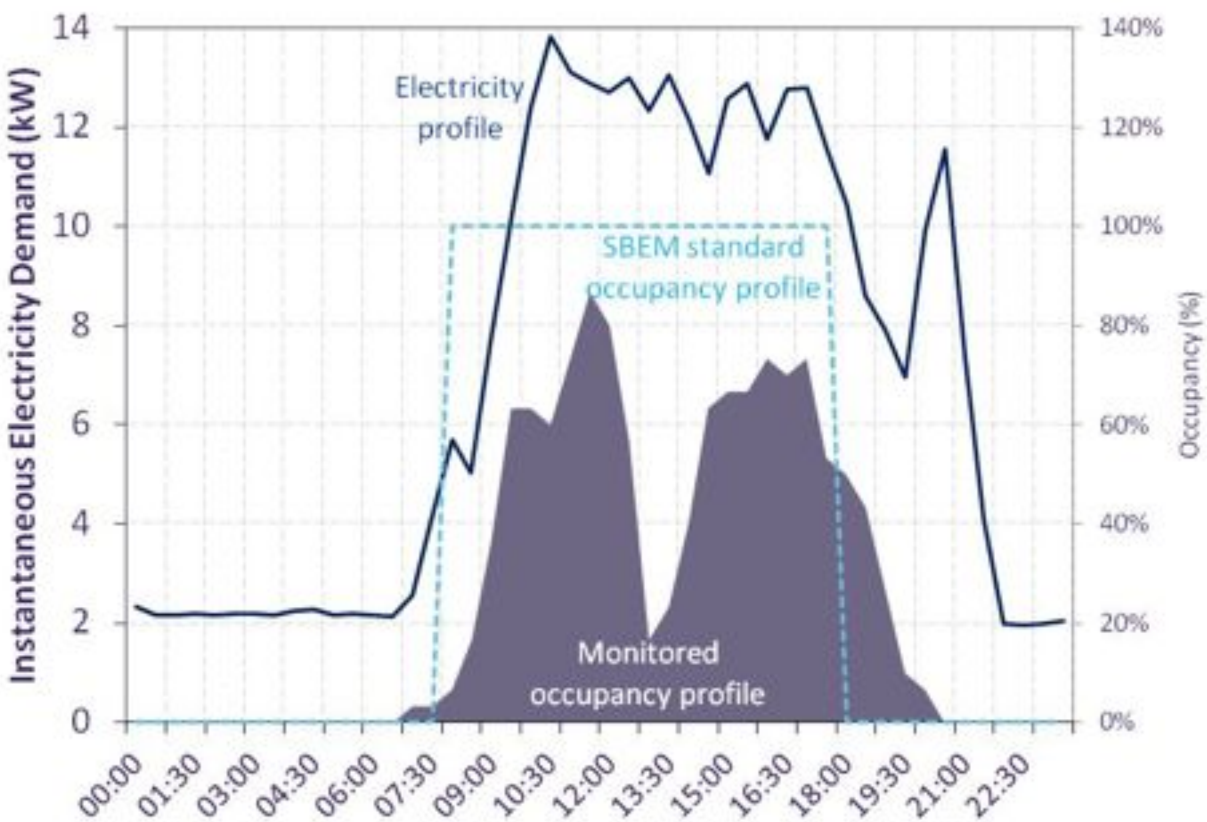


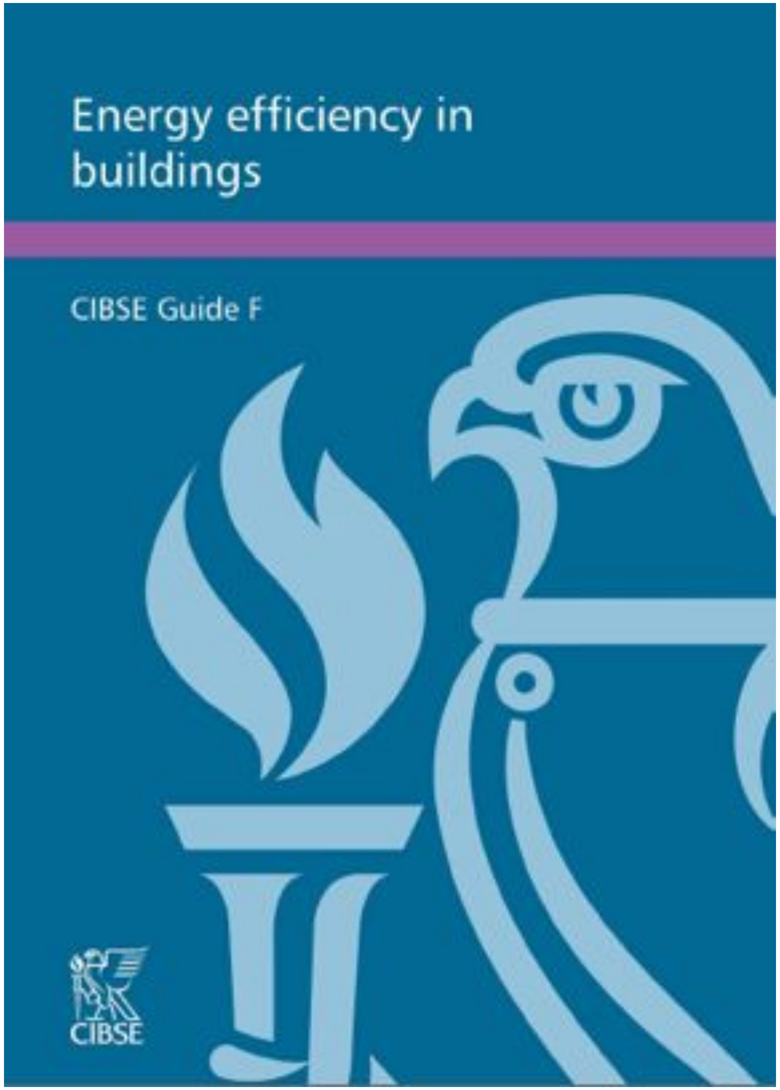
KEY OBSERVATIONS

- Realistic predictions can be made if the building usage is clearly understood and appropriately represented in a model
- Getting the hours of occupation right is key – so is the use of representative benchmarks.

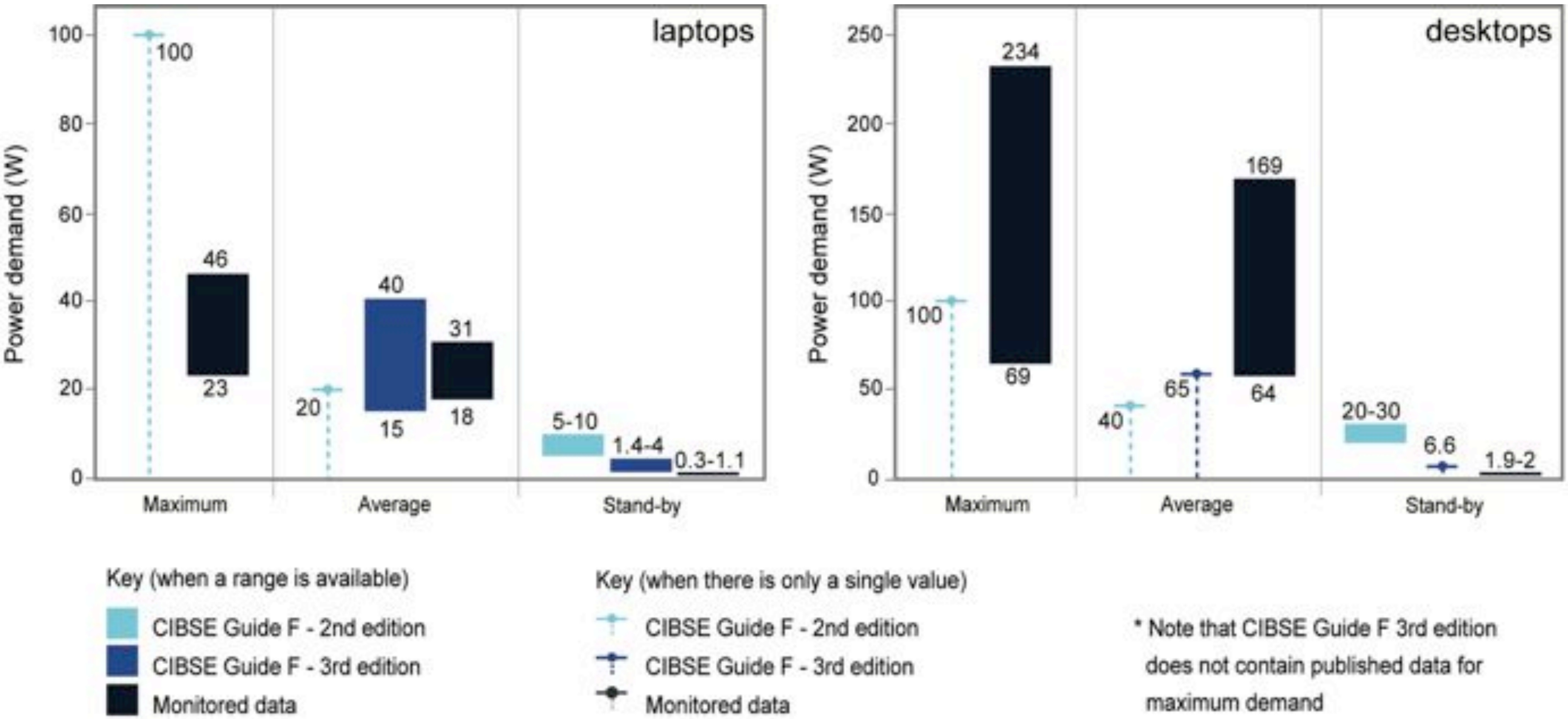


EXISITING BENCHMARKS FOR SMALL POWER

- CIBSE Guide F provides benchmarks for small power equipment in offices and is the main source of reference for such data.
- Benchmarks were updated in the latest edition of the guide published in 2012.
- Monitoring of a small sample of small power equipment through the use of plug monitors/loggers was undertaken to assess the validity of the benchmarks (old and new).
- Results have been published in the Building Services Engineering Research and Technology Journal.

