Attachment B1

Planning Proposal Attachment 2 – Performance Standards for Net Zero Energy Buildings Project Report

Planning for net zero energy buildings

Performance standards pathways to achieve high-performing net zero energy buildings in Greater Sydney

CITY OF SYDNEY
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An accessible version of this document will be available soon

Artist impression of Sydney Place Tower at 180 George St, Sydney. Image by Lendlease.

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Abbreviations

Acronym	Description
AHU	Air handling unit
ASBEC	Australian Sustainable Built Environment Council
ATAP	Australian Tourism Accreditation Program
ACH	Air change per hour
BASIX	Building Sustainability Index
BIPV	Building integrated photovoltaic panels
CAV	Constant air volume
CBA	Cost benefit analysis
COP	Coefficient of performance
DCP	Development Control Plan
DHW	Domestic hot water
DISER	Department of Science, Energy and Resources
DPIE	Department of Planning, Industry and Environment
EER	Energy efficiency ratio
FCU	Fan coil unit
GBCA	Green Building Council of Australia
GFA	Gross floor area
GLAR	Gross lettable area - retail
GSC	Greater Sydney Commission

Acronym	Description
HHW	Heating hot water
HVAC	Heating, ventilation and air conditioning
IPLV	Integrated part-load value
IRR	Internal rate of return
LEP	Local Environmental Plan
LPD	Lighting Power Density
NABERS	National Australian Built Environment Rating System
NatHERS	Nationwide House Energy Rating Scheme
NCC	National construction code
NLA	Net lettable area
NSA	Net sellable area
PCA	Property Council of Australia
PV	Photovoltaic
SHGC	Solar heat gain coefficient
TRY	Test reference year
VAV	Variable air volume
VRF	Variable refrigerant volume
VSD	Variable speed drive
VT	Vertical Transport
WWR	Window to wall ratio

Units

Units	Description
$	Dollars (AUD)
oC	Degree Celsius
kW	Kilowatt
kWh/a	Kilowatt per annum
kWh/yr/m^2	Kilowatt per year, per square meter
MWh/a	Megawatt per annum
MJ/a	Megajoule per annum
GJ/a	Gigajoule per annum
l/s/p	Litre per second per person
l/s/m^2	Litre per second per square metre
ACH	Air change per hour
mm	Millimetre
m	Metre
m^2	Square metre
m^2/p	Square metre per person
W/m^2	Watt per square metre
m^2K/W	Square metre kelvin per watt (R value)
W/m^2K	Watt per square metre kelvin (U value)

Executive summary

Why net zero?

It is globally recognised and agreed that to meet the ambitions of the Paris Agreement, global carbon emissions must reach net zero by around 2050.

Councils work within international, national and state frameworks to reduce greenhouse gas emissions. The aim to drive down greenhouse gas emissions in the built environment – the subject of this report – is part of the City of Sydney's (the City) ambition to reach net zero emissions by 2040 and work together with other Greater Sydney councils to support them achieve their net zero goals.

As part of this work, the City, recognises that the energy used in the operation of buildings is the largest contributor to greenhouse gas emissions in Greater Sydney. It accounts for around 55 per cent of greenhouse gas emissions in Greater Sydney[1] .

The City is looking to understand how the planning system can be optimised to drive down greenhouse gas emissions from the built environment. This will respond to the NSW Government and the City's net zero emissions target, as well as 'the low carbon city' objective in the *Greater Sydney Region Plan - A Metropolis of Three Cities* (Region Plan), and other local government greenhouse gas emission reduction targets.

A net zero energy building is highly energy efficient and consumes no more energy than that which is generated on-site and/or procured from off-site renewable energy sources.

Councils use existing planning and design tools such as NABERS, Green Star and BASIX to drive lower energy use in developments – these will help the progress towards net zero. However, most buildings, such as those that shape the skyline across Sydney, require off-site solutions to achieve a net zero target.

There are limited market incentives for the development industry to go above and beyond mandated standards and codes to achieve net zero emissions – the benefits of an energy efficient building go largely to the asset owner and tenants after completion in the form of lower energy costs.

This report looks at how the City and other Greater Sydney councils can embed **optimum energy efficiency, on-site renewable energy** and **off-site renewable energy** to set a path to net zero in the planning and design process for larger buildings. It proposes:

- performance standards
- controls within the planning system.

The performance standards are step change improvements in energy performance to transition to net zero energy developments, as well as major refurbishments of existing buildings. Implementing the performance standards will have a tangible impact on lowering greenhouse gas emissions in the built environment and improve building resilience in a cost-effective manner, as well as contribute to a positive and sustainable business recovery for Greater Sydney.

1 Exploring Net Zero Emissions for Greater Sydney, prepared by Kinesis for the Greater Sydney Commission, 2015

About this report

This report summarises an extensive program of work that began in 2018 to:

- identify the most appropriate performance standards (or targets) that, if met, can achieve high-performing, net zero energy **office, shopping centre, hotel, multi-unit residential, and mixed-use developments** (including new and major refurbishments) and that could be incorporated into planning controls
- develop an evidence base, including stakeholder engagement and a robust cost benefit analysis, to support the recommended performance standards
- recommend approaches to implement the performance standards within the NSW planning system.

Stakeholder engagement at Forum 2 in November 2018.

Developing the performance standards

This program of work was informed by two City of Sydney-facilitated industry and government forums held in 2018. The forums identified issues and opportunities to support the net zero emissions by 2050 target within the NSW planning system and to meet the ambitions of the Region Plan and Resilient Sydney.

From this foundation, the program of work considered four building asset classes:

1. Office (base building)
2. Shopping centre (base building)
3. Hotel (whole building)
4. Multi-unit residential (whole building)

Mixed use was also considered as component uses of the four asset types.

The program then:

- included **stakeholder engagement** to understand stakeholder needs and objectives and secure stakeholder support for the performance standards
- **established a baseline** for each non-residential asset type, based on Section J of the National Construction Code (NCC) 2019 and BASIX requirements for residential buildings
- included consultation with specialist energy-efficiency engineers to determine **energy reduction measures**, which were applied to each building type to identify the maximum potential on-site improvement and to individually cost the capital expenditure increase associated with the energy reduction measures for each type of building
- used a **cost benefit analysis (CBA)** of the recommended energy reduction measures for each building type to determine commercial viability, based on a comparison of capital expenditure increase to ongoing energy savings across a 15 to 25-year timeline, by:
  - identifying and combining cost effective measures to determine the most energy efficient and cost effective first step for each building type
  - forecasting changes in costs and benefits over time to inform the staging of more stringent requirements, on the assumption that different measures will become more cost effective
  - considering the costs and benefits to direct development participants (developers, owners and occupants) and indirect participants (the public) through energy savings.
- determined recommended performance standards or targets through **robust industry and government stakeholder engagement** sessions and a review of planning and design tools, to avoid introducing new requirements, such as:
  - National Australian Built Environment Rating System (NABERS)
  - Environmental Planning Policy (Building Sustainability Index: BASIX) 2004
  - Green Star Design and As Built (and Green Star Buildings.

Workable targets and implementation

The report recommends a first and second target for each asset class, with the first target implemented in 2023 and the second in 2026. This includes a single on-site energy intensity (kWh/yr/m^2) target for each asset class or equivalent options to meet that target within existing planning and design tools. These targets are shown in Table 1.

In recognition that most buildings will not achieve net zero through cost effective energy efficiency and on-site renewables alone, off-site renewables will need to be purchased. The additional cost of the off-site option was included in the CBA and the final results.

Table 1: Asset classes and targets

Asset class	First target (2023)	Second target (2026)
Office (base building)	Maximum 45 kWh/yr/m^2, or equivalent NABERS Energy or Green Star Buildings credits, or equivalent	Maximum 45 kWh/yr/m^2, or equivalent NABERS Energy or Green Star Buildings credits, or equivalent, and renewable energy procurement to net zero
Shopping centre (base building)	Maximum 55 kWh/yr/m^2, or equivalent NABERS Energy or Green Star Buildings credits, or equivalent	Maximum 45 kWh/yr/m^2, or equivalent NABERS Energy or Green Star Buildings credits, or equivalent, and renewable energy procurement to net zero
Hotel (whole of building)	Maximum 245 kWh/yr/m^2, or equivalent NABERS Energy or Green Star Buildings credits, or equivalent	Maximum 240 kWh/yr/m^2, or equivalent NABERS Energy or Green Star Buildings credits, or equivalent, and renewable energy procurement to net zero
Multi-unit residential (whole of building)		
6-10 storeys	Basix Energy 40	Basix Energy 45 and renewable energy procurement to net zero
11-20 storeys	Basix Energy 35	Basix Energy 40 and renewable energy procurement to net zero
21-30 storeys	Basix Energy 30	Basix Energy 35 and renewable energy procurement to net zero
Mixed use	Individual asset component targets identified above	Individual asset component targets identified above

Off-site renewable energy will be an imperative for most developments. This requires provision within the planning system to ensure appropriate and lasting implementation.

The following planning options were considered to support implementation of the targets. These options can be implemented individually or in combination. Options A and B provide the preferred balance of legislative weight to achieve the net zero objective while being less prescriptive to provide flexibility.

The options are:

- Option A: Amend Local Environmental Plan (LEP)

  Add clauses to the Standard LEP requiring best practice environmentally sensitive design, coupled with a specific clause relating to the targets.

- Option B: Amend Development Control Plan (DCP)

  Add DCP controls to set targets. This allows flexibility for development that achieves a high degree of efficiency and meets the net zero objectives yet cannot meet the specific target.

- Option C: Amend Region Plan and district plans

  In addition to amending the LEP and DCP, add a clear policy direction to the Region Plan and district plans to implement the performance standards to net zero energy across Greater Sydney.

- Option D: Amend BASIX

  Amending BASIX targets provides consistency across Greater Sydney and progress to net zero for residential development.

- Option E: Add to the proposed Design and Place SEPP

  Add the performance standards and options to demonstrate compliance.

Project recommendations

The project identified key changes needed inside and outside of planning to support the transition to net zero emissions and implement the performance standards. These recommendations have been developed through engagement with industry and government and are detailed in the Project Recommendations section.

A summary of the recommendations is included below:

- incorporating targets into planning controls
- advocating to the Department of Planning, Industry and Environment (DPIE) to implement the targets in legislation and state policies
- updating Region Plan and district plans to support the implementation of the targets across Greater Sydney
- embedding methods to recognise off-site renewables in planning
- updating design and planning tools to maintain relevance
- reviewing targets over time to maintain relevance
- providing educational programs for councils, industry and the community to assist with implementation of the targets
- exploring mandatory building performance disclosure for more asset classes
- advocating for the extension of the Renewable Energy Target to 2050 to support the use of off-site renewables.

Development under construction (Western City District), Image by Greater Sydney Commission.

Background

Why net zero?

Global efforts to tackle climate change include a united undertaking to reduce greenhouse gas emissions, as required under the Paris Agreement. The Paris Agreement, signed by 94 countries – including Australia – aims to:

"*Strengthen the global response to the threat of climate change by keeping global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue other efforts to limit the temperature increase even further to 1.5 degrees Celsius.*" (United Nations, 2017).

It is globally recognised and agreed that to meet this goal, global carbon emissions must reach net zero by around 2050.

Australia is committed to reducing economy-wide greenhouse gas emissions by 26 to 28 per cent below 2005 levels by 2030. All states and territories have committed to be net zero by 2050 or earlier.

Image by City of Sydney.

The NSW Government aligns with national and international commitments through the NSW Climate Change Policy Framework, which:

- identifies a net zero emissions objective by 2050
- aims to build NSW's resilience to a changing climate.

Further, the *Net Zero Plan Stage 1: 2020 – 2030* sets out the NSW Government's plan to reduce emissions, with an initial focus on implementing proven emission reduction technologies and empowering consumers and business to make sustainable choices.

Councils work within international, national and state frameworks to reduce greenhouse gas emissions. The City of Sydney's (the City) ambition is to achieve net zero emissions by 2040 and work together with other Greater Sydney councils to support them achieve their greenhouse gas emission reduction targets, the NSW Government's net zero emissions target and 'the low carbon city' objective in the *Greater Sydney Region Plan - A Metropolis of Three Cities* (Region Plan). The City is looking to understand how the planning system can be optimised to drive down greenhouse gas emissions from the built environment.

As part of this work, the City, recognises that the energy used in the operation of buildings is the largest contributor to greenhouse gas emissions in Greater Sydney. It accounts for around 55 per cent of greenhouse gas emissions in Greater Sydney[2].

Achieving net zero emissions requires action across several sectors of the economy. The focus of this report is on the greenhouse gas emissions of the built environment, specifically offices, shopping centres, hotels, multi-unit residential and buildings accommodating a mix of these uses (mixed use).

Many newly built assets will be operational for more than 20 years with minimal changes to their energy using systems. As the party responsible for planning and building approvals, councils can drive lower built environment greenhouse gas emissions.

2 Exploring Net Zero Emissions for Greater Sydney, prepared by Kinesis for the Greater Sydney Commission, 2015

Definition of net zero for this project

For the purposes of this project, **a net zero energy development** means a development that consumes no more energy than is provided by a combination of:

- renewable energy generated on-site, or
- renewable energy procured from off-site sources for a period of 5 years.

In this definition, energy includes electricity, thermal energy and gas, and excludes diesel used for emergency back-up generation. Other emissions, such as those from refrigerants, are not included.

This definition recognises that the energy consumption considered in the analysis undertaken as part of this overall program of work is operational only and associated with building emissions from on-site gas and electricity consumption. The analysis does not include energy associated with waste, transport or embodied energy.

Benefits

Net zero buildings will bring direct benefits to the community by achieving health savings through reduced pollution, as well as cost savings through reduced infrastructure requirements. It will also help to build greater resilience within the community to a changing climate.

In terms of the economy, net zero buildings can help to:

- create jobs and demand for new skills in the energy efficiency (design and operation) component of the building construction and management sectors, as well as in the renewable energy sector
- reduce the need to build additional energy infrastructure, potentially reducing costs
- lower operational costs
- drive growth in the renewable energy sector
- drive innovation in the sustainable building sector.

The environment will benefit from the overall contribution to the global effort to reduce emissions.

The challenge

Driving sustainability in the built environment has been a focus of government and industry since the 1990s, with the implementation of many mechanisms to improve the energy efficiency of buildings such as NABERS, Green Star, BASIX and Section J of the National Construction Code.

These mechanisms have helped to move the energy efficiency of buildings towards net zero; more is required to achieve net zero.

The program of work behind this report has found that the use of energy efficiency and on-site renewable energy alone will not always achieve net zero energy. In large building asset classes such as offices, shopping centres, hotels, multi-unit residential and mixed-use developments, purchasing off-site renewable energy is nearly always required to achieve net zero energy.

Some developers already purchase off-site renewable energy through schemes such as power purchase agreements (PPAs) and GreenPower. These schemes are voluntary.

Further, there is little incentive for developers to go above and beyond mandated standards and codes to achieve net zero, as the benefits of an energy efficient building are largely split between the long-term asset owner and the occupants or tenants.

To ensure energy efficient buildings are built, **optimum energy efficiency and on-site generation must be embedded into the planning and design process** of these asset classes and performance standards and controls within the planning system will be an essential mechanism.

Objectives of the report

This report focuses on addressing this challenge in the context of the Greater Sydney region.

This report summarises an extensive program of work, focused on Greater Sydney, that began in 2018 to:

- identify the most appropriate performance standards (or targets) to achieve high-performing, net zero energy, **office, shopping centre, hotel, multi-unit residential, and mixed-use developments** (including new and major refurbishments)
- develop an evidence base, including stakeholder engagement and a robust cost benefit analysis, to inform the development of the performance standards for Greater Sydney
- recommend approaches to implement the performance standards within the NSW planning system.

The report considers the performance standards required to make each asset class as efficient as possible in its design and use of on-site renewables, before looking to off-site renewables to make up any remaining energy balance.

Stakeholder engagement

Consultation and engagement with developers, industry experts and across government has been essential to a full consideration of the challenges and opportunities of net zero energy buildings and to inform the development and implementation of the performance standards.

The program of work kicked off with two industry and government forums in 2018. These were facilitated by the City to identify issues and opportunities in land use planning to support the NSW Government's target of net zero emissions by 2050, and 'the low carbon city' objective in the Region Plan and Resilient Sydney.

The forums in 2018 explored the planning challenges associated with achieving high-performance, net zero energy buildings. This included:

- lack of mandatory regulation relating to energy performance for all asset classes and where it exists, it is not up to date and therefore limits rather than facilitates energy performance
- design and planning tools such as NABERS and BASIX are not updated regularly. BASIX is slow to respond and keep up to date with technology and doesn't encourage higher levels of performance. councils have limited options to influence energy performance of residential developments
- high rise buildings cannot achieve net zero on-site and need to use off-site renewables or shared precinct energy infrastructure
- the process from buying a site to the submission of a development application is long and therefore expectations need to be known upfront to provide certainty
- councils require more resources and support to improve knowledge, understanding, monitoring and enforcement of design and planning tools
- there is inadequate post-development monitoring and enforcement of energy performance
- developers would like incentives to overcome financial barriers and internal organisational resistance. While some councils would prefer, they are not used to bridge the gap between minimum and higher performance requirements
- lack of clarity on what the developer must submit to council to demonstrate compliance with sustainability requirements
- lack of transparency and accountability in monitoring and enforcing energy efficiency outcomes by councils and private certifiers
- lack of leadership and overall strategic direction for achieving net zero. The property industry would like clear requirements from government to support a transition to net zero developments.

Additional engagement sessions during 2019 to 2020 informed the development of the performance standards. This included:

- three meetings with the Planning Leadership Advisory Group, an external industry and government group, on project methodology, technical elements and implementation
- two industry and government workshops with many participants from the first two forums to seek feedback on the initial energy modelling, cost benefit analysis and potential off-site measures that could be recognised in planning
- meetings with industry experts, including Paul Bannister, an energy efficiency specialist who completed the energy modelling for the regulatory impact statement for Australian Building Codes Board (ABCB), and industry groups such as Australian Sustainable Built Environment Council (ASBEC), Clean Energy Finance Corporation (CEFC), Green Building Council of Australia (GBCA) and the Shopping Centres Council. These meetings discussed energy efficiency measures, offsite renewable energy procurement and other offset options.

