energy efficiency COUNCIL

Determining office tenancies energy end use

A research project to determine disaggregated energy consumption in office tenancies

Final report – June 2021

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Energy Efficiency Council 2021

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Glossary

Term	Meaning
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CBD	Commercial Building Disclosure
CIBSE	Chartered Institution of Building Services Engineers
CIBSE ECG	Chartered Institution of Building Services Engineers Energy Consumption Guide
DISER	Department of Energy, Science, Industry and Resources
EEC	Energy Efficiency Council
EUF	Environmental upgrade finance
FS	Functional Space
GEMS	Greenhouse and Energy Minimum Standards
HVAC	Heating ventilation and air-conditioning
MEPS	Minimum Energy Performance Standards
NABERS	National Australian Built Environment Rating System
NCC	National Construction Code
NLA	Net Lettable Area
NLPD	Nominal Lighting Power Density
TLA	Tenant Lighting Assessment

Acknowledgements

The Energy Efficiency Council (EEC) gratefully acknowledges the support of CitySwitch, NABERS and Property NSW, as well as energy consultancies Point Advisory, DeltaQ and Strategy. Policy. Research. in completing this research project.

CitySwitch played an integral role of facilitating responses to the survey, with NABERS providing expert technical advice and the NABERS data against which the bottom-up energy use model was validated. Property NSW provided the data used to estimate supplementary HVAC load, with DeltaQ undertaking the analysis on their behalf. Strategy. Policy. Research. reviewed methodological approaches to determining office tenancies energy end use. And, importantly, Point Advisory developed the model and led on the analysis of the results of the research.

The EEC worked closely with CitySwitch, NABERS and Point Advisory on developing the discussion and conclusions of this research.

Lastly, the EEC thanks the Commonwealth Department of Industry, Science, Energy and Resources (DISER) for funding this research, which has enabled CitySwitch and the Energy Efficiency Council to better support office-based businesses with improving their energy performance through a targeted campaign and the establishment of a dedicated resource detailing opportunities for office-based businesses, with a particular emphasis on office tenancies. To learn more, go to energybriefing.org.au/sector-spotlights/offices

Executive summary

Overview

The Energy Efficiency Council (EEC) has been engaged by the Commonwealth Department of Industry, Science, Energy and Resources (DISER) to conduct research to determine office tenancies energy end use. The purpose of the research is to determine:

- The proportion of office buildings' energy use attributable to office tenants;
- The proportion of office tenants' energy use attributable to lighting, supplementary heating, ventilation and air-conditioning (HVAC) and plug-load;
- The breakdown – by average value and energy intensity – of office tenants' energy use attributable to lighting, supplementary HVAC and plug-load energy use, broken down by office equipment type; and
- How these figures are anticipated to change between 2020 and 2030, and what this means for the relative size of energy savings opportunities for office tenancies.

This research demonstrates the relative size of energy savings opportunities for office tenancies. It aims to facilitate the uptake of and investment in energy upgrades that offer the largest energy and emissions savings for office tenancies.

Note: The bulk of this research was completed between July and November 2020. In April 2021, once the relevant data was collected, additional research was completed to determine the proportion of an office tenancy's energy consumption attributable to supplementary HVAC.

Results

The key findings relate to the:

Energy split between the base building and the office tenancy

Base buildings are estimated to consume 56% of all energy use in office buildings, while tenancies account for the remaining 44%. This energy use split includes both electricity and gas.

It is possible that the true energy use share of office tenancies is higher than 44%, as the NABERS tenancy dataset is likely to contain higher performing tenancies as compared with the national average.

Breakdown of energy consumption in office tenancies

Figure 1 demonstrates that:

- Lighting is the single largest energy consumer in office tenancies, accounting for 29% of all energy use in office tenancies;
- Computer monitors make up the largest share of plug load, at 17%, and when combined with desktop and laptop computers, account for approximately one quarter of all energy consumption in office tenancies;
- Servers, as opposed to dedicated data centres – i.e. rooms housing stacks of servers and nothing else – make up the next largest plug load, at 7%;
- Printers and multi-functional devices are the largest plug load user of the remaining office and kitchen equipment; and
- The remaining 33% is for all other energy consumption present in office tenancies, including supplementary HVAC, data centre equipment and its associated HVAC services, and some end uses that are beyond the scope of office tenancies, for example base building HVAC services connected to an office tenancy meter, or warehouse equipment usage connected to an office tenancy meter.

Importantly, given the varied nature of the "other energy consumption", much of the analysis and discussion in this report focuses on the remaining 67% of electricity consumption that comes from lighting and equipment.

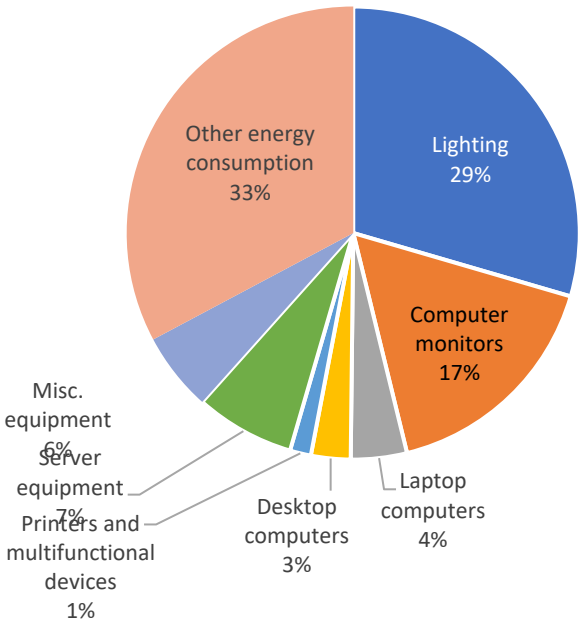

Figure 1: Overall average office tenancy energy use breakdown

NABERS data was used to determine the share of energy consumed by supplementary HVAC in tenancies. It was found that the percentage of supplementary HVAC energy use ranges from less than 1% up to 79% of an office tenancy's consumption, resulting in an average of approximately 18-25% of electricity consumption in office tenancies. Noting this variability, much of the analysis included in this report represents office tenancy energy consumption exclusive of supplementary HVAC – see Figure 2. However, when in use, supplementary HVAC can be a significant energy consumer, as represented by the "other energy consumption" share of Figure 1, which also includes data centres and other miscellaneous energy consumers, like tenancy metered gas hot water, which were not common in the surveyed tenancies.

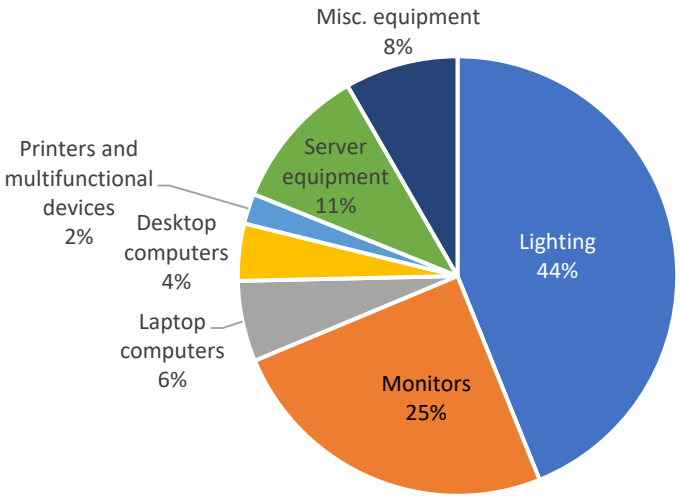

Figure 2: Office tenancy energy use breakdown estimate (without supplementary HVAC and other energy consumption)

It is noted that due to the energy use variability among office tenancies, these results are not intended to be representative of a typical Australian office tenancy. Rather, they are indicative of the overall energy use breakdown for Australian office tenancies within the tolerance of errors defined in this research – i.e. the results represent office tenancies as a whole, not as individuals. Additionally, the data points that make up this research have been supplied by CitySwitch signatories, who can reasonably be assumed to be higher performing tenancies due to the nature of CitySwitch being a voluntary program for members seeking to improve energy and resource efficiency in office-based buildings.

Projected energy breakdown for office tenancies from 2020 to 2030

The total office lighting and equipment energy is expected to decrease by 34% from the current 191 MJ/m^2 to approximately 126 MJ/m^2 in 2030. Current lighting and equipment energy is down approximately 30% from 273 MJ/m^2 in 2012. Office tenancy energy use is decreasing due to the following trends:

- Reducing average lighting power density;
- Reducing average monitor energy consumption;
- Conversion of desktop computers to laptop computers; and
- Minimum efficiency improvement for office equipment under Minimum Energy Performance Standards (MEPS).

While the overall energy intensity of office tenancies is predicted to decrease between 2020 and 2030, the proportional distribution of energy consumption is unlikely to change drastically. This is because the largest energy consumers – namely lighting and equipment covered by MEPS such as monitors and computers – are exactly where energy performance improvements are anticipated – see Figure 3.

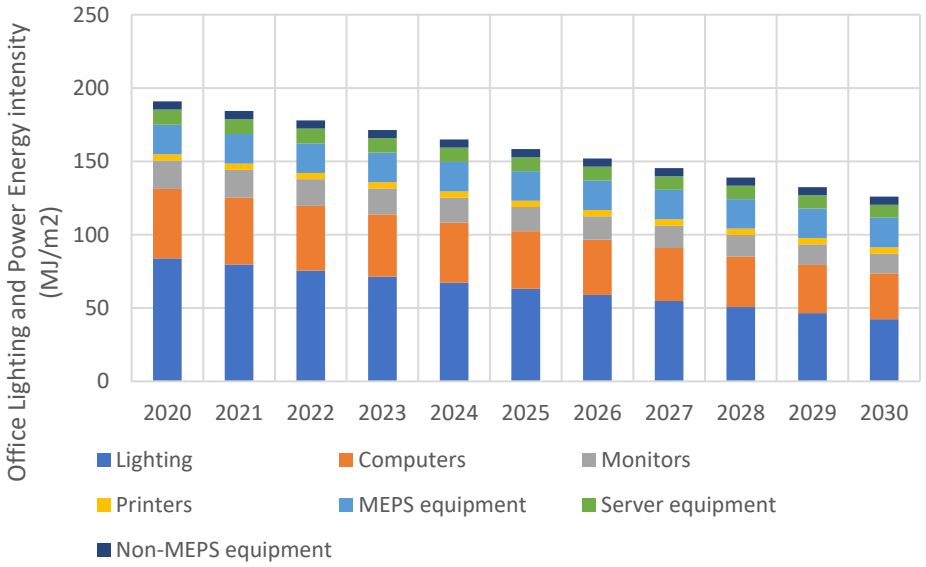

Figure 3: Office tenancy lighting and power end use energy intensity changes over time

For example, it was found that lighting system upgrades and computer monitor for energy performance improvements present the two biggest opportunities for reducing energy consumption in office tenancies in Australia, offering energy reductions of 22% and 8% respectively over the decade.

Conclusions and recommendations for office tenancies

The research in this project demonstrates that there is considerable opportunity for improving the energy performance of office tenancies, even in leading CitySwitch signatories. In particular, the research suggests that there are two leading opportunities for improving energy performance in office tenancies: lighting and monitors.

Further, for office tenancies with supplementary HVAC, this also proved to be able to have a considerable power draw. Existing federal and jurisdictional policies and programs can help office tenancies unlock savings associated with this equipment, and additional or expanded funding, financing or support programs may support additional improvements.

Importantly, the research demonstrates that there is limited data available relating to energy consumption from supplementary HVAC in office tenancies. More data is needed to facilitate a greater understanding of these systems, thereby enabling more informed decisions to be made on how to reduce the energy intensity of these services. Programs that support the estimation and/or sub-metering of HVAC and server equipment should be encouraged.

The energy consumption of server, network and other telecommunication equipment is another area where additional research could prove useful for identifying energy performance improvement opportunities.

For office tenancies to realise these opportunities, the EEC recommends that they:

1. Upgrade low performing lighting to LEDs as a priority as lighting is the single largest opportunity to improve energy performance in office tenancies;
2. Estimate and/or undertake sub-metering of supplementary HVAC to determine load and the potential for energy performance improvements;
3. Explore the opportunity to move servers to offsite high energy performance data centres and review cooling requirements for servers that must remain onsite;
4. Review procurement guidelines for office equipment, especially monitors and computers, ensuring that only high performing office equipment is purchased;
5. Explore the opportunity to use energy efficiency obligation and environmental upgrade finance (EUF) schemes – which are available in some jurisdictions – to upgrade lighting and HVAC; and
6. Explore the opportunity to use energy efficiency obligation schemes – which are available in some jurisdictions – to upgrade monitors and other office equipment.

These recommendations are incorporated into the business-focused *Navigating a dynamic energy landscape: a briefing for office-based businesses* that the EEC and CitySwitch are using to directly engage with office tenancies.

Tenancy actions

Office-based businesses, including office tenancies, are encouraged to follow a three-step action plan:

1. Reach out:
    - Join CitySwitch to access one-on-one support and a network of like-minded businesses
    - Contact your local council or industry association for resources and support
    - Connect with your landlord to explore opportunities
2. Begin their energy management journey by:
    - Starting with what can be seen
    - Benchmarking performance with a NABERS Energy rating
    - Adopting energy management as a discipline
3. Continue their sustainability journey:
    - Achieve carbon neutrality
    - Explore other sustainability opportunities

1 Introduction

An independent review of the Commercial Building Disclosure (CBD) Program was conducted for the Commonwealth Department of Energy, Science, Industry and Resources (DISER) in 2019. The draft report for the review, released in October 2019, stated:

> *"…if compliance costs can be minimised through co-assessments and a requirement for ratings every second year (rather than every year), expanding mandatory disclosure requirements to office tenancies could deliver a net benefit to the community. We estimate that these benefits could be around $61 million in net present value terms (using a discount rate of 7 per cent) over ten years."*[1]

Acknowledging this potential, it should be noted that there is a diminished pool of energy consumption data for office tenancies as compared with base buildings. Only 358 office tenancies received NABERS Energy ratings in FY20, 188 of which were NABERS Co-Assess ratings. This is compared with the 1,189 office base buildings that received NABERS Energy ratings in the same period.

