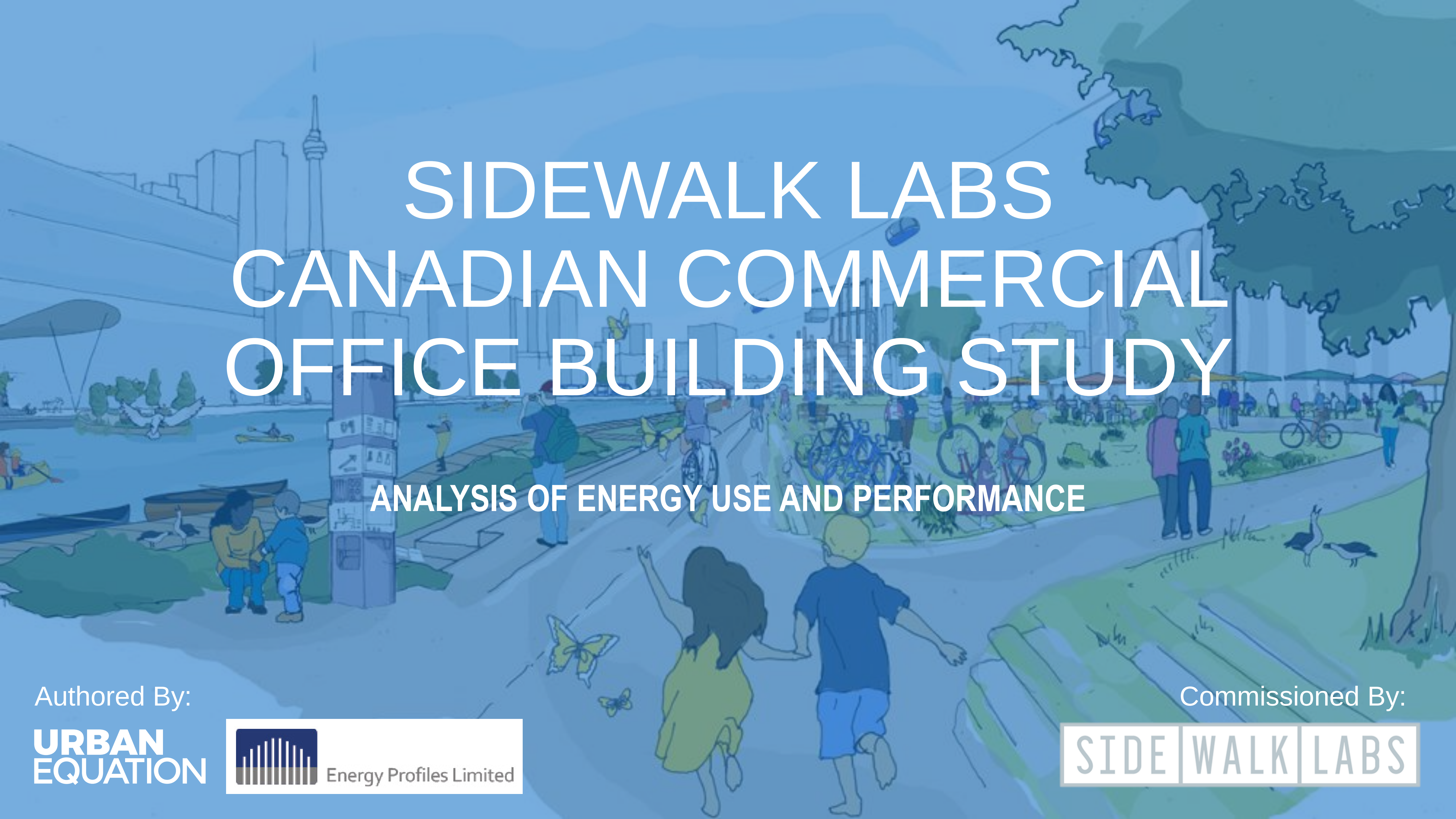

SIDEWALK LABS CANADIAN COMMERCIAL OFFICE BUILDING STUDY

ANALYSIS OF ENERGY USE AND PERFORMANCE

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SIDEWALK LABS

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HOW CAN THE COMMERCIAL OFFICE MARKET USE THESE FINDINGS?

SUMMARY

1. Use normalized energy performance metrics for setting targets.
2. Submeter in-suite tenant energy use and consider exceptional use in normalizations.
3. Target performance at least equivalent to that of the country's top-performing buildings: 139 $ekWh/m^2$-year (12.9 $ekWh/ft^2$-year).
4. Systems and design decisions are important, but also consider how to achieve targeted performance from what is installed – through a post-occupancy commissioning program.

APPROACH

BACKGROUND – OFFICE BUILDING DATA.

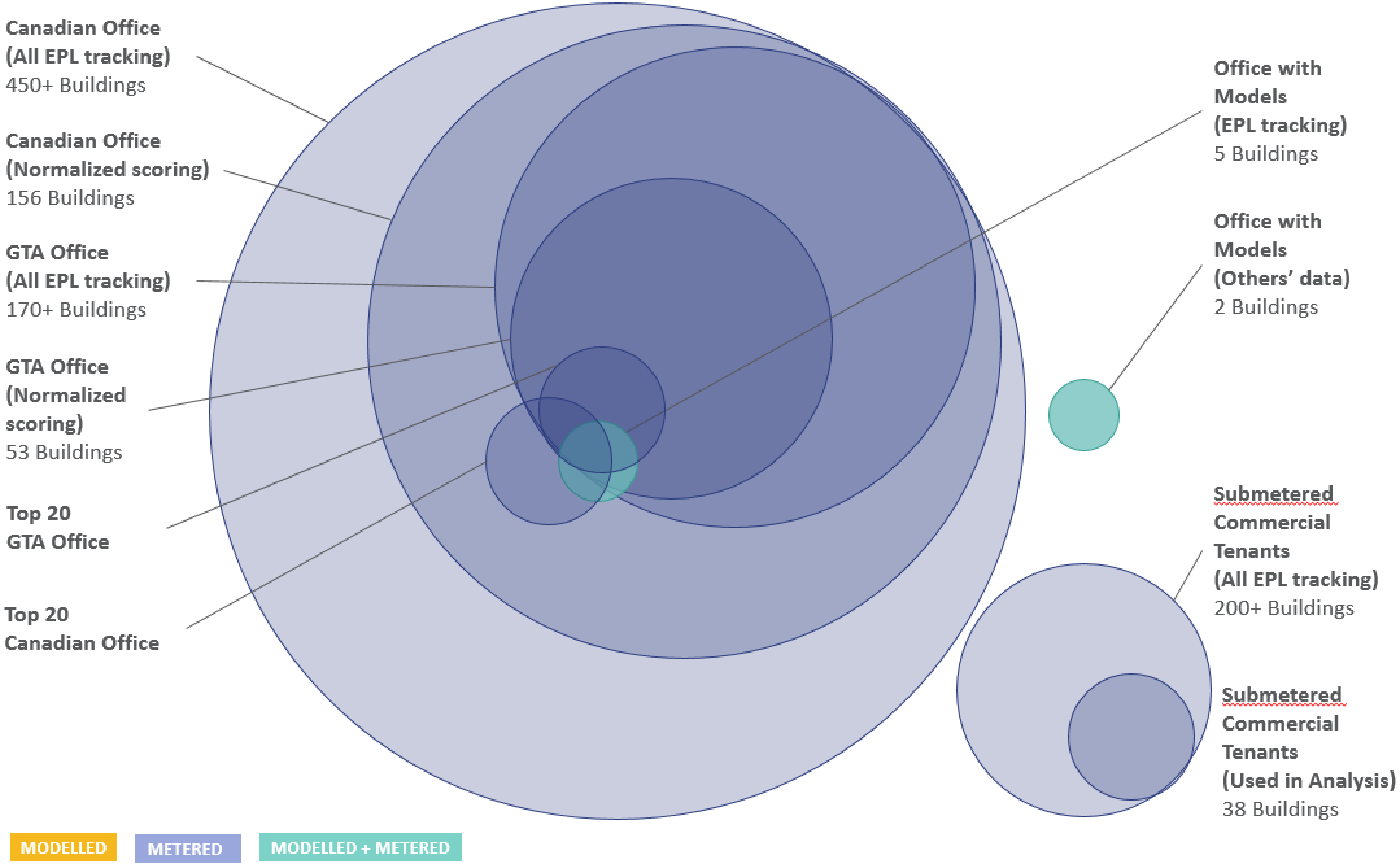
HOW CAN DATA FROM EXISTING BUILDINGS HELP DESIGN AND OPERATE NEW BUILDINGS?