These sessions highlighted the following issues.

1. Performance standards

Stakeholders were consulted on the preference between a performance standard per asset class (four standards) or performance standards per building typology within an asset class (12 standards). While both options were supported, feedback indicated that per asset class is the approach most likely to allow clarity through the planning controls. The per-typology option could complicate planning controls, as they could cause confusion or limit the ability for developments dissimilar to the proposed building typologies to apply the performance standards.

2. Structure of the targets

There was a preference for setting overall targets for each asset class, including a minimum energy efficiency requirement, which can be met through energy efficiency measures and on-site renewable energy generation. An overall target approach for each asset class offers greater flexibility for each specific building.

3. Steepness of the performance standards to achieve net zero energy

Stakeholders were asked whether the performance standards should have a shallow or steep trajectory. Stakeholders agreed to immediate action, however noted that they require ample lead time to factor in cost and design implications to prepare for increasing targets.

Most stakeholders agreed the first step should be a step up but not cost prohibitive.

4. Industry-wide communication and education

To support early integration of net zero energy design strategies and avoid costs that arise when these are addressed too late in the design process, performance standards must be clearly communicated. Planning controls must be clear, consistent and enforceable.

5. Offsite renewable energy procurement options

Stakeholders want choice and flexibility in potential off-site renewable energy procurement options rather than a specific offset mechanism.

Further engagement took place between 2020 and 2021 to get feedback on the draft performance standards and timeframes, development thresholds and the integration of off-site renewables:

- individual meetings with nine developers. The nine developers were Mirvac, Stockland, Lendlease, Frasers, Aqualand, Greenland, Charter Hall, Dexus and Crown Group. The meetings sought feedback on the implementation of the performance standards given the impacts of COVID
- a meeting with executive directors and directors from DPIE and commissioners and staff from the GSC. Feedback from the individual meetings with developers was also discussed
- a meeting with staff from the Government Architect NSW
- meetings with the Western Sydney Regional Organisation of Councils, Southern Sydney Regional Organisation of Councils and the Northern Planners, a subset of Northern Sydney Regional Organisation of Councils
- meetings with representatives of the Property Council of Australia committees, other peak bodies and project partners.

The feedback received in these meetings was incorporated into the performance standards as follows:

- reduced the minimum energy efficiency and onsite renewables standards in step 2 for office and shopping centres
- removed the ability to use Energy Saving Certificates to achieve to net zero energy as an offsite measure
- removed the need to apply the standards to the refurbishment of shopping centres
- delayed the implementation of the performance standards to respond to impacts from COVID.

This level of engagement has been consistent throughout the program of work. Successful implementation will only come with support for the performance standards from property developers, owners, industry groups and government.

NSW planning system

Land use planning has a key role to play in reducing greenhouse gas emissions and making buildings more resilient in NSW, as well as responding to council and NSW Government plans and strategies. There is an opportunity to transition buildings to net zero energy across Greater Sydney through the NSW planning system.

The performance standards have been developed for use in the NSW planning system. The planning system covers planning controls such as state environment planning policies (SEPPs), local environmental plans (LEPs) and development controls plans (DCPs). It also covers strategic planning, such as Greater Sydney Region Plan - A Metropolis of Three Cities (Region Plan), district plans and local strategic planning statement (LSPSs).

Aerial view of Parramatta CBD (Central City District). Image by Greater Sydney Commission.

State and local planning controls

- A **SEPP** is prepared by the NSW Government. They provide the framework for the LEP and DCP and cannot be overridden by the LEP. It deals with issues important to NSW or a region. Of more than 30 SEPPs, several include high level sustainability objectives or requirements. For example, State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004 aims to reduce water and greenhouse gas emissions in NSW residential development in NSW.
- **LEPs** are prepared by councils in NSW. They guide local land planning decisions through zoning and development controls, providing a framework for land use, and the size and form of development. Several LEPs, such as those for the City of Sydney, City of Ryde, City of Parramatta and City of Canterbury-Bankstown, already include clauses relating to energy efficiency and provide controls or incentives to achieve better energy outcomes in buildings, including renewable energy.
- **DCPs** are prepared by councils in NSW. They provide detailed planning and design guidelines to support the LEP and must be considered during a development assessment. DCPs differ depending on an area's location, context, community needs or design requirements. Many Greater Sydney councils include sustainability guidelines in DCPs that address energy efficiency and on-site renewables.

Strategic planning documents

- The **Region Plan** is prepared by the Greater Sydney Commission (GSC) and approved by the NSW Government. The Region Plan provides a 40-year vision and a 20-year strategic direction to manage change and growth for Greater Sydney. It informs the district plans, LSPSs, LEPs and assessment of planning proposals. There is a 'a low carbon city' objective in the Region Plan that supports initiatives that contribute to the NSW Government net zero emissions target.
- Each of the five **district plans** in Greater Sydney are prepared by the GSC. They provide a 20-year plan to manage growth in the context of economic, social and environmental matters to achieve the vision of the Region Plan. They contain planning priorities and actions for implementing the Region Plan at a district level, providing a bridge between Greater Sydney and local government planning. They contain actions that support the implementation of the performance standards.
- **Local strategic planning statements (LSPS)** are prepared by council. They give effect to the Region Plan and district plans in Greater Sydney and inform reviews and amendments to LEPs. The LSPS is a 10-year strategic land use plan. Some Greater Sydney councils recognise the NSW Government net zero emissions by 2050 target in their LSPS or include provisions to achieve more energy efficient buildings. Many councils also have actions in their LSPS to work with the NSW Government on improving BASIX to increase the energy efficiency of residential buildings.

The performance standards and evidence base have been developed for use by all Greater Sydney councils, as well as the NSW Government for implementation through state and local planning controls. This will also be a key opportunity for Greater Sydney councils and the NSW Government to contribute to their net zero emissions targets and respond to their plans and strategies.

International learnings

The program of work considered experiences from jurisdictions around the world in addressing climate change through planning policy.

Planning systems and mechanisms in New York, Seattle, Vancouver and the state of California include increasingly higher energy efficiency standards to achieve net zero buildings over time.

International case studies show that policies and codes to increase energy efficiency in buildings are reviewed every few years. This aligns with the NCC, which is updated every three years. Conversely, the BASIX SEPP (applying to the residential sector in NSW) has been subject to minimal review other than one stringency uplift for the energy (greenhouse gas) target in 2017.

Incentives are used in some jurisdictions. Seattle uses a system of voluntary incentives. New York includes incentives in the planning ordinance to achieve levels of on-site solar energy generation in developments. Similar incentives are part of the City of Vancouver Zero Emissions Building Plan (2016). An incentives framework is available under the NSW system – for example Bankstown LEP 2015 – however, this is not largely utilised across Greater Sydney.

The most ambitious emissions reduction programs are in Vancouver, where the framework includes an incremental approach to emissions and energy use and relies on a series of incentives to encourage innovation and best practice.

Other common elements from overseas experiences are the need for:

- a strong national or state policy position supported by legislation
- a planning hierarchy that establishes the long-term strategy for the development of energy efficiency in buildings
- zoning plans, codes and ordinances that control land use and built form at a local level that include controls relating to energy
- incentives to achieve energy outcomes above code.

Image by Greater Sydney Commission.

Pathways to net zero

Assessment process

An iterative collaboration between energy modelling, cost benefit analysis (CBA) and stakeholder engagement informed the energy reduction targets and proposed performance standards.

Stakeholder engagement

Industry and government stakeholders provided feedback on the approach to the assessment including energy efficiency initiatives modelled, draft results of the energy modelling, cost benefit analysis and potential off-site renewables mechanisms. Where feedback differed, it was tested with other stakeholders and industry experts.

Determination of a baseline

A baseline was established for each asset class. This was based on Section J of the NCC for the office, shopping centre and hotel asset classes and the NatHERS protocol and BASIX requirements for residential assets.

Energy reduction measures

Energy reduction measures were applied to each building typology to identify the maximum potential on-site improvement. The capital expenditure increase associated with each measure was individually costed for each typology. Energy efficiency measures were selected based on the application of current technologies and practices.

Cost benefit analysis

Energy reduction measures for each typology underwent a CBA to determine commercial viability based on capital expenditure increase compared to energy savings across a 15 to 25-year life of a building. An internal rate of return (IRR) was developed to determine the return on investment. An IRR above zero is the point at which a project breaks even. The CBA process identified and combined cost-effective measures to determine the most energy efficient and cost effective first step for each typology.

The analysis forecast the change in costs and benefits over time as different measures becoming cost effective in the future.

A further public CBA considered the costs and benefits to direct participants such as developers, owners and occupants of buildings, and indirect benefits to the public arising from energy savings.

Implementation options

An analysis of the NSW planning system to incorporate the performance standards to net zero energy into planning controls was discussed with senior planners and planning lawyers. Several approaches to both the energy reduction and mechanisms for recognising off-site renewables were considered, with opportunities and challenges for each approach considered.

Off-site energy procurement

A range of off-site renewable energy and energy efficiency options were investigated and discussed with stakeholders to close the gap between cost effective on-site measures and the achievement of net zero energy buildings. The CBA included the off-site renewable energy options and the timing for possible implementation.

Stakeholder engagement on draft performance standards

The project team met with key industry associations and developers to outline the draft targets, timing, development thresholds and the integration of off-site renewables. This allowed for direct feedback based on the current development market, updates to the rating tools and trends in the procurement of renewable energy and related certificates.

Final recommendations

From these activities, targets, timing of implementation, development thresholds, offsite measures and implementation options in the NSW planning system have been recommended.

Asset classes

The program assessed four asset classes:

- office (base building)
- shopping centre (base building)
- hotel (whole building)
- multi-unit residential (whole building).

Three building typologies based on recently approved development in Greater Sydney were analysed for each asset class.

A mixed-use asset class was also considered as component uses of the four asset types.

Table 2: Asset classes and typologies

Asset class	Typologies selected for assessment purposes	Gross floor area	Scope
Office	Premium grade (PCA) - 37 storeys	67,684m^2	Base building
	Grade A (PCA) - 20 storeys	35,635m^2	
	Grade B (PCA) - 4 storeys	8,878m^2	
Shopping centre	Regional - 5 storeys	114,443m^2	Base building
	Sub-regional - 2 storeys	26,560m^2	
	Neighbourhood - 1 storey	7,359m^2	
Hotel	5 Star (ATAP) - 50 storeys	38,975m^2	Whole building
	4 Star (ATAP) - 24 storeys	11,262m^2	
	4 Star (ATAP) - 10 storeys	4,420m^2	
Multi-unit residential	High rise - 25 storeys	16,995m^2	Whole building
	Mid rise - 15 storeys	9,858m^2	
	Low rise - 9 storeys	7,847m^2	

Rouse Hill Town Centre (Western City District). Image by Greater Sydney Commission.

Determination of baseline

A baseline was established for each asset class.

NCC Section J

For office, shopping centre and hotel asset classes the baseline was based on Section J "Energy Efficiency" of Volume One of the National Construction Code (NCC) 2019. Section J sets the minimum, mandatory standards for energy efficiency and greenhouse gas emissions performance for residential and non-residential buildings in Australia. The Australian Building Control Board (ABCB) is responsible for developing and improving the NCC.

This was used to develop the baseline energy performance in the analysis for the office, shopping centre and hotel asset classes, as all buildings must meet the minimum NCC energy efficiency requirements.

Two primary compliance pathways exist to meet the Section J requirements:

- deemed-to-satisfy (DTS) pathway, which mandates minimum requirements for individual building elements
- performance pathway, which requires energy modelling to demonstrate the proposed design meets the minimum standard when one or more of the minimum DTS requirements cannot be met. Energy modelling is carried out either using the NCC prescribed JV3 methodology or using Green Star Design & As Built or NABERS Energy methodologies for office buildings.

The NCC is updated every three years. The ABCB is aiming to increase the stringency of energy efficiency provisions on a financial cost/benefit basis at each interval. The next update is due in 2022, so industry engagement could start in 2021.

BASIX

For multi-unit residential development, the baseline was based on BASIX Energy minimum compliance requirements. BASIX is referred to in the NCC as the standard for residential buildings in NSW.

BASIX is a legislated state planning instrument that regulates the energy and water efficiency and thermal comfort of residential buildings in NSW. The BASIX tool sets minimum compliance requirements (targets) for residential development at all scales from single dwellings to high rise apartments. Department of Planning, Industry and Environment (DPIE) is responsible for developing and improving BASIX.

Relevant planning and design tools

Industry uses the following planning and design tools to demonstrate compliance with planning controls:

- National Australian Built Environment Rating System (NABERS)
- State Environmental Planning Policy (Building Sustainability Index: BASIX) 2004
- Green Star Design and As Built.

Each of these three existing planning and design tools allow for third-party verification of performance, boosting confidence in the accuracy of the predicted building performance through an established and consistent methodology. This provides assurance that the design will meet the intent for councils, developers and property owners. Third-party verification also improves the efficiency of the planning assessment process by reducing the complexity for planning assessors.

Stakeholders noted that some of these tools are not always kept up to date with industry practice; that the methodologies behind the tools should be more transparent; and given Green Star is administered by a non-government organisation, there is a risk that the tools are not aligned. Further information on the issues and opportunities with the planning and design tools are detailed in Appendix 4.

The performance standards to net zero use these existing tools where they apply to an asset class. See further information below on these tools.

An energy intensity target can also be used to demonstrate compliance with the controls. It is not an existing tool and there is no existing third-party verification method. To demonstrate compliance with the energy intensity target proponents will use the NABERS Independent Design Review Panel to formally verify energy modelling. This will confirm that the development can reasonably achieve the performance standard if constructed in accordance with its approved design and technology. Using the NABERS Independent Design Review Panel ensures there is a robust third-party verification process for the energy intensity standard, similar to the verification method for NABERS and Green Star.

NABERS

NABERS is a benchmarking tool that measures the environmental performance of buildings in terms of energy, water, waste and the indoor environment. The DPIE is responsible for developing and improving NABERS. For this assessment, the NABERS Energy tool has only been applied to the non-residential asset classes analysed. While NABERS Energy can be used for multi-unit residential assets, it only considers the common areas and not the individual apartments, unlike BASIX which considers both. In addition, in NSW, BASIX is the regulatory tool applicable to residential building energy efficiency, so the use of NABERS as the planning and design tool is not relevant for multi-unit residential development.

NABERS is a voluntary tool and uses recorded energy usage data to rate building performance. A NABERS rating can be agreed at the design stage of new buildings through a commitment agreement that binds a development to a level of performance that is verified post occupancy. This ensures the early consideration and implementation of design strategies.

A commitment agreement involves an independent review of the building and system design and energy system modelling to ensure it can achieve the targeted NABERS rating.

NABERS ratings are benchmarked in half-star increments from 0 stars to 6.0 stars, where a zero-star rating indicates the building is performing well below average, while a six-star rating indicates the building is market-leading.

Green Star

Green Star Design and As Built is one of several Green Star rating tools developed by the GBCA. It is a voluntary rating tool and covers the design, construction and commissioning phase of a building.

Green Star ratings apply to any type of building and cover a range of sustainable design elements. Energy consumption represents 20 Green Star rating credits out of a possible 110 credits.

The energy credit rewards reduced operational greenhouse gas emissions and uses three pathways to demonstrate compliance.

The pathways include:

- prescriptive pathway - points awarded where operational greenhouse gas emissions are reduced through specific best-practice building attributes
- alternative pathways based on building use - points awarded where NatHERS, BASIX or a NABERS commitment agreement is used to demonstrate that predicted greenhouse gas emissions will be reduced compared to a typical building
- reference building pathway - points awarded from achieving the minimum conditional requirement of a 10 per cent improvement on a Green Star reference building to achieving maximum carbon neutral operations. The reference building is derived from the Section J minimum requirement for non-residential buildings or BASIX/NatHERS for residential buildings.

The office asset class is subject to two modelling pathways: 15C NABERS Commitment Agreement pathway or 15E Reference building pathway.

The 15E Reference building pathway is selected as the pathway for analysis as it applies to all asset classes and allows for comparison between asset classes as well as a straightforward understanding of the targets by industry. Similar to NABERS, for this assessment, Green Star has only been applied to the non-residential asset classes analysed.

Green Star recognises projects for specific initiatives such as the provision of on-site energy storage, on-site renewable energy systems, off-site renewable energy procurement through the ability to purchase LGCs, GreenPower and PPAs.

The GBCA has developed a new version of Green Star called Green Star for New Buildings. This was released in October 2020. The current proposition is that before 31 December 2021 either the old or new tool can be used but from January 2022, newly registered projects must use Green Star for New Buildings.

One of the key changes in the Green Star for New Buildings tool is the development of the 'Energy use' credit in the 'Positive' category. This change more closely aligns with the net zero performance standards and awards developments achieving 20 per cent and 30 per cent improvement in energy use against NCC compliance with 'Credit achievement' and 'Exceptional performance' respectively and a 10 per cent improvement in energy stipulated as the 'Minimum expectation'.

Further information of how the Green Star Design and As Built energy credit compares to the Green Star for New Buildings energy use credit is shown in Appendix 5.

BASIX

The BASIX tool sets minimum compliance requirements(targets) for residential development at all scales from single dwellings to high rise apartments in NSW. Development proponents must demonstrate compliance with the following minimum BASIX Energy targets, measured as residential greenhouse gas emission savings per person:

- six storeys or higher = BASIX Energy 25
- four to five storeys = BASIX Energy 35
- three storeys and under = BASIX Energy 45

Only residential buildings 6 storeys and above were used for this assessment.

Thermal comfort which is factored into the BASIX Energy score and is modelled using tools approved under the federal government NatHERS scheme. It assesses the performance of passive design elements in minimising theoretical energy demand for space heating and cooling within apartment dwellings. Passive design elements include fabric and glazing, shading, orientation and natural ventilation.

The estimated energy demand related to maintaining year-round thermal comfort (i.e. estimated annual mechanical space heating and cooling demands) is combined with other building services for lighting, domestic water heating, ventilation and other equipment to calculate a percentage improvement against a specific benchmark. Different target scores must be achieved depending on the number of storeys and climate zone.

Image by Paul Patterson.

Cost effective energy reduction measures

To improve performance beyond what can be achieved through existing minimum energy requirements in NCC Section J or BASIX, additional energy reduction measures such as façade improvements, energy efficiency measures, fuel-switching technologies and on-site renewable electricity were investigated. These were selected based on.