Moreover, energy consumption data, as presented in NABERS ratings and most other benchmarks, only reflects the *overall* consumption of office tenancies, rather than *disaggregated* consumption broken down by different types of equipment – e.g. lighting, computers, supplementary HVAC, etc. Additionally, NABERS tenancies ratings are often provided through the NABERS Co-Assess process,[2] meaning that little to no engagement is had with the tenant.

The lack of energy use data that is broken down for office tenancies makes it difficult to estimate the real benefits of improving energy performance among office tenancies. Matched with the already small pool of actively engaged office tenancies, it can be difficult to empower these consumers to invest in energy efficiency opportunities.

This research project has been undertaken to provide the following information to DISER to support improving the energy performance of the office tenancies sector:

- The proportion of office building energy use attributable to office tenants;
- The proportion of office tenants' energy use attributable to lighting, supplementary HVAC and plug-load;
- The breakdown by average value and energy intensity of office tenants' energy use attributable to lighting, supplementary HVAC and plug-load energy use, broken down by office equipment type; and
- Expected changes in office tenancy energy use from 2020 to 2030 and the relative size of energy saving opportunities for office tenancies.

Note: The bulk of this research was completed between July and November 2020. In April 2021, once the relevant data was collected, additional research was completed to determine the proportion of an office tenancy's energy consumption attributable to supplementary HVAC.

[1] Centre for International Economics (CIE), The 2019, *Draft Report: Independent review of the Commercial Building Disclosure Program*, Centre for International Economics, Canberra, Australia.
[2] NABERS Co-Assess ratings made up 188 of the 358 NABERS Energy for tenancies ratings in FY20.

2 Literature review

At the commencement of this project, a literature review was undertaken to:

1. Find existing energy use breakdown data and/or sub-system consumption data in office tenancies, which was designed to be used either as assumptions for the modelling or validation of the research results; and
2. Assess the methodologies used in similar research projects to validate the chosen methodology and results, as well as to provide guidance regarding future research opportunities, particularly in terms of plug metering and sub-metering in office tenancies.

This section provides an overview of existing publications and literature on disaggregated energy consumption in office tenancies and offices more broadly both in Australia and globally.

2.1 Australian research

The most relevant research on office tenancy energy use in Australia is the *Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia* report, published by the then Department of Climate Change and Energy Efficiency in 2012.[3] This research created a bottom-up model of energy use and greenhouse gas emissions associated with commercial buildings in Australia for the period from FY99 to FY20, with FY09 as the base year.

This research used a combination of energy audit data, NABERS Energy rating data, data from building owners and managers, including government agencies, and other publicly available data to develop overall energy intensity and end-use intensities, and projected these figures to FY20. According to this study, the average energy intensity of an office tenancy in Australia was around 385 MJ/m^2 per annum in the base year of 2009. It was found that the average office tenancy energy intensity only saw a very weak downward trend from FY99 to FY09.

An end use energy breakdown was also developed in this study and is presented in 4. It was found that lighting accounted for 37% of electricity use in office tenancies, followed by 31% from total equipment. Supplementary HVAC accounted for 18% of electricity use in office tenancies, and other electrical processes accounted for 11%, although the coverage of this last category is unclear from the report. It was not possible to construct significant time series trends for energy end use; therefore, the data presented in Figure 4 represents averages over the period 1999 to 2012.

[3] pitt&sherry 2012, *Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia*, Department of Climate Change and Energy Efficiency, Canberra, Australia.

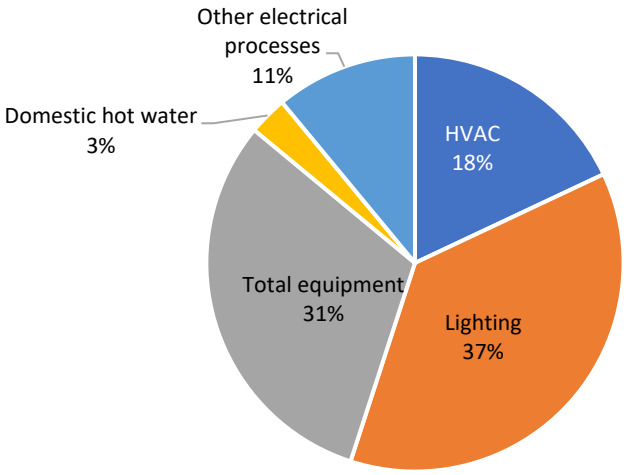

Figure 4: Office tenancies electricity end use breakdown developed for the period 1999-2012

2.2 International research

Menezes et al. conducted a study that estimated the energy consumption and power demand of small power equipment in UK office buildings in 2014.[4] This study adopted two methodologies: random sampling of monitored data, and a bottom-up model. The study achieved a good correlation between metered consumption and modelled consumption. The bottom-up modelling methodology estimated the energy consumption of small office equipment by estimating its operating hours, operating mode and power draw for each mode. The energy consumption modelled and validated for office equipment and catering equipment in this study was between 30 kWh and 40 kWh per m^2 per annum, which is equivalent to between 108 MJ and 144 MJ per m^2 per annum.

Sarfraz and Bach conducted a study in 2018 in the US that developed weekday and weekend power consumption profiles for different office equipment.[5] In addition, load factor profiles were developed for typical office spaces and were compared against the peak load factors listed in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *Handbook of Fundamentals* (2017). Recommendations for the minimum number of testing days necessary to obtain the equipment peak heat gain were also made. It was found that one week of equipment testing provides estimated office load factor profiles with a normalised root mean square error (RMSE) of below 5%.

Hafer from Stanford University in the United States conducted a study in 2017 titled "*Quantity and electricity consumption of plug load equipment on a university campus*".[6] This study collected equipment-level data and developed an inventory on 55 types of office equipment, which involved visiting every room in a total of 220 buildings on campus. The energy consumption was applied to a total of 110,529 pieces of equipment to estimate aggregate energy consumption and the underlying energy use breakdown. The study found:

- The equipment density was 13.9 devices per thousand square feet in office space, which is equivalent to 0.15 devices per m^2. The electricity consumption of this office equipment accounted for approximately 32% of the energy use of the 220 buildings included in the inventory;

[4] Menezes, AC, et al 2014, "Estimating the energy consumption and power demand of small power equipment in office buildings," *Energy and buildings,* pp. 199-209.
[5] Sarfraz, O & Bach, CK 2018, "Equipment power consumption and load factor profiles for buildings' energy simulation (ASHRAE 1742-RP)," *Science and Technology for the Built Environment,* pp. pp. 1054-1063.
[6] Hafer, M 2017, "Quantity and electricity consumption of plug load equipment on a university campus," *Energy Efficiency*, pp. 1013-1039.

- Energy consumption for the 'computers and monitors' category was found to be 3.64 kWh per square feet per annum (which equates to approximately 39 kWh per m^2 per annum), representing 36% of the plug load electricity consumption captured in this study. Servers were found to account for 60% of the total consumption in this category;
- The top three energy end uses found in the 'kitchen equipment' category were refrigerators, coffee machines and personal refrigerators;
- 'Printers and scanners' were listed as a separate category, and it was found that there were 0.43 printers per occupant in office buildings; and
- Overall, the study found that the average plug load energy use intensity was approximately 4.72 kWh per square feet per annum (51 kWh per m^2 per annum) in office buildings on campus.

Moorefield et al. conducted an office plug load field monitoring study in 2008 in the US using a plug-metering approach.[7] The team visited 47 different office building sites, inventoried a total of 6,943 plug load devices and metered a total of 430 devices. It was found that plug loads consumed about 30% of total office electricity in the sites that participated in the study. Computers and monitors were found to account for 66% of all plug load consumption followed by 17% from office electronics and 17% from small kitchen equipment. The energy intensity for office plug-load equipment was estimated to be 2.19 kWh to 3.58 kWh per square feet per annum. This is equivalent to 23.5 kWh to 38.5 kWh per m^2 per annum. More detailed annual energy consumption for different types of office equipment at different modes were also presented in this study.

2.3 Lessons from the literature review

Limited research has been completed on energy end use breakdown in office tenancies, particularly in Australia. Variability between base building and tenancy equipment and systems in different countries means that the energy use breakdown developed by researchers from outside Australia may not be directly comparable to the Australian context. However, some of the research results are still especially useful for this research - particularly in relation to the energy use by office equipment.

The bottom-up modelling methodology that is being used for the research outlined in this report is similar to those used in the Menezes et al. and the Hafer studies. The Hafer study inventoried equipment data on Stanford University's campus and developed an energy use breakdown using inventory data, whereas this study is using a tenancy survey to collect equipment data and will construct an energy use breakdown model using the survey results.

The energy intensity figures in the Menezes et al. and Hafer studies are a particularly useful guide, enabling the results from the study to be validated against these figures. The 2012 Commonwealth Government study provides a snapshot of energy intensity in office tenancies in 2012. Although it was not possible to develop the energy use breakdown in office tenancies in 2012 due to lack of data, the average energy use breakdown from 1999 to 2012 still provides a good benchmark with which to compare results from this study. The energy intensity figures for office equipment developed from actual metering in the Moorefield, Frazer & Bendt study and the Menezes et al. study also provides us with reference figures for comparison, assuming the usage patterns of office equipment are similar between the US, UK and Australia, which have equivalent socio-cultural demographics.

Another useful lesson from the literature review is for the plug-metering methodology, if this approach is to be used in future research. Sarfraz and Bach's study suggested that the minimum equipment testing period needs to be one week to reduce the sampling variance and improve the accuracy of results. Specifically, in relation to computer monitors, it was also found that increasing the number of monitors to be metered from five to ten can greatly improve the accuracy of the results.

[7] Moorefield, L, Frazer, B & Bendt, P 2008, *Office Plug Load Field Monitoring Report*, ECOS Consulting, California, US.

3 Methodology

On behalf to the Energy Efficiency Council, Strategy. Policy. Research. previously undertook a review of suitable methodologies for determining the requirements of this research report. The preferred methodology from the *Office Tenancy Energy End-Use Trends: Methodology Report* was used to conduct this research. This methodology involved data collection, a tenancy survey and data analysis, and modelling, with limited sub-metering to validate the results of the survey and modelling.[8]

A tenancy survey with a total of 43 questions was designed by the EEC, with the support of CitySwitch, NABERS and Point Advisory. The tenancy survey poses questions in relation to the tenancy's energy management practices, together with an equipment count. Survey responses, in particular the equipment count information, were used to build a bottom-up energy use model for each individual tenancy.

The modelled energy consumption was then validated against NABERS rated energy consumption or indicative NABERS rating energy consumption, which have been validated by CitySwitch. A total of 27 valid survey responses were received, and the sampling margin of error based on the number of valid responses is approximately 14%.

Details of the methodologies used in this project are documented below along with a summary of limitations and the data sources.

3.1 Methodology for base building and tenancy energy consumption split

The energy consumption split between base building and tenancies was developed based on energy intensity data in NABERS Energy ratings. The following assumptions were made to develop this consumption split:

- Since it is not the intention to estimate the total energy consumed by base buildings and tenancies in Australia, the building stock used for this study is limited to buildings that undertook certified NABERS Energy ratings in FY20 rather than the whole office building stock. The total office net lettable area (NLA) included in this study was approximately 16 million m^2, which is the total rated area for NABERS base building ratings;
- The base building energy consumption for the building stock in this research is taken directly from the NABERS Energy rating data; and
- The tenancy energy consumption for the building stock in this research is estimated using the total rated area in base building ratings and tenancy energy intensity data from available NABERS tenancy rating data. The total tenancy area was assumed to be the same as the total rated area in base building ratings; the tenancy energy intensity in a particular building was assumed to be the average of available tenancy energy intensity figures in that particular building identified by "Premises ID". If this figure was not available, the tenancy intensity was assumed to be the average energy intensity in that state.

3.2 Methodology for tenancy energy use breakdown development

3.2.1 Methodology summary

The EEC previously contracted Strategy. Policy. Research. to undertake a methodological review of options for determining the energy use breakdown in office tenancies. The preferred methodology put forward by the Strategy. Policy. Research. review – and adopted in this research project – involves implementing a combination of NABERS and Tenant Lighting Assessment (TLA) data collection and analysis, tenancy surveys and analysis, and energy

[8] The legal frameworks necessary to collect and use sub-metered energy consumption data proved to be an insurmountable hurdle to achieving the validation of the supplementary HVAC loads. As an alternative validation method, Property NSW undertook a review of a number of office tenancies' server rooms energy consumption, and the data collected as part of this was used to estimate the proportion of an office tenancy's energy consumption attributable to supplementary HVAC, when present.

data modelling. Tenancy surveys were used to develop an inventory of office equipment data in office tenancies. An energy data model was then developed using typical annual energy consumption for each type of equipment identified in the tenant surveys. The three major energy use categories in office tenancies were defined as lighting, office equipment and supplementary HVAC. The energy use modelling approach is presented below and illustrated in Figure 5.