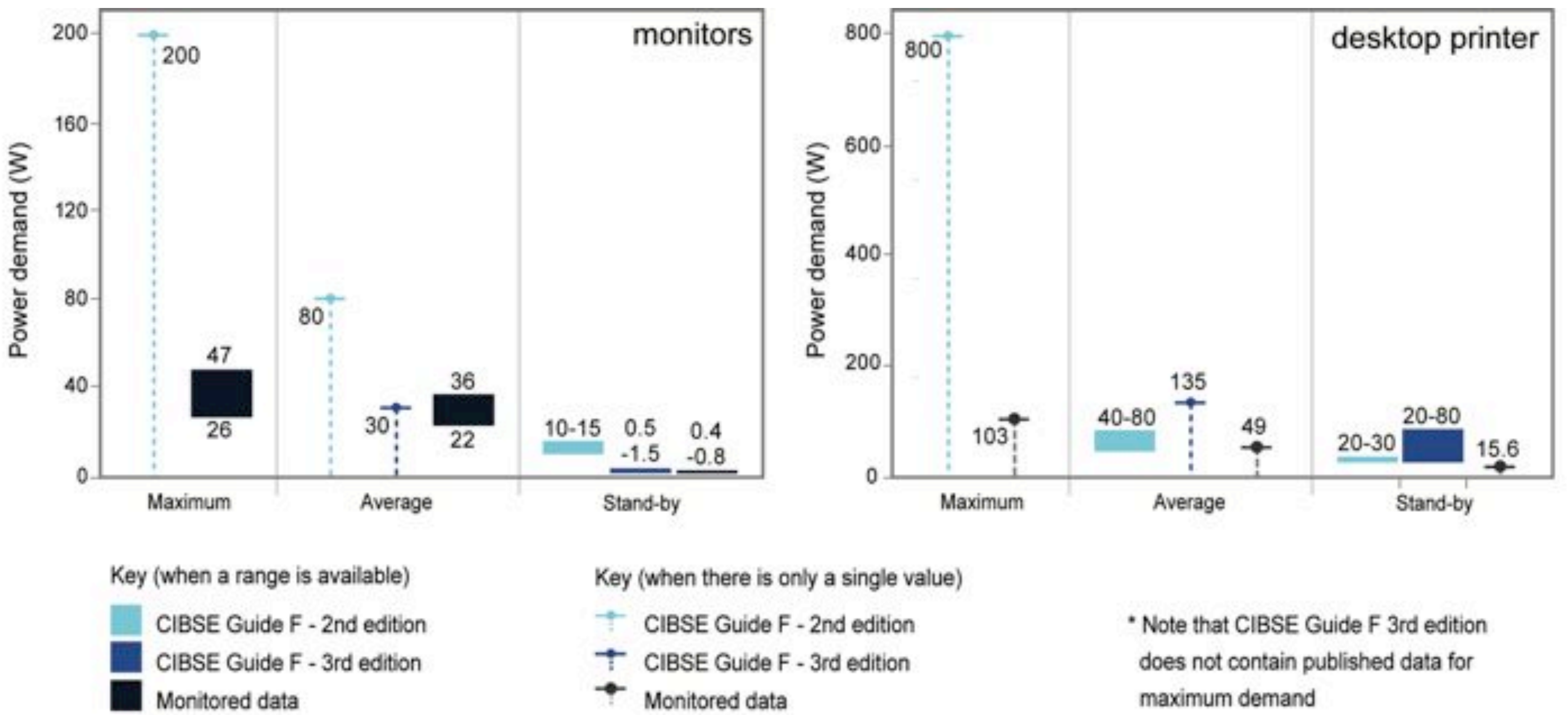


EXISITING BENCHMARKS FOR SMALL POWER

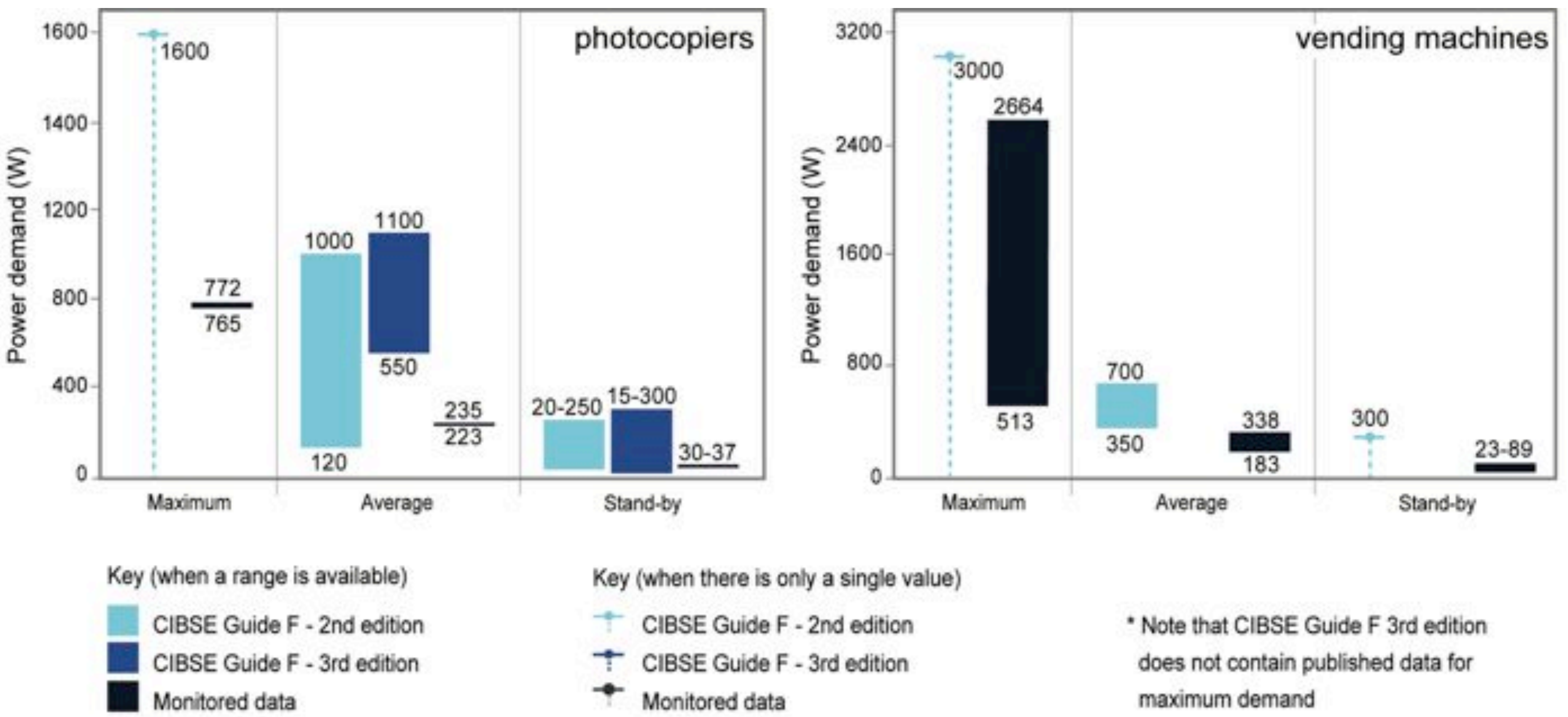


* Note that CIBSE Guide F 3rd edition does not contain published data for maximum demand

EXISITING BENCHMARKS FOR SMALL POWER



EXISITING BENCHMARKS FOR SMALL POWER



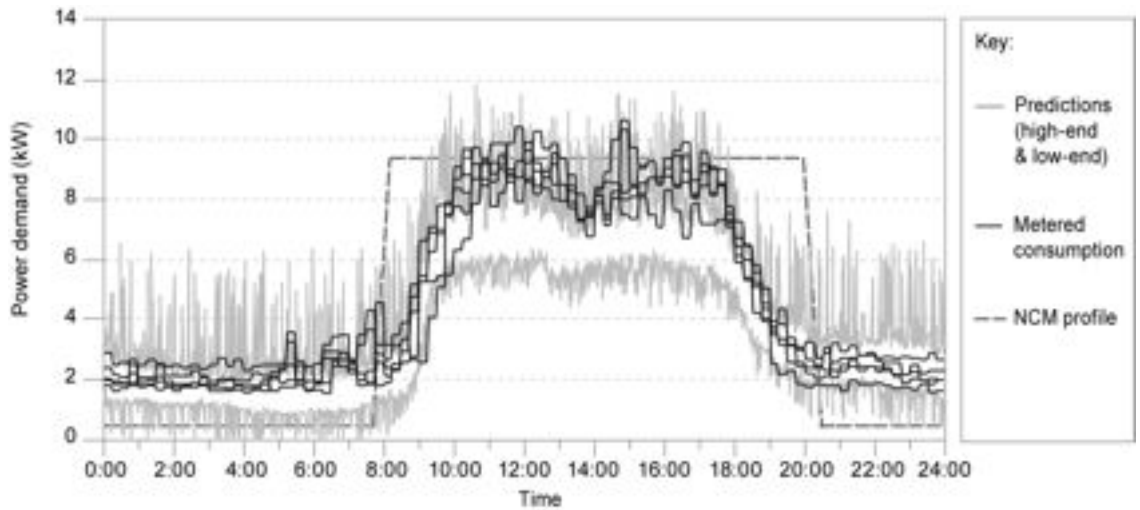
EXISITING BENCHMARKS FOR SMALL POWER

- Benchmarks in the previous edition of Guide F were broadly unrepresentative of small power equipment currently being used in office buildings.
- The 2012 update demonstrated significant improvement to the validity of benchmarks.
- Key areas for further improvement include:
  - ✓ Stand-by demands appear to be overestimated in most of the benchmarks
  - ✓ High specification desktops fall outside the given range published in the updated guide
  - ✓ Updated benchmarks for vending machines and other catering equipment would have been useful
  - ✓ Typical hours of usage information would be of great use to inform prediction of power demand and energy consumption.