- Energy Profiles Limited (EPL), along with Urban Equation and EQ Building Performance, was engaged by Sidewalk Labs to undertake a study of the performance of commercial office buildings in Canada to help lay a foundation for:
- Setting building energy performance targets
- Developing energy modeling guidelines
- And ultimately, designing buildings in Sidewalk Toronto-led developments

BACKGROUND – OFFICE BUILDING DATA.

EPL TRACKS

- Whole-building utility data for hundreds of Canadian commercial office buildings.
- Electricity data from thousands of submeters in these buildings.



KEY FINDINGS

NORMALIZATION IS KEY.

RAW, NON-NORMALIZED ENERGY USAGE IS OF LITTLE VALUE IN TRACKING A BUILDING'S PERFORMANCE OVER TIME AND COMPARING IT TO THAT OF ITS PEERS.

- Building energy use is affected by factors that vary over time and from building to building, including weather and occupancy.
- EPL therefore calculates and tracks normalized performance metrics for its client buildings using standard industry methodologies.

METRICS IN THIS REPORT

Non-Normalized Energy Use Intensity (**EUI**) is simply the sum of the total annual energy use (in equivalent kWh/year) divided by the gross leasable floor area (GLA, in m^2 or ft^2).

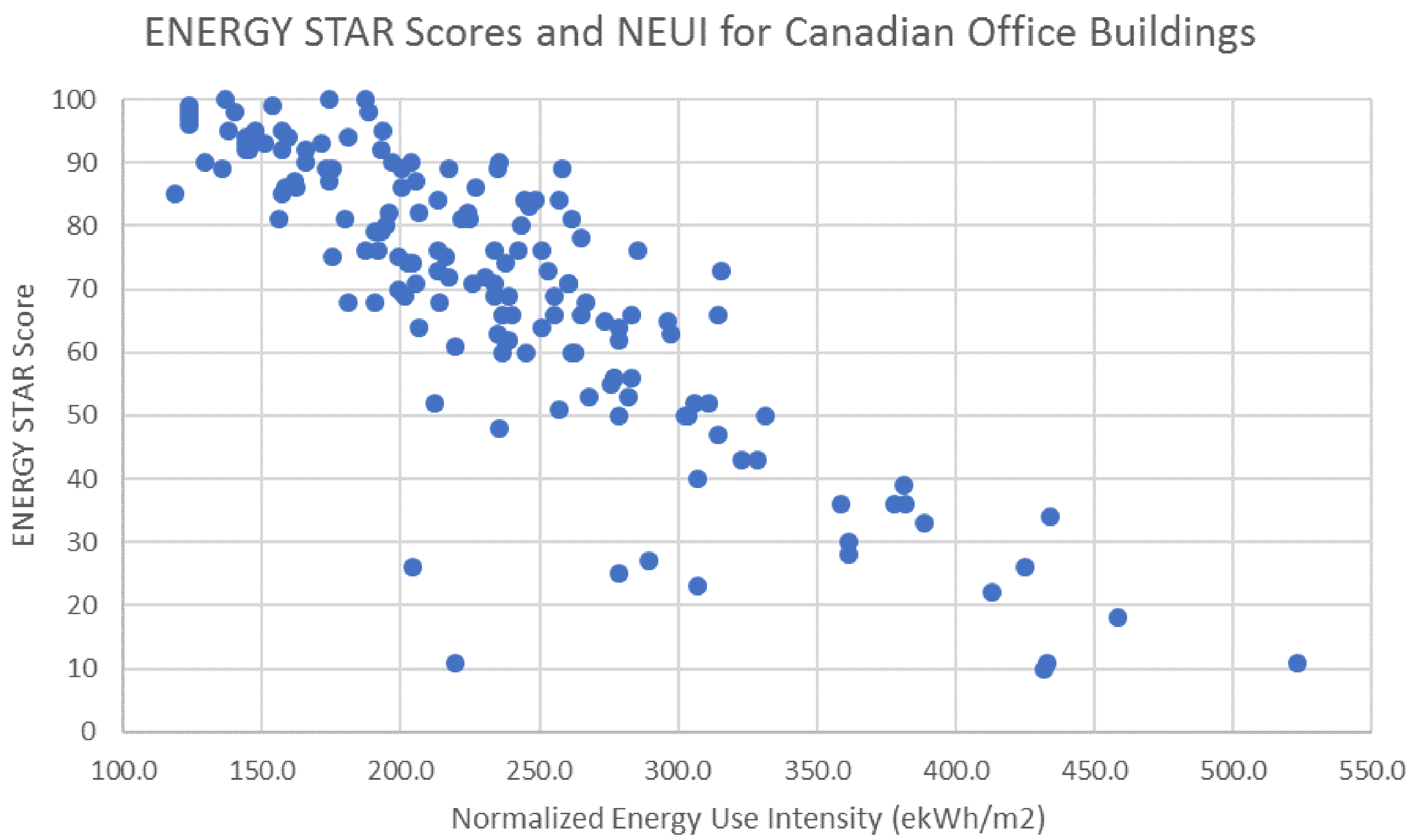
Normalized Energy Use Intensity (**NEUI**) is also expressed as $ekWh/m^2$ -year. It is based on a methodology developed by the Real Property Association of Canada (REALPAC) and accounts for gross floor area (GFA), location (weather) and exceptional, submetered energy use (generally retail or data centres), plus occupant-dependant variables (occupant density - people per m^2, vacancy - unoccupied floor area, and operating hours).

ENERGY STAR is another widely-used, independent benchmark. Its scoring system normalizes a building's energy performance based on a number of factors (similar to those from NEUI) and ranks it relative to a representative data set of the country's buildings.

NORMALIZATION IS KEY.

SIMILARLY, RAW, NON-NORMALIZED ENERGY USE CANNOT USEFULLY BE COMPARED TO DESIGN-STAGE ENERGY MODELS.