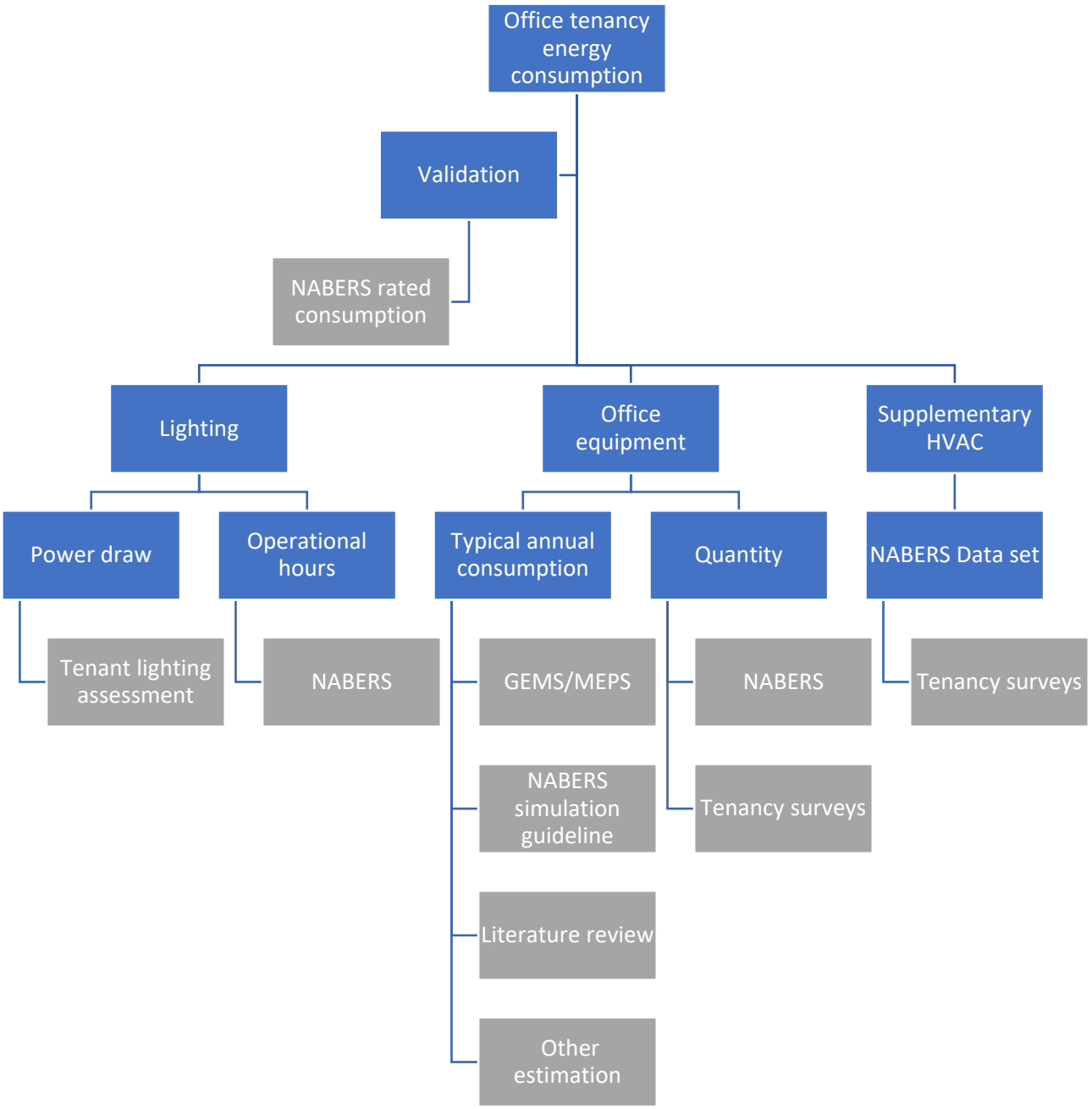

Figure 5: Tenancy energy use breakdown development methodology

3.2.2 Modelling approach

3.2.2.1 Lighting

The power draw of the lighting system was based on the lighting power density in the TLA data, and the operational hours were based on NABERS rated hours.

3.2.2.2 Office equipment

Two inputs were needed to model the energy consumption of office equipment: the quantity and the typical annual energy consumption of the equipment. The quantity of office equipment was taken directly from the tenancy surveys, with the typical energy use consumption of certain office equipment being based on one of the following approaches:

- Product registration database under Greenhouse and Energy Minimum Standard (GEMS) Act 2012;[9]
- Relevant Minimum Energy Performance Standards (MEPS) for certain equipment;[10]
- NABERS simulation guidelines V1.1-February 2019;[11]
- Literature review; and
- Other estimation methods.

3.2.2.3 Supplementary HVAC

Supplementary HVAC is for special tenant air-conditioning needs, often relating to meeting rooms and server rooms for which the heating or cooling load is more than what the base building's HVAC system was designed. During the design of the tenancy surveys, there was a concern that the office manager may not know all the details of supplementary HVAC and its operation schedules. As such, the energy use breakdown between office lighting, plug load from equipment and supplementary HVAC was not developed based on survey responses. Instead, electricity account information records in the NABERS Energy office tenancy ratings were used to develop this breakdown. However, only five tenancy ratings were found to have separate electricity accounts for supplementary HVAC in addition to main lighting and general power, i.e. equipment, accounts.

Note: In April 2021, once the relevant data was collected, additional research was completed to determine the proportion of an office tenancy's energy consumption attributable to supplementary HVAC.

In March and April 2021, nine tenancies with supplementary HVAC in server rooms were reviewed as part of an assessment of the impact of the energy use and energy opportunities within these spaces. The sites - from across metropolitan and regional NSW – did not have any sub-metering of their server rooms, or other end use equipment in the tenancy.

Based on the operational hours and the equipment nameplates, as well as the below assumptions, the expected load attributed to the server rooms' supplementary HVAC was estimated.

HVAC total kW nameplate

The HVAC load was estimated by the equipment kW nameplates; these nameplates provided the nominal power consumption on KW for the equipment. For the types of air conditioning units onsite, the energy between the fan (tend to be a small constant load) and the condenser (tend to be a larger modulating load) was split.

[9] Greenhouse and Energy Minimum Standards Regulator 2020, *Energy Rating Registration* Database, accessed 15 June 2020, <https://reg.energyrating.gov.au/comparator/product_types>.
[10] Standards Australia 2012,A. *5813.2:2012:*, *Minimum energy performance standards (MEPS) for computers*, Standards Australia, Sydney, Australia, 2012.
[11] Office of Environment and Heritage 2019, *Handbook for estimating NABERS ratings*, NABERS, Sydney, Australia.

Annual load

The load of the server rooms was assumed to be constant throughout the year. Server rooms typically operate 24/7, and as unoccupied spaces, generally have a reasonably constant thermal load. Conversely, supplementary HVAC in meeting rooms do not have a constant load, and therefore were not considered appropriate for estimation.

Duty cycle

The duty cycle is the percentage of time that the HVAC operates at its kW nameplate, which was split into two components: fans and condensers. The relative duty cycle applied to the components was:

- **Fans = 100%**
  Fans are expected to operate 100% of the time, and thus their duty cycle is 100%
- **Condensers = 20-50%**
  Condensers are expected to operate between 20% to 50% of the time.[12]

Individual server room HVAC annual energy

The HVAC annual energy for each server room was calculated based on the below formula, noting that annual hours is 8760 hours/year:

$$Eserver\ room = H(Pfan \times D + Pcon \times D)$$

Where:

- $Eserver\ room$ – annual HVAC energy of individual server room (kWh)
- H – time (hours)
- $Pfan$ – nameplate power consumption of fan (kW)
- $Pcon$ – nameplate power consumption of condenser (kW)
- D – duty cycle (%)

Total site server room supplementary HVAC annual energy

Four of the nine tenancies contained multiple server rooms with supplementary HVAC; for these tenancies the individual server rooms' annual energy was summated to estimate the supplementary HVAC load of the total tenancy.

Office tenancy annual energy consumption

Due to the lack of onsite submetering, only whole building (base + tenant) energy data (kWh) was available. From the whole building energy consumption, the office tenancies' consumption was calculated based on a proportion of the whole building.[13]

Supplementary HVAC as a proportion of the office tenancies' annual consumption

The estimated total site server room supplementary HVAC annual energy was divided by the estimated office tenancy annual energy consumption to determine the proportion of the office tenancies' annual energy consumption.

[12] The variance is due to the size of the HVAC equipment when compared with the thermal load of the server room. For example, where there is a large condenser servicing a small server room, a 20% duty cycle has been applied as the larger unit runs less frequently.
[13] The methodology utilised for determining the breakdown between base building and tenancy energy consumption is outlined in Section 3.1.

3.2.3 Tenancy surveys

Tenancy surveys were used in this project to collect relevant tenancy data for the purpose of energy data modelling. The survey covers five areas, with the purpose and main questions asked in each section presented below. A copy of the complete tenancy survey is included in Appendix 2.

3.2.3.1 Site identification

This section asked tenants about the location of their tenancies to identify the tenancy and subsequently match survey responses with existing NABERS Energy data.

3.2.3.2 Basic information

This section aimed to identify basic characteristics of each office tenancy. Questions included whether they were CitySwitch members, if they had received a NABERS Energy rating before, what their building type is, where the tenancy is located, whether there is a data centre or servers in the tenancy and/or if there is supplementary HVAC.

3.2.3.3 Energy management practice

This section aimed to find out where the tenants are on their energy management improvement journey – from novice to advanced – and what steps they have taken to improve their energy performance. CitySwitch will use this data to provide tenants with tailored advice in the future.

2.2.3.4 Office equipment counts

This section is integral to the study as it surveyed tenants about the quantity and energy performance (if applicable) for each type of office equipment in their office tenancy. This data was then used to build an energy use breakdown for each tenancy to compare the aggregated energy consumption against NABERS rated consumption for validation.

3.2.3.5 Other information

Tenants were invited to provide additional information (if available) like asset registers and energy audit reports to compliment surveyed data.

3.2.4 Methodology for estimating typical annual energy consumption of equipment

The listed sources in Table 1 were used to estimate the typical annual energy consumption of office equipment. A full list of office equipment and its associated estimated annual consumption is included in Appendix 1.

Table 1: Office equipment typical annual energy consumption estimation methods

Office equipment	Typical annual consumption source	Modelling method
Desktop computers	AS/NZS 5813.2:2012 Information technology equipment-Energy performance of computers Part 2: Minimum energy performance standards MEPS for computers (Standards Australia 2012)	Annual consumption based on Category A, base category, base requirements only.
Laptop computers	AS/NZS 5813.2:2012 Information technology equipment-Energy performance of computers Part 2: Minimum energy performance standards MEPS for computers (Standards Australia 2012)	Annual consumption based on Category A, base category, base requirements only.
Computer monitors	*Energy Rating Registration Database* (GEMS 2020)	Annual energy consumption based on size and energy star bands

Office equipment	Typical annual consumption source	Modelling method
Dishwashers	*Energy Rating Registration Database* (GEMS 2020)	Annual energy consumption based on size and energy star bands
Fridges	*Energy Rating Registration Database* (GEMS 2020)	Annual energy consumption based on size and energy star bands
Televisions	*Energy Rating Registration Database* (GEMS 2020)	Annual energy consumption based on size and energy star bands
Printers and multifunctional devices	Online search: Energy star data cross-validated by using operational profiles from Menezes's study (Menezes 2014) and operating power draw from *Handbook for estimating NABERS ratings* (OEH 2019)	Annual energy consumption based on size and type
Coffee machines	Literature review (Hafer 2017)	N/A
Task lamps	Literature review (Moorefield, Frazer & Bendt 2008)	N/A
Portable fans	Literature review (Hafer 2017)	N/A
Microwaves	*Handbook for estimating NABERS ratings* (OEH 2019)	Assuming one hour of operation per weekday per unit
Ovens	*Handbook for estimating NABERS ratings* (OEH 2019)	Assuming one hour of operation per weekday per unit
Toasters	*Handbook for estimating NABERS ratings* (OEH 2019)	Assuming one hour of operation per weekday per unit
Server racks	*Handbook for estimating NABERS ratings* (OEH 2019)	140 W per server room computer (rack), plus 4.5W per computer for all computers in the tenancy
Ziptaps	*Handbook for estimating NABERS ratings* (OEH 2019)	N/A
Portable heaters	Other estimation	Assuming 1kW power draw per unit, operating 8 hours/day for 60 days/year
Kettles	Other estimation	A nominal 100kWh p.a.

3.2.5 NABERS tenancy rating dataset

The FY20 NABERS Energy rating dataset, which contains the ratings certified between 1 July 2019 and 30 June 2020, was used. It is noteworthy that at the time of conducting this research and submitting the draft report – July to November 2020 – Australia was in the midst of the COVID-19 pandemic.

With a nationwide lockdown starting in mid-March 2020, most offices were forced to close. Since then, many workers have not returned to their offices – with Victorians still under work from home orders – and it is likely that the flexibility around working arrangements has been changed permanently. This has certainly had an impact on the energy intensity in office tenancies reported in the FY20 NABERS Energy ratings. However, energy coverage and billing records in these tenancy ratings were provided, and the vast majority of the tenancy ratings only used energy data from before mid-March 2020. It was therefore concluded that FY20 NABERS Energy tenancy rating data could be used to analyse energy intensities in office tenancies under normal operation before the pandemic impacted energy consumption.

3.2.6 Sample size

As the research subject is energy use in office tenancies, energy intensity was used as the metric to assess the variability of energy use in office tenancies and to conduct statistical tests to determine an appropriate sample size.

Table 2 presents key statistics of the energy intensity (MJ/m^2) in the FY20 NABERS Energy rating dataset. As there is a significant discrepancy between the minimum and maximum values, data points with more than three standard deviations above the mean value were considered as outliers.

Table 3 presents the same statistics for the NABERS Energy dataset excluding outliers; Figure 6 presents a histogram of energy intensities.