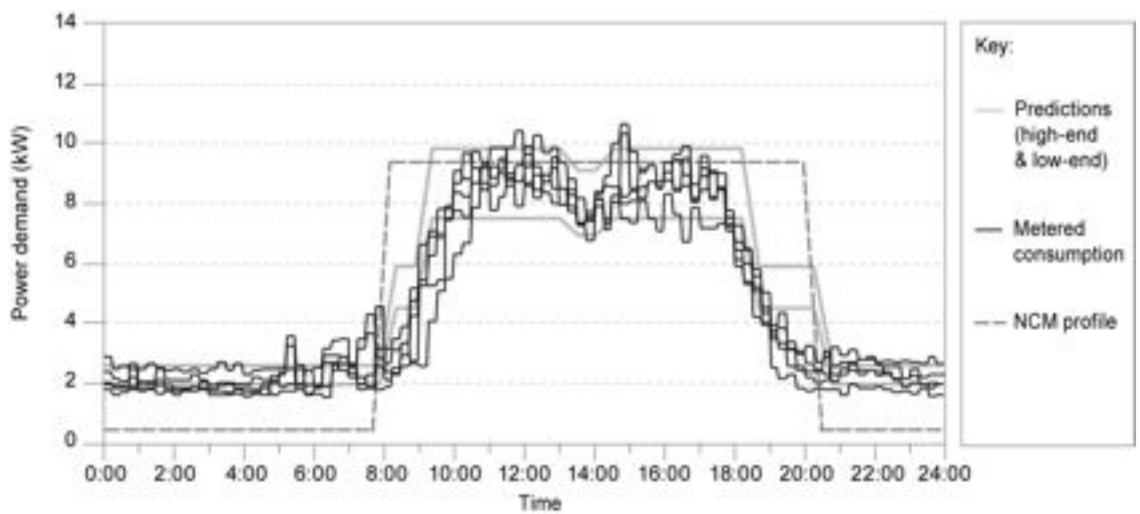
PREDICTIVE MODELS

- Fuelled by the study into the existing benchmarks, 2 models for developed to predict small power consumption in office buildings.
  - Model 1 relies on the random sampling of detailed monitored data
  - Model 2 addresses the industry's needs more closely taking a simple 'bottom up' approach.
- Results are illustrated in the graphs against measured data and a typical NCM profile.

Model 1: Random sampling

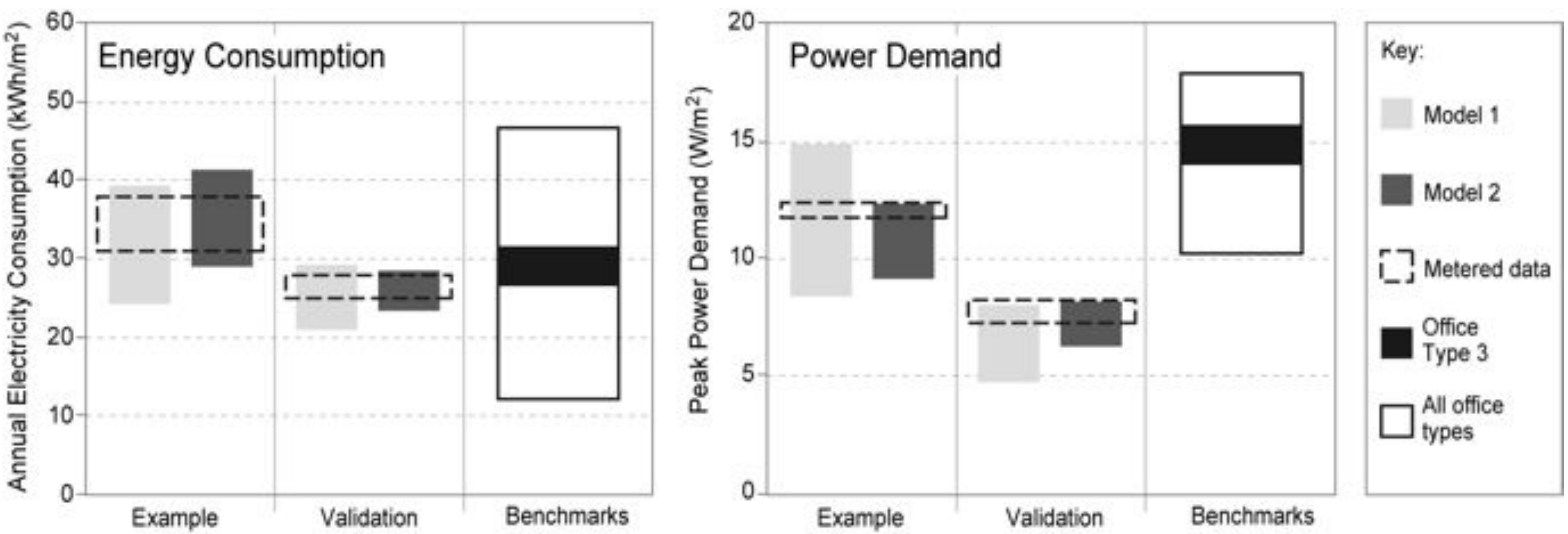


Model 2: Bottom-up



RESULTS

- Metered data for energy consumption and power demand for an example and validation building falls within the prediction range for both models.
- Compared to benchmarks, using the wider range (all office types) could result in a serious over under estimation of loads.