These were selected based on:

- existing published studies used for similar analyses[3]
- industry trends and future projections (e.g. increase in equipment efficiencies)
- best-practice measures to reduce energy consumption (e.g. ceiling fans for residential buildings).

The façade is a vital building component to high-performing, energy efficient buildings. For this assessment, the façade was optimised to improve the efficiency of the building itself, rather than through passive design such as building orientation or form, as these issues are only determined based on the context of each site or commercial requirements.

Close to 20,000 combinations of parameters were assessed to derive the optimum combination for each asset class. This included building orientation; window to wall ratio; insulation of wall, floor, and roof; glazing performance; and the extent of shading. This is detailed in Appendix 1.

After investigating the optimum performance for the façade, further energy reduction was sought through a wide range of energy efficiency measures. These are outlined in Table 3.

3 ASBEC, Climate Works Australia (July 2018) Built to Perform, Building Code Energy Performance Trajectory Project; and Low Carbon Living (October 2018), SP0016 Building Code Energy Performance Trajectory Final Technical Report

Table 3: Energy reduction measures by building component

Building component	Description
Building envelope	The building envelope includes all the walls, floors, roof, windows and shading that enclose the building from its surroundings to reduce unwanted heat gain and loss. A higher performing façade encloses the building and prevents thermal transfers to maintain the internal conditions, achieve desired internal conditions with minimum effort, saving energy. Enhanced building sealing avoids the transfer of heat through uncontrolled air infiltration and exfiltration, maintaining internal conditions and requiring less energy from building systems to maintain the desired thermal environment. This can lead to more resilient buildings that can withstand extreme temperatures with less energy.
Fan system	Fans circulate the air in heating, ventilation and air conditioning (HVAC) systems. Different types – such as axial or centrifugal are suitable for different applications. Each has different efficiencies. Fans account for a high proportion of building energy consumption and 34 per cent of total HVAC consumption[4]. Efficiencies in fans will result in energy savings for the building overall.
Mechanical plant - heating and cooling	Large buildings typically have dedicated mechanical heating and cooling systems to maintain internal temperatures to comfortable levels and humidity at specified levels. Demand might be driven by heating or cooling dependent on the use of the building and the location/orientation. Improving the energy performance of the mechanical plant increases energy savings and improves thermal comfort.
Lighting	Lighting is generally provided for regular hours of occupancy with some lights on outside those hours (e.g. security lights, after hours usage or signage). Where appropriate, lighting controls can be provided, avoiding unnecessary lighting and associated energy consumption. Optimised lighting layouts can reduce the number of fixtures. Lighting is a key consumer of energy in a building; improved efficiency will see greater energy reductions.
Vertical transport	Vertical transport (lifts) distributes people and goods through multi-storey buildings. It is an essential service provided by the base building. Enhancing lift efficiencies by reducing the number of floors they service and maximising the efficiency of mechanical equipment can reduce base building power consumption while providing the same level of service.
Appliances and equipment	Appliances and equipment cover items such as white goods, computers, printers and audio-visual equipment. While each appliance might use comparatively little energy, when scaled across a whole building the equipment makes up a significant portion of total electricity consumption. This consumption is not included in base building energy, so is not considered for offices and shopping centres within this analysis. High efficiency appliances and equipment can reduce the operational energy of buildings through the direct reduction in electricity, and in some cases through the reduction in HVAC energy consumption due to lower heat generated in the space.
Renewable electricity	Renewable electricity can be produced on-site and consumed directly within a building with excess electricity being stored on-site or exported to the grid. On-site electricity generation in Australia is typically achieved through rooftop photovoltaic (PV) panels. To maximise the electricity production, the orientation of the panels needs to be optimised and the roof space needs to be free from shading. On-site renewable energy generation reduces a building's dependence on the electricity grid and enhances the building's resilience, particularly during adverse events such as blackouts. If batteries are installed, the stored electricity form on-site generation can help to reduce the demand for electricity in the peak usage times. A financial return can be achieved through energy savings and, if the system is large enough, from exporting electricity. Off-site renewable electricity is typically produced in solar or wind farms and is fed into the grid. Through contractual arrangements such as power purchase agreements, a developer can purchase an equivalent amount of electricity as renewable electricity to achieve net zero as defined in this report.

4 www.energy.gov.au/sites/default/files/hvac-factsheet-energy-breakdown.pdf?acsf_files_redirect

Omitted measures

Several energy efficiency measures were considered but omitted from the assessment for this program of work, including natural ventilation, temperature setpoints, and battery storage. They are detailed later in the modelling methodology for the cost benefit analysis (Appendix 2).

Heat pumps were included in the opportunity analysis and were found to be cost effective for residential, but generally not for non-residential assets. Apart from heat pumps, electrification was not further investigated. The City understands some developers are starting to design and construct fully electric buildings, with no connection to natural gas. The City supports electrification of buildings in the drive to net zero, however in recognition that not all planning and design tools encourage electrification and it isn't always cost-effective for all asset classes, at this stage the City has not required electrification.

Limitations of this assessment

For the purposes of this report, the assessment focused on finding a solution that is feasible for most building typologies within an asset class. At an individual building level, there may be innovative technologies and approaches that could be applied to achieve a better result than what is reported as the 'maximum energy efficiency potential' performance of a building.

Further information about the assessment of energy reduction measures is provided in Appendix 2.

Stakeholder engagement at Forum 2 in November 2018.

Performance standards (targets)

Following modelling and CBA of the energy reduction measures for each typology in each asset class, as well as stakeholder feedback, targets were set against applicable planning and design tools.

A first (2023) and second (2026) target has been determined for each asset class. There is a gap in the implementation of the targets in planning controls to allow for industry to adapt to the targets and innovate, especially as the second target is known well in advance.

Timeline

The timing of the implementation of the targets was discussed with stakeholders. Where the targets could be met with cost effective energy reduction measures, as determined by the CBA, stakeholders indicated these could be implemented through a sound and sustainability focused design process almost immediately; 2023 allows for the exhibition of the targets to the broader industry and time for implementation across multiple Sydney councils. This will be 1 year later than the next version of the NCC.

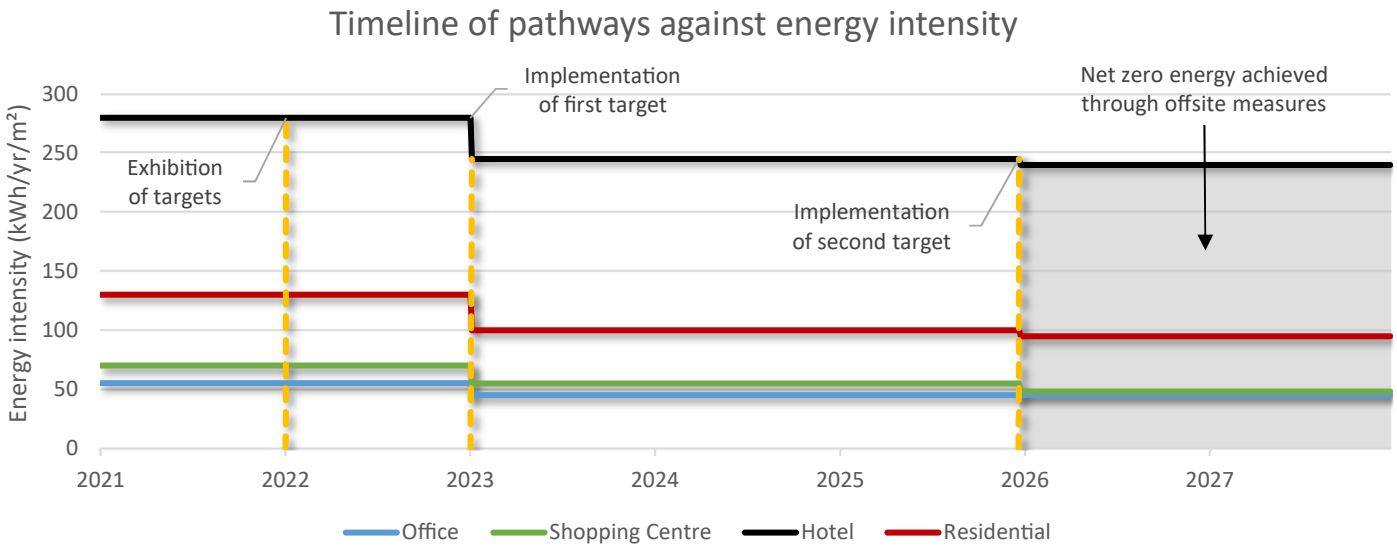
The implementation timing of the second target again aligns to be 1 year later than the subsequent NCC update and allows sufficient lead time for industry to plan and adjust their strategies, especially with the application of the off-site renewable energy component. Figure 1 below shows the key dates and targets for each asset type.

Target measure

A single on-site energy intensity (kWh/yr/m^2) target is identified for each asset class, along with equivalent options to meet that target using existing planning and design tools.

As the number and extent of energy reduction and on-site generation measures varies across the different building typologies, the easiest to achieve target across an asset class has been selected.

Figure 1: Timeline of the performance standard pathways towards net zero



An energy intensity target of 45 kWh/yr/m^2 for the base building, or a similar equivalent in NABERS Energy or Green Star Buildings credits, is recommended as the first target.

The energy intensity target for the second stage remains the same, however there is the additional requirement to invest in off-site renewable energy procurement to achieve the net zero target. Both these targets, including the off-site renewable procurement would achieve a positive financial return with positive internal rates of return (IRRs).

Table 4: Office asset class targets

Target	Target tools	Methods	IRR (25 year)/ Capital expenditure increase
NCC 2019 baseline	NCC 2019, or 5.5 star NABERS Energy Commitment Agreement	-	-
First target (2023)	45 kWh/yr/m^2, or 5.5 Star NABERS Energy Commitment Agreement (+25%), or Certified Green Star Buildings rating with a "credit achievement" in Credit 22: Energy Use, or equivalent	Energy efficiency On-site renewables	IRR: 10-37% Capital expenditure increase: 0.11%-0.58%
Second target (2026)	First step, and Renewable Energy Procurement equivalent to "net zero energy" or a maximum of 45 kWh/yr/m^2 of GFA	Energy efficiency Onsite renewables Offsite renewable procurement	IRR: 16-28% Capital expenditure increase: 0.16%-0.52%

An energy intensity target of 55 kWh/yr/m^2 for the base building, or a similar equivalent in NABERS Energy or Green Star Buildings credits, is recommended as the first target.

A further improvement in maximum energy intensity and off-site renewable energy procurement is needed for the second target of 45 kWh/yr/m^2. Both these targets, including the off-site renewable procurement will achieve a positive financial return with positive IRRs.

Table 5: Shopping centre asset class targets

Target	Target tools	Methods	IRR (25 year)/ Capital expenditure increase
NCC 2019 baseline	NCC 2019, equivalent to 3.5 Star NABERS Energy	-	-
First target (2023)	55 kWh/yr/m^2, or 4 Star NABERS Energy Commitment Agreement, or Certified Green Star Buildings rating rating achieving the "minimum expectation" in Credit 22: Energy Use, or equivalent	Energy efficiency On-site renewables	IRR: 2-23% Capital expenditure increase: 0.16%-0.42%
Second target (2026)	45 kWh/yr/m^2 GFA, or 5 star NABERS Energy Commitment Agreement, or Certified Green Star Buildings rating with "exceptional performance" in Credit 22: Energy Use, or equivalent and Renewable Energy Procurement equivalent to "net zero energy" or a maximum of 45 kWh/yr/m^2 of GFA	Energy efficiency On-site renewables Off-site renewable procurement	IRR: 9-11% Capital expenditure increase: 0.95%-1.28%

An energy intensity target of 245 kWh/yr/m^2 for the whole building, or a similar equivalent in NABERS Energy or Green Star Buildings credits, is recommended as the first target.

A slight improvement in maximum energy intensity is needed for the second target to 240 kWh/yr/m^2, with additional off-site renewable energy procurement allowed. These targets will achieve a positive financial return with positive IRRs, including off-site renewable procurement.

Table 6: Hotel asset class targets

Target	Target tools	Methods	IRR (25 year)/ Capital expenditure increase
NCC 2019 baseline	NCC 2019, equivalent to 3.5 Star NABERS Energy	-	-
First target (2023)	245 kWh/yr/m^2, or 4.0 star NABERS Energy Commitment Agreement, or Certified Green Star Buildings rating achieving the "minimum expectation" in Credit 22: Energy Use, or equivalent	Energy efficiency On-site renewables	IRR: 17-20% Capital expenditure increase: 0.15%-0.35%
Second target (2026)	240 kWh/yr/m^2, or 4.0 star NABERS Energy Commitment Agreement (+10%), or Certified Green Star Buildings rating with a "credit achievement" in Credit 22: Energy Use, or equivalent and Renewable Energy Procurement equivalent to "net zero energy" or a maximum of 240 kWh/yr/m^2 of GFA	Energy efficiency On-site renewables Off-site renewable procurement	9-10% (IRR 25 years) Capital expenditure increase: 0.24%-0.86%

For mixed use developments, the targets for office, shopping centre, hotel or the residential portion of the development applies.

Different BASIX targets for the whole building have been set for three different height bands to reflect the modelling and developer experiences that BASIX ratings are harder to achieve as height increases.

The portion of off-site renewable energy procurement has been calculated for the whole building (common area and individual apartments) to align with how BASIX operates.

As BASIX covers whole building, there are challenges applying off-site renewable energy procurement to individual units, due to the nature of strata governance.

These can be met by an Owners Corporation changing its by-laws (s135 SSMA) or by changes to NSW Government legislation. By similar means it could be practically required for common areas of strata buildings and may be possible for whole building for Build to Rent as this asset class develops, depending on how the NSW legislation is designed.

The targets outlined in Table 7 achieve a positive financial return with positive IRRs, including off-site renewable procurement.

Table 7: Residential asset class targets

6-10 Storeys

Target	Target tools	Methods	IRR (25 year)/ Capital expenditure increase
NCC 2019 baseline	BASIX 25	-	-
First target (2023)	BASIX 40	Energy efficiency + On-site renewables	IRR: 28% Capital expenditure increase: 0.64%
Second target (2026)	BASIX 45 and Renewable energy procurement equivalent to "net zero energy" or a maximum of 85 kWh/yr/m^2 of GFA	Energy efficiency + On-site renewables and Off-site renewable procurement	IRR: 20% Capital expenditure increase: 1.56%

11-20 Storeys

Target	Target tools	Methods	IRR (25 year)/ Capital expenditure increase
NCC 2019 baseline	BASIX 25	-	-
First target (2023)	BASIX 35	Energy efficiency + On-site renewables	IRR: 23% Capital expenditure increase: 0.64%
Second target (2026)	BASIX Energy 40 and Renewable energy procurement equivalent to "net zero energy" or a maximum of 90 kWh/yr/m^2 of GFA	Energy efficiency + On-site renewables and Off-site renewable procurement	IRR: 18% Capital expenditure increase: 0.79%

21-30 Storeys

Target	Target tools	Methods	IRR (25 year)/ Capital expenditure increase
NCC 2019 baseline	BASIX 25	-	-
First target (2023)	BASIX 30	Energy efficiency + On-site renewables	IRR: 22% Capital expenditure increase: 0.64%
Second target (2026)	BASIX 35 and Renewable energy procurement equivalent to "net zero energy" or a maximum of 95 kWh/yr/m^2 of GFA	Energy efficiency + On-site renewables and Off-site renewable procurement	IRR: 20% Capital expenditure increase: 0.67%

Parramatta shopping centre development (Central City District). Image by Greater Sydney Commission.

Implementation

Implementation will rely on a combination of embedding energy reduction targets and a model for off-site renewables procurement in the NSW planning system.

Implementation options

There are options or a combination of options to implement the performance standards in the NSW planning system.

The most immediate implementation opportunity is for councils to amend their LEPs and DCPs to include the performance standards. Other options include amending state-based plans, policies and legislation, to provide consistency across Greater Sydney.

A combination of options A and B will provide the preferred balance of legislative weight to achieve the net zero objective while being less prescriptive to provide flexibility.

Option A: LEP amendment

LEPs guide development outcomes and have statutory weight. Amending the Standard LEP to include clauses requiring best practice environmentally sensitive design, coupled with a specific clause relating to the targets, is suitable to meet the first and second target. Amending the LEP does not require policy or legislative change by the NSW Government.

The timeframe to make amendments to an LEP could be up to 12 months.

Councils could make one or numerous amendments to clauses in the LEP based on the structure of their LEP. The LEP could include clauses that require developments to address energy targets across the asset classes based on a trajectory towards net zero, or a new Part or Division for energy targets, including the land/development to which the Part or Division applies, objectives, definitions and direct reference to the consent authority.

The clauses should detail the staged approach by identifying the overall target with interim steps such as applications lodged between a date range must achieve a target and applications lodged after that date range must achieve a different target. Councils may provide an incentive clause such as additional height and/or floorspace ratio (FSR) to enable the application of targets beyond BASIX compliance requirements for certain residential development.

Pros

- A LEP provision provides the necessary legislative weight during the assessment of applications to ensure the net zero objective can be achieved.
- Councils can choose the appropriate clause to implement net zero energy targets to suit their LGA.
- The process to amend an LEP is driven by the council and can be commenced within a timeframe determined by the council.
- The Minister may provide delegation to council to make the LEP which can expedite its implementation.

Cons

- An LEP amendment requires the approval of the Minister, unless the Minister delegates the determining LEP amendments to councils. The Minister must support the amendments for the LEP to be made.
- The clause may need to be supported by additional incentive clauses for residential development.
- Once incorporated into the LEP, there is limited flexibility to vary the planning controls for particular developments and amending the development standard requires an amendment to the LEP.

Option B: DCP amendment

This approach would see DCP controls include details of the performance standards.

It allows flexibility for councils to consider scenarios where a development achieves a high degree of efficiency and meets the net zero objectives yet cannot meet the specific target.

Councils are responsible for amending the DCP, so they have control over the timing and implementation of the standards. The LEP and DCP amendments could occur simultaneously and could take up to 12 months.

The DCP would include a control with the specific targets and the details of the staged approach to meet net zero energy development. It would also identify the development to which the control applies and any other detail required to support the assessment and implementation of the performance standards.