Table 2: Key statistics of energy intensities (MJ/m^2) in the FY20 NABERS rating data set

Mean	Standard deviation	Minimum	Maximum	Count
297	185	44	2,597	358

Table 3: Key statistics of energy intensities (MJ/m^2) in FY20 NABERS rating data set (excluding outliers)

Mean	Standard deviation	Minimum	Maximum	Count
275	100	44	608	348

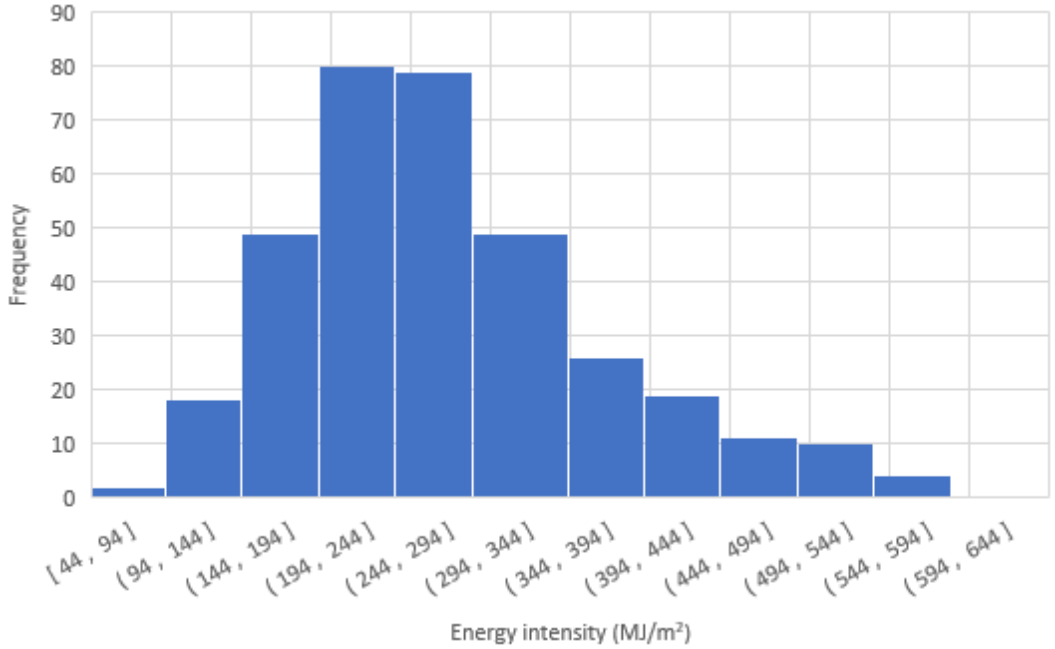

Figure 6: Energy intensity distribution excluding outliers

The following formula was then used to estimate the sample size required to achieve an acceptable margin of error:

$$Margin\ of\ error = t - statistic \times \frac{S}{\sqrt{n}}$$

- t-statistic: t value at n-1 degree of freedom
- S: Standard deviation of energy intensity in NABERS dataset
- n: sample size

Table 4 presents a range of different sample sizes and their associated margin of error. For the purposes of this research, the sampling margin of error was set at 15%, and approximately 14% was achieved.

Table 4: Sample size and margin of error

Sample size	Standard error	Margin of error at 95% confidence level	% of margin of error over mean
5	44.76	124.27	45%
10	31.65	71.60	26%
20	22.38	46.84	17%
30	**18.27**	**37.37**	**14%**
50	14.15	28.44	10%
100	10.01	19.86	7%

3.3 Methodology for modelling of tenancy energy use between 2020 and 2030

To forecast the change of energy use in office tenancies in Australia between 2020 and 2030, the following trends were modelled:

- Average lighting power density decreasing from the current level of 8.9 W/m^2 to 4.5 W/m^2, which is equivalent to the current National Construction Code (NCC) Section J requirement for maximum illumination power density in Class 5 office buildings;[14]
- Average annual consumption per monitor decreasing from the current level of 97 kWh p.a. to 64 kWh p.a. which is equivalent to the current average annual consumption for monitors with an energy rating of 6 stars and above;
- Replacement of all desktop computers with laptop computers; and
- Minimum Energy Performance Standards (MEPS) equipment efficiency improvements at an annual rate of 1.5%, as this represents the previous trend.

All the above changes were expected to be linear between 2020 and 2030.

[14] Australian Building Codes Board 2019, "Maximum illumination power density," *National Construction Code 2019*, Canberra, Australia, p. 378.

3.4 Methodology limitations

The following methodology limitations were noted for this project:

- Supplementary HVAC consumption was not estimated using a bottom-up approach; rather, the share of supplementary HVAC was developed using limited NABERS data;
- Lighting consumption estimates assume 100% lighting load operating during rated hours, with the modelling not considering any lighting controls or out-of-hours operation;
- It was assumed that all surveyed equipment was typically in active use; and
- For the purposes of developing office base building and tenancy energy use splits as well as average energy intensity for different energy end uses, FY20 NABERS Energy tenancy ratings were used as a basis. The actual energy intensity in average Australian tenancies is likely to be higher than this number, because tenancies conducting NABERS ratings are likely to be higher performing than those who do not. As a result, the actual share of energy use in office tenancies across Australia and the average energy intensities are likely to be higher than the findings of this research.

3.5 List of data sources

The following data sources were used for this project:

- FY10-FY20 NABERS office base building and whole building ratings summary data;
- FY10-FY20 NABERS office tenancy ratings summary data;
- TLA data from 2011 to 2020;
- Tenant survey responses; and
- Product registration database under the GEMS Act 2012.

4 Results

4.1 NABERS Energy office ratings summary

Figure 7 presents the total number of NABERS office base building ratings and the associated total rated area from FY10 to FY20. The number of NABERS base building ratings conducted each financial year has been steadily increasing from 312 in FY10 to 1,189 in FY20, while the total rated area increased from approximately 5.7 million m^2 to approximately 16 million m^2 over the same period. A significant increase is evident from FY10 to FY11 when the CBD legislation was introduced.

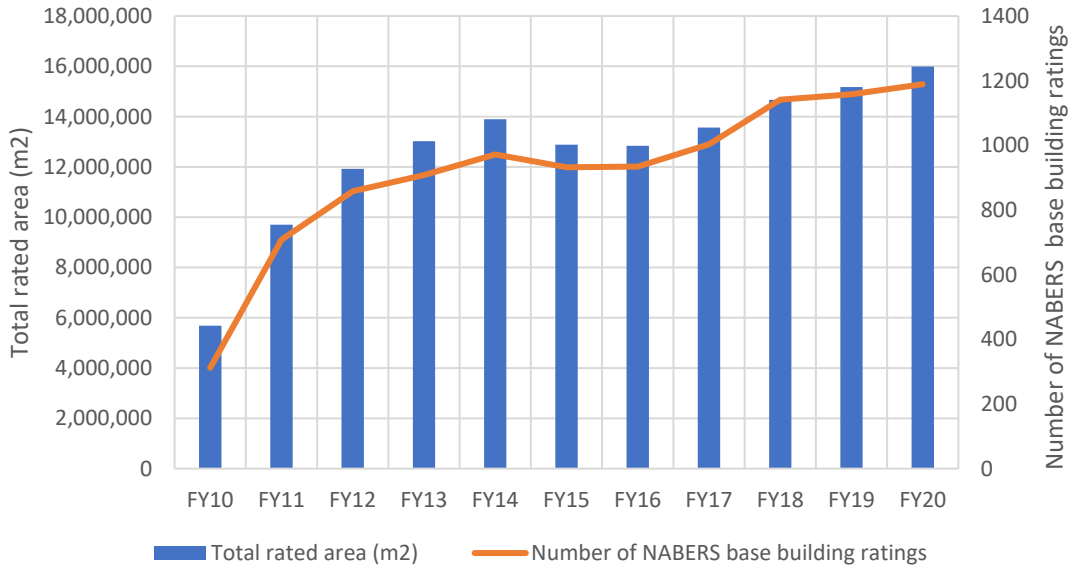

Figure 7: NABERS base building rating uptake FY10-FY20

Figure 8 presents the distribution of NABERS-rated office base building energy intensities from FY10 to FY20. The median energy intensity decreased from 535 MJ/m^2 in FY11 to 365 MJ/m^2 in FY20 while the area-weighted average decreased from 538 MJ/ m^2 to 373 MJ/ m^2, representing a 30% reduction. The trend is mostly evident among buildings with energy intensities in the top 25th percentile, i.e. less efficient buildings.

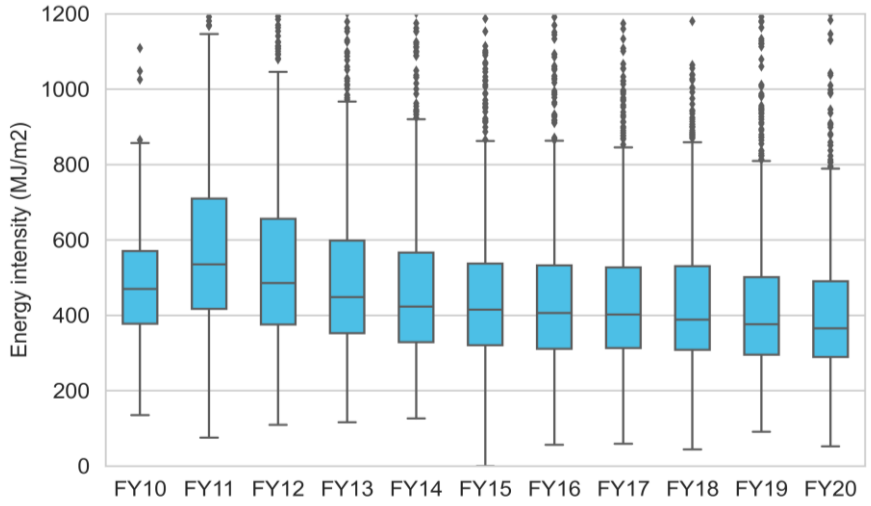

Figure 8: NABERS base building energy intensity changes over time

Figure 9 presents the total numbers of NABERS office tenancy ratings and the associated total rated area from FY10 to FY20. The number of NABERS office tenancy ratings conducted each financial year has increased from 128 in FY10 to 358 in FY20, while the total rated area each year increased from approximately 580,000 m^2 to approximately 2.3 million m^2. There was a notable increase in the number of ratings from 224 in FY19 to 358 in FY20, a nearly 60% increase.

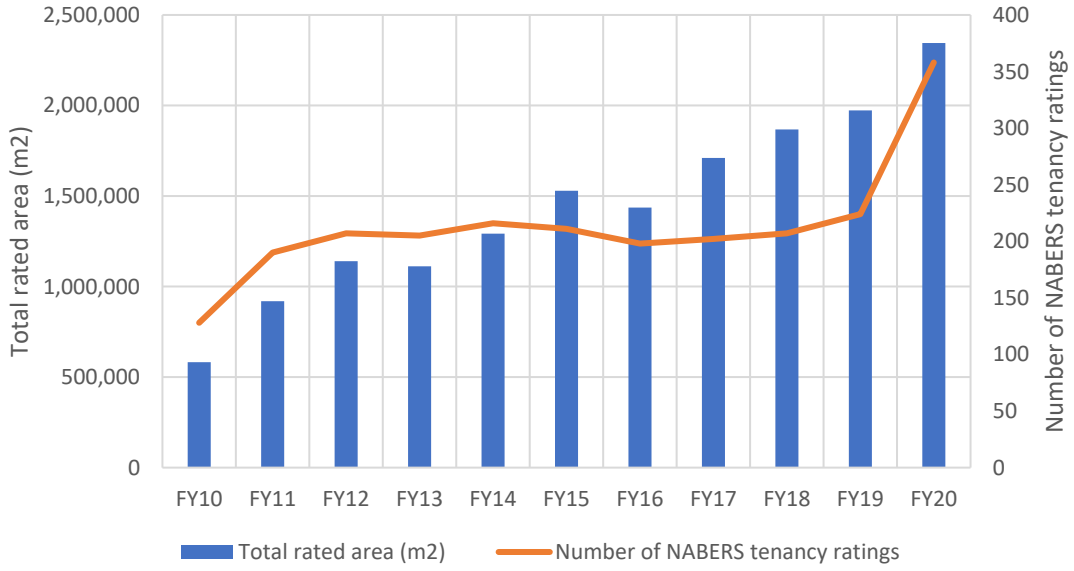

Figure 9: NABERS tenancy rating uptake FY10-FY20

Figure 10 presents the distribution of NABERS-rated office tenancy energy intensities from FY10 to FY20. The median energy intensity decreased from 390 MJ/m^2 in FY11 to 265 MJ/m^2, while the area-weighted average decreased from 469 MJ/ m^2 to 301 MJ/ m^2, representing a 36% reduction. The trend is mostly evident among buildings with energy intensities in the top 25th percentile, i.e. less efficient tenancies.

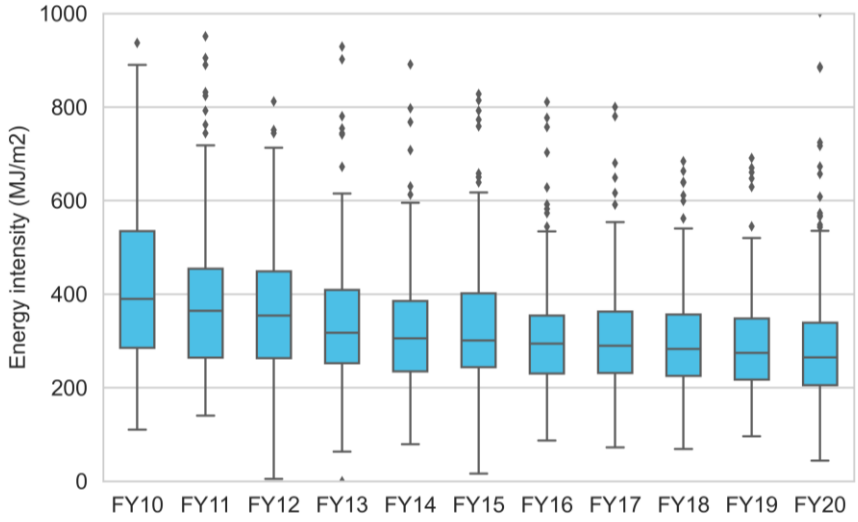

Figure 10: NABERS tenancy energy intensity changes over time

It is estimated that only 2% of total energy consumption comes from gas, meaning that most energy consumed in office tenancies is electricity at 98% of the overall share. This split was developed based on the FY20 NABERS dataset and is presented in Figure 11. Due to the minor share of gas consumption in office tenancies, this study focused only on electricity use.