REALISTIC PREDICTIONS

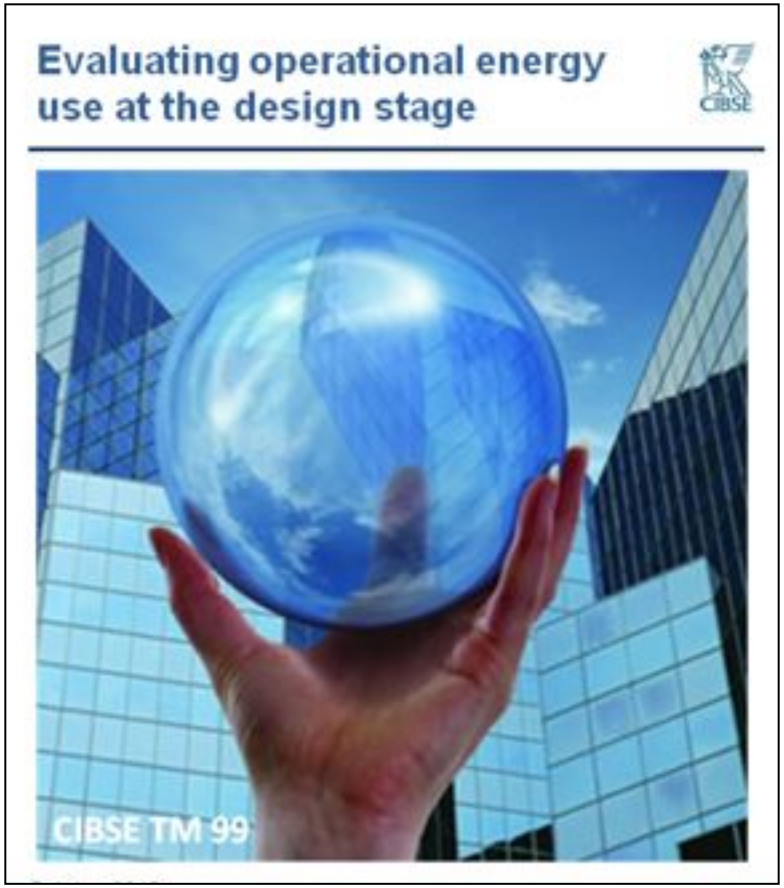
- CIBSE has recently published a Technical Memorandum aimed at helping designers evaluate operational energy use at design stage

- The aims of the document include:

  - ✓ Address the issue of how to deal with energy targets that have been set in the brief

  - ✓ Provide a methodology that engineers can use to undertake better-informed calculations of energy use in operation

  - ✓ Demonstrate that energy performance is dependent on how the building is run as well as how it is designed and constructed