Pros

- The DCP provides flexibility for alternative solutions that meet the net zero objectives.
- Amending the DCP is council's responsibility and can be undertaken within a timeframe determined by the council.

Cons

- A standalone DCP clause will not to provide sufficient legislative weight to achieve the net zero objective.
- The clause may need to be supported by additional incentive clauses for residential development.

Option C: Amendment to Region Plan and district plans

Amending the Region Plan and district plans to include a clear policy direction to implement the performance standards across Greater Sydney provides a secure line of sight between state and local strategic planning documents and planning controls.

Given the requirement for LEPs and DCPs to demonstrate consistency with state, regional strategies and district plans, aligning the Region Plan and district plans will assist in the required justification for LEP and DCP amendments. The amendment to the Region Plan and district plans would also give greater weight to each council's LSPS.

This approach requires the GSC, in collaboration with councils, to include the performance standards in the next review of the Region Plan and district plans. This would be the responsibility of the GSC and authorised by the NSW Government.

This could take up to 12 months and could be linked to the broader updates in 2022-23.

A new objective or an amendment to Objective 33 of the Region Plan could require all development to be net zero energy by 2026 with suggested wording:

Strategy 34.1 - Support the transition to net zero emissions through implementing controls to achieve net zero energy in all office, shopping centre, hotel and residential flat buildings by 2026.

Pros

- More certainty at a regional and district level will ensure a clear line of sight across the hierarchy of strategic documents.
- Supports council LEP amendments which will demonstrate consistency with the Region Plan and NSW Government strategies.
- This will demonstrate commitment in the planning system to achieving the NSW Government net zero emissions target.

Cons

- Strategic plans are not a matter for consideration in the assessment of development applications.
- Only likely to occur as part of a broader review under a timeframe that will be driven by the NSW Government.
- Region Plan requires support by the GSC and approval by the Minister for Planning.
- Amendments to the Region Plan or district plans may still be too broad.

Option D: Amendment to BASIX

Amending BASIX targets would provide the line of sight, certainty, transparency for both short-term and long-term targets to net zero energy residential buildings in the NSW planning system. It is an option that would provide consistency across Greater Sydney and is necessary to progress net zero for residential development.

Pros

- Essential to deliver net zero for residential buildings given the restrictions of the BASIX SEPP.
- Provides planning certainty and consistency.
- Avoids the needs for separate council amendments.

Cons

- The significant work required to make the amendments may be a cause of hesitation by the NSW Government and councils to take action.
- Limited to residential development with other options needed to implement net zero for office, shopping centre and hotel developments.
- May require the BASIX tool to be updated to recognise off-site renewables in addition to updating the targets.

Option E: Inclusion to the proposed Design and Place SEPP

The proposed Design and Place SEPP will put design and place quality at the forefront of any new residential, mixed use, commercial and industrial development. The NSW Government aims to reduce prescriptive measures and encourage innovation with the overriding goal to promote the sustainable growth and resilience of regions and cities. The draft SEPP will amalgamate some existing SEPPs, design guides, frameworks and tools, including BASIX. This also provides an opportunity to update existing planning policies, such as reviewing the targets in BASIX. The Explanation of Intended Effect document also proposes alternative compliance pathways for residential development other than BASIX.

The inclusion of the performance standards in the SEPP would provide certainty and transparency for the implementation of the targets in the NSW planning system.

Options D and E could be implemented in combination.

Pros

- The Explanation of Intended Effect for the SEPP proposes a principle for net zero.
- Provides planning certainty for inclusion of net zero energy targets in residential and non-residential development.

Cons

- The SEPP will include new design considerations, which are unknown at this time.
- The proposed SEPP will cover NSW and doesn't currently reflect the difference in regions, cities and LGAs. A state-wide approach to the targets would miss the opportunities specific to the development and climate of different regions.
- There is no assurance at this stage that the performance standards will be included.

Off-site renewable energy and efficiency procurement

Prior to the industry and government stakeholder forums in 2018, developers identified the current technology challenges for high rise development to achieve net zero energy buildings. On-site options are limited due to shading and small roof spaces of large buildings in Greater Sydney so a mechanism for the purchase of off-site renewable energy or equivalent certificates was needed to allow developments to achieve net zero.

Ideally any method to recognise off-site measures in planning should:

- allow a proponent to achieve a percentage of off-site renewables
- cover predicted operational energy use for a set period
- encourage competition
- meet national energy retail laws
- include easy to understand documentation for planning assessment
- meet compliance requirements
- fit within a recognised accreditation scheme
- be enabled through the NSW planning system or a legal framework.

Wind turbines - Saphhire wind farm, Inverrewl.
Image source www.sapphirewindfarm.com.au

The following four off-site renewable energy and energy efficiency mechanisms were identified for exploration following consultation with stakeholders such as the CEFC, Integral Group, Frasers, Greenland, AMP Capital, DPIE, GBCA and Six Capitals:

- Purchasing Greenpower. GreenPower is a government accredited renewable energy product and is purchased with an electricity contract. Once purchased it cannot be sold again.
- Retiring large-scale generation certificates (LGCs). LGCs are certificates created from generation of renewable energy by an accredited renewable energy generator. One LGC is equal to one megawatt hour (MWH) of renewable electricity generated from an accredited generator. Purchased LGCs are tradable, so to ensure they are not used again or sold, they need to be retired.
- Retiring energy efficiency saving certificates (ESCs). ESCs are a NSW Government scheme based on credits arising from implemented energy efficiency projects in NSW. Similar to LGCs they are a tradable commodity so need to be retired to ensure they have the desired effect.
- Enter into or adding a new development to an existing renewable energy power purchase agreement (PPAs). A PPA involves purchasing renewable electricity directly from a renewable energy generator or retailer. LGCs are provided to the user and need to be retired.

It was also considered that these options could be in place for a period of five to ten years.

These options were considered due to their recognition in the Australian market as suitable greenhouse gas emission offsets. Each option is already subject to a robust governance system, such that clear documentation can be provided to meet planning requirements. LGCs, GreenPower and PPAs are in use and accepted through the Green Star rating tool. Under NABERS currently, GreenPower is the only recognised form of renewable energy procurement. NABERS will be updating this to voluntarily retiring LGCs in 2022.

There are some issues for further consideration with the use of these options, including:

- diesel and gas cannot be offset through generation of off-site renewables or energy efficiency under the Greenhouse Gas Protocol unless a renewable fuel is available, which means the building in theory is not *net zero energy*; only *net zero electricity*
- the Federal Government's policy relating to LGCs is currently set to end in 2030
- LGCs, ESCs and GreenPower must be purchased annually based on the energy used for a development to be branded net zero energy
- estimations are required in terms of calculating the projected percentage of renewable energy in the grid for a five-year period.

In discussion with industry and government as part of the stakeholder engagement, it was agreed that the use of ESCs was not suitable for use in this program. ESCs are not currently being recognised by the Federal Government Climate Active Program or considered a suitable offset under the Greenhouse Gas Protocol for calculating the greenhouse gas emissions footprint of an organisation.

Next steps

These options will require more discussion with developers, industry groups, councils and state agencies, including DPIE, to refine the options and establish a robust assessment process (including clarity around required documentation to support a development application).

This could begin with voluntary pilots of the options by proponents of development ahead of 2026 to finetune processes and assess industry acceptance.

Preferred options for successful implementation

The targets need to be included in the planning controls. This will have greater impetus if supported by references to net zero energy development within strategic planning documents such as the Region Plan and district plans.

Both approaches need to be practical and achievable within the timeframe. Given this, the following approaches are recommended:

Achieving the first target (2023)

For all asset classes, councils could implement a combination of Options A and B (see Implementation section) by amending the LEP and DCP.

Amendments to the LEP and DCP in combination allows councils some flexibility in how they will achieve the target while still providing the necessary legislative weight to the net zero objective in the assessment of development applications.

Implementation of the performance standards in LEPs and DCPs is not possible for multi-unit residential development without the use of incentives. If a council wants to implement a higher BASIX Energy score for residential developments that is higher than the BASIX SEPP, either the SEPP needs to be altered or the council will need to amend its LEP to incorporate incentives for developers to reach the recommended target. As not all councils support an incentives-based approach in planning, it is recommended that the BASIX SEPP is amended to ensure widespread and consistent implementation of the first target.

Achieving the second target (2026)

For many developments, the purchase of offsite renewable energy will be a key element to reach the second target of net zero. The NSW planning system will need to allow for the purchase of offsite renewables to be recognised in the assessment of development applications.

Currently this approach is voluntarily, through agreements outside the planning system such as power purchase agreements. Any council requirements for off-site renewables applied through a condition of consent could be challenged in the Land and Environment Court. To negate this risk and to ensure a consistent approach, it is recommended that the Region Plan or district plans be amended to reflect the targets, creating a direct link.

Benefits

The economic benefits of implementing the proposed performance standards are significant. If implemented across Greater Sydney, cost-benefit analysis modelling estimates a net economic benefit to 2050 of **$3.1 billion**, comprising **$1.3 billion** to direct development participants (developers, owners and occupants) through energy bill savings and **$1.8 billion** to indirect participants (the public) from the avoided public cost associated with energy savings. All costs and benefits in this analysis are discounted at a rate of 7%, and dollar values are in real (2020) AUD$.

Direct participant impacts

The costs for direct development participants (developers, owners and occupants) include increased construction costs and the cost of purchasing offsite renewable energy, and benefits accrued from lower energy bills. The total compliance costs for direct development participants between 2023 and 2050 are estimated to be $0.9 billion. These costs are offset by discounted energy bill savings of $2.3 billion as detailed in Table 8. That means an estimated net economic benefit of $1.4 billion.

Other benefits associated with net zero and energy efficient buildings, including increased property values, increased occupant comfort, building resilience and investor premiums for corporate emission reductions are not quantified.

Table 8: Total direct impacts, 2023-2050

Category	Office	Shopping centre	Hotel	Multi-unit residential	TOTAL Sydney
Upgrade costs ($m)	46	62	19	819	946
Total electricity savings (GJ)	3,141,364	3,282,762	180,354	51,764,254	58,368,735
Total gas savings (GJ)	-170,588	-10,276	2,705,445	15,559,238	18,083,818
Bill savings ($m)	106	101	40	2,040	2,287

Indirect participant impacts

The public benefit of implementing the performance standards is significant. Indirect benefits include both long term and short term avoided costs associated with lower electricity and gas generation and lower network demands, along with avoided greenhouse gas emission costs and health benefits from avoided coal-fired electricity generation.

The total public benefits from implementing the targets are estimated to be $1.8 billion, as detailed in Table 9. The public costs associated with administration is not expected to be significant, as planning conditions already apply to all participants. The incremental administrative costs, which are the extra costs to the public to implement these targets compared to business as usual are estimated to comprise approximately $10 million between 2023 and 2050.

Table 9: Total indirect impacts, 2023-2050

Category	Office	Shopping centre	Hotel	Multi-unit residential	TOTAL Sydney
Avoided greenhouse gas emissions (tonnes CO2-e)	233,717	4,535,678	237,324	150,366	**5,157,085**
Off-site greenhouse gas emissions (tonnes CO2-e)	602,799	6,462,053	321,462	840,596	**8,226,910**
Avoided energy generation costs ($m)	46	745	48	3	**842**
Avoided energy network costs ($m)	29	574	17	-1	**618**
Avoided carbon emission costs ($m)	15	278	15	9	**316**
Avoided health costs ($m)	2	31	2	0	**35**
Total public benefit ($m)	**91**	**1,627**	**81**	**11**	**1,811**

Total economic impact

The total economic impact of the scheme is determined by the total net cost to direct participants and the indirect costs and benefits to the broader public. As seen in Table 10, the total net present value of the scheme is **$3.1 billion**.

Overall, the total benefit to cost ratio for the initiative is 4.3 for each dollar invested to achieve the target, direct and indirect participants receive $4.30. This confirms that implementing the targets for all asset classes is highly cost effective.

Table 10: Total indirect impacts, 2023-2050

Category	Office	Shopping centre	Hotel	Multi-unit residential	TOTAL Sydney
Discounted private costs ($m)	46	819	62	19	946
Discounted private benefits ($m)	106	2,040	101	40	2,287
Discounted public costs ($m)	0	8	1	0	10
Discounted public benefits ($m)	91	1,627	81	11	1,811
Total economic value ($m)	150	2,841	120	32	3,142
Total benefit to cost ratio	17	4.4	2.9	2.6	4.3

Project recommendations

The project identified key changes needed inside and outside of planning to support the transition to net zero emissions and implement the performance standards.

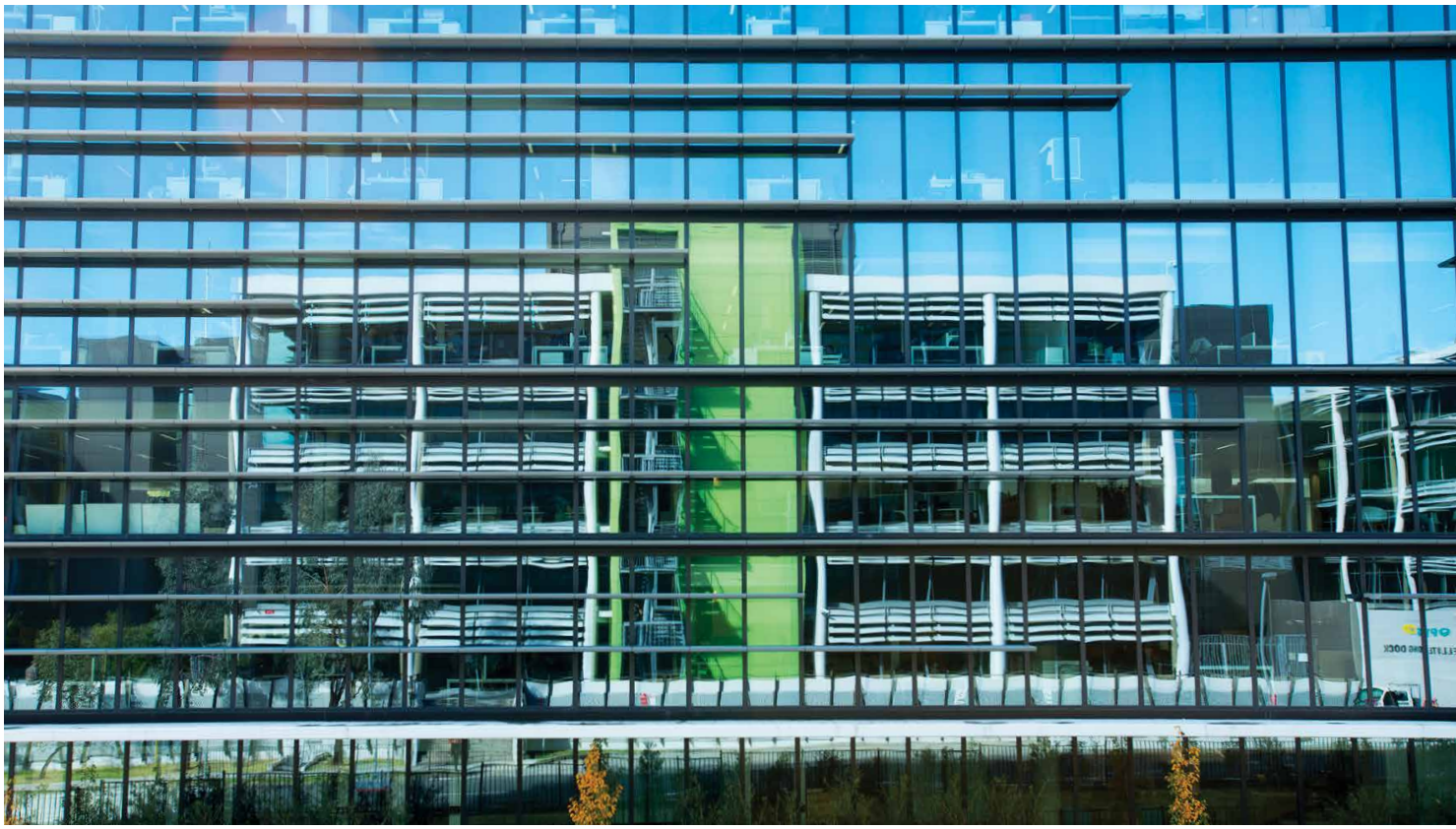
These recommendations have been developed through engagement with industry and government. Electrification, waste, transport and embodied energy are not included in these recommendations, as they were not in the original project scope.

Recommendations are grouped as short-term, medium-term and long-term.

Planning

Short (1-2 years)

- DPIE and all councils across Greater Sydney consistently implement the performance standards and timeframes, as identified in Table 8, in their planning controls (see options on how these can be implemented in an LEP and DCP in the Implementation Options).



Office buildings in Macquarie Park (North City District). Image by Greater Sydney Commission.