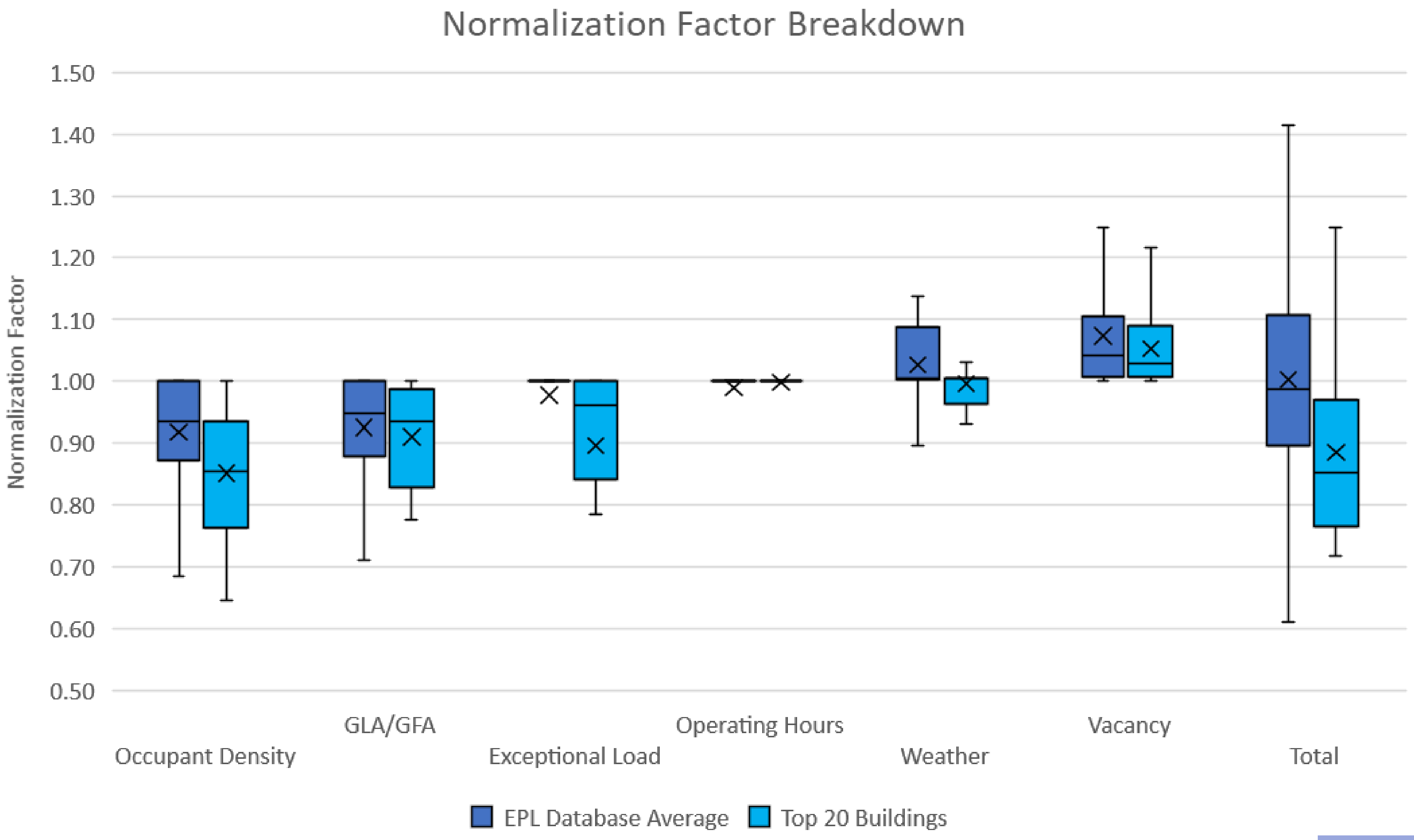
- Those models are typically based on default assumptions of weather and occupancy.
- As a result, non-normalized energy use is not a useful basis for setting performance targets for new buildings, nor for holding development teams accountable for hitting those targets.



NORMALIZATION IS KEY.

NEUI AND ENERGY STAR NORMALIZE FOR THESE IMPORTANT OPERATIONAL FACTORS.

- In simplistic terms, individual factors (values between zero to one) are calculated for each variable and then multiplied by the non-normalized EUI to arrive at a NEUI.

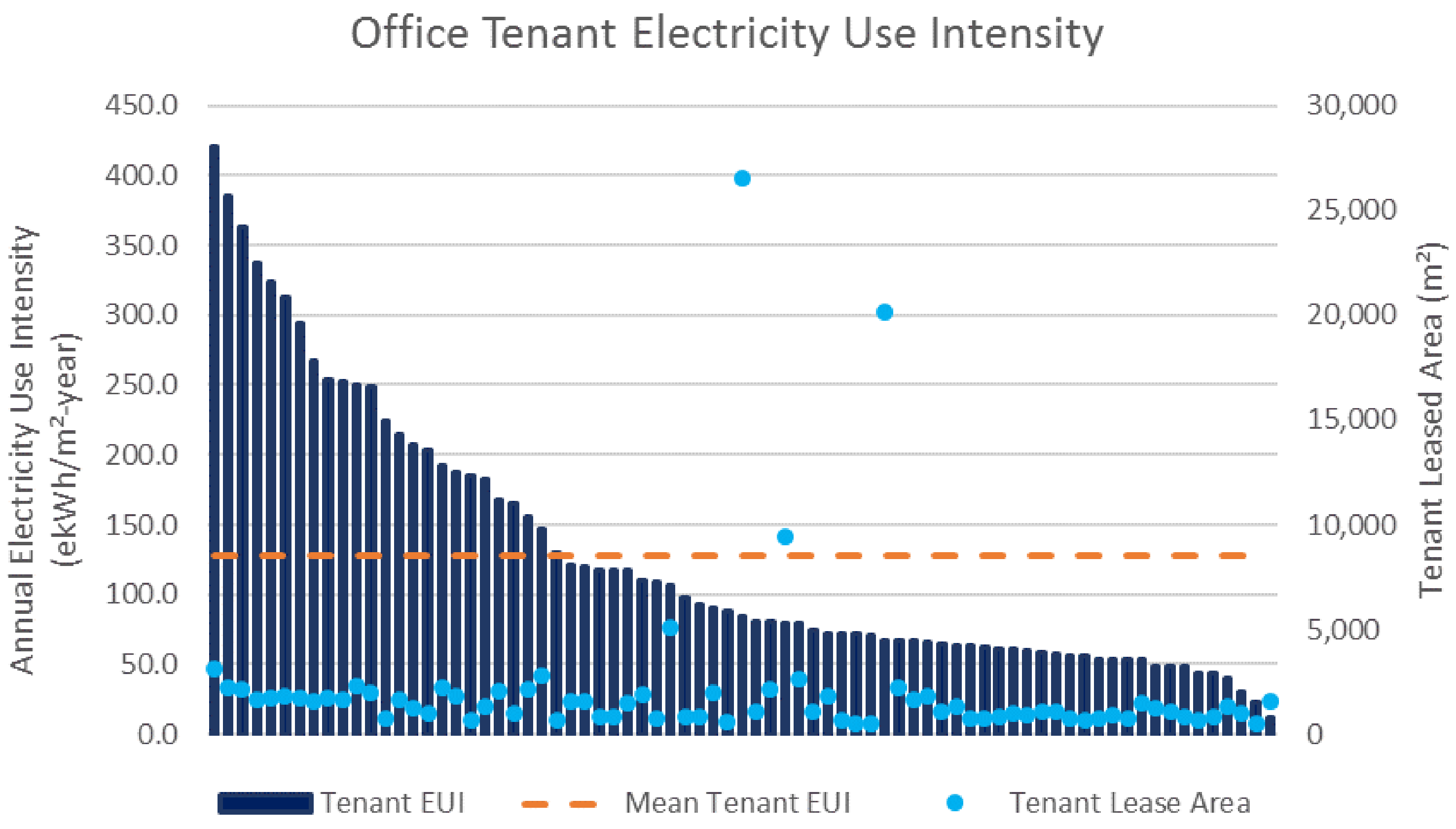


METERED

IN-SUITE TENANT LOADS VARY WIDELY.

THE 10% OF OFFICE TENANTS WITH THE HIGHEST IN-SUITE CONSUMPTION CONSUME ABOUT THREE TIMES MORE THAN AVERAGE. THE LOWER 10% CONSUME ONLY ABOUT A THIRD THE AVERAGE.

- EPL's database contains data from thousands of submeters in hundreds of commercial office buildings.
- For some tenants, only lighting is submetered; for others, just plug loads.
- This chart shows data from tenants where both are submetered.
- In all three submetering scenarios, there is a large range of electricity use intensity.



SO WHAT?