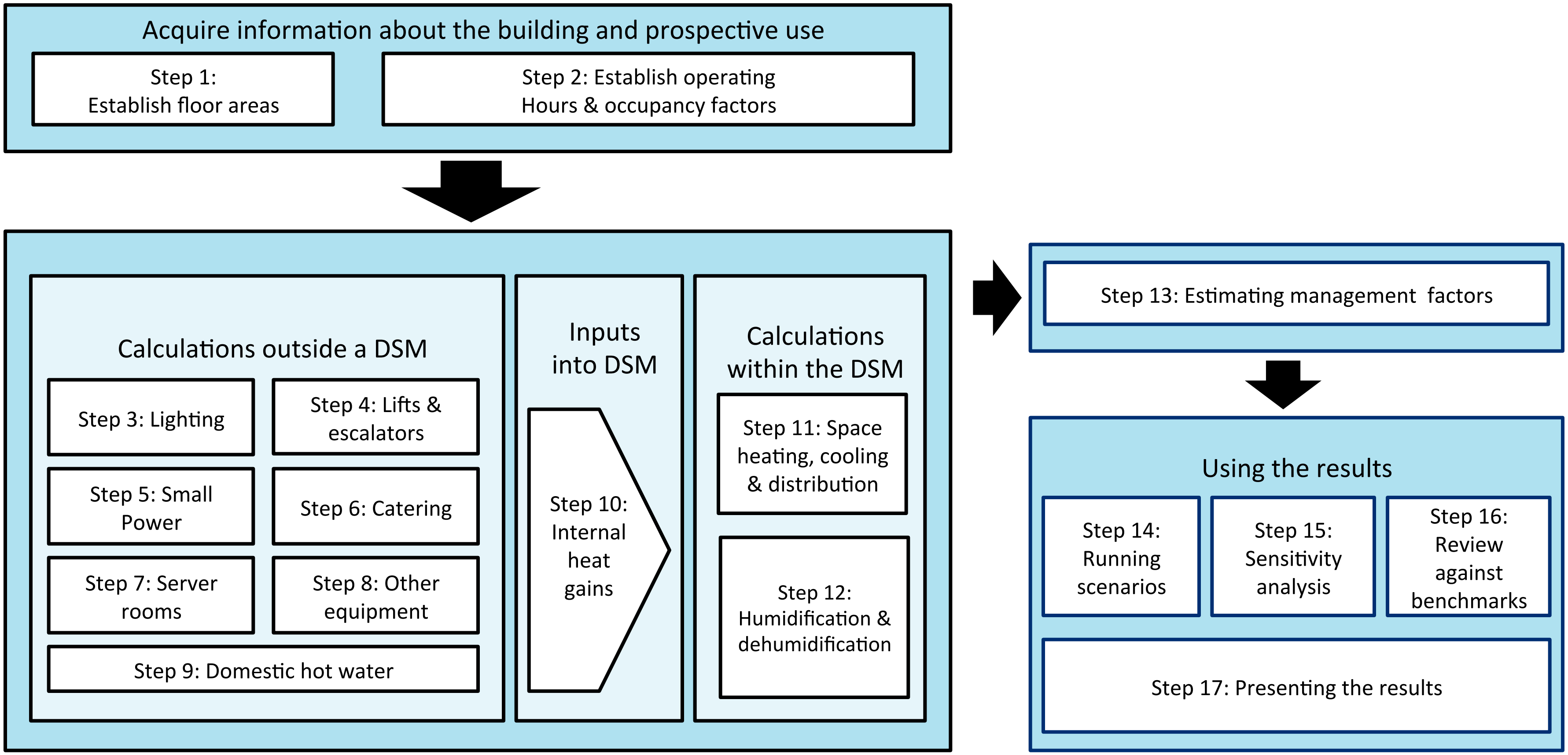


WHY ESTIMATE ENERGY CONSUMPTION

- The document starts by explaining why estimates of operational energy use might be beneficial at the design stage will.
- Main reasons include:
  - ✓ Provide prospective occupiers with a clearer indication of the likely range of energy use, carbon dioxide emissions and costs of running their new building;
  - ✓ Allow designers and prospective occupiers to understand where / how energy is likely to be used in the building;
  - ✓ Allow designers to understand where energy will be used and which measures have the greatest impact on energy use;
  - ✓ Ensure that prospective occupiers do not have unrealistic expectations about the performance of their new building.

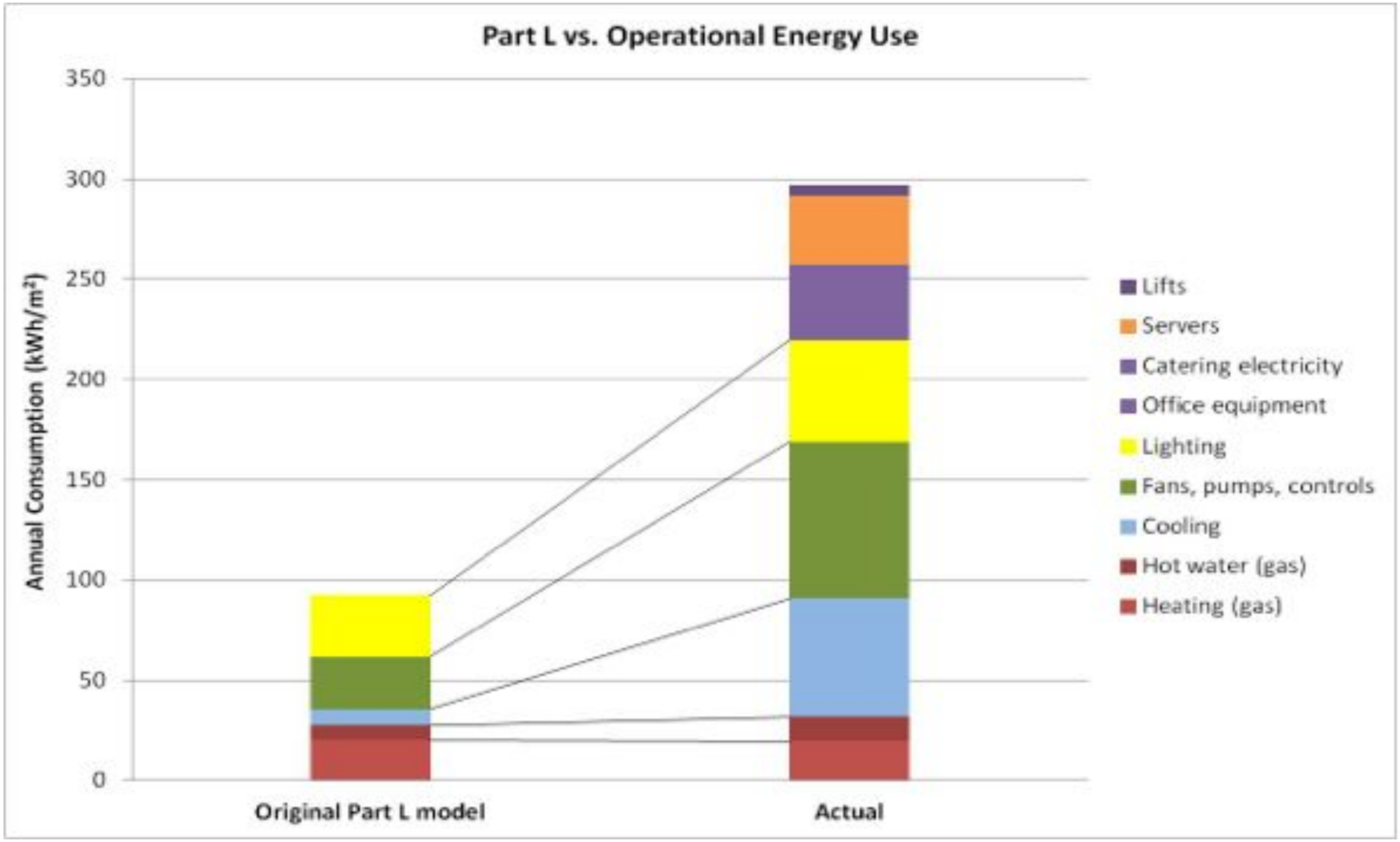
PROPOSED METHODOLOGY

- The methodology based on the TM22 bottom-up approach but relies on Dynamic Simulation Models (DSMs) to calculate energy consumption for heating and cooling