Table 11: Summary of targets and development size triggers

Proposed use	Development threshold for performance standards	Performance standards **Step one** Applications submitted between 1 January 2023 – 31 December 2025	Performance standards **Step two** Applications submitted from 1 January 2026 onwards
Office (base building)	A new office building containing a net lettable area (NLA) of 1,000m² or more A refurbishment* to an existing office building that contains a NLA of 1,000m² or more An existing office building of 1,000m² NLA or more with an addition of 50% or more NLA	Maximum 45 kWh/yr/m² of Gross Floor Area (GFA), or 5.5 Star NABERS Energy Commitment Agreement (CA) + 25%, or Certified Green Star Buildings rating with a "credit achievement" in Credit 22: Energy Use, or equivalent	Maximum 45 kWh/yr/m² of GFA, or 5.5 Star NABERS Energy CA + 25%, or Certified Green Star Buildings rating with a "credit achievement" in Credit 22: Energy Use, or equivalent and Renewable energy procurement equivalent to "net zero energy" or a maximum of 45 kWh/yr/m² of GFA
Retail (applies to shopping centre base building only)	A new shopping centre containing a gross lettable area – retail (GLAR) of 5,000m² or more An existing shopping centre of 5,000m² GLAR or more with an addition of 50% or more GLAR	Maximum 55 kWh/yr/m² of GFA, or 4 star NABERS Energy CA, or Certified Green Star Buildings rating achieving the "minimum expectation" in Credit 22: Energy Use, or equivalent	Maximum 45 kWh/yr/m² of GFA, or 5 star NABERS Energy CA, or Certified Green Star Buildings rating with "exceptional performance" in Credit 22: Energy Use, or equivalent and Renewable energy procurement equivalent to "net zero energy" or a maximum of 45 kWh/yr/m² of GFA
Hotel (whole of building)	A new hotel of 100 rooms or more A refurbishment* to an existing hotel that contains 100 rooms or more An existing hotel of 100 rooms or more with an addition of 50% or more hotel rooms	Maximum 245 kWh/yr/m² of GFA, or 4 star NABERS Energy CA, or Certified Green Star Buildings rating achieving the "minimum expectation" in Credit 22: Energy Use, or equivalent	Maximum 240 kWh/yr/m² of GFA, or 4 star NABERS Energy CA + 10%, or Certified Green Star Buildings rating with a "credit achievement" in Credit 22: Energy Use, or equivalent and Renewable energy procurement equivalent to "net zero energy" or a maximum of 240 kWh/yr/m² of GFA

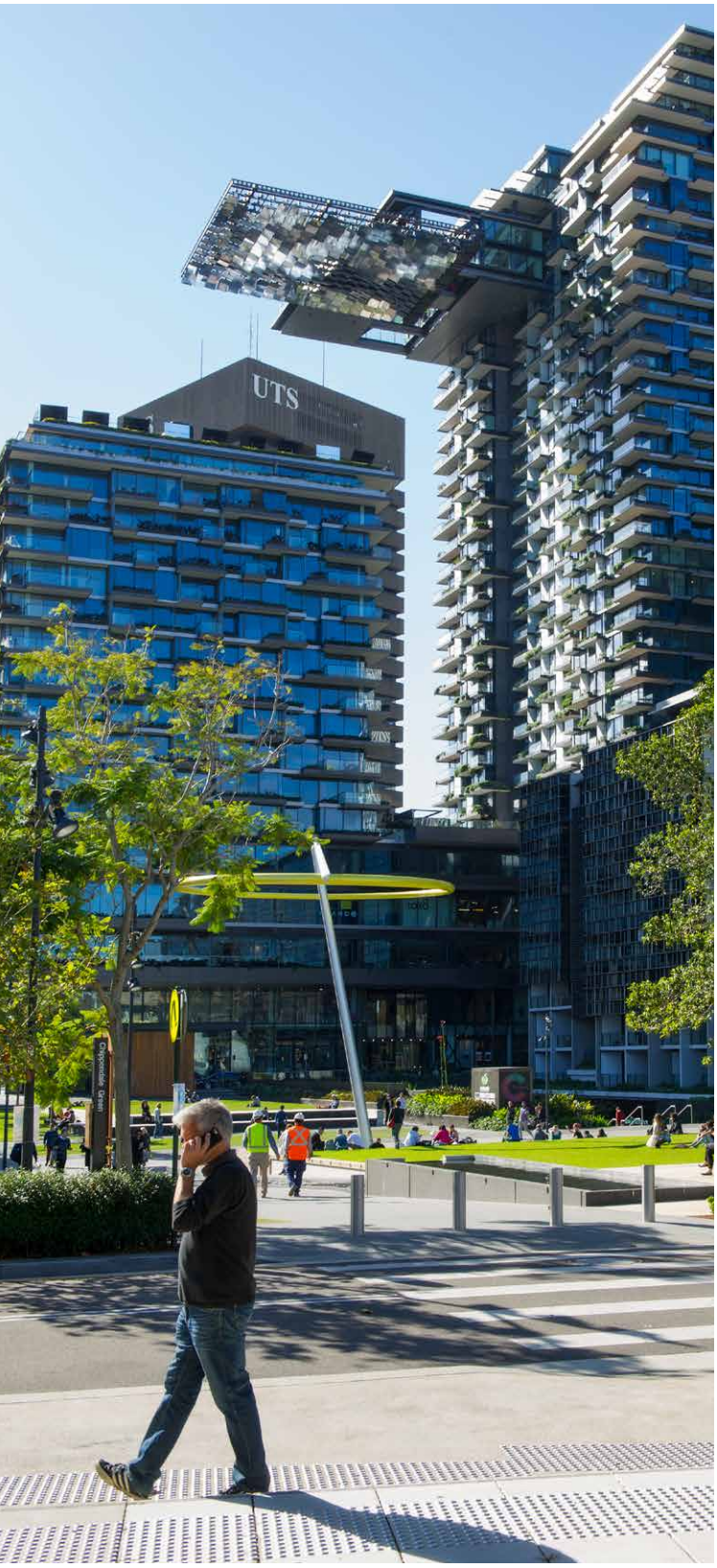
Proposed use	Development threshold for performance standards	Performance standards **Step one** Applications submitted between 1 January 2023 – 31 December 2025	Performance standards **Step two** Applications submitted from 1 January 2026 onwards
Multi-unit residential (whole of building)	6-10 storeys	BASIX Energy 40	BASIX Energy 45 and Renewable energy procurement equivalent to "net zero energy" or a maximum of 85 kWh/yr/m² of GFA
	11-20 storeys	BASIX Energy 35	BASIX Energy 40 and Renewable energy procurement equivalent to "net zero energy" or a maximum of 90 kWh/yr/m² of GFA
	21-30 storeys	BASIX Energy 30	BASIX Energy 35 and Renewable energy procurement equivalent to "net zero energy" or a maximum of 95 kWh/yr/m² of GFA
Mixed use	The above threshold for each use	The above performance standards apply for each proposed use	The above performance standards apply for each proposed use

* Refurbishment means carrying out of works to an existing building where the works affect at least half the total volume of the building measured over its external roof and walls and where there is no increase in the gross floor area. In calculating the extent of the building's volume that is being changed, the proposed works and all other building work completed or authorised within the previous three years is to be included.

* Refurbishments and additions - fifty per cent threshold has been used as:

  – Most developments would typically upgrade their plant and systems when development involves rebuilding or an alteration to more than half of the existing building

  – Clause 2, Section 94 of the Environmental Planning and Assessment Regulation 2000, allows a consent authority to require an existing building to be brought into total or partial conformity with the NCC This can be required where the development involves rebuilding or an alteration to more than half of the existing building. At that point an upgrade to of the plant and systems may occur to ensure conformity with the NCC.



Central Park urban renewal development (Eastern City District).

- DPIE to explore reviewing BASIX Energy targets for multi-unit residential development above 6 storeys and introducing additional targets for specific height bands in high-rise development (defined by BASIX as above 6 storeys) for BASIX Energy. For example, for 6-10 storeys, for 11-20 storey and 21-30 storeys.
- DPIE to consider regularly updating and publicly disclosing the emissions factors in the BASIX and NABERS tools.
- The City to collaborate with the property industry to finalise the methods to recognise and embed offsite renewables in planning.

Medium (2-3 years)

- GSC to consider amending the Region Plan and/or the district plans to support the implementation of the performance standards to achieve net zero energy in all office, shopping centre, hotel and residential apartment developments by 2030.
- DPIE to investigate updating BASIX to reference net zero energy by 2026 to support the implementation of the multi-unit residential high-rise targets and timeframes across Greater Sydney.

Long term (4-5 years)

- GSC to consider including an action in the district plans to require all councils across Greater Sydney to reflect the performance standards to achieve net zero energy for all new developments by 2030.
- The City to review the performance standards to maintain relevance, as industry adapts to higher standards and the planning and design tools change.

Non-planning

Short (1-2 years)

- The City to work with the Office of the Local Government to investigate the opportunity for all councils across Greater Sydney to include an action in their Community Strategic Plan (CSP) for all new developments to be net zero energy by 2026 (dependent on councils timing of their CSP review.)
- DPIE to consider working with the development industry and councils to regularly update their tools (BASIX and NABERS) to implement the pathways, maintain relevance as industry adapts to higher standards and to improve compliance.
- GBCA to consider working with the development industry and councils to regularly update their Green Star to implement the pathways, maintain relevance as industry adapts to higher standards and to improve compliance.
- DPIE with assistance from councils across Greater Sydney to explore implementing an education program to support planning and assessment officers, architects, sustainability consultants and developers to understand energy use in buildings, how the planning and design tools work and required documentation needed for them to determine compliance with the targets.

Medium (2-3 years)

- DPIE to explore implementing an education program that targets purchasers and tenants so they value the investment made to design and deliver energy performance that goes beyond minimum standards.
- DPIE with the Department of Industry, Science, Energy and Resources (DISER) to investigate introducing a mandatory building performance disclosure for hotels to drive demand for efficient hotels and support hotel operators to manage operational performance.
- DPIE with the DISER to investigate developing a rating tool and process that supports the disclosure of energy performance of multi-unit residential buildings at point of sale. This will drive demand for energy efficient apartments and save tenants money.

Long term (4-5 years)

- The City, GBCA, ASBEC and other key stakeholders to advocate for extending the Renewable Energy Target to 2050 to support the use of off-site renewables and the transition to net zero emissions by 2050.

Appendix 1

Building and systems description

Typology description

Office

The office typologies that were used for the analysis are shown below ranging in height and floor plate.

Table 1: Office typologies

Premium (PCA) - 37 storeys	Grade A (PCA) - 20 storeys	Grade B (PCA) - 4 storeys
		
Floors above ground: 37	Floors above ground: 20	Floors above ground: 4
GFA: 67,684m^2	GFA: 35,635m^2	GFA: 8,878m^2
NLA: 59,419m^2	NLA: 30,121m^2	NLA: 6,960m^2
Floor plate: 1,870m^2	Floor plate: 1,790m^2	Floor plate: 2,757m^2
Car parking spaces: 200 (Underground)	Car parking spaces: 65 (Underground)	Car parking spaces: 17 (Ground level)
WWR: 76%	WWR: 76%	WWR: 81%

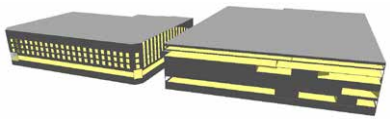
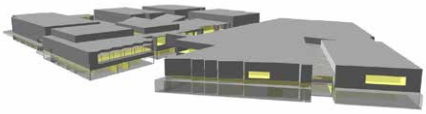
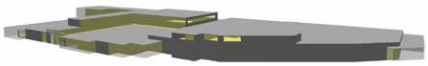
The parameters used for the baseline models were a combination of:

- deemed-to-Satisfy provisions of Section J of NCC 2019 Volume One
- parameters arising from Performance Verification method JV3 of NCC 2019 Volume One
- PCA Quality Matrix 2019 (3rd Edition) parameters for each office grade
- business as usual for parameters not covered by the above references.

Shopping centre

The shopping centre typologies that were used for the analysis are shown below.

Table 2: Shopping centre typologies

Regional - 5 storeys	Sub-regional - 2 storeys	Neighbourhood - 1 storey
		
Floors above ground: 5	Floors above ground: 2	Floors above ground: 1
GFA: 114,443m^2	GFA: 26,560m^2	GFA: 7,359m^2
GLAR: 84,813m^2	GLAR: 23,414m^2	GLAR: 3,021m^2
Floor plate: 19,413m^2	Floor plate: 17,321m^2	Floor plate: 7,359m^2
Car parking spaces: 850 (Underground)	Car parking spaces: 690 (Underground)	Car parking spaces: 314 (External)
WWR: 28%	WWR: 20%	WWR: 20%

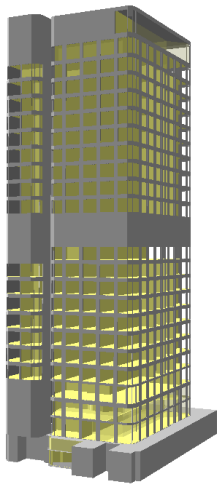
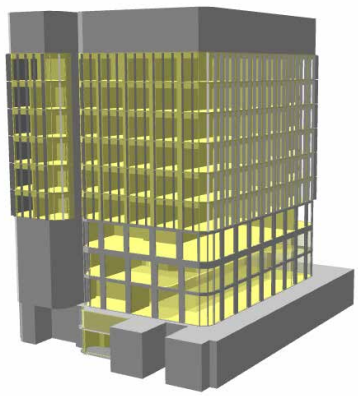
The parameters used for the baseline models were a combination of:

- deemed-to-Satisfy provisions of Section J of NCC 2019 Volume One
- parameters arising from Performance Verification method JV3 of NCC 2019 Volume One
- business as usual for parameters not covered by the above references.

Hotel

The hotel typologies that were used for the analysis are shown below.

Table 3: Hotel typologies

5 Star (ATAP) - 50 storeys	4 Star (ATAP) - 24 storeys	4 Star (ATAP) - 10 storeys
		
Floors above ground: 50	Floors above ground: 24	Floors above ground: 10
GFA: 38,975m^2	GFA: 11,262m^2	GFA: 4,420m^2
Floor plate: 886m^2	Floor plate: 564m^2	Floor plate: 548m^2
Rooms: 514	Rooms: 252	Rooms: 92
Car parking spaces: 100 (Underground)	Car parking spaces: 30 (Underground)	Car parking spaces: 0
WWR: 66%	WWR: 57%	WWR: 58 %

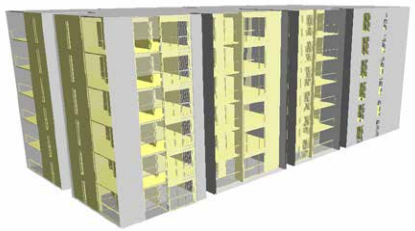
The parameters used for the baseline models were a combination of:

- deemed-to-Satisfy provisions of Section J of NCC 2019 Volume One
- parameters arising from Performance Verification method JV3 of NCC 2019 Volume One
- business as usual for parameters not covered by the above references.

Multi-unit residential

The shopping centre typologies that were used for the analysis are shown below.

Table 4: Multi-unit residential typologies

25 storeys	15 storeys	9 storeys
		
Floors above ground: 25	Floors above ground: 15	Floors above ground: 9
GFA: 16,995m^2	GFA: 9,858m^2	GFA: 7,847m^2
NSA: 14,165m^2	NSA: 8,286m^2	NSA: 6,599m^2
Floor plate: 691m^2	Floor plate: 657m^2	Floor plate: 872m^2
Apartments: 194	Apartments: 105	Apartments: 90
Car parking spaces: 170 (Underground)	Car parking spaces: 100 (Underground)	Car parking spaces: 60 (Underground)
WWR: 35%	WWR: 34%	WWR: 33%

The parameters used for the baseline models were a combination of:

- NatHERS protocol compliant parameters determined through modelling
- BASIX requirements determined through modelling
- business as usual for parameters not covered by the above references.

Appendix 2

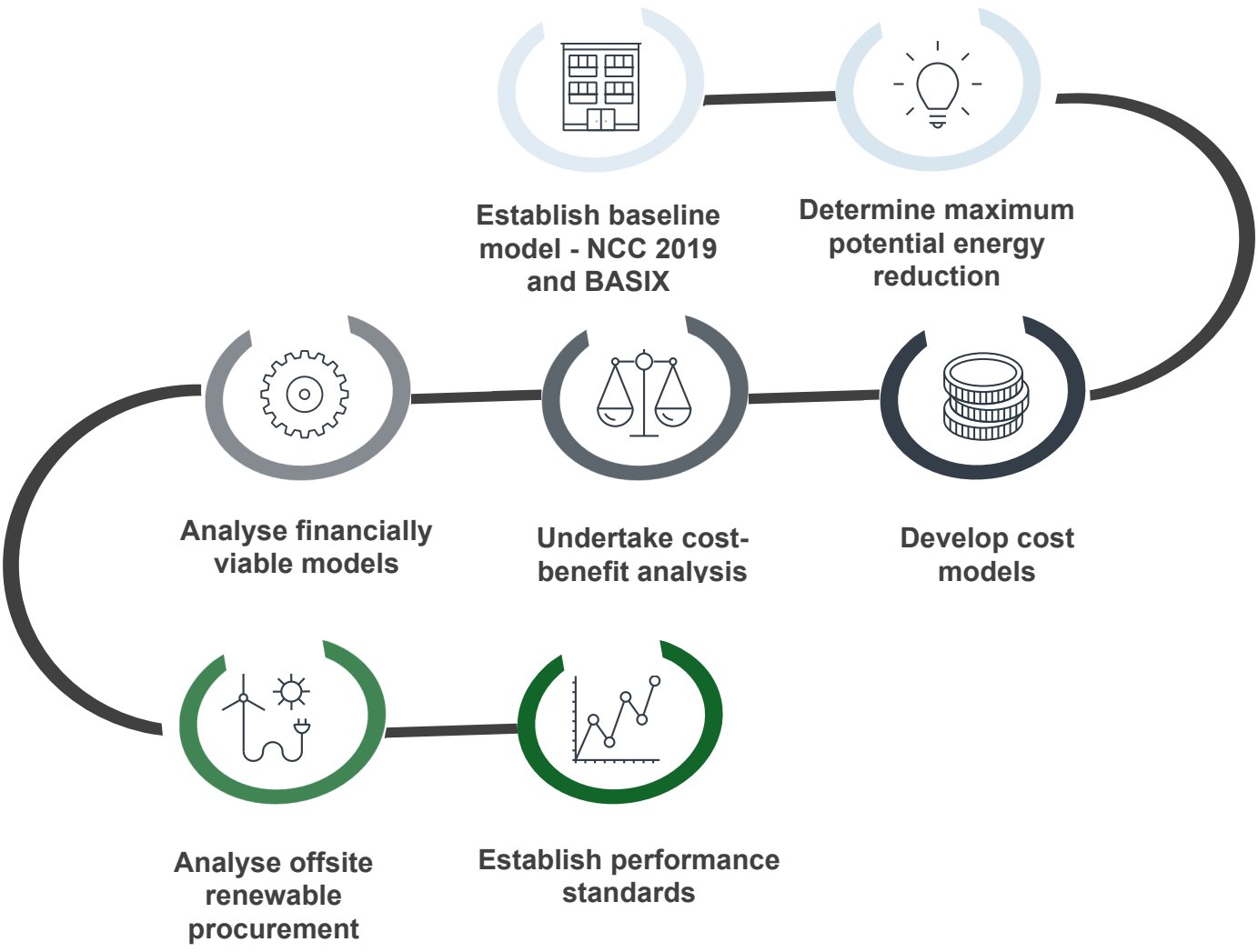
Modelling and cost benefit analysis

Modelling methodology

Energy consumption modelling was based on existing and proposed development designs, across five asset classes

This seven-phase approach is shown in Figure 1.