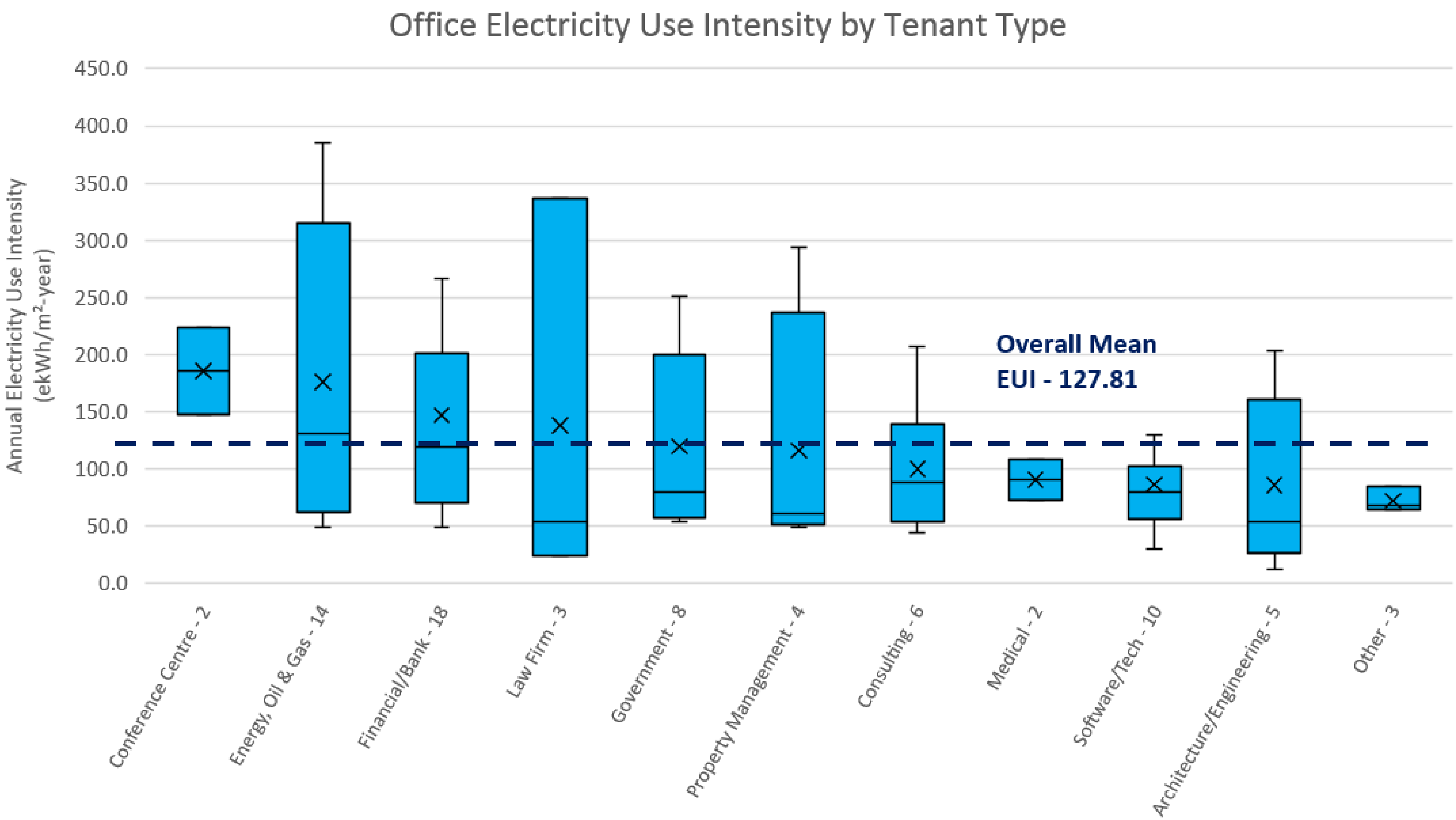
Tenant in-suite consumption can form a substantial portion of whole-building energy use.

Therefore tenant loads and behaviour are important to delivering high-performance buildings.

IN-SUITE TENANT LOADS VARY WIDELY.

MOST OFFICE TENANT "TYPES" HAVE A WIDE RANGE OF IN-SUITE CONSUMPTION.

- Without detailed information about these tenant spaces and the goings-on within them, it is impossible to say why similar tenants' energy use ranges so widely.
- Many factors could contribute: number of occupants, hours they work, amount and type of equipment, type of lighting and controls in place, whether there are other non-office uses within the space (conference facilities, showrooms, data centres, etc).
- In addition, we suspect that tenants with the highest consumption (the top 10%) likely have some form of high-intensity computing – i.e. non-submetered data centres.
- We found no relationship between tenant EUI and building NEUI.

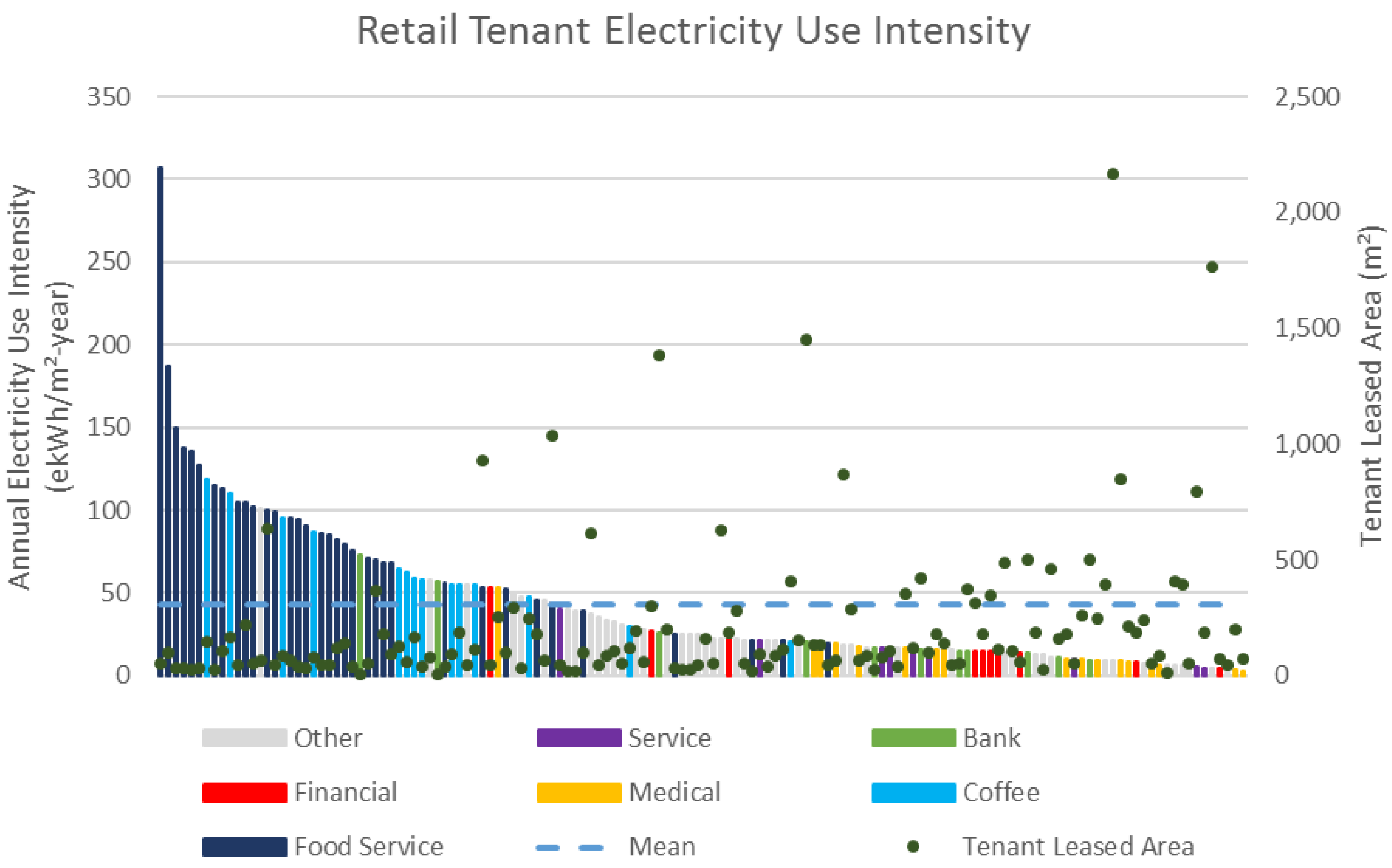


METERED

IN-SUITE TENANT LOADS VARY WIDELY.

RETAIL TENANT IN-SUITE CONSUMPTION VARIES EVEN MORE WIDELY THAN OFFICE.

- We conclude that energy use intensity based solely on floor area is of limited value for target-setting in retail space.
- The size of a retail tenant's space does seem to be significant to the tenant's EUI. Larger suites clearly tend to have lower EUIs, but there remains a large spread among small retail spaces. The trend is similar for both food service tenants and non-food service.