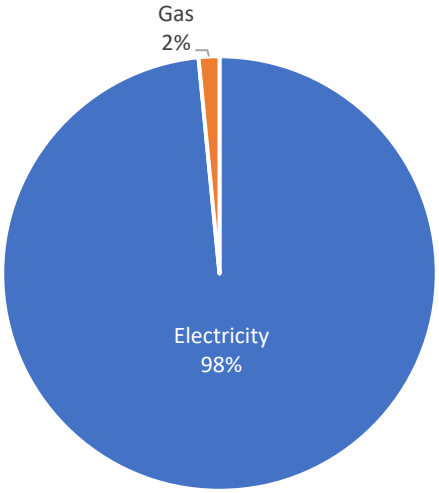

Figure 11: Energy sources in office tenancies

The yearly energy intensity changes for tenancies in each state over the last 11 years is presented in Figure 12. Both New South Wales and Victoria made a significant 40% improvement in energy intensity reduction in office tenancies from FY10 to FY20. The Northern Territory has seen the lowest average energy intensity in office tenancies in FY20; however, the total number of ratings in the NT was only three compared with a total of 143 ratings in NSW in the same period. This means that the figure is not statistically significant and cannot be used as a fair comparison to NSW.

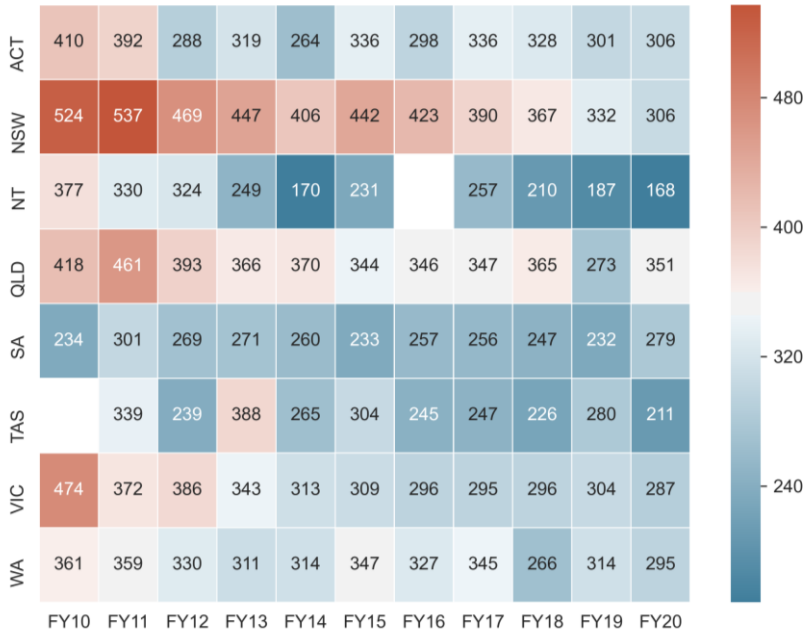

Figure 12: NABERS tenancy area-weighted average energy intensity (MJ/m^2) by states and territories over time

Figure 12 depicts a chart with the area-weighted average energy intensity (MJ/m2) of NABERS rated tenancies by state and territory between FY10 and FY20. Individual boxes for each jurisdiction in each year are colour-coded according to their energy intensity. The overall trend for all jurisdictions is that the average energy intensity decreases over time.

4.2 Tenant lighting assessment results summary

Figure 13 presents the distribution of Nominal Lighting Power Density (NLPD) in office tenancies (as taken from TLAs) since the introduction of CBD legislation in 2011. The median lighting power density per functional space has decreased from 14.9 W/m^2 to 8.6 W/m^2 since 2011. The area-weighted average decreased from 13.6 W/m^2 to 8.8 W/m^2 over the same period.

Figure 14 presents the area weighted average NLPD by states over time. All states have shown significant NLPD reductions from 2011 to 2020. The NLPD in TLAs in 2020 ranges from 7 W/m^2 to 10 W/m^2.

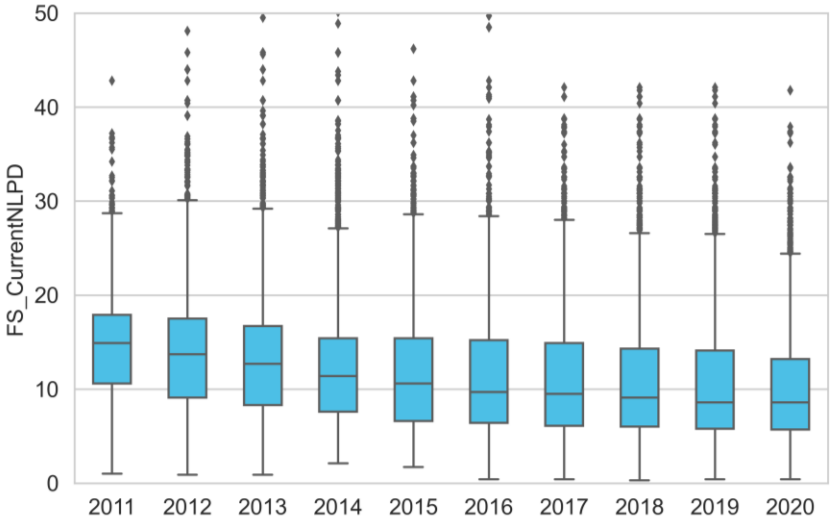

Figure 13: TLA NLPD changes over time (W/m^2)

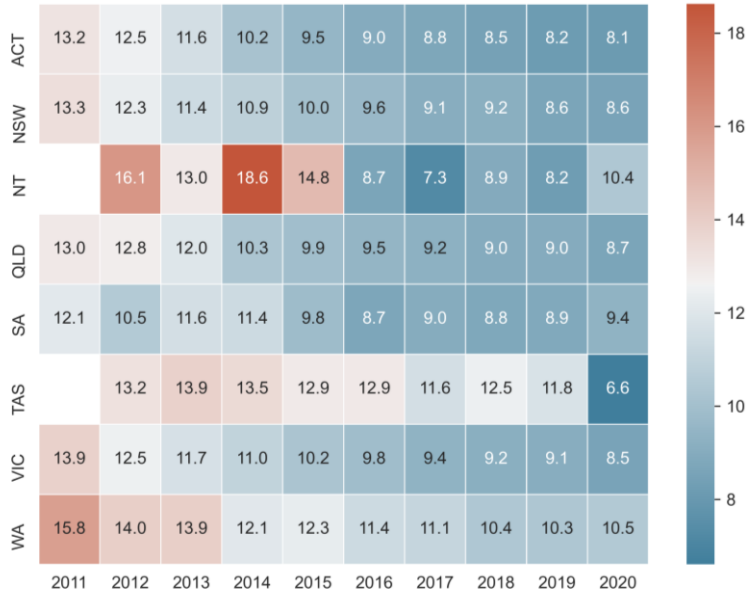

Figure 14: Tenant lighting assessment area-weighted average NLPD (W/m^2) by states and territories over time

Figure 14 depicts the tenant lighting assessment area-weighted average NLPD (W/m2) for each state and territory between 2011 and 2020. Boxes for each jurisdiction for each year are colour-coded according to the NLPD strength. The overall trend is that NLPD decreases from 2011 to 2020 in all jurisdictions.

4.3 Office buildings base building and tenancy energy split

The first key output from the research is the energy use split between base buildings and tenancies. Figure 15 presents the results of this energy use split. Base buildings are estimated to consume 56% of all energy use in office buildings, while tenancies account for the remaining 44%. This energy use split includes both electricity and gas.

The NABERS FY20 dataset was used to develop this energy use split. Compared with base office buildings, comparatively few tenancies have received a rating. As a result, the energy intensity figures from NABERS tenancy ratings have been used to estimate the energy use in *all* office tenancies. This approach is highly likely to underestimate the true energy usage, and share of that usage, in office tenancies, as the NABERS tenancy dataset is likely to contain more high-performing tenancies than the national average. Therefore, the actual average energy use share across all office tenancies is likely higher than 44%.

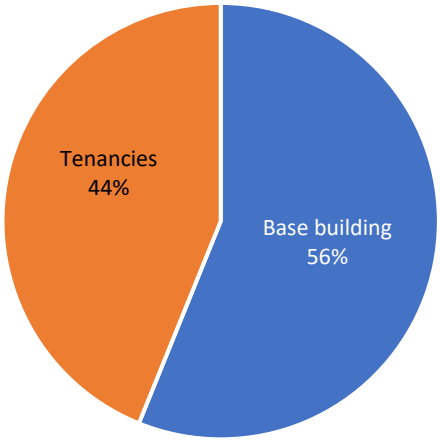

Figure 15: Average office building energy use split across base building and tenancies

4.4 Survey response summary

A total of 27 valid survey responses were received.[15] The key statistics of the energy intensity within the survey group are presented in Table 5. Figure 16 presents the distribution of the survey group against the NABERS FY20 group in the energy intensity histogram.

Table 5: Key statistics of survey responses

Metric	Value
Number of valid responses	27
Mean of sample energy intensity (MJ/m^2)	284
Mean of NABERS dataset energy intensity (MJ/m^2)	275
Minimum sample energy intensity (MJ/m^2)	115
Maximum sample energy intensity (MJ/m^2)	567
Total area (m^2)	31,229

[15] A valid response is a tenancy survey response with either a valid NABERS Energy tenancy rating or an indicative tenancy rating provided by CitySwitch.

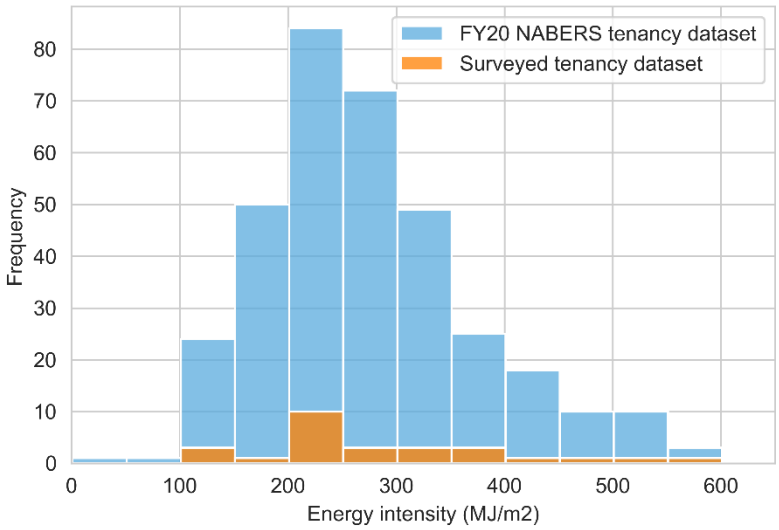

Figure 16: Survey group energy intensity histogram against FY20 NABERS dataset

4.5 Office tenancy energy use breakdown

The second key output of this study is the energy use breakdown in office tenancies. Figure 17 presents an average office lighting and plug load energy use breakdown, without supplementary HVAC, and Figure 18 and Figure 19 present an average energy use breakdown between office lighting and plug load as compared with supplementary HVAC, where supplementary HVAC is present.

In office tenancies where supplementary HVAC is not present, lighting accounts for 44% of all energy use, followed by monitors and computers with a combined total share of 35%.[16] Other office and kitchen equipment make up the balance of 21%. Of that, server equipment accounts for approximately 11% of all tenant power consumption in this study, while printers and multifunctional devices only account for 2%.

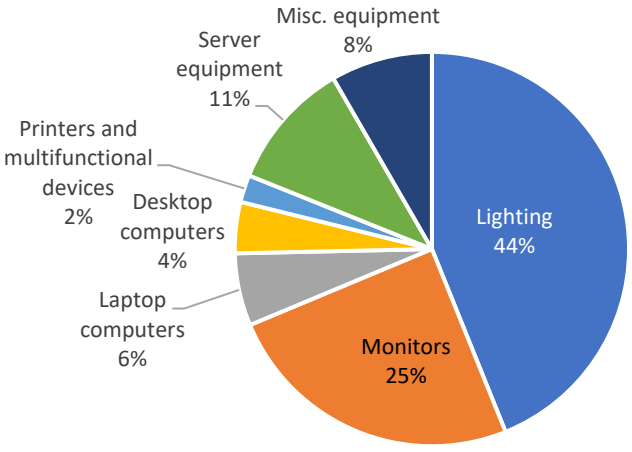

Figure 17: Office tenancy energy use breakdown estimate (without supplementary HVAC)

[16] See the Section 5.5.5 for analysis regarding laptop versus desktop computer energy consumption.

The energy use breakdown between office lighting, plug load and supplementary HVAC was not developed based on survey responses. Instead, electricity account information presented as part of the NABERS Energy tenancy ratings were used to develop this breakdown. Only five tenancy ratings from recent years (2016 – 2019) were found to have separate electricity accounts for supplementary HVAC in addition to main lighting and plug load accounts. Table 6 presents the detailed records of these tenancies with supplementary HVAC. As can be seen, the percentage of supplementary HVAC energy use ranges from 1% up to 79%. The average share of electricity consumption from supplementary HVAC – where supplementary HVAC is present – is approximately 25%.