Figure 1: Modelling approach



Modelling approach

1. Establish baseline model

This step determined the suitable typologies for each asset class from a range of existing or proposed development designs that represented development in Greater Sydney, with a focus on high rise development. Three typologies were selected for each asset class, with each uplifted to meet NCC 2019 Section J.

2. Determine maximum potential energy reduction

This step determined maximum level of energy efficiency that could be achieved by optimising the building envelope and ensuring best practice building systems were provided in developments. The installation of onsite renewable energy generation was also considered in this analysis up to a maximum of 60% of a developments roof area.

3. Develop cost models

Cost models, based on this maximum level of energy efficiency, were developed for the baseline model and each individual energy reduction measure of the maximum energy reduction potential model.

4. Undertake cost-benefit analysis

The cost benefit analysis identified which individual energy efficiency measures within the maximum energy efficiency potential model were financially viable or would become financially viable before 2050. An internal rate of return (IRR) was developed for each initiative and compared against the uplift in capital investment.

5. Analyse financially viable models

Individually viable measures were aggregated to determine the financially viable energy efficiency measures for each typology from implementation to 2050. Feedback was sought from the external advisory group, as well as industry and government stakeholders at workshops on the measures.

6. Analyse offsite renewable procurement

Accounting for onsite energy reductions, offsite renewable procurement options were assessed for their viability in planning and their cost impact. This was informed by feedback from stakeholders.

7. Establish performance standards

The final phase determined the targets from the financially viable energy reductions by considering the financially viable energy efficiency measures and feedback from stakeholders.

The analysis covered major refurbishments as well as new developments where major refurbishment means only the existing façade, floorplates and key structures are retained. It was assumed that the base case for a major refurbishment is a building with non-NCC compliant building fabric and glazing. Therefore, a major refurbishment would trigger Section J and all building fabric and glazing would need to be upgraded to meet Section J requirements.

It was therefore assumed that all energy efficiency initiatives applied for a new development can be achieved in a major refurbishment without modifying the building structure.

Assets and typologies

Table 1 shows the typologies in each asset class, how they are defined for the purposes of this assessment, and the scope considered in this analysis. The building typologies ranged in size and scale and were drawn from recent development applications in Greater Sydney.

Energy reduction measures

To improve the typologies beyond the baseline performance (in line with Section J NCC 2019 Volume One for non-residential developments or NatHERS and BASIX modelling requirements for multi-unit residential), additional energy reduction measures were investigated.

Several energy reduction measures were investigated in the analysis including façade improvements, HVAC improvements, fuel-switching technologies and onsite renewable electricity. The full list of measures investigated and applicability to each asset class is detailed in Table 2.

Table 1: Asset classes and typologies

Asset class	Typologies selected for assessment purposes	Gross floor area	Scope
Office	Premium grade (PCA) - 37 storeys	67,684m^2	Base building
	Grade A (PCA) - 20 storeys	35,635m^2	
	Grade B (PCA) - 4 storeys	8,878m^2	
Shopping centre	Regional - 5 storeys	114,443m^2	Base building
	Sub-regional - 2 storeys	26,560m^2	
	Neighbourhood - 1 storey	7,359m^2	
Hotel	5 Star (ATAP) - 50 storeys	38,975m^2	Whole building
	4 Star (ATAP) - 24 storeys	11,262m^2	
	4 Star (ATAP) - 10 storeys	4,420m^2	
Multi-unit residential	25 storeys	16,995m^2	Whole building
	15 storeys	9,858m^2	
	9 storeys	7,847m^2	

Table 2: Energy efficiency measures considered and applicability

Measure	Building component	Description	Applicability of measure to asset class Office	Applicability of measure to asset class Shopping centre	Applicability of measure to asset class Hotel	Applicability of measure to asset class Residential
Façade optimisation	Building envelope	Improved fabric thermal performance with increased insulation, higher performance glazing and increased shading provision	Applicable	Applicable	Applicable	Applicable
Improved building sealing	Building envelope	Improved sealing of building fabric to reduce air infiltration	-	-	Applicable	Applicable
Fan ductwork optimisation	Fan system	Increased duct sizes	Applicable	-	Applicable	-
Variable speed drive fan system	Fan system	Installation of VSD and controls on fans	-	Applicable	Applicable	Applicable
Additional fan systems	Fan system	Installation of ceiling fans	-	-	-	Applicable
Plant efficiency improvement	Mechanical plant	Improving mechanical plant efficiencies for chillers or heat pumps	Applicable	Applicable	Applicable	Applicable
Heat recovery plant	Mechanical plant	Improvement of heat recovery systems	-	Applicable	Applicable	-
Electrification of energy	Mechanical plant	Converting heat plant for DHW or HHW to heat pumps	Applicable	Applicable	Applicable	Applicable
Improved LPD	Lighting	Increased efficiency and/or improved layout of light fittings	Applicable	Applicable	Applicable	Applicable

Measure	Building component	Description	Applicability of measure to asset class Office	Applicability of measure to asset class Shopping centre	Applicability of measure to asset class Hotel	Applicability of measure to asset class Residential
Additional lighting controls	Lighting	Additional lighting control features including daylight, motion sensors and time controls	Applicable	Applicable	Applicable	Applicable
VT efficiency improvement	Vertical transport	Improving lift and/or escalator efficiency and reducing standby power	Applicable	Applicable	Applicable	Applicable
Improved efficiency of appliances	Appliances and equipment	Installation of higher efficiency rated appliances and equipment	-	-	Applicable	Applicable
Onsite renewable energy generation	Renewable electricity	Installation of rooftop PV panels to 60% of the roof area or to net zero electricity consumption, whichever is smaller	Applicable	Applicable	Applicable	Applicable

These measures were selected based on:

- published studies used for similar analyses[1]
- industry trends and future projections (e.g. increase in equipment efficiencies)
- best practice measures for reduction of energy consumption (e.g. ceiling fans for multi-unit residential buildings).

1 ASBEC, Climate Works Australia (July 2018) Built to Perform, Building Code Energy Performance Trajectory Project; and Low Carbon Living (October 2018), SP0016 Building Code Energy Performance Trajectory Final Technical Report

The façade is an important building component to consider when assessing the potential for high-performing, energy efficient buildings. In this analysis, the façade was optimised to improve the envelope of the building rather than driving efficiency through passive design such as building orientation or form.

Passive design typically responds to the site context and is constrained by the shape of the site and commercial requirements. These elements cannot be accounted for in this assessment.

Close to 20,000 combinations of parameters were assessed to derive the optimum combination of various façade performance parameters and design to achieve the best energy efficiency outcome for each typology. The parameters for façade improvements were:

- building orientation
- window to wall ratio
- insulation of wall, floor and roof
- glazing performance
- extent of shading.

After investigating the optimum performance for the façade, further energy reduction was sought through energy efficiency measures.

Selected energy reduction measures were initially assessed individually to determine cost and energy viability. Combined, these measures can outperform or underperform compared to individual improvements depending on the measure.

For example, pairing the efficiency of the cooling system with more efficient lighting systems will generally result in a lower percentage of energy improvement than if the measures were taken independently. While adding improvements together will result in a better lighting system and reduce both energy consumption and cooling load.

As such, the aggregate models' energy and cost results in this analysis are not equal to the sum of the energy results of the individual components.

Electrical infrastructure

Electrical infrastructure in the built environment is determined by IEC60439[2] and AS/NZS3008[3]. These standards determine the capacities of electrical infrastructure such as distribution boards and cable sizes. Energy efficiency and onsite renewables can impact the electrical infrastructure requirements of a building.

As a particular energy efficiency measure or combination of measures could decrease or increase electrical infrastructure requirements, the cost impact has been accounted for by a quantity surveyor in the cost benefit analysis.

Renewable energy options

The following renewable energy options were considered:

- photovoltaic (PV) panels for electricity generation
- building integrated PV (BIPV)
- solar thermal panels for domestic hot water
- small-scale wind turbine for electricity generation.

Of these, BIPV, solar thermal panels and small-scale wind turbines were considered unviable.

The viability of BIPV would be affected by overshadowing, as is common in urban centres across Greater Sydney. Solar thermal panels are not practical for high rise buildings due to their relatively short design life and would typically only be able to serve the top three floors without impacting efficiency. Small scale wind turbines need reliable and fast wind to be cost effective; unlikely in an urban, high-rise environment where wind tunnels and turbulence is common.

Roof mounted PV panels were selected as the most feasible renewable energy option due to their ease of installation and comparatively short return on investment. They are a proven, common and accepted technology for all building typologies.

2 IEC 60439: Low-voltage switchgear and control gear assemblies

3 AS/NZS3008: Cable sizing calculator

The onsite renewable energy generation measure includes a PV array sized to the smaller of 60% of the roof area to account for space required for mechanical plant equipment and other services (e.g. cooling towers, building maintenance unit equipment etc.), or to achieve net zero electricity onsite.

The selection of PV panels is not intended to dictate PV as the only viable onsite renewable energy generation; rather, it is indicative of the potential viable performance of onsite renewable energy generation across the asset classes. Designers should investigate potential options to suit each site during concept and design development.

Omitted measures

Several energy efficiency measures were considered but omitted for the purposes of this technical energy analysis. Recognising that many projects would benefit from several of these measures, their viability could be investigated on a project by project basis. The energy modelling was based on conservative scenarios to ensure all development proposals across the analysed asset classes can achieve the targets without being onerous.

The measures discounted in this analysis are:

- commissioning, building tuning and operational management - a building that is commissioned and tuned correctly results in lower energy consumption; however, this is difficult to influence at the planning stage as it relies on mechanical and electrical contractors.
- temperature set points - while using a wider temperature set point range can reduce energy consumption significantly, this is determined by the occupants and building management not the building designer
- passive design - measures that would require redesign of the selected typologies (e.g. measures related to adjustment of floor depths, integrated shading or orientation) are project specific, and should be investigated on a project by project basis.
- natural and cross ventilation - energy efficiency improvements derived from natural and cross ventilation need to be incorporated into the design of the building based on its exposure and site context. Through good design, and if external conditions are suitable, there are many opportunities for maximising cross or natural ventilation opportunities to improve performance.
- reduction of thermal bridging - thermal bridges generally occur in the building fabric where the thermal performance is compromised due to framing. The level of bridging depends on the construction methods and detailing used in the building. As there are currently no accepted metrics in Australia to quantify thermal bridging, it is not possible to include it as a potential energy reduction measure.
- ground source heat pumps - this technology is still in development in Australia. In high-density urban areas, typically only vertical ground source heat pumps would be viable (as opposed to horizontal) due to space limitations and underground tunnelling. For vertical ground source heat pumps, a network of pipes would need to be 100m deep, which results in very high initial capital costs compared to other technologies. In less constrained sites, the opportunity to use horizontal ground loops reduces initial capital costs.
- batteries - batteries store electricity to be used when needed. The electricity could come from onsite renewables or imported grid electricity during peak hours. While this technology can reduce operational electricity costs and emissions, it does not reduce total energy used.
- hydrogen technology - this technology has near zero emissions and can be used as an alternative for natural gas in heating systems or cogeneration. However, there are still financial and technical hurdles to overcome with this technology for building projects.

Further, diesel for emergency generators were not considered as they typically only use diesel in emergencies or during testing, meaning the energy associated is negligible.

The analysis did not consider specific environmental contexts such as overshadowing or cooling effects from nearby water bodies.

Approach to cost benefit analysis

A cost benefit analysis (CBA) determines whether it is economically viable to proceed with a project. Measured through metrics such as internal rate of return (IRR), a CBA can determine how likely the investment is to give a return and how quickly the return will be realised.

The CBA:

- estimates the private and public benefits of different energy efficiency measures in newly constructed buildings and major refurbishments, and how these benefits vary over time
- determines the cost effectiveness of these measures based on construction costs and calculates benefits to inform the development of the performance standards
- estimates the net costs and benefits at a metropolitan scale based on estimated costs and benefits, and expected levels of new construction and major refurbishments in Greater Sydney.

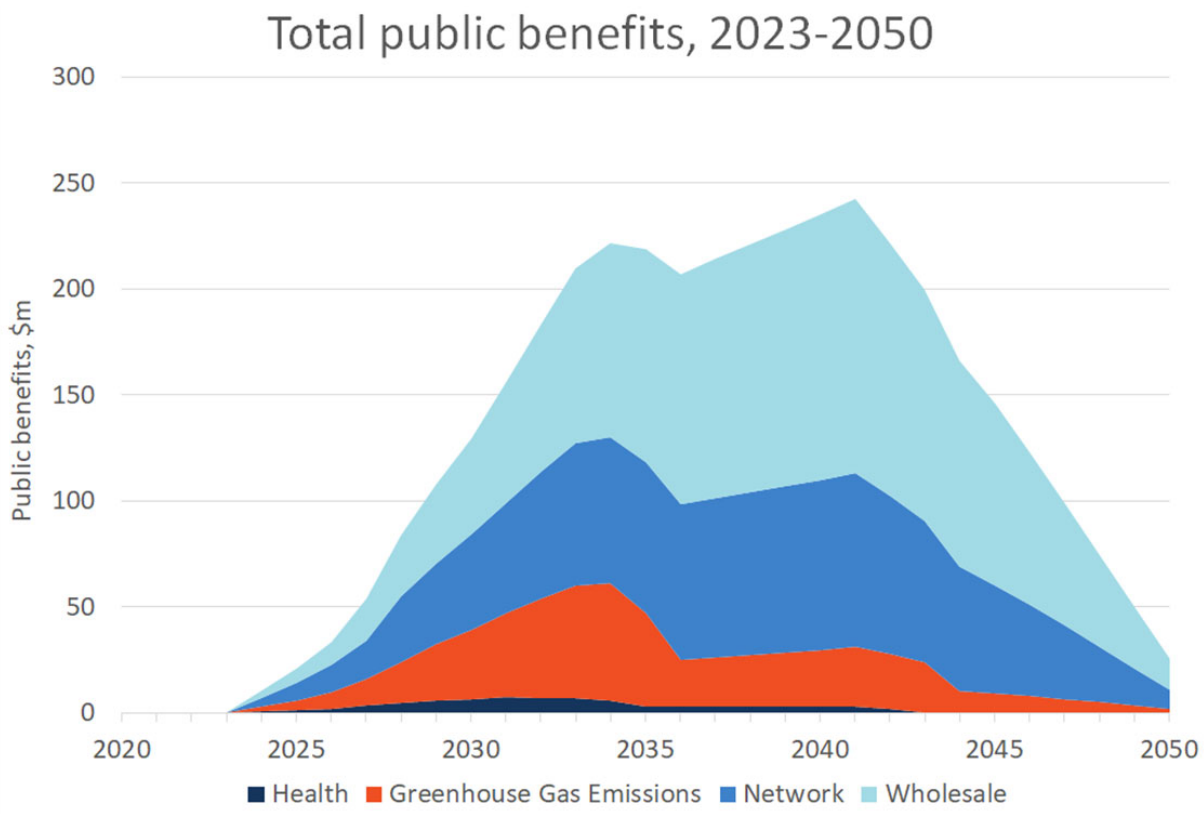
The analysis includes both costs and benefits to developers, owners and occupants, and indirect benefits to the public arising from energy savings.

These public benefits include:

- avoided network costs, realised through the reduction in energy network infrastructure and maintenance costs
- avoided generation costs, realised through the reduction in costs associated with the generation of energy, particularly in terms of fuel and facilities required to generate electricity
- avoided costs to health services, realised through reduced pollution from the reduction in burning of fossil fuels
- avoided greenhouse gas emission costs, realised through the reduction in offset credits required to be purchased in order to meet requirements.

These public benefits will change over time, as shown in Figure 2. Avoided greenhouse gas emissions benefits increase from 2026 due to the purchase of renewable energy procurement for compliance from that time. Greenhouse gas emissions benefits and health benefits decline from 2030 due to the forecast retirement of coal-fired generators in NSW, which will reduce the greenhouse gas intensity and pollution.

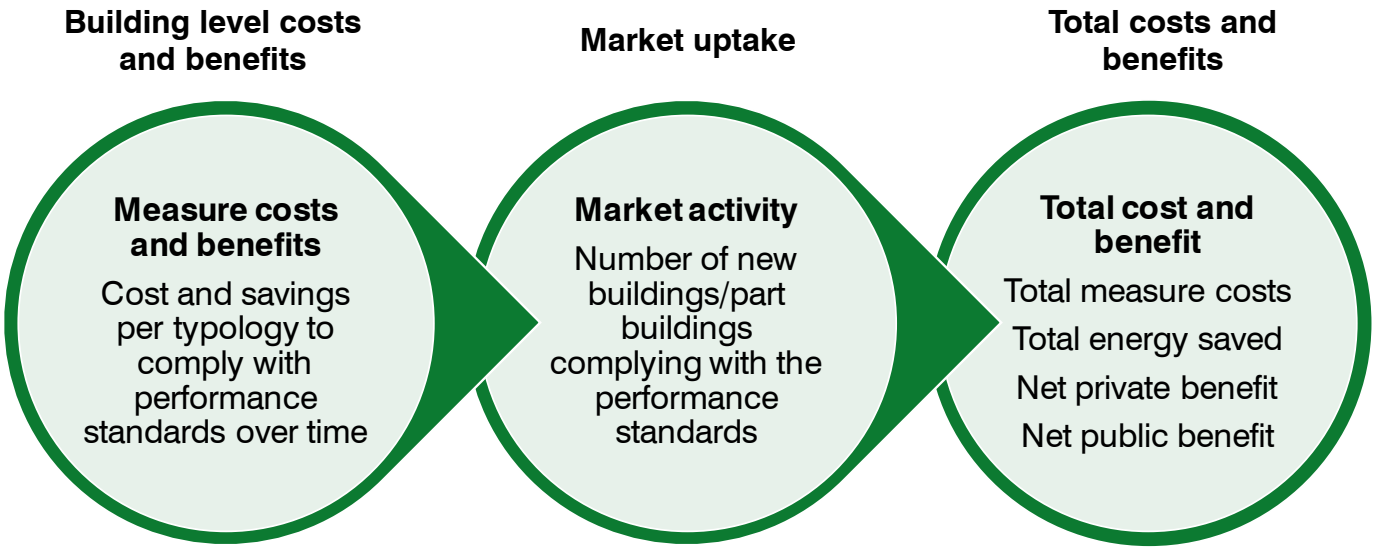
Figure 2: Public benefits from net zero compliance, 2023-2050



The CBA determined cost effective energy efficiency measures for each building type, as well as forecasting changed costs and benefits over time. This informed the staging of targets, as different upgrade activities are expected to become more cost effective in the future.