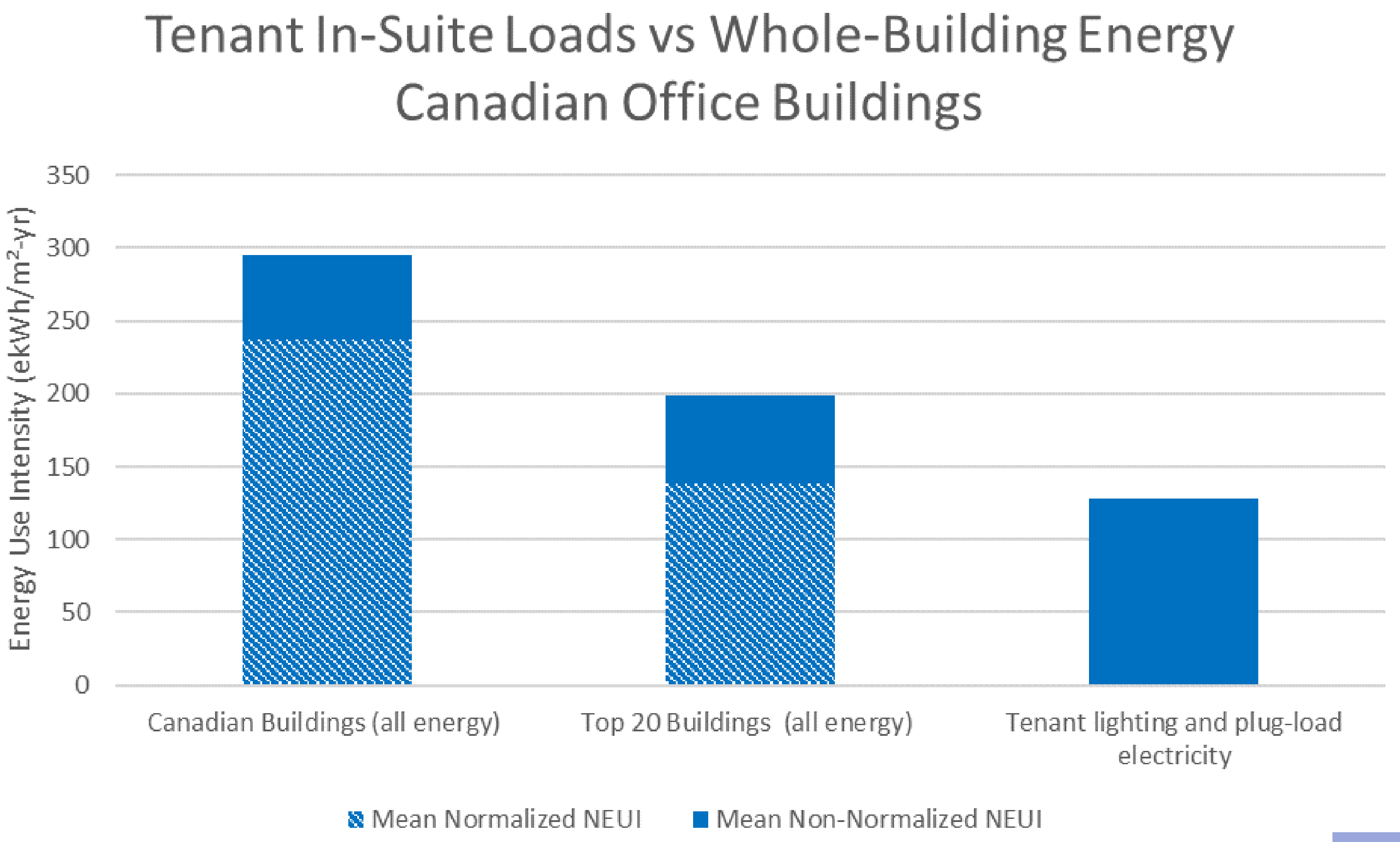


METERED

IN-SUITE TENANT LOADS VARY WIDELY.

AVERAGE IN-SUITE TENANT ENERGY USE IS ABOUT THE SAME AS *WHOLE-BUILDING* ENERGY USE OF THE TOP CANADIAN OFFICE BUILDINGS.

- In-suite tenant use can be a large component of whole-building energy.
- And the landlord's "sphere of influence" can sometimes be quite small.
- Clearly, the tenant in-suite use in the highest-performing buildings must be much less than average. (Otherwise, they could not have achieved this high level of performance.)



METERED

PERFORMANCE OF TOP OFFICE BUILDINGS.

THE TOP 20 CANADIAN OFFICE BUILDINGS IN EPL'S DATABASE ARE REPRESENTATIVE OF THE TOP COMMERCIAL OFFICE BUILDINGS IN THE COUNTRY.

- For the purposes of this report, we define "top" performance as the twenty buildings with the lowest NEUI.
- EPL tracks normalized energy performance metrics for 156 office buildings in Canada.
- The Top 20 buildings in EPL's database are generally representative of the best commercial office buildings in the country.
- That said, we know of a small number of "bleeding edge" office buildings that perform considerably better. (They are discussed later.)

AVERAGE PERFORMANCE

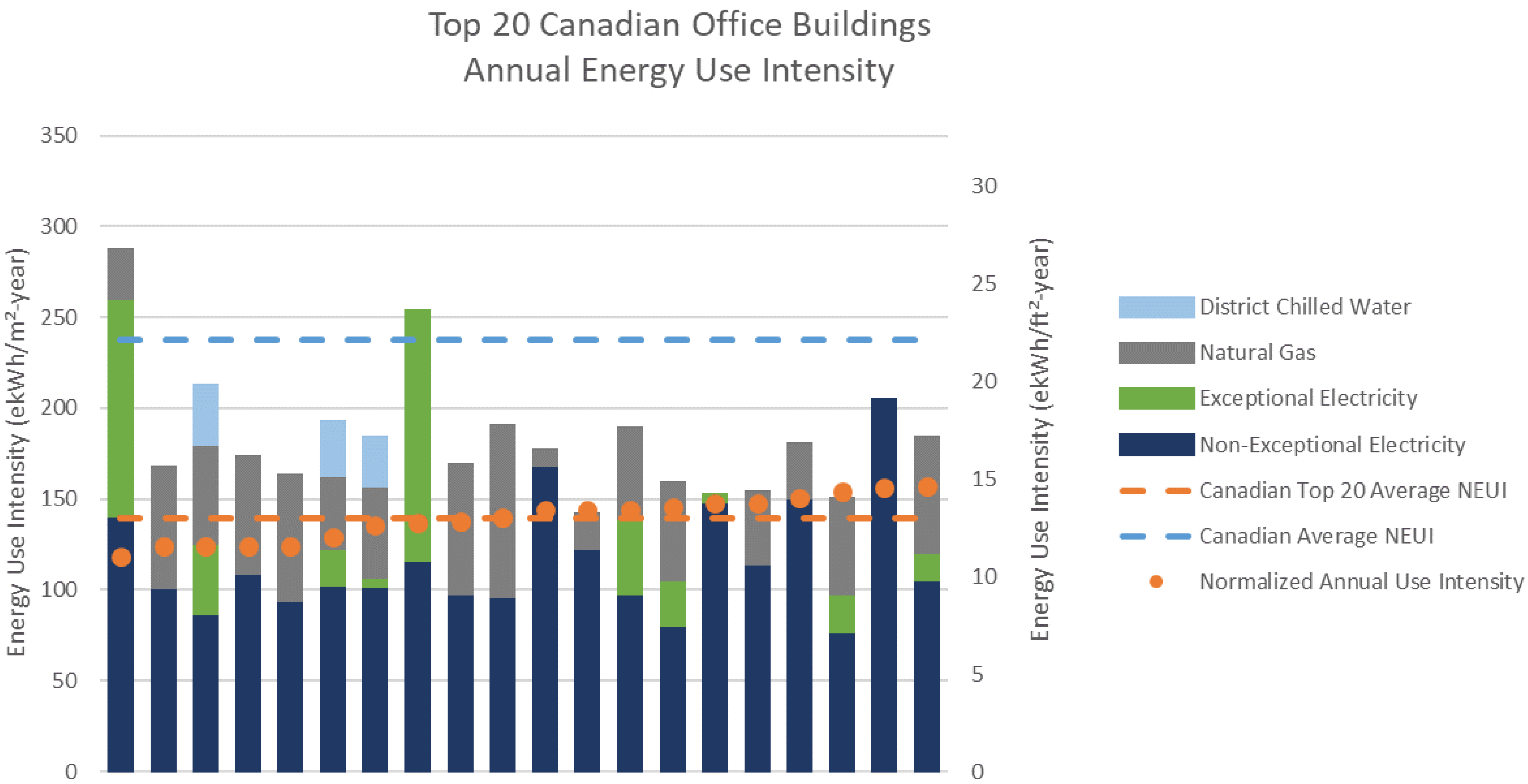
EPL tracks normalized energy performance metrics for 156 office buildings in Canada. The average NEUI for these buildings is 237 ekWh/m^2-year (22.0 ekWh/ft^2-year), and the average ENERGY STAR score is 70.