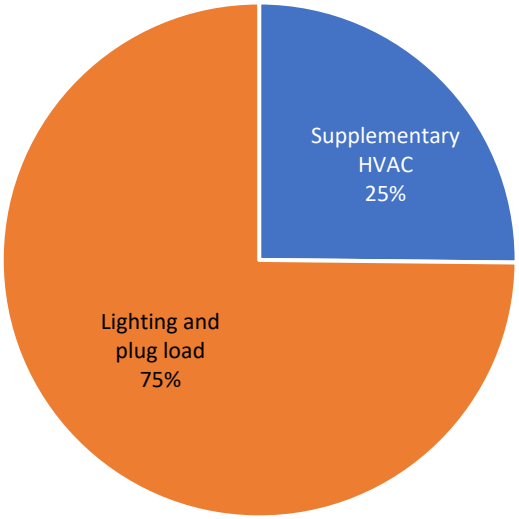

Figure 18: Office tenancy supplementary HVAC consumption estimate from NABERS Energy ratings dataset

Note: In April 2021, once the relevant data was collected, additional research was completed to determine the proportion of an office tenancy's energy consumption attributable to supplementary HVAC.

In March and April 2021, nine tenancies with supplementary HVAC in server rooms were reviewed as part of an assessment of the impact of the energy use and energy opportunities within these spaces. The sites - from across metropolitan and regional NSW – did not have any sub-metering of their server rooms, or other end use equipment in the tenancy.

The estimated load ranged from 3% to 46% of the total tenancies' energy consumption, with an average of 18%.

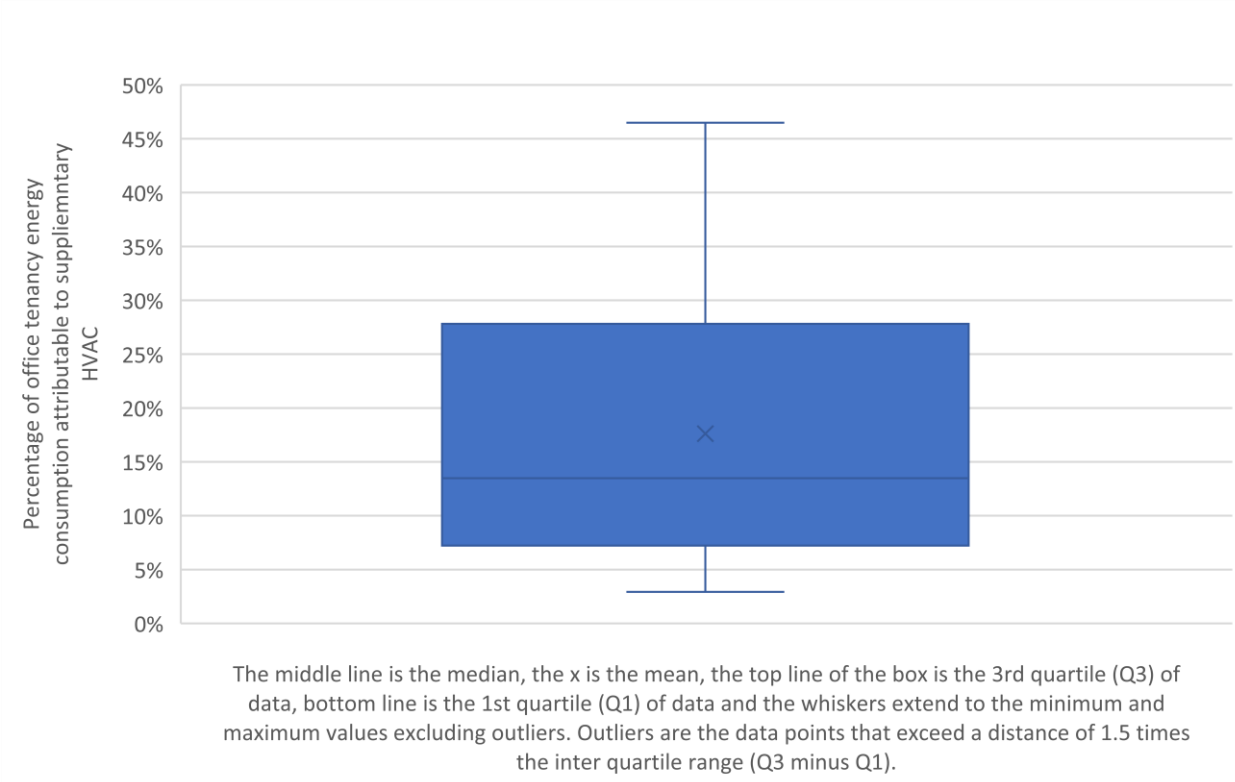

Figure 19: Office tenancy supplementary HVAC consumption estimate from server rooms

Figure 19 depicts a box and whisker plot, in which the middle line is the median, the x is the mean, the top line of the shaded box is the 3rd quartile (Q3) of data, bottom line is the 1st quartile (Q1) of data and the whiskers extend to the minimum and maximum values excluding outliers. Outliers are the data points that exceed a distance of 1.5 times the inter quartile range (Q3 minus Q1).

Table 6: Tenancy supplementary HVAC use from NABERS records

NABERS rating number	Total rated consumption (kWh)	Total supplementary HVAC (kWh)	Supplementary HVAC energy use percentage
N46703	1,541,280	9,461	0.61%
N47739	7,955,592	2,237,764	28.13%
N47766	536,451	425,472	79.31%
N47768	564,018	4,203	0.75%
N51706	100,626	15,009	14.92%
Total	**10,697,967**	**2,691,909**	**25.16%**

Figure 20 presents an overall energy use breakdown for office tenancies in Australia. It was found that within the surveyed group of office tenancies, lighting and equipment accounts for approximately 67% of the total energy use. The balance of the 33% energy is for other uses including supplementary HVAC, data centre equipment and its associated HVAC services, and some end uses that are beyond the scope of office tenancies, for example base building HVAC services connected to an office tenancy meter, or warehouse equipment usage connected to an office tenancy meter. Given the varied nature of the "other energy consumption", much of

the analysis and discussion in this report focuses on the remaining 67% of electricity consumption that comes from lighting and equipment.

It is noted that due to the energy use variability among office tenancies, these results are not intended to be representative of a typical Australian office tenancy. Rather, they are indicative of the overall energy use breakdowns for Australian office tenancies within the tolerance of errors noted in the previous section of this report – see Section 3.4. Specifically, the data points that make up this research have been supplied by CitySwitch signatories, who can reasonably be assumed to be higher performing tenancies due to the nature of CitySwitch being a voluntary program for improving energy and resource efficiency in office-based buildings.

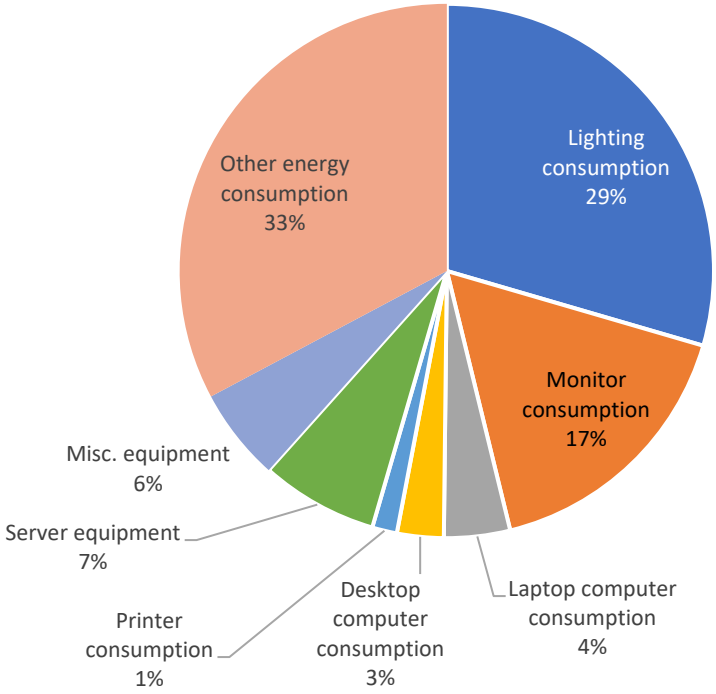

Figure 20: Overall average office tenancy energy use breakdown

Based on the results of energy use breakdown in the survey group, Table 7 presents the average energy intensity (MJ/m^2) for each energy end use category per annum.

Table 7: Average energy intensity of different office tenancy end uses per annum

Energy end use	Average energy intensity (MJ/m²)	Percentage
Lighting	84	29%
Monitors	47	17%
Laptop computers	11	4%
Desktop computers	8	3%
Printers and multifunctional devices	4	1%
Server equipment	20	7%
Misc. equipment	16	6%
Others	93	33%
Total	**284**	**100%**

4.6 Modelling of office tenancy energy use between 2020 and 2030

Using the energy use breakdown developed previously, the energy use changes between 2020 and 2030 were modelled by incorporating the following trends:

- Average lighting power density change from 8.9 W/m² to 4.5 W/m²;
- Average monitor consumption reduced from 97 kWh p.a. to 64 kWh p.a. per monitor;
- Conversion of desktop computers to laptop computers; and
- Minimum efficiency improvement for office equipment under MEPS.

Refer to the metrics used to do this in Section 3.3.

Figure 21 and Table 8 show this change over time. The total office lighting and equipment energy is expected to decrease by 34% from the current 191 MJ/m² to approximately 126 MJ/m² in 2030. Most of the energy intensity reduction will come from lighting energy intensity improvements, followed by energy intensity improvements in monitors. Figure 22 presents the general office lighting and power breakdown comparison between 2020 and 2030. As the lighting consumption share decreases, it is expected that the consumption percentage of server equipment and other office equipment will increase.

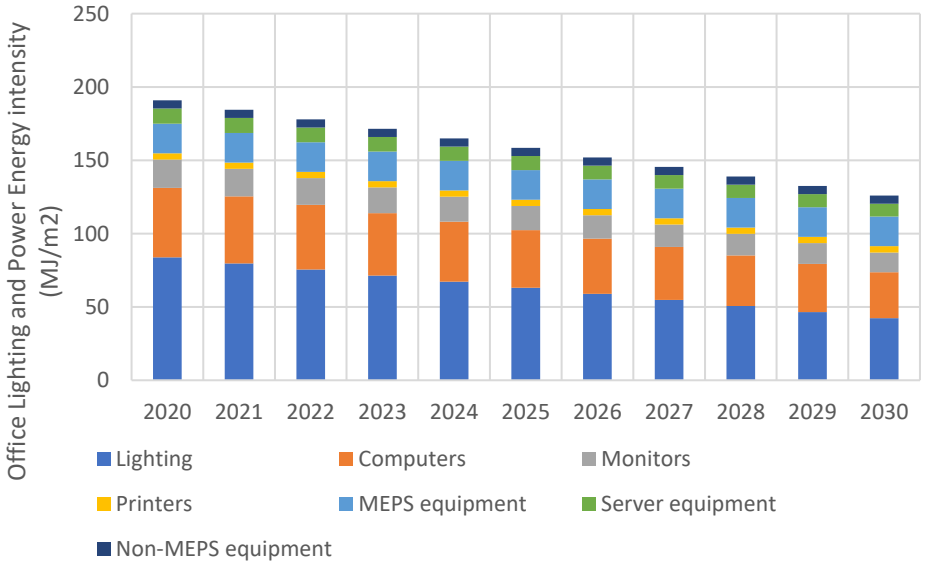

Figure 21: Office tenancy lighting and power end use energy intensity changes over time

Table 8 presents yearly energy intensity changes for each end use over the period from 2020 to 2030.

Table 8: Tenancy average energy intensity modelling from 2020 to 2030

Energy end use	Average energy intensity (MJ/m^2)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Lighting system	84	84	80	76	71	67	63	59	55	51	47	42
Computers	19	19	19	18	18	17	16	16	15	15	14	14
Monitors	47	47	46	44	43	41	39	38	36	34	33	31
Printers and multifunctional devices	4	4	4	4	4	4	4	4	4	4	4	4
MEPS equipment	10	10	10	10	10	10	10	9	9	9	9	9
Server equipment	20	20	20	20	20	20	20	20	20	20	20	20
Non-MEPS equipment	6	6	6	6	6	6	6	6	6	6	6	6
Total lighting and power	**191**	**191**	**184**	**178**	**171**	**165**	**158**	**152**	**145**	**139**	**132**	**126**