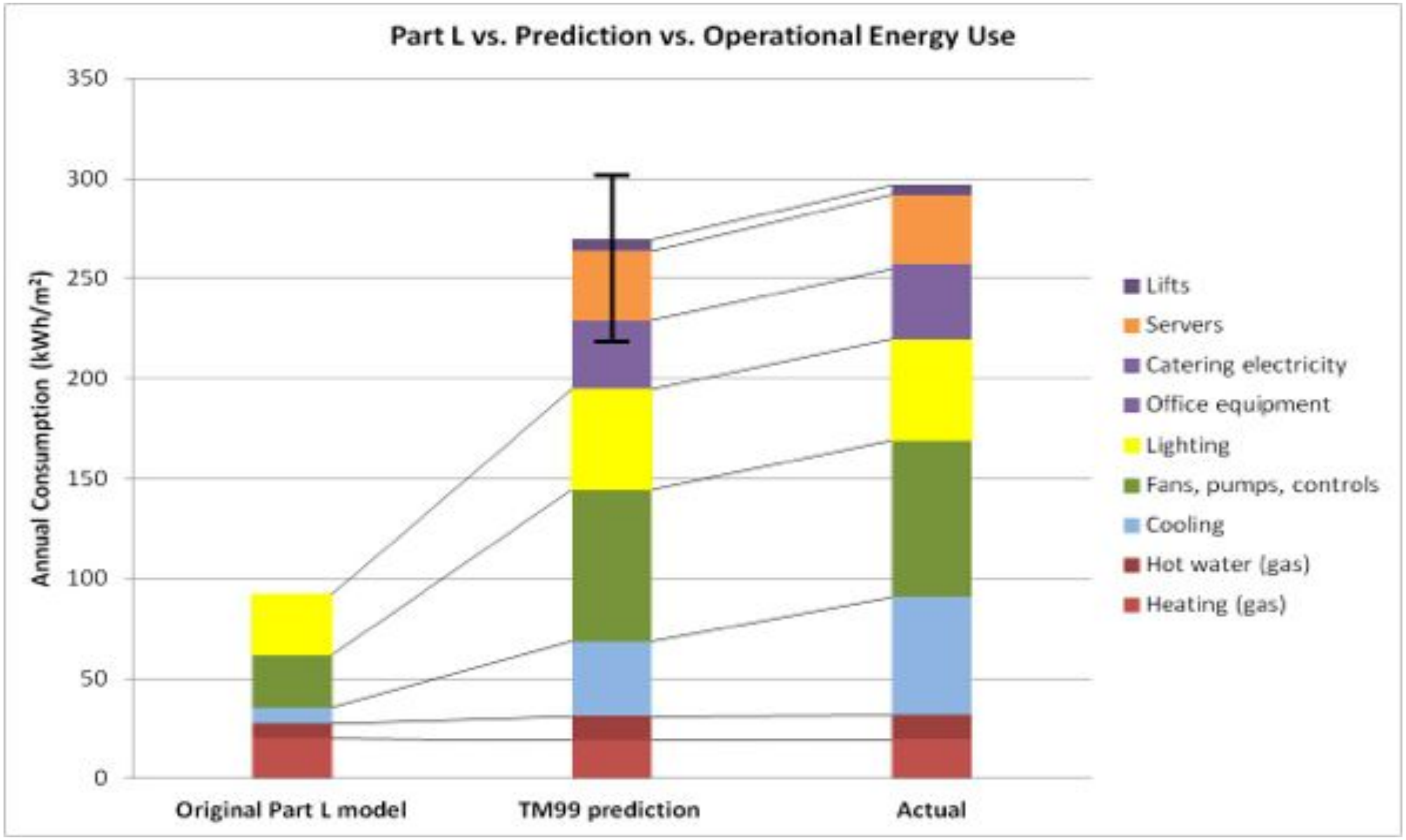
THE CASE STUDY BUILDING

- Comparing the results from Part L model to operational performance demonstrated a discrepancy of more than 300%



RESULTS FOR THE CASE STUDY BUILDING

- Following the proposed methodology has resulted in a prediction that is within 9% of the operational energy use of the case study building



KEY CONCLUSIONS

- Hours of occupation and operation of different building equipment are a key factor in predicting operational energy use realistically
- Internal heat gains need to be realistically represented in DSMs in order to predict realistic heating and cooling demands
- A large proportion of internal heat gains are determined and controlled by the occupants making it very difficult to predict

THANK YOU FOR LISTENING

Anna Carolina Menezes

anna.c.menezes@uk.tesco.com

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