These buildings outperform the Canadian market overall, considering the average Canadian office building should have (by definition) an ENERGY STAR score of 50.

PERFORMANCE OF TOP OFFICE BUILDINGS.

THE TOP 20 CANADIAN OFFICE BUILDINGS HAVE A NEUI 41% LOWER THAN AVERAGE.

- The Top 20 Canadian office buildings in EPL's database have an average NEUI of 139 ekWh/m^2-year (12.9 ekWh/ft^2-year), 41% lower than the average of EPL's Canadian dataset.
- For comparison this is not far off the Toronto Green Standard Tier 2 modeled performance target of 130 ekWh/m^2 (12.1 ekWh/ft^2) for new construction.
- The average ENERGY STAR score for these Top 20 buildings is 94 – 24 points better than the average of Canadian buildings in EPL's database.



METERED

PERFORMANCE OF TOP OFFICE BUILDINGS.

AN EVEN HIGHER LEVEL OF PERFORMANCE IS POSSIBLE, BUT CONSIDERED "BLEEDING EDGE".

- Manitoba Hydro Place in Winnipeg, Manitoba and A Grander View in Kitchener, Ontario are two office buildings that perform considerably better than even the best buildings in the EPL database.
- We do not have access to a NEUI (calculated using the REALPAC methodology) for these two buildings, but their metered (actual) energy use is reported to be around 75 ekWh/m^2-year (7.0 ekWh/ft^2-year) – 46% lower than that of the Top 20 buildings in EPL's database and 68% lower than the Canadian average.
- These two buildings feature design elements and technologies not found in even the best "market" buildings. While this level of performance is technically possible, it is not representative of what the commercial market currently considers viable.

BLEEDING EDGE SYSTEMS

These buildings have energy-saving features are not generally found in "market" office buildings:

- Double-facades, and/or building envelopes with higher insulating values and much lower window-to-wall ratios
- Floor plates focused on optimizing daylight harvesting and envelope-to-floorplate ratios, not on optimizing land-use in locations where land values are high
- Earth-tubes and/or thermal chimneys
- Ground-source heat-pumps

PERFORMANCE OF TOP OFFICE BUILDINGS.

THERE ARE NO OBVIOUS PATTERNS IN THE PHYSICAL CHARACTERISTICS OF THE TOP-PERFORMING BUILDINGS IN EPL'S DATABASE.

That is, they are more different than they are similar. Or, put another way, there is no sign that a building need be new nor conform to a certain mould in order to achieve a high level of performance.

- Some are big (over 50,000 m^2) and some are small (under 10,000 m^2).
- Some are tall (over 20 floors) and some are low-rise (less than 5 floors).
- Some are new (less than 5 years) and some are old (more than 30 years).
- About half are urban and the other half suburban.
- Many are located in Ontario, but four other provinces are represented.

METERED

PERFORMANCE OF TOP OFFICE BUILDINGS.

THE TOP 20 OFFICE BUILDINGS FEATURE A VARIETY OF HVAC SYSTEM TYPES AND ENERGY SOURCES THAT ARE NOT UNIQUE TO THESE BUILDINGS.

There are, however, some common patterns to be gleaned:

- Most have ventilation systems separate from heating and cooling, allowing each system to be better controlled to its demand, saving energy.
- All have HVAC systems broken into smaller, more easily controllable zones (on a floor-by-floor basis, at minimum) allowing fans and other equipment to be shut off and controlled to suit occupant needs and schedules – “compartmentalized”, as opposed to large, central systems.
- Whether a building had a distributed heat-pump heating and cooling system or a fan-coil unit system was not an indicator of performance. There are buildings with each of these systems among the best- and worst-performing buildings.

METERED

PERFORMANCE OF TOP OFFICE BUILDINGS.

THE TOP-TIER BUILDINGS SHARE COMMON CHARACTERISTICS IN THE REALM OF OPERATIONS AND MAINTENANCE.

In our opinion, these factors contribute to the high performance of these buildings, relative to the average of the dataset:

- Each is managed by a top-class organization, with programs and policies around building performance.
- Most are participants in some form of data-driven BAS and submeter analytics (i.e. “monitoring-based commissioning”) program.
- Most have extensive submetering in place, used for cost allocations and data/performance analytics.
- Those with substantial exceptional tenant loads – such as data centres – have those submetered and excluded from their normalized EUIs.

METERED

MODELED VS METERED (ACTUAL) OFFICE ENERGY USE.

BACKGROUND – MODEL DATA COMPARED FOR SEVEN BUILDINGS

- EPL currently has access to design-phase energy modeling data from five recently-constructed, high-performance office buildings for which they also track actual utility consumption and performance.
- For reference, we have also included publicly-available data for two other buildings, recognized as among Canada's highest-performing office buildings.
- Note that, in contrast to the multi-unit residential building study – prepared in parallel with this commercial building study, we did have access to the models themselves and could not "calibrate" them to actual operating conditions. Instead, we compared the model data to the normalized, metered (actual) energy use.

The five buildings chosen from EPL's database for this analysis:

- Are all new. They were constructed within the last seven years.
- Are all large. They have gross floor areas of more than 40,000 m2 and are over 25 stories tall.
- Are high-performers. They have an average, actual normalized energy use intensity (NEUI) of 139 ekWh/m2-year (12.9 ekWh/ft2-year) – about 41% lower than the national average. Coincidentally, this is the same average performance as the Canadian "Top 20".