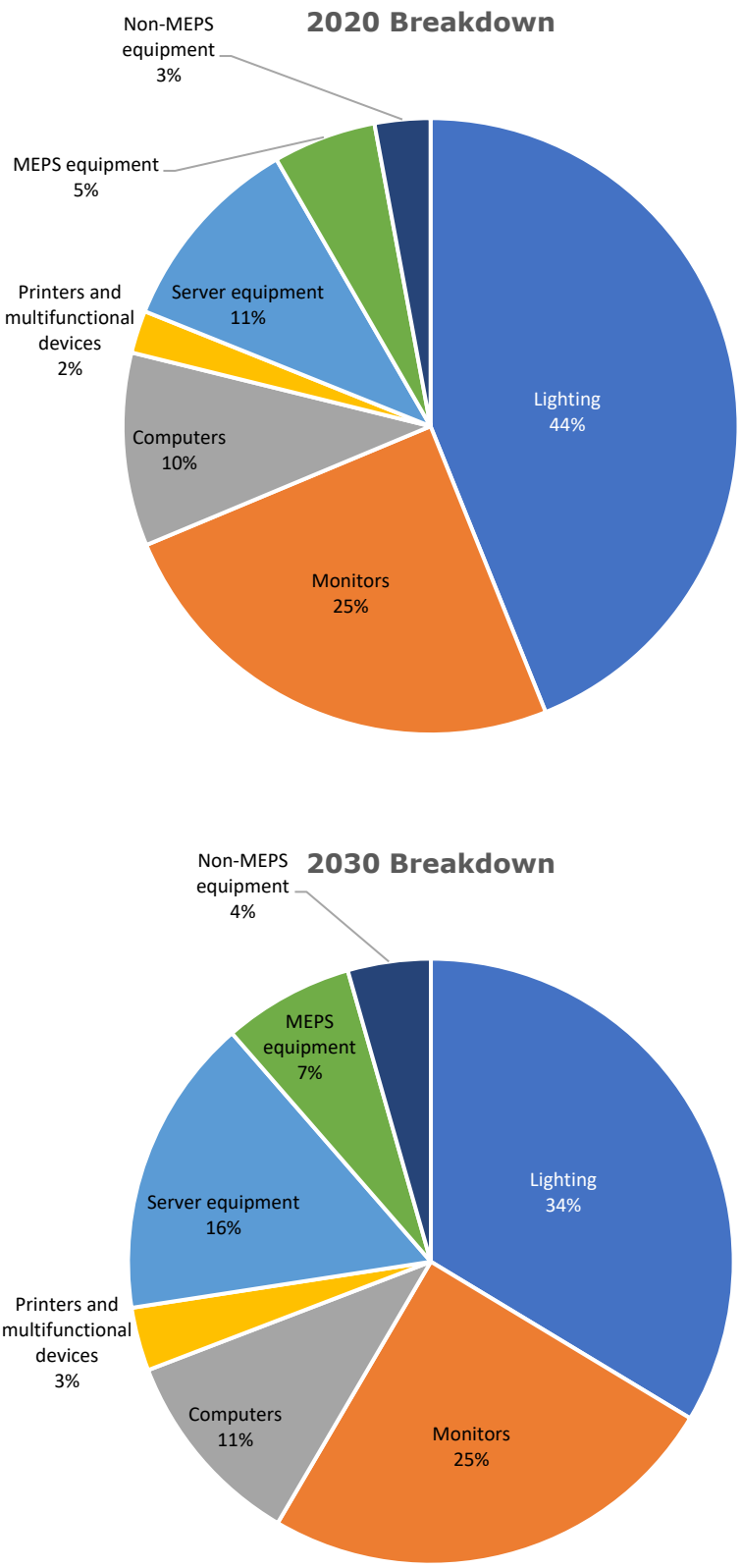

Figure 22: Office tenancy general lighting and power end use breakdown 2020 vs 2030 (without supplementary HVAC)

5 Discussion

5.1 Validation of estimated consumption

To validate the estimated energy consumption and breakdown, the data was compared against NABERS Energy rated consumption. Table 9 presents the results of the comparison. Tenancies were split into groups according to whether or not they had a data centre or supplementary HVAC:

- Group 1 has neither a data centre nor supplementary HVAC;
- Group 2 has no data centre but has supplementary HVAC;
- Group 3 has a data centre but no supplementary HVAC; and
- Group 4 has both a data centre and supplementary HVAC.

Table 9: Differences between estimated consumption and rated consumption

Group ID	Data centre	Supplementary HVAC	Number of tenancies	Total rated annual consumption (kWh)	Total estimated annual consumption (kWh)	Difference of estimation to actual consumption
1	No	No	5	57,294	61,599	7.5%
2	No	Yes	7	551,850	478,482	-13.3%
3	Yes	No	7	606,222	414,783	-31.6%
4	Yes	Yes	6	1,115,330	643,110	-42.3%

Group 1 has a total of five tenancies. This group of tenancies does not have either data centres or supplementary HVAC services in their tenancies. The estimated consumption is approximately 7.5% higher than the actual consumption. Although it is a little higher, it is considered a good indication of the estimation approach for the energy consumption of different end uses in office tenancies. One possible reason for the overestimation in this group is that it is likely that not all the computers and monitors were being actively used, and this can be explained by increased flexible working arrangements in advance of the COVID-19 pandemic changing working patterns.

It is noted that Group 1 – office tenancies that identified as neither having data centres or supplementary HVAC – actually has a total of seven tenancies, but two have been excluded from this analysis. It has been confirmed that the tenancy consumption for at least one of these tenancies covers base building HVAC services. The energy intensity of the other tenancy was twice as much higher as the others in the group. Therefore, those two tenancies have been excluded from this analysis.

5.2 Differences between estimated consumption and actual consumption

To understand the differences between estimated consumption and rated consumption, data was summarised for three more groups. Group 2 has a total of seven tenancies that indicated they have supplementary HVAC services in their tenancies but no data centres. The estimated consumption is approximately 13.3% under the actual consumption. This is expected as the modelled estimation did not estimate the consumption for supplementary HVAC. Therefore, the consumption difference indicates the amount of energy consumed by these services.

Group 3 also has a total of seven tenancies; they indicated they have data centres but no supplementary HVAC. The estimation was approximately 32% less than the actual consumption. Similarly, Group 4 has a total of six tenancies where both data centres and supplementary HVAC services exist. The estimation was approximately 42% less than the actual consumption.

The disparities between Groups 3 and 4 estimated and rated consumptions were also expected to be less as data centres' energy consumption were not accounted for in the methodology. However, as the result of Group 1 tenancies validated the approach to estimating general office lighting and plug load energy consumption, the consumption differences in Groups 2, 3 and 4 are good indications of the consumption of supplementary HVAC services and data centres respectively.

5.3 Comparison with other benchmark figures

The literature review identified several results that can be used to compare and validate the results of this research. Specifically, the overall energy intensity and end use breakdown found in the 2012 Commonwealth Government report[17] proved a useful benchmark. This report estimated the average energy intensity in Australian office tenancies to be approximately 385 MJ/m^2 in 2009,[18] while the average energy intensity in this study in 2020 is 297 MJ/m^2 based on the FY20 NABERS dataset, including outliers.[19] The true average intensity is likely to be higher than 284 MJ/m^2 – the average for the FY20 NABERS dataset excluding outliers – as the FY20 NABERS dataset is likely to be skewed towards higher performing tenancies.

The energy use breakdown from this study was also compared with the breakdown from the 2012 study, as shown in Table 10. In general, the breakdown in the 2020 study aligns with that of the 2012 study. The share of lighting decreased from 37% to 29%, which is to be expected given the increasing penetration of LED lighting. Although the percentage only decreased slightly, the absolute energy intensity decrease in lighting is significant with a 36% reduction of area-weighted average intensity. The share of other electrical processes and HVAC increased, which reflects the changes to lighting consumption. The share of total equipment or plug load increased from 34% to 38%, indicating that the intensity reduction rate in total equipment is unlikely to be as much as the lighting system.

Comparing just lighting and total plug load – due to the variable nature of supplementary HVAC – the average energy consumption of office tenancy, without accounting for supplementary HVAC, in these studies has decreased from 273 MJ/m^2 in 2012 to 191 MJ/m^2 in 2020, and is anticipated to reduce further to 126 MJ/m^2 in 2020.

Table 10: Tenancy energy use breakdown comparison with 2012 study

Energy end use	2012 study	2020 study
Lighting	37%	29%
Total equipment	34%	38%
Other electrical processes & HVAC	29%	33%
Total	**100%**	**100%**

The Menezes et al (2014). Study cited benchmark figures for office plug-load equipment from the Chartered Institution of Building Services Engineers Energy Consumption Guide (CIBSE ECG).[20] The benchmark for a Type 3 airconditioned standard office ranges from 28 kWh/m^2 p.a. to 37 kWh/m^2 p.a., while the metered data indicates a range from 25 kWh/m^2 to 38 kWh/m^2 p.a. In comparison, the total equipment energy intensity in this study, including computers, monitors, printers and miscellaneous equipment, is 107 MJ/m^2 p.a., equivalent to approximately 30 kWh/m^2 p.a. The total equipment energy intensity in this study is within the bounds of both the CIBSE ECG 19 guide and the metered data from that study.

5.4 Differences between 2020 and 2030 consumption

The research demonstrates that there are several simple ways in which office tenancies' energy consumption will diminish between now and 2030 – see Section 3.3. Importantly, these are projected savings, and for them to be realised, the assumptions outlined need to be included in policies and programs. Particular opportunities are explored in more detail in Section 5.5.

[17] pitt&sherry 2012, *Baseline Energy Consumption and Greenhouse Gas Emissions in Commercial Buildings in Australia*, Department of Climate Change and Energy Efficiency, Canberra, Australia.
[18] Ibid, p. 8.
[19] Outliers are defined as tenancies with energy intensities three times of a standard deviation higher than the average intensity; see Section 3.2.6 for an explainer of outliers.
[20] Menezes, AC, et al 2014, "Estimating the energy consumption and power demand of small power equipment in office buildings," *Energy and buildings*, pp. 199-209.

5.5 Key areas for energy efficiency improvements for office tenancies

5.5.1 Lighting

Lighting consumption accounts for almost half (44%) of total energy consumption in office tenancies without supplementary HVAC. Despite a significant improvement in NLPD with a decrease of the area-weighted average lighting power density from 13.6 W/m^2 to 8.8 W/m^2 since 2011, it remains the most significant opportunity to reduce energy consumption in office tenancies. The area-weighted average lighting power density in the surveyed group was 8.9 W/m^2, while the maximum allowed illumination power density for Class 5 office buildings in the NCC 2019 is 4.5 W/m^2. Given this, there is potential to reduce the lighting consumption in office tenancies by almost 50%. The actual impact of lighting upgrades is likely to be more than 50% for the whole office tenancy sector, as the surveyed group is likely to be made up of market leaders. Indeed, the survey responses indicate that only 16 of the surveyed 27 tenancies have undertaken LED lighting upgrades.

5.5.2 Monitors

Monitor usage is approximately 25% of total energy consumption in office tenancies without supplementary HVAC. Based on the analysis of the monitor product registration database regulated by GEMS, there are significant differences in annual energy consumptions among monitors with different energy star ratings. For example, a medium-sized monitor (between 21 inches to 32 inches) with less than three energy stars consumes an average of 181 kWh p.a., while the same-sized monitor with more than six energy stars consumes an average of only 64 kWh p.a., a consumption reduction of nearly two thirds. The survey results demonstrate that the vast majority of respondents did not know the energy star rating of their monitors, which could indicate that the share of monitor energy consumption in office tenancies is underestimated, as an average energy consumption was used. Noting the breadth of energy consumption for monitors, they represent another significant opportunity to reduce energy consumption in office tenancies and likely offices more generally.

5.5.3 Server equipment

NABERS's simulation guidelines[21] were used to estimate the energy consumption of server equipment in this research, with the findings demonstrating that the energy consumption of office server equipment accounts for approximately 11% of all office general lighting and equipment consumption.

However, there is little actual consumption data for server equipment in office tenancies. Although server virtualisation is a trend in which actual servers are replaced by cloud-based servers – and offsite data centres – half of the respondents indicated they have physical servers in their office. Further research is needed to understand the usage and trends around servers and data centres, and NABERS's data centre expertise could be leveraged for such exploration.

5.5.4 Supplementary HVAC

Due to the highly varied usage nature of supplementary HVAC, its use was not accounted for in the main methodology and modelling. Rather, the share of supplementary HVAC in office tenancies was estimated using two separate methodologies:

1. A limited NABERS dataset of five office tenancies where separate electricity usage data for these services was available; and
2. Estimating the energy consumption of supplementary HVAC in server rooms based on the kW nameplates.

Based on this restricted dataset, the energy consumption proportion of supplementary HVAC varied significantly with the maximum proportion making up approximately 80% of total energy consumption, and the minimum proportion making up less than 1%.

[21] Office of Environment and Heritage 2019, *Handbook for estimating NABERS ratings*, NABERS, Sydney, Australia.

Admittedly, there may be electricity account coverage issues in these data, such that the consumption data may be for more than just supplementary HVAC services or vice versa. However, these data points reveal that the consumption of supplementary HVAC services is highly variable, which is a reasonable conclusion as these services are on demand and depend on the needs of the given office tenancy.

Notably, HVAC can account for a significant proportion of energy consumption in office tenancies where these services are available. Given this, it is reasonable to recommend that individual office tenancies with supplementary HVAC services estimate energy consumption utilising the methodology outlined in Section 3.2.2.3 and/or undertake sub-metering of these services to determine the energy performance improvement opportunities. If they are significant energy end users, energy efficiency opportunities should be investigated on a case-by-case basis.

Notably, cost-effective recommendations to improve energy performance were made at the nine sites in which the energy performance of the supplementary HVAC in server rooms was reviewed. These recommendations included:

- Increasing the HVAC temperature set point as it was commonly set at a much lower temperature than what is required to not affect system availability of the server equipment; and
- Improving building fabric to minimise heat gains from adjacent rooms, outside weather and solar irradiation.

5.5.5 Computers

Laptop computers account for 6% of total energy consumption in office tenancies without supplementary HVAC, while desktop computers account for 4%. Importantly, the smaller percentage of desktop computers' energy consumption share is not due to less consumption per unit. Rather, it is due to the significantly lower number of desktop computers compared with laptop computers.

The survey group had a total of 470 desktop computers and 2,462 laptops, meaning that desktop computers only made up 16% of the total computer figure, and that laptops were found to be much more efficient than desktop computers. Based on MEPS for computers,[22] one desktop computer consumes 148 kWh p.a. compared with 40 kWh p.a. for a laptop computer. Given this, a targeted campaign to replace desktop computers with laptops should be considered by CitySwitch and other relevant parties.

5.5.6 Printers and multifunctional devices

While printers and multifunctional devices only account for 2% of energy consumption in office tenancies without supplementary HVAC, this figure is derived from the surveyed office tenancies having an average of 3.3 printers and multifunctional devices, or 0.003 printers per m^2 and 0.03 printers per person. This demonstrates that a single printer can have a substantial power draw. Although this is not significant in the overall context of this study, for office tenancies and businesses more generally that have greater numbers of printers and multifunctional devices, as many do, this proportion could grow significantly. Importantly, the 2017 Hafer study undertaken at Stanford University found that there were 0.43 printers per occupant in office buildings, demonstrating that the result of 0.03 printers is lower than what was anticipated, but again reinforces the power consumption of printers.