The individual components of the analysis model are detailed in Figure 3.

Figure 3: Analysis model



The CBA considered the costs and benefits of between 8 and 12 individual measures, six scenarios representing a combination of measures, and offsite renewable scenarios for each asset class. The costs and benefits of each of these analyses were modelled for 15 asset class typologies and two different climate zones. The steps involved in the model are detailed in Table 3.

Table 3: CBA model

Model step	Description
Determine costs	Costs for energy reduction measures were adjusted over time using industry learning factors that account for product cost changes (e.g. price reductions due to increased demand, or due to technological innovation), and construction cost changes (e.g. lower trade costs as familiarity increases and innovations in construction techniques). Offsite renewable procurement was estimated based on long-term projections of spot prices for LGC.
Determine private savings	Annual and lifetime energy bill savings were estimated using projected energy prices for larger users (commercial buildings and the strata component of residential buildings) and household energy prices for apartment energy consumption.
Determine net private benefit	The net private benefit represented the net value for direct market participants, apportioned between developers, owners, and occupants, with building developers paying upfront compliance costs, and building owners and occupants enjoying ongoing energy cost savings. In this context, 'cost effective' implies that the energy cost savings offset the upfront capital costs of the measure. The CBA does not model any imperfect transfers between parties such as between the developer and owner/tenant. The private net benefit of each energy reduction measure is calculated in terms of: • the IRR on the investment (over 15 and 25 years, reflecting the effective life of some technologies) • the net present value (NPV) of the investment (discounted at seven per cent) where NPV is the present dollar equivalent value of the investment at the end of the period • the increased capital cost as a proportion of total building cost and per m^2 of building space • the annual bill savings per m^2 of building space.
Determine market activity	Costs and benefits at a metropolitan scale were estimated using historic and short-term projections of building activity for the Greater Sydney office, shopping centre, hotel and residential markets, based on published data.
Estimate short run and long run avoided costs	The CBA estimated public benefits from data on the broader benefits of reduced pollution (including greenhouse gas emissions) from reductions in non-renewable energy generation such as coal, and reduced public costs from energy networks as energy efficiency activity reduces the demand on the electricity grid (marginal avoided operation and capacity costs).

Results

Energy results are presented as an energy intensity rate in kWh/yr/m^2 and expressed as a percentage energy reduction against the NCC 2019 or BASIX compliant baseline. The CBA results are shown as an IRR for 15 and 25 years, as well as a capital cost increase of each measure.

The IRR is the discount rate which would make the NPV of cash flows associated with the measure equal zero. This IRR can then be compared to alternative investments to determine whether the measure is considered cost effective.

A negative IRR implies the total positive cash flows (bill savings) are less than the negative cash flow (upfront cost). A positive IRR means that the bill savings outweigh the upfront cost. Higher IRRs show a greater overall return on investment.

The IRR is calculated in real terms; it does not include inflation. Table 4 shows a range of typical returns for alternative investments to provide some context on investment returns available to proponents of development in comparison to the IRRs available for investing in higher energy efficiency and onsite renewables.

The results presented for each of the asset classes below include the assessment of both financially viable and non-financially viable measures, which were used to inform the performance standards. The final targets are generally more achievable than the final financially viable models presented below, as not every financially viable measure needs to be implemented for the targets to be achieved.

A long return period reflects the effective life of some measures. Most measures have an effective life of between 7 and 15 years, and with continued energy bill reductions ending from this point. For these measures, the IRR does not change if a much shorter period is selected.

The analysis was based on conservative modelling, irrespective of development context. As such, developments designed to their context should exceed the performance indicated with little to no cost impact.

Table 4: Reference rates of return for cost effectiveness

Activity	Typical rate of return	Notes
Cash rate	0-4%	Based on range year to year - Reserve Bank of Australia www.rba.gov.au/statistics/cash-rate/
10 year government bond	1-3%	Based on range year to year – Reserve Bank of Australia www.rba.gov.au/statistics/tables
Australian shares	4%	Based on average annual S&P/ASX 200 Price Index increase year to year https://www.asx.com.au/about/historical-market-statistics.htm
Central rate for cost effectiveness (Australian and NSW Government guidelines)	7%	NSW Treasury (current as at 2020) - TPP17-03 NSW Guide to Cost Benefit Analysis Department of Prime Minister and Cabinet – Cost Benefit Analysis Guidance Note March 2020

Office

The office asset class can reduce energy consumption by approximately 35 per cent compared to an NCC 2019 compliant office development even before onsite renewable energy generation is applied to the building, which can further reduce energy consumption to more than 40 per cent compared to an NCC 2019 compliant office development. However, when the CBA is applied not all the 40 per cent energy reduction is cost effective.

The detailed energy and CBA results for each of the measures analysed for the office asset class are presented in Table 5 below. The results present a relatively consistent percentage reduction in energy across each of the models analysed; given variances these are presented as a range in Table 5.

The largest difference in energy reduction potential between the typologies is from onsite renewable energy generation. This difference relates to the ratio of roof area to floor area. A typology with a large roof area and a small floor area will have the capacity to integrate a larger amount of renewable energy generation over the roof area and offset a smaller energy consumption over the floor area.

The energy efficiency opportunities in larger office buildings with more centralised services are generally more cost effective while small buildings can more easily achieve financial viability from onsite renewables due to a higher ratio of roof area to floor area albeit at greater percentage increase of capital expenditure.

The office asset class considers base building energy only and does not account for a tenant's energy consumption, typically tenancy power and lighting.

Table 5: Office results

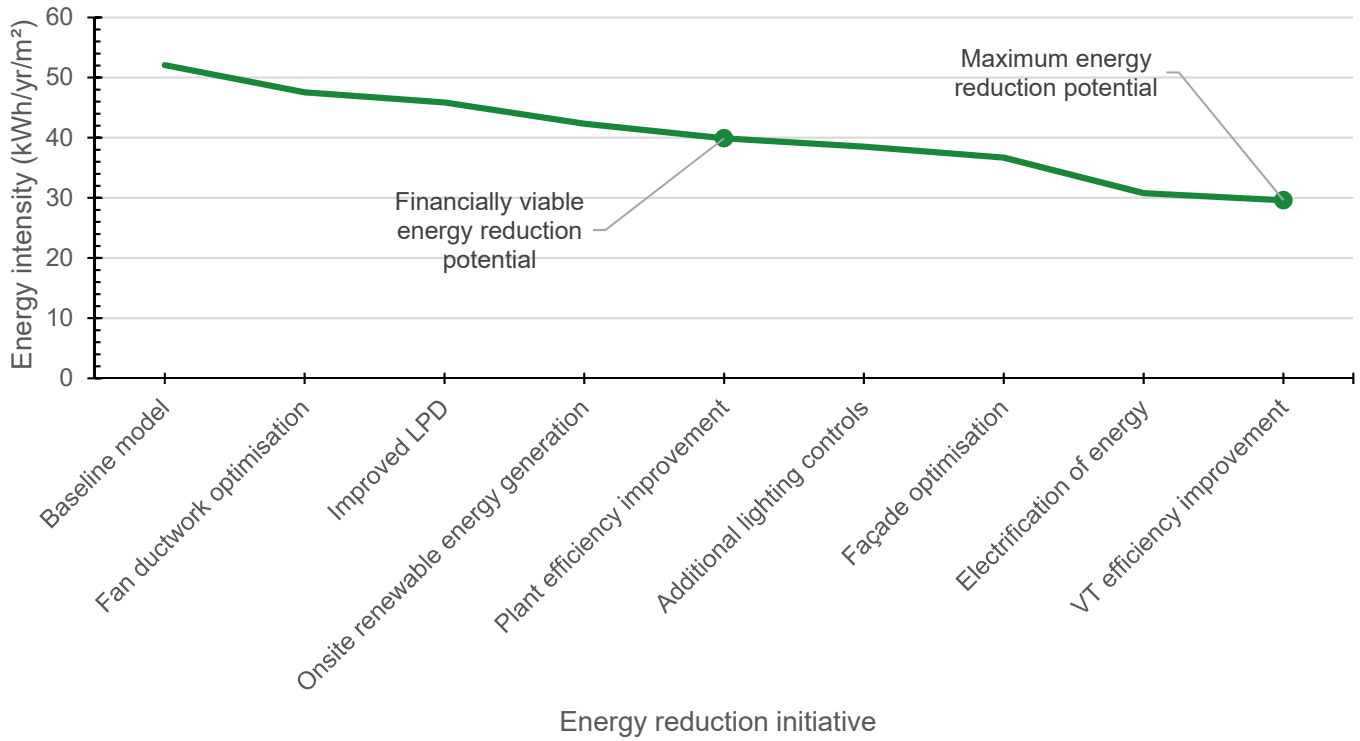
Energy reduction measure	Energy reduction	IRR (15 years)	IRR (25 years)	Capital cost increase (as % of development)
Façade optimisation	1.4% - 5.8%	(-35%) - (-24%)	(-21%) - (-12%)	2.95% - 3.50%
Fan ductwork optimisation	7.5% - 9.6%	32% - 82%	33% - 82%	0.03% - 0.10%
Plant efficiency improvement	5.3% - 7.4%	0% - 5%	1% - 5%	0.40% - 0.51%
Electrification of energy	8.0% - 12.9%	(-17%) - (-14%)	(-16%) - (-13%)	0.44% - 0.86%
Improved lighting power density	1.9% - 7.1%	3% - 21%	3% - 21%	0.06% - 0.12%
Additional lighting controls	1.9% - 3.3%	(-10%) - (-3%)	(-10%) - (-3%)	0.08% - 0.17%
Vertical transport efficiency improvement	2.6% - 2.9%	(-19%) - (-16%)	(-17%) - (-14%)	0.69% - 0.89%
Onsite renewable energy generation	7.9% - 64.5%	1% - 3%	6% - 8%	0.27% - 3.66%

The cumulative reductions in order of financial viability are plotted in Figure 4. The limit of financial viability occurs at approximately 40 kWh/yr/m^2 and the maximum energy intensity reduction potential is approximately 30 kWh/yr/m^2.

Only four of the analysed measures in Figure 4 achieve a positive IRR on a cost-effective basis and return a 23 per cent to 85 per cent improvement on energy performance over the NCC 2019 baseline:

- fan ductwork optimisation
- improved lighting power density
- onsite renewable energy generation
- plant efficiency improvement.

Figure 4: Office cumulative energy intensity reduction of energy efficiency reduction measures



The financially viable energy reduction measures were aggregated and the results translated into the planning and design tools. The results are shown in Table 6. Note, the percentage values in the NABERS Energy rating column refer to the percentage above the NABERS star band.

Table 6: Office energy results for financially viable measures

Energy reduction model	Energy intensity kWh/yr/m²	NCC 2019 energy reduction	NABERS Energy rating	Green Star Buildings certified rating and Credit 22 criteria
NCC 2019 baseline model	48.9 - 55.2	-	5.5 star (+9%) - 5.5 star (+19%)	-
Financially viable model without onsite renewable energy generation	39.4 - 48.3	11.9% - 21.2%	5.5 star (+27%) - 6.0 star (+4%)	Minimum Expectation - Credit Achievement
Financially viable model with onsite renewable energy generation	7.6 - 40.7	23.3% - 84.9%	6.0 star (+13%) - 6.0 star (+94%)	Credit Achievement - Exceptional Performance
Maximum energy potential without onsite renewable energy generation	30.7 - 36.5	33.9% - 37.3%	5.5 star (+31%) - 6.0 star (+8%)	Exceptional Performance
Maximum energy potential with onsite renewable energy generation	-0.9 - 29.6	42.7% - 101.8%	6.0 star (+19%) - 6.0 star (+101%)	Exceptional Performance

Table 7: Office CBA results for financially viable measures

Energy reduction model	IRR (15 years)	IRR (25 years)	Capital cost increase
Financially viable model without onsite renewable energy generation	0% - 7%	0% - 7%	0.49% - 0.74%
Financially viable model with onsite renewable energy generation	(-5%) - 4%	(-4%) - 4%	0.76% - 4.39%
Maximum energy potential without onsite renewable energy generation	(-13%) - (-5%)	(-11%) - (-8%)	4.65% - 6.16%
Maximum energy potential with onsite renewable energy generation	(-15%) - (-11%)	(-8%) - 0%	4.92% - 9.82%

As shown in the previous table, it is financially viable to achieve a 12 to 21 per cent reduction on NCC 2019 Section J without renewable energy generation and approximately a 2 to 85 per cent reduction with onsite renewable energy generation, depending on the ratio of roof to floor area.

In NABERS Energy this translates to between a high (i.e. significantly exceeding the star-band threshold) 5.5 star to a low (i.e. just exceeding the threshold) 6.0 star rating without renewable energy generation and a high 6.0 star rating with onsite renewable energy generation. In Green Star Buildings the financially viable model will achieve credit achievement through Credit 22.

Office developments with fewer floors have the potential to go beyond net zero energy and achieve net positive energy if the development generates more energy than it would consume annually through onsite renewable energy generation, as the building form has a high ratio of roof area to floor area.

Commercial office buildings (Eastern City District). Image by Jamie Williams.

Shopping centre

The shopping centre asset class considers base building energy only and does not account for a tenant's energy consumption.

The energy analysis indicates a reduction in energy consumption of approximately 35 per cent compared to an NCC 2019 compliant shopping centre development. The inclusion of onsite renewable energy generation increases the energy reduction to at least 80 per cent compared to an NCC 2019 compliant development and potentially up to net zero, given the significant roof area to floor area ratio of shopping centre developments.

However, when the CBA is applied not all the 80 per cent energy reduction is cost effective.

The detailed energy and CBA results for each of the measures are presented in Table 8.

The results indicate a reasonable variation between the energy analysis and CBA. The largest range in an energy reduction measure relates to the onsite renewable energy due to the ratio of roof area to floor area. The largest range for a measure in the CBA relates to the heat recovery plant and the financial viability of applying the energy reduction measure to central services of larger shopping centres compared to the decentralised services of smaller shopping centres.

Table 8: Shopping centre results

Energy reduction measure	NCC 2019 energy reduction	IRR (15 years)	IRR (25 years)	Capital cost increase
Variable air fan system	9.8% - 16.2%	(-3%) - 19%	(-3%) - 19%	0.17% - 0.34%
Plant efficiency improvement	3.6% - 4.7%	(-13%) - 13%	(-12%) - 14%	0.21% - 1.01%
Heat recovery plant	0.3% - 1.6%	OPEX Increase - 621%	(-32%) - 621%	0.00% - 0.14%
Electrification of energy	11.4% - 26.2%	(-9%) - 20%	(-8%) - 21%	0.20% - 0.39%
Improved lighting power density	1.9% - 3.5%	12% - 20%	12% - 20%	0.07% - 0.11%
Additional lighting controls	0.7% - 8.0%	(-18%) - 18%	(-18%) - 18%	0.06% - 0.09%
Vertical transport efficiency improvement	1.3% - 1.7%	(-18%) - (-14%)	(-16%) - (-12%)	0.40% - 0.40%
Onsite renewable energy generation	33.4% - 64.2%	(-2%) - 4%	4% - 8%	1.57% - 2.60%

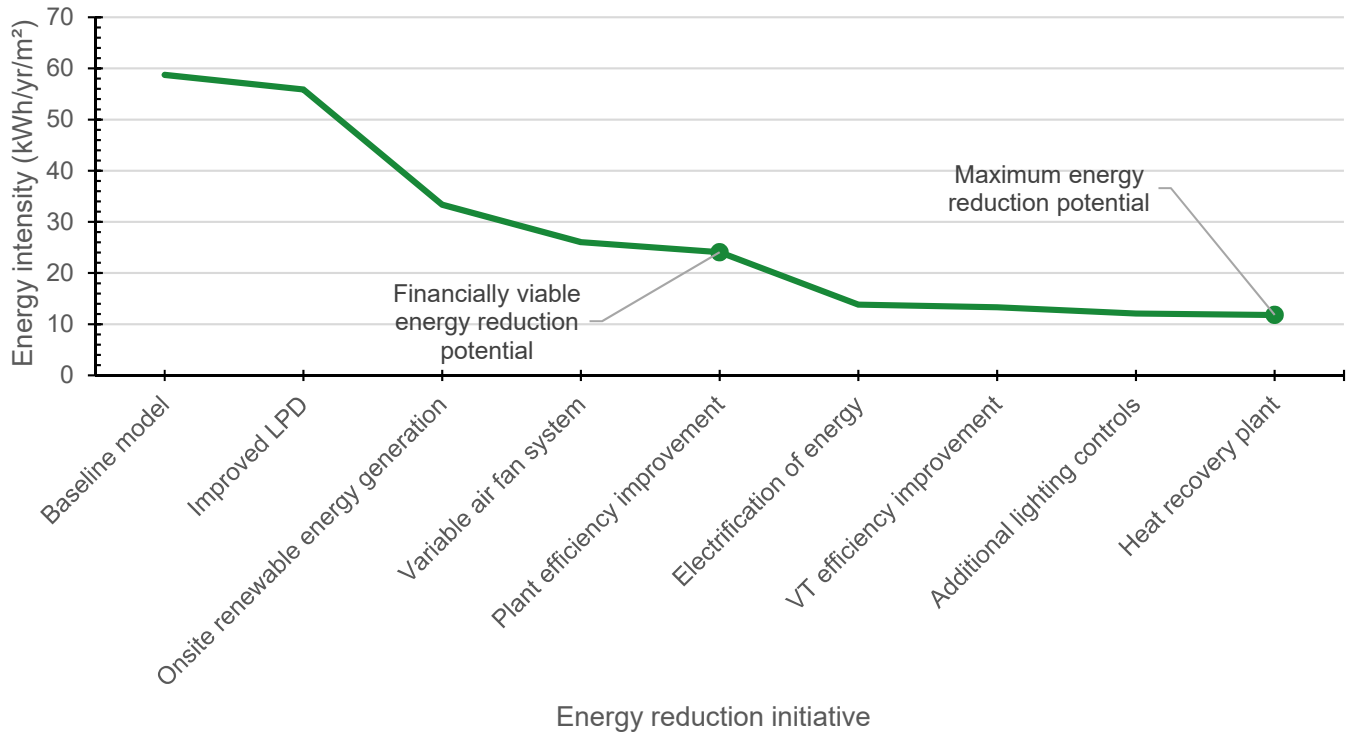
The cumulative reductions in order of financial viability are plotted in Figure 5. These indicate the cumulative reduction in energy intensity when measures are aggregated. The limit of financial viability occurs at approximately 25 kWh/yr/m^2 and a maximum energy intensity reduction occurs at approximately 10 kWh/yr/m^2.