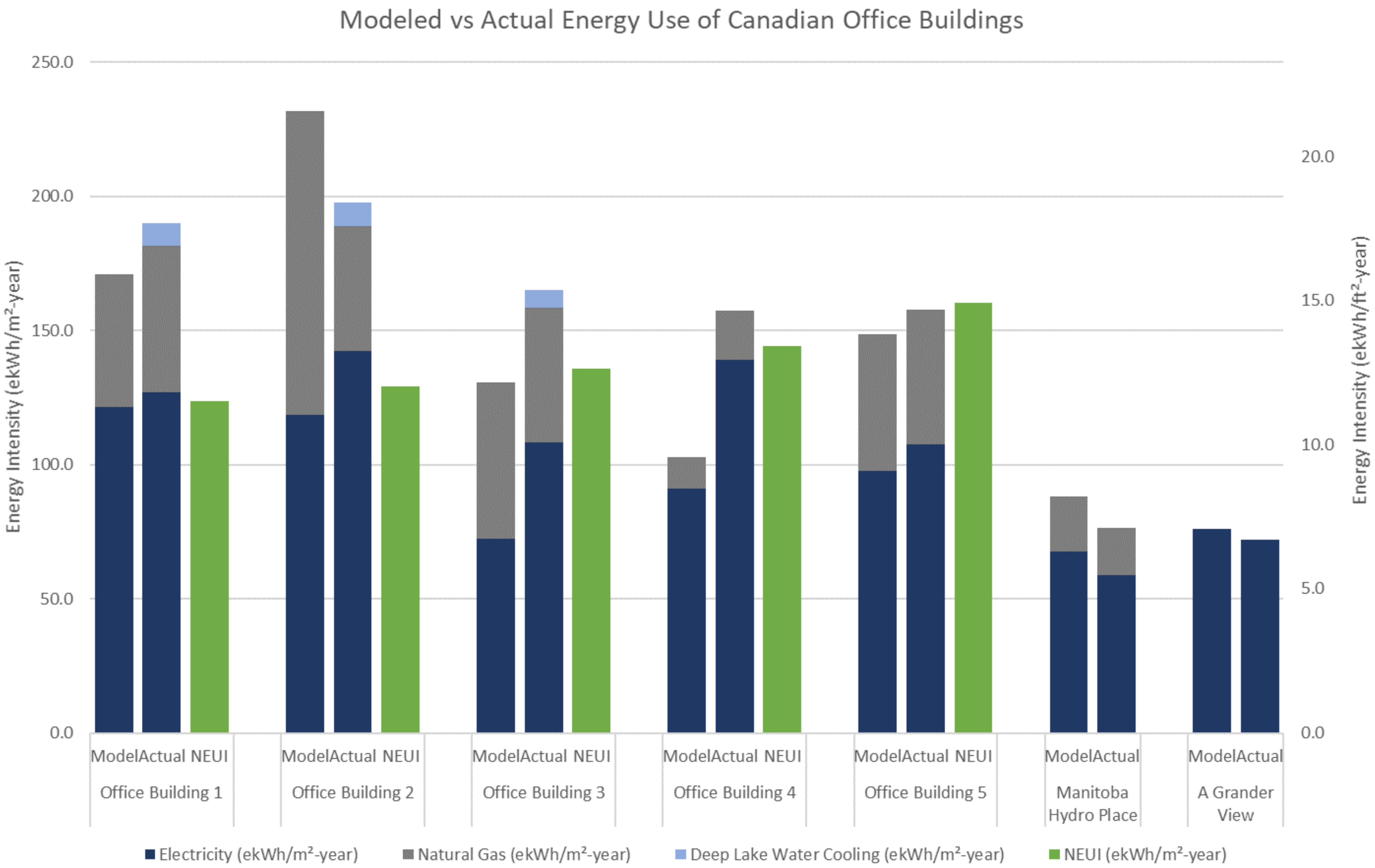
MODELED VS METERED (ACTUAL) OFFICE ENERGY USE.

EVALUATING THE “PERFORMANCE GAP”.

Gap between Modelled and Actual Metered Energy Use:

On average, the energy usage of the five buildings was 18% higher than modeled.

This difference was expected because in EPL’s experience, normalizing energy data (either the model or the actual use) is crucial to valid comparison.



MODELLED + METERED

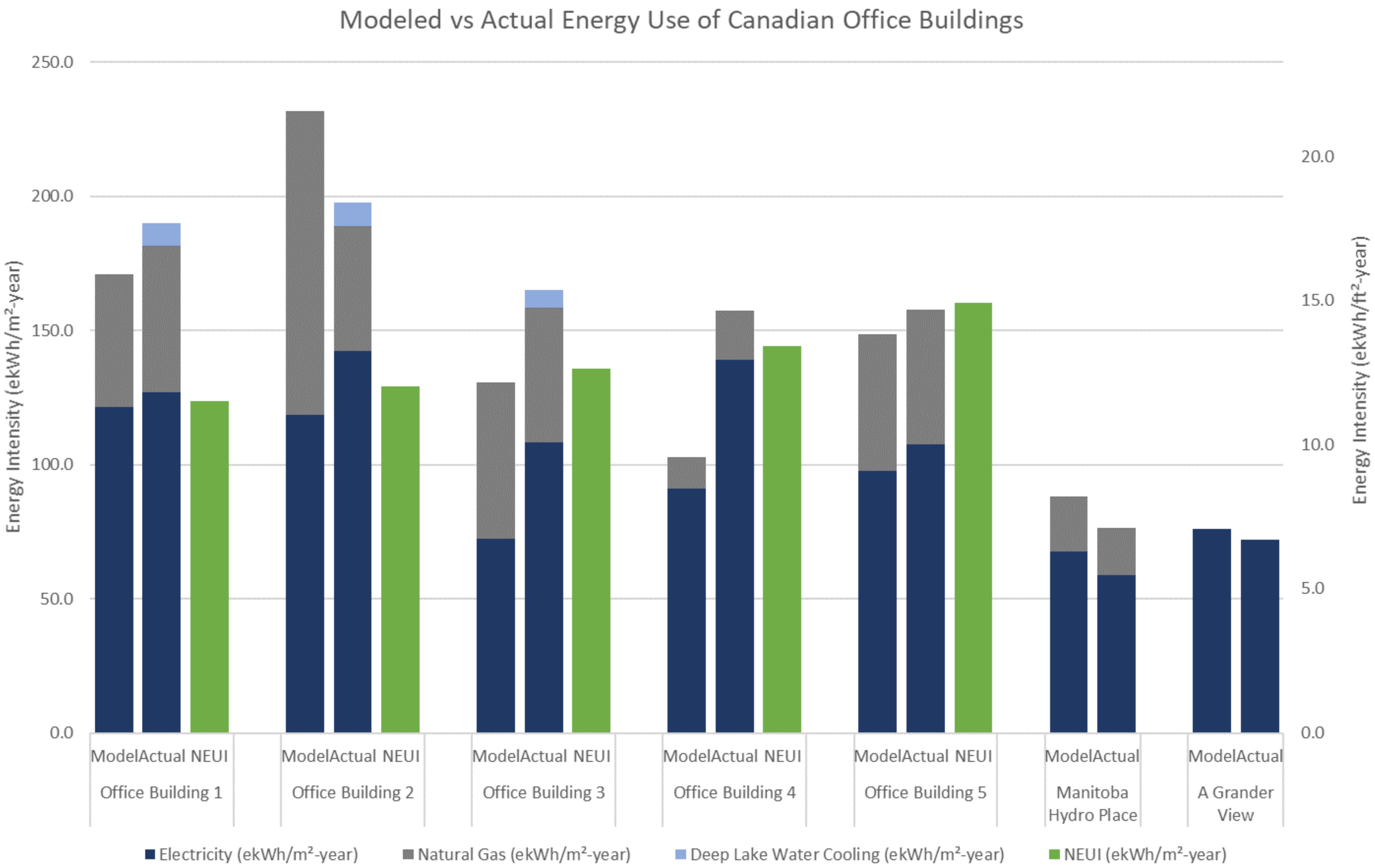
MODELED VS METERED (ACTUAL) OFFICE ENERGY USE.

EVALUATING THE “PERFORMANCE GAP”.

No Gap between Modelled* and Normalized *Metered Energy Use:

On average, the normalized energy usage of the buildings was 9% less than modeled.

Based on this data, and on our experience, it is generally possible for a new office building to perform as well as, or better than, projected by its design-stage energy model.