[22] Standards Australia 2012, *5813.2:2012: Minimum energy performance standards (MEPS) for computers*, Standards Australia, Sydney, Australia.

5.6 Understanding office tenancies' energy management journey

Survey respondents were asked to complete a small number of qualitative questions to help qualify the efficacy of the CitySwitch Program, and to support CitySwitch with providing tailored advice to respondents. In particular, the survey asked two key questions:

- Which of the following – novice, curious, doer, leader – best describes where your organisation is on your energy management journey?
- Have you implemented any of the following energy efficiency/management activities?

Table 11: Energy management practice and energy intensity

Energy management journey	Count	Number of actions	Average actions	Group average energy intensity (MJ/m2)
Novice	1	2	2	327
Curious	7	14	2	366
Doer	12	55	4.6	262
Leader	7	44	6.3	236

Table 11 presents the group average energy intensity and the number of energy management actions based on the office tenants' responses to these questions. The table demonstrates a clear trend of decreasing energy intensity as energy management activities are undertaken in office tenancies. The group average energy intensity for self-identified *leaders* is 236 MJ/m^2 p.a., which demonstrates a clear trend downwards from self-identified *curious* and *doer* office tenancies.[23]

Importantly, survey respondents were initially asked to self-identify the stage of their energy management journey before then being asked what specific energy management activities they had undertaken. The results demonstrate alignment between self-identification and actual performance, thereby demonstrating the CitySwitch Program's efficacy with regards to increasing energy literacy and energy performance of office tenancies.

Interestingly, several non-office tenancies – i.e. building owners and occupiers – also completed the survey with a similar trend also apparent, validating the suggestion of CitySwitch's efficacy.

The self-identified *leaders* are approximately 30% more efficient than tenancies in the lower end of the office market. It is noted that the research group as a whole is likely a higher-performing group than average Australian office tenancies, due to CitySwitch being a voluntary program, and NABERS Energy rating for tenancies being voluntary. These results demonstrate that the CitySwitch Program is effectively supporting office tenancies – and office-based businesses more broadly – with improving their energy performance. The research also demonstrates a clear linear relationship between upgrade activities and energy performance metrics, suggesting that increased engagement with office tenancies through programs like CitySwitch could enable substantial energy performance improvements.

Importantly, CitySwitch identified the survey as being particularly useful for identifying tailored opportunities for individual office tenancies. CitySwitch and NABERS highlighted that developing an online portal that enabled office tenancies to compare their NABERS Energy rating, or indicative rating, with their survey responses in real time, leading to automated recommendations and further reading, would be a cost-effective way to support office tenancies with improving their energy performance. Further, such a resource would prove useful for building owners that are looking to support their tenancies with lowering their energy and emissions.

Notably, an equivalent survey could also be developed for owner-occupiers as there are several smaller businesses that own the building in which they operate, but do not have the resources to have a dedicated energy or facilities manager.

[23] See Appendix 2 to review the definitions of the various levels of the energy management journey.

6 Conclusions and recommendations

The research in this project demonstrates that there is considerable opportunity for improving the energy performance of office tenancies, even in leading CitySwitch signatories. In particular, the research suggests that there are two leading opportunities for improving energy performance in office tenancies: lighting and monitors.

Further, for office tenancies with supplementary HVAC, this also proved to be able to have a considerable power draw. Existing federal and jurisdictional policies and programs can help office tenancies unlock savings associated with this equipment, and additional or expanded funding, financing or support programs may support additional improvements.

Importantly, the research demonstrates that there is limited data available relating to energy consumption from supplementary HVAC in office tenancies. More data is needed to facilitate a greater understanding of these systems, thereby enabling more informed decisions to be made on how to reduce the energy intensity of these services. Programs that support the estimation and/or sub-metering of HVAC and server equipment should be encouraged.

The energy consumption of server, network and other telecommunication equipment is another area where additional research could prove useful for identifying energy performance improvement opportunities.

For office tenancies to realise these opportunities, the Energy Efficiency Council recommends that office tenancies:

1. Upgrade low performing lighting to LEDs as a priority as lighting is the single largest opportunity to improve energy performance in office tenancies;
2. Estimate and/or undertake sub-metering of supplementary HVAC to determine load and the potential for energy performance improvements;
3. Explore the opportunity to move servers to offsite high energy performance data centres and review cooling requirements for servers that must remain onsite;
4. Review procurement guidelines for office equipment, especially monitors and computers, ensuring that only high performing office equipment is purchased;
5. Explore the opportunity to use energy efficiency obligation and environmental upgrade finance (EUF) schemes – which are available in some jurisdictions – to upgrade lighting and HVAC; and
6. Explore the opportunity to use energy efficiency obligation schemes – which are available in some jurisdictions – to upgrade monitors and other office equipment.

These recommendations are incorporated into the business-focused *Navigating a dynamic energy landscape: a briefing for office-based businesses* that the EEC and CitySwitch are using to directly engage with office tenancies.

All of the opportunities are explored in more detail and office-based businesses, including office tenancies, are encouraged to follow a three-step action plan:

1. Reach out:
    - Join CitySwitch to access one-on-one support and a network of like-minded businesses
    - Contact your local council or industry association for resources and support
    - Connect with your landlord to explore opportunities
2. Begin their energy management journey by:
    - Starting with what can be seen
    - Benchmarking performance with a NABERS Energy rating
    - Adopting energy management as a discipline
3. Continue their sustainability journey:
    - Achieve carbon neutrality
    - Explore other sustainability opportunities

To learn more read section four, pp. 23–26, of the *briefing for office-based businesses*.

7 References

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Appendices

Appendix 1 Office equipment annual consumption

Office equipment	Energy rating label	Annual estimated consumption (kWh)
Desktop computer		148
Laptop computer		40
Small monitor	Less than 3 stars	73
Small monitor	Between 3 and 6 stars	73
Small monitor	More than 6 stars	45
Small monitor	Unknown	62
Medium monitor	Less than 3 stars	181
Medium monitor	Between 3 and 6 stars	102
Medium monitor	More than 6 stars	64
Medium monitor	Unknown	97
Large monitor	Less than 3 stars	249
Large monitor	Between 3 and 6 stars	162
Large monitor	More than 6 stars	95
Large monitor	Unknown	170
Small printer		224
Multi-functional device		531
Small dishwasher	Less than 3.5 stars	165
Small dishwasher	More than 3.5 stars	135
Small dishwasher	Unknown	149
Medium dishwasher	Less than 3.5 stars	287
Medium dishwasher	More than 3.5 stars	200
Medium dishwasher	Unknown	284
Large dishwasher	Less than 3.5 stars	315
Large dishwasher	More than 3.5 stars	252
Large dishwasher	Unknown	270
Minibar fridge	Less than 4 stars	230
Minibar fridge	More than 4 stars	131
Minibar fridge	Unknown	229
Bar fridge	Less than 4 stars	270
Bar fridge	More than 4 stars	146
Bar fridge	Unknown	268
Medium fridge	Less than 4 stars	378
Medium fridge	More than 4 stars	282

Office equipment	Energy rating label	Annual estimated consumption (kWh)
Medium fridge	Unknown	366
Large fridge	Less than 4 stars	533
Large fridge	More than 4 stars	367
Large fridge	Unknown	497
Small TV	Less than 3 stars	146
Small TV	Between 3 and 6 stars	117
Small TV	More than 6 stars	90
Small TV	Unknown	114
Medium TV	Less than 3 stars	562
Medium TV	Between 3 and 6 stars	366
Medium TV	More than 6 stars	232
Medium TV	Unknown	362
Large TV	Less than 3 stars	1,315
Large TV	Between 3 and 6 stars	720
Large TV	More than 6 stars	476
Large TV	Unknown	774
Microwave		16
Oven		15
Toaster		25
Coffee machine		730
Kettle		100
Ziptaps		318
Task lamp		100
Portable heater		480
Portable fan		73

Appendix 2 Tenancy survey

See overleaf.

CitySwitch

Thank you for agreeing to provide your information to the CitySwitch team.
The survey will take around 15-20 minutes to complete.

CitySwitch is collecting this information about office tenancies to understand the energy consumption of different equipment including lighting, air conditioning, computers and printers.

Your responses will be used by CitySwitch, the Energy Efficiency Council our appointed consultants and the participating local government authorities for improving the CitySwitch program and enhancing our understanding of Australia's business energy usage levels. Your organisation's details and responses provided will be treated with strict confidence and not be used for any purposes other than improving the CitySwitch program.
If you have any concerns or questions, please contact us at cityswitch@cityofsydney.nsw.gov.au.

1. Please tell us about your organisation.
   This information is being collected so that we can match your responses with your existing CitySwitch and NABERS data disclosure.

Organisation name
Number of floors business operates
Number and street of location
Suburb
Postcode
State

2. Is your organisation a CitySwitch member?

- Yes
- No

5. Have you undertaken a NABERS Office Tenancy Energy rating?

- Yes
- No

6. What type of building does your business occupy?

- Office building
- Industrial building
- Mixed use building

7. How many full-time equivalent employees does your business employ?

8. Noting that some of your staff may be working remotely due to Covid-19, what is the estimated current occupancy of your tenancy?

Proportion of current occupancy %

9. What year did you move into the tenancy?

Year

10. Do you have any tenant installed air conditioning units?

- Yes
- No
- Unsure

12. Does you have a data centre in your tenancy?
Data centres typically have multiple rows of several racks, taking up a sizeable portion of floor plans and serve computers beyond the office in which they are located.

- Yes
- No
- Unsure

13. Which of the following best describes where your organisation is on your energy management journey?

- **Novice** - we're brand new to the space
- **Curious** - we've started to think about how we can improve our energy management
- **Doer** - we've implemented one or more actions to improve our energy management
- **Leader** - we're doing everything we can to improve our energy management

14. Have you implemented any of the following energy efficiency/management activities?
(multiple choice)

- "Switch off" behaviour campaign
- Conduct regular NABERS Office Tenancy ratings
- Reported your energy use and/or emissions (other than through NABERS)
- Procurement of energy efficient office equipment
- LED lighting upgrade
- Conducted an energy audit in the past five years
- Review energy supply contracts annually
- Procurement of renewable energy
- Developed a strategic energy management system for continuous improvement
- Lighting control upgrade
- Other
- None of these activities

15. Do you have any of the following equipment?

	Yes	No	Unsure
Desktop computer			
Laptop computer			
Computer monitor			
Printer/multi-functional device			

Dishwasher

Fridge

Television

Microwave

Oven

Toasters/sandwich press

Coffee machine

Kettle

Instant hot/cold water (Zip) tap or urn

Task lamp (desk or floor, with wall plug)

Portable heater (winter)

Portable or ceiling fan (summer)

Server room

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Office equipment details

16. How many desktop computers does your business have?

Quantity

Any further commentary you'd like to provide?

17. How many laptop computers does your business have?

Quantity

Any further commentary you'd like to provide?

18. How many **small** computer monitors do you have?
(less than 21 inches)

Quantity

Average energy star rating
(0 - 10 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

19. How many **medium** computer monitors do you have?
(21 to 32 inches)

Quantity

Average energy star rating
(0 - 10 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

20. How many **large** computer monitors do you have?
(more than 32 inches)

Quantity

Average energy star rating
(0 - 10 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

21. How many printers/multi functional devices do you have?

Small desktop printers

Large floor mounted printers

Any further commentary you'd like to provide?

22. How many **small** dishwashers do you have?
(single draw)

Quantity

Average energy star rating
(0 - 6 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

23. How many **medium** dishwashers do you have?
(narrow drawbridge door)

Quantity

Average energy star rating
(0 - 6 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

24. How many **large** dishwashers do you have?
(standard width drawbridge door or double drawer)

Quantity

Average energy star rating
(0 - 6 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

25. How many **small mini-bar** fridges do you have?
(less than 100L)

Quantity

Average energy star rating
(0 - 6 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

26. How many **bar** (counter height) fridges do you have?
(100-200L)

Quantity

Average energy star rating
(0 - 6 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

27. How many **medium** fridges do you have?
(200-500L)

Quantity

Average energy star rating
(0 - 6 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

28. How many **large** fridges do you have?
(more than 500L)

Quantity

Average energy star rating
(0 - 6 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

29. How many **small** televisions do you have?
(less than 39 inches)

Quantity

Average energy star rating
(0 - 10 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

30. How many **medium** televisions do you have?
(39 to 69 inches)

Quantity

Average energy star rating
(0 - 10 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

31. How many **large** televisions do you have?
(more than 69 inches)

Quantity

Average energy star rating
(0 - 10 stars, okay to use 0.5)

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

32. How many microwaves do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

33. How many ovens do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

34. How many toasters and/or sandwich presses do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

35. How many coffee machines do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

36. How many kettles do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

37. How many instant hot/cold water taps or urns do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

38. How many task lamps do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

39. How many portable heaters do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

40. How many portable or ceiling fans do you have?

Quantity

Annual energy consumption, if available on the label (kWh p.a.)

Any further commentary you'd like to provide?

41. How many racks does your server room have?

Number of racks

Any further commentary you'd like to provide?

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42. There may be an opportunity for your office tenancy to receive a complimentary energy audit that would include sub-meeting and/or plug metering of your office energy consumption.

    Is this something you would be interested in?

- Yes
- No
- Unsure

44. Finally, please upload your asset register and energy audit report, if available.

+ Add

File Name	Actions
Asset register	

Thank you for taking the time to answer this survey for CitySwitch today. That is all the questions we have for you.
Please click the 'finalise' button to submit your responses.
Good bye.

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Previous **Finalise**

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energy efficiency
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