Like offices, energy efficiency opportunities are more likely to be financially viable in multi-storey shopping centres with more centralised services, compared to small centres with few storeys that can achieve higher financial viability through onsite renewables due to a higher ratio of roof area to floor area albeit at greater percentage increase of capital expenditure.

The CBA demonstrates that only four of the analysed measures achieve a positive IRR and could be implemented on a cost-effective basis, returning a 48 to 85 per cent improvement on energy performance over the NCC 2019 baseline:

- improved lighting power density
- onsite renewable energy generation
- variable air fan system
- plant efficiency improvement.

Figure 5: Shopping centre cumulative energy intensity reduction by energy efficiency reduction measure



The financially viable energy reduction measures were aggregated and results translated into the planning and design tools (Table 9). Percentage values in the NABERS Energy rating column refer to the percentage above the NABERS star band.

Table 9: Shopping centre energy results for financially viable measures

Energy reduction model	Energy intensity kWh/yr/m²	NCC 2019 energy reduction	NABERS Energy rating	Green Star Buildings certified rating and Credit 22 criteria
NCC 2019 baseline model	50.9 - 68.4	-	3.5 star (+3%) - 5 star (+1%)	-
Financially viable model without onsite renewable energy generation	39.7 - 57.5	14.7% - 22.1%	4.0 star (+12%) - 5.5 star (+4%)	Minimum Expectation - Credit Achievement
Financially viable model with onsite renewable energy generation	8.4 - 34.9	48.2% - 84.8%	6.0 star (+48%) - 6.0 star (+91%)	Exceptional Performance
Maximum energy potential without onsite renewable energy generation	31.3 - 35.1	37.5% - 49.5%	4.5 star (+0%) - 5.5 star (+7%)	Exceptional Performance
Maximum energy potential with onsite renewable energy generation	-1.9 - 11.8	82.5% - 103.3%	6.0 star (+52%) - 6.0 star (+108%)	Exceptional Performance

Table 10: Shopping centre CBA results for financially viable measures

Energy reduction model	IRR (15 years)	IRR (25 years)	Capital cost increase
Financially viable model without onsite renewable energy generation	(-12%) - 12%	(-12%) - 12%	0.44% - 1.46%
Financially viable model with onsite renewable energy generation	(-9%) - 1%	(-6%) - 1%	2.01% - 4.06%
Maximum energy potential without onsite renewable energy generation	(-3%) - 5%	(-9%) - 8%	1.10% - 2.49%
Maximum energy potential with onsite renewable energy generation	(-9%) - 8%	3% - 7%	2.67% - 5.09%

The analysis shows that it is financially viable to achieve a 15 to 22 per cent reduction on NCC 2019 Section J without renewable energy generation and a 48 to 85 per cent reduction with the inclusion of onsite renewable energy generation, depending on the proportion of roof space to building height.

In NABERS Energy this translates to between a 4.0 star and 5.5 star rating without renewable energy generation and a high 6.0 star rating with onsite renewable energy generation. In Green Star Buildings the financially viable model will achieve the minimum expectation or credit achievement without onsite renewable energy generation for Credit 22. However, with onsite renewable energy generation the model will easily achieve exceptional performance.

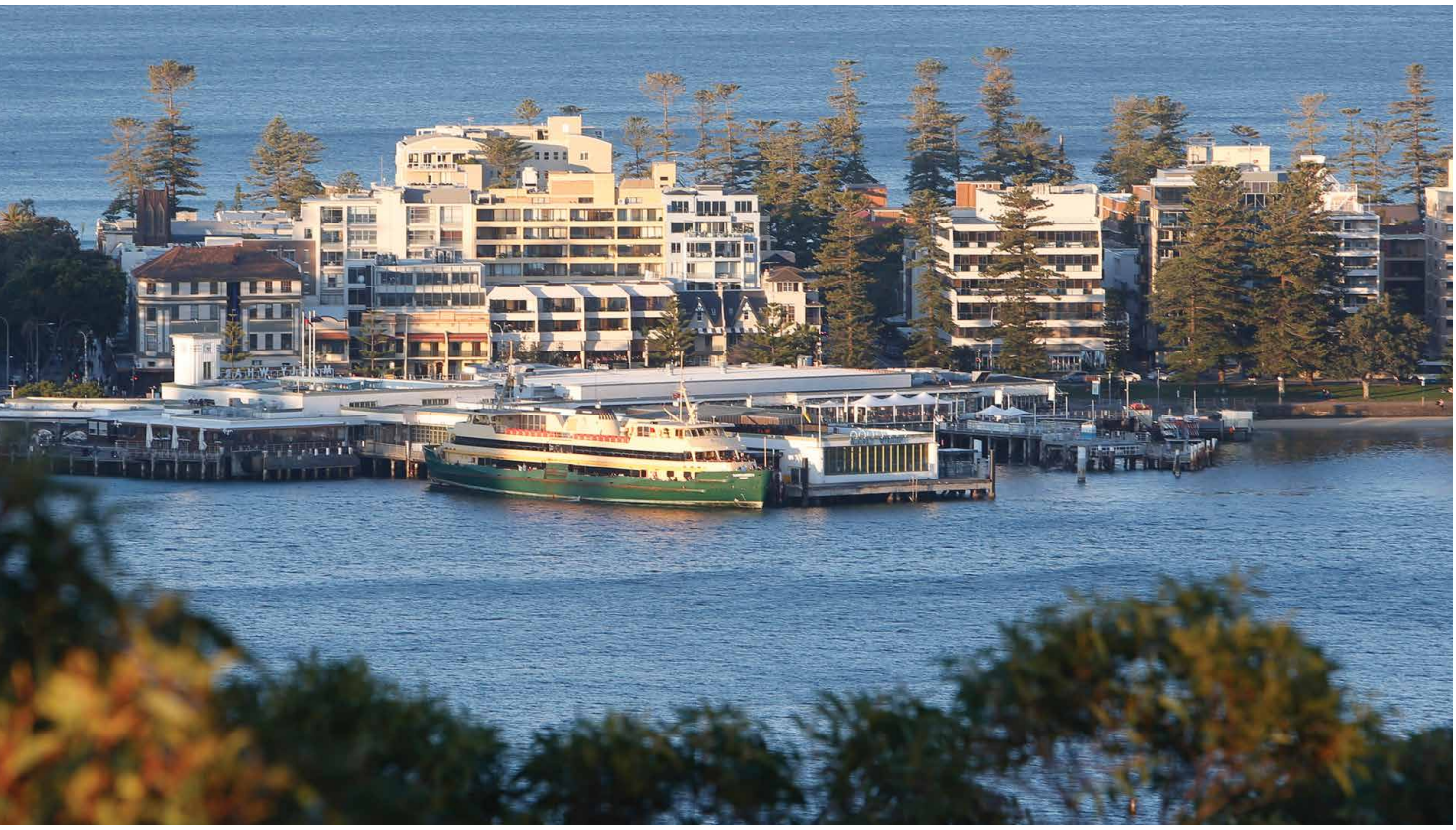
Like offices, shopping centres with fewer floors have the potential to go beyond net zero energy and achieve net positive energy via onsite renewables as the development would generate more energy than it would consume annually as the building form has a high ratio of roof area to floor area.

Image by Paul Patterson.

Hotel

The hotel asset class considers whole of building energy. Whole of building includes the base building, the individual hotel rooms, and other amenities like bars, cafes and pools.

Hotel analysis results differ vastly compared to offices and shopping centres. Before financial viability is considered, an improvement of more than 45 per cent compared to an NCC 2019 compliant hotel development can be achieved. Onsite renewable energy generation significantly increases the energy reduction to approximately 50 per cent compared to an NCC 2019 compliant hotel development. However, when the CBA is applied, not all the energy reduction is economically viable.



Manly skyline (North City District). Image by Greater Sydney Commission.

The results of the models analysed, presented in Table 11, remain relatively consistent both in energy reduction and in the CBA. The hotel asset class includes additional applicable measures, including improved building sealing due to overnight operation and improved efficiency of appliances due to the whole of building scope.

These measures show the largest financial return and the second largest energy intensity reduction respectively. The greatest energy intensity reduction is achieved through the electrification of energy due to the larger domestic hot water demand.

Further, while the onsite renewable energy generation was one of the most effective energy intensity reduction measures in the office and shopping centre asset classes the impact is less pronounced in the hotel asset class due to the larger energy consumption associated with the whole of building scope and typically small roof area of hotels in Greater Sydney.

The detailed energy and CBA results for the hotel asset class are presented in Table 11.

The hotel asset class considers whole of building energy, which means it accounts for the energy consumption of the hotel rooms and amenities.

Table 11: Hotel results

Energy reduction measure	NCC 2019 energy reduction	IRR (15 years)	IRR (25 years)	Capital cost increase
Façade optimisation	2.1% - 2.9%	(-32%) - (-27%)	(-18%) - (-15%)	7.40% - 9.94%
Improved building sealing	1.3% - 1.9%	140% - CAPEX Decrease	140% - 170%	-0.01% - 0.01%
Fan ductwork optimisation	1.0% - 1.3%	(-10%) - (-4%)	(-2%) - 3%	0.23% - 0.32%
Variable air fan system	2.0% - 3.4%	(-25%) - (-18%)	(-25%) - (-18%)	0.80% - 1.79%
Plant efficiency improvement	1.1% - 1.5%	(-9%) - 35%	(-7%) - 35%	0.08% - 0.94%
Heat recovery plant	1.2% - 1.5%	(-19%) - (-13%)	(-19%) - (-13%)	0.17% - 0.44%
Electrification of energy	22.0% - 26.6%	(-5%) - 15%	(-4%) - 15%	0.31% - 1.74%
Improved lighting power density	2.6% - 3.6%	(-8%) - (-5%)	(-8%) - (-5%)	0.42% - 0.58%
Additional lighting controls	1.0% - 1.1%	(-22%) - (-16%)	(-22%) - (-16%)	0.30% - 0.42%
Vertical transport efficiency improvement	0.4% - 1.3%	(-19%) - (-11%)	(-17%) - (-9%)	0.35% - 0.57%
Improved efficiency of appliances	10.3% - 10.7%	13% - 17%	13% - 17%	0.15% - 0.34%
Onsite renewable energy generation	0.4% - 6.5%	(-1%) - 1%	5% - 7%	0.14% - 1.14%

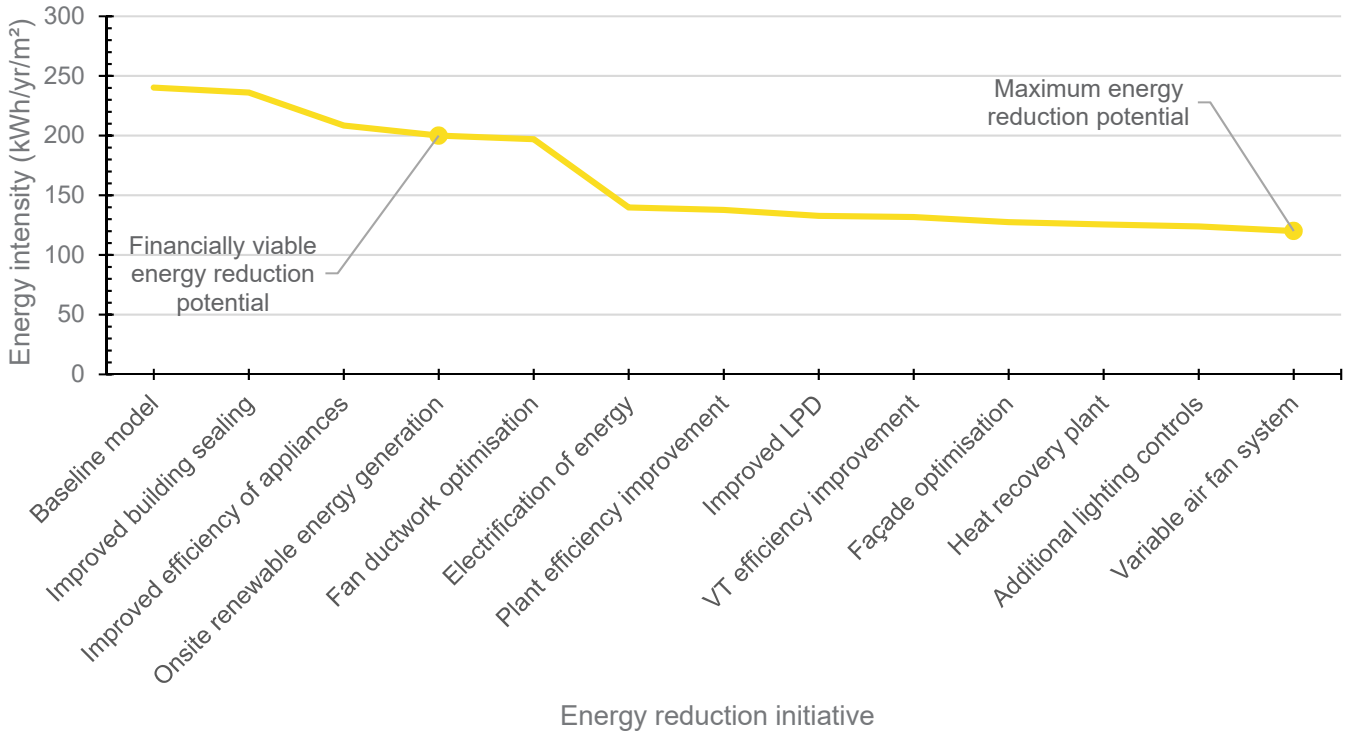
The cumulative reductions in order of financial viability are plotted in Figure 6. These indicate that when energy efficiency measures are aggregated, the maximum point of financial viability occurs at approximately 200 kWh/yr/m^2 and the maximum energy intensity reduction potential occurs at approximately 120 kWh/yr/m^2.

Larger developments achieve a more positive IRR for energy efficiency, especially with building system and management controls over non-regulated energy use (plug-in loads such as appliances). Onsite renewable energy generation has less impact in the hotel asset class compared to other classes.

The CBA demonstrates that only three of the analysed measures achieve a positive IRR and could be implemented on a cost-effective basis and return a 14 to 19 per cent improvement on energy performance over the NCC 2019 baseline:

- improved building sealing
- improved efficiency of appliances
- onsite renewable energy generation.

Figure 6: Hotel cumulative energy intensity reduction per energy efficiency reduction measure



The financially viable energy reduction measures were aggregated and results translated into the planning and design tools (Table 12). Percentage values in the NABERS Energy rating column refer to the percentage above the NABERS star band.

It is financially viable to achieve an approximately 12 per cent reduction on NCC 2019 Section J without renewable energy generation and an approximately 14 to 19 per cent reduction with onsite renewable energy generation, depending on the ratio of roof area to floor area.

In NABERS Energy this translates to approximately a 4 star rating. In Green Star Buildings, the financially viable model without renewable energy generation is generally only able to achieve minimum expectation for Credit 22. Even with onsite renewable energy incorporated the modelling indicates it is still unable to achieve the credit achievement threshold in energy reduction of 20%.

Table 12: Hotel energy results for financially viable measures

Energy reduction model	Energy intensity kWh/yr/m²	NCC 2019 energy reduction	NABERS Energy rating	Green Star Buildings certified rating and Credit 22 criteria
NCC 2019 baseline model	190.4 - 278.6	-	3.5 star (+15%) - 4.0 star (+13%)	-
Financially viable model without onsite renewable energy generation	167.6 - 246.2	11.5% - 12.4%	4.0 star (+3%) - 4.0 star (+16%)	Minimum Expectation
Financially viable model with onsite renewable energy generation	164.6 - 239.5	13.5% - 18.7%	4.0 star (+13%) - 4.0 star (+18%)	Minimum Expectation
Maximum energy potential without onsite renewable energy generation	102.7 - 146.7	44.8% - 48.1%	4.5 star (+7%) - 4.5 star (+14%)	Exceptional Performance
Maximum energy potential with onsite renewable energy generation	99.6 - 140.0	47.6% - 52.0%	4.0 star (+16%) - 4.5 star (+12%)	Exceptional Performance

Table 13: Hotel CBA results for financially viable measures

Energy reduction model	IRR (15 years)	IRR (25 years)	Capital cost increase
Financially viable model without onsite renewable energy generation	0% - 12%	16% - 24%	0.15% - 0.35%
Financially viable model with onsite renewable energy generation	16% - 24%	0% - 12%	0.29% - 1.49%
Maximum energy potential without onsite renewable energy generation	(-14%) - (-11%)	(-15%) - (-12%)	10.20% - 17.09%
Maximum energy potential with onsite renewable energy generation	(-15%) - (-12%)	(-14%) - (-10%)	10.34% - 18.23%

Multi-unit residential

The multi-unit residential asset class considers whole of building energy. It accounts for the energy consumption of the apartments as well as common area services.

The multi-unit residential analysis indicates similar results to the hotel asset class. Before consideration of financially viable measures, an improvement of approximately 30 per cent compared to a BASIX 25 compliant multi-unit residential development can be achieved. Onsite renewable energy generation increases the energy reduction to approximately 40 per cent compared to a BASIX 25 compliant development. However, when the CBA is applied not all the energy reduction measures are economically viable.

The results in Table 14 are relatively consistent between the energy reduction model and the CBA. However, the largest difference in energy reduction is achieved from onsite renewable energy generation associated with the ratio of roof area to floor area.

Further, many of the energy reduction measures produce a significantly greater financial return compared to the other asset class analysed. This is due to the latest version of the NCC increasing the stringency of compliance of non-residential building classes while the targets for BASIX have remained the same since 2017.

The detailed energy and CBA results for the multi-unit residential asset class are presented below.

Table 14: Multi-unit residential results