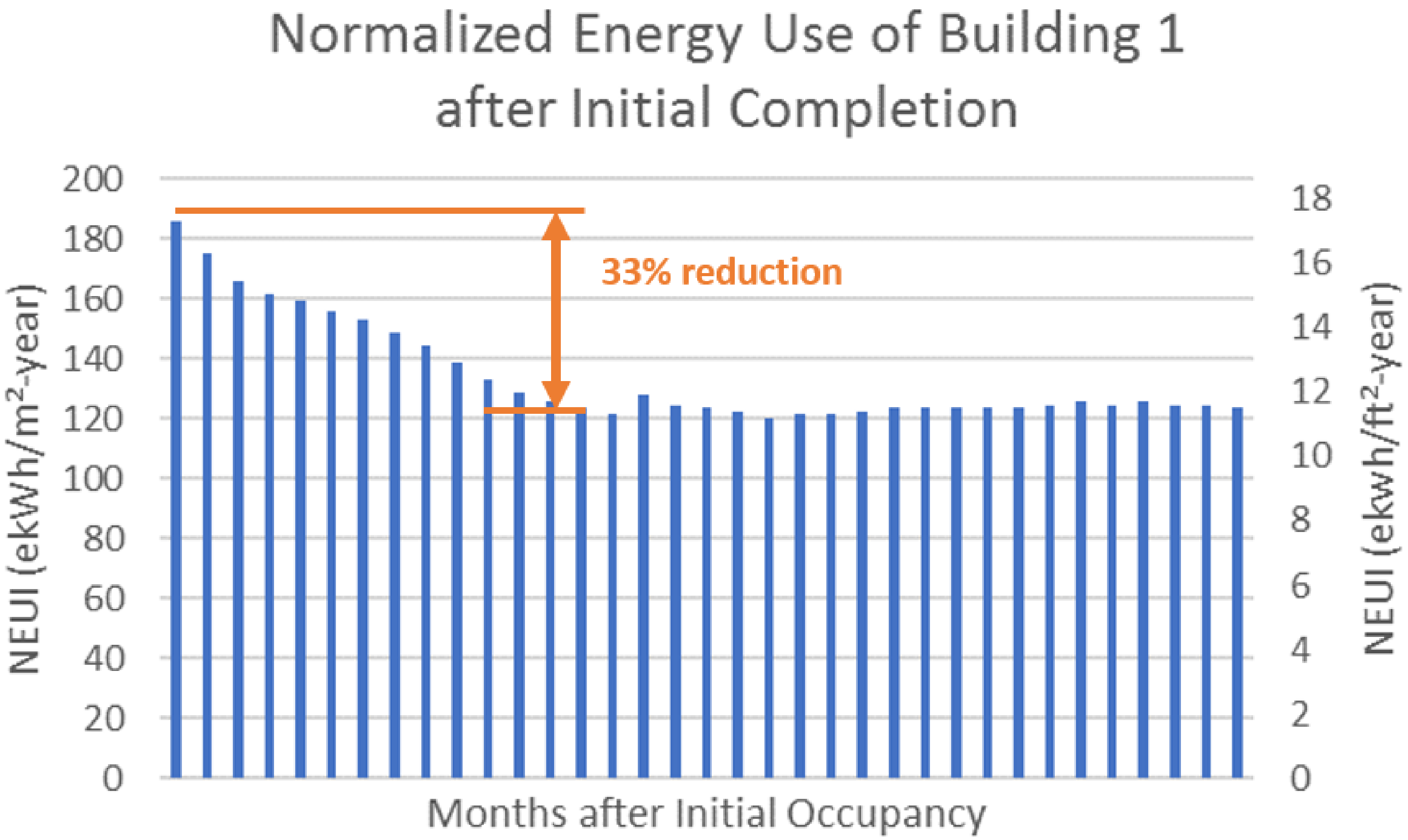


MODELLED + METERED

MODELED VS METERED (ACTUAL) OFFICE ENERGY USE.

IT CAN TAKE YEARS – AND A FOCUSED, POST-OCCUPANCY COMMISSIONING PROCESS – TO ACHIEVE OPTIMUM/MODELED PERFORMANCE.

- EPL has performance data for some of these buildings since they were first constructed.
- Building 1 had a NEUI of around 190 ekWh/m^2-year shortly after its completion – higher than its model projected. It took more than a year for performance to improve to its current level – considerably better than modeled.
- EPL was involved in a monitoring-based commissioning process for the first few years of this building's existence, and in our opinion, a large part of that performance improvement was due to the operational improvements instituted during that time.

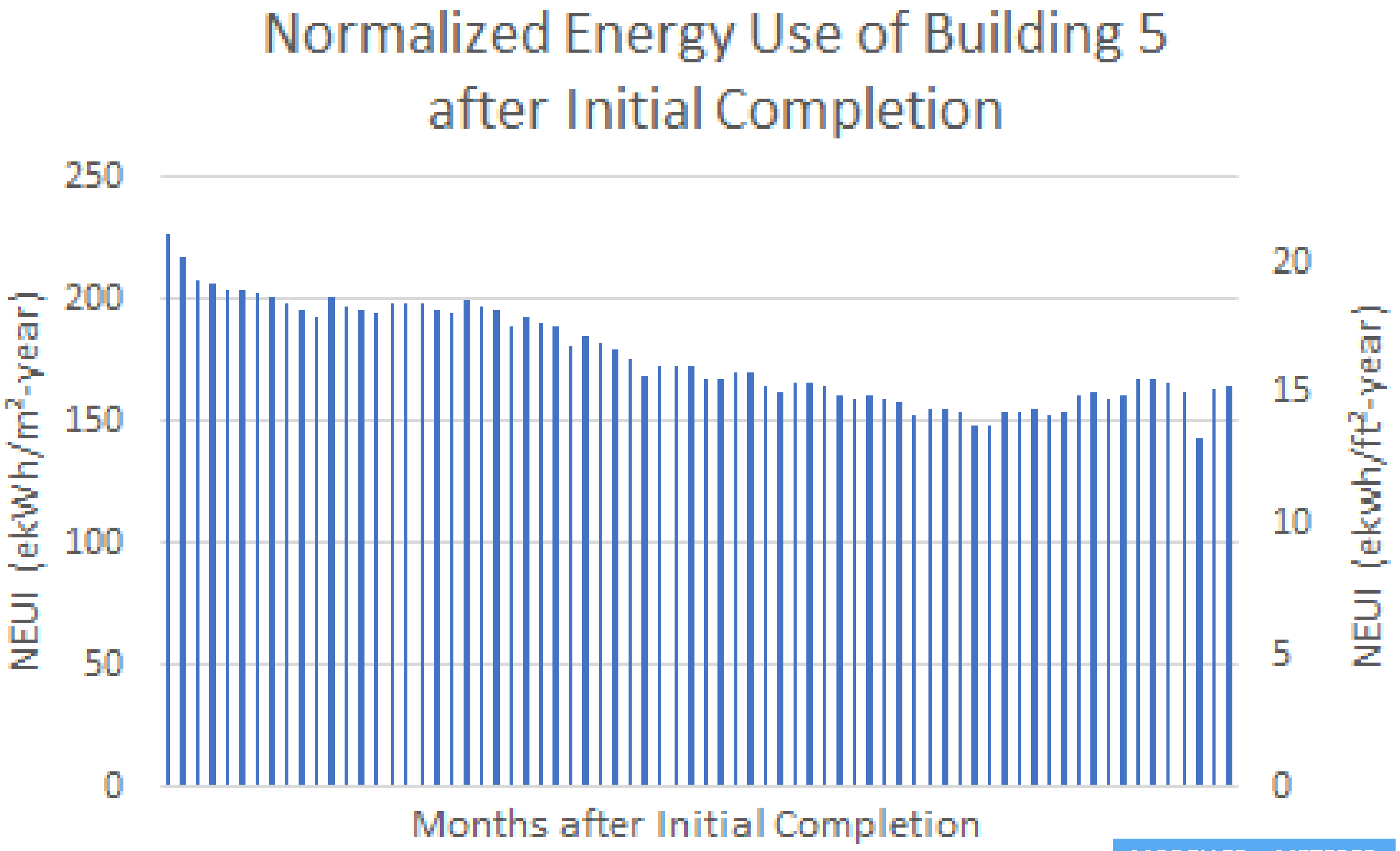


MODELLED + METERED

MODELED VS METERED (ACTUAL) OFFICE ENERGY USE.

IT CAN TAKE YEARS – AND A FOCUSED, POST-OCCUPANCY COMMISSIONING PROCESS – TO ACHIEVE OPTIMUM/MODELED PERFORMANCE.

- Building 5 had an initial, post-completion NEUI of around 220 ekWh/m^2-year, and it took several years for performance to improve to its current level (close to that modeled).
- There has not been an ongoing commissioning program in place at this building, and one might infer that – at least in part – this is why it took longer for performance to improve.
- It is difficult to know how widely applied ongoing, monitoring-based commissioning is. EPL is delivering this type of service to about 50 Canadian office buildings – only a fairly small portion the hundreds of buildings in our client portfolio. In the wider Canadian office market, we suspect that fewer than 5% have any form of ongoing commissioning program in place.



MODELLED + METERED

DISCUSSION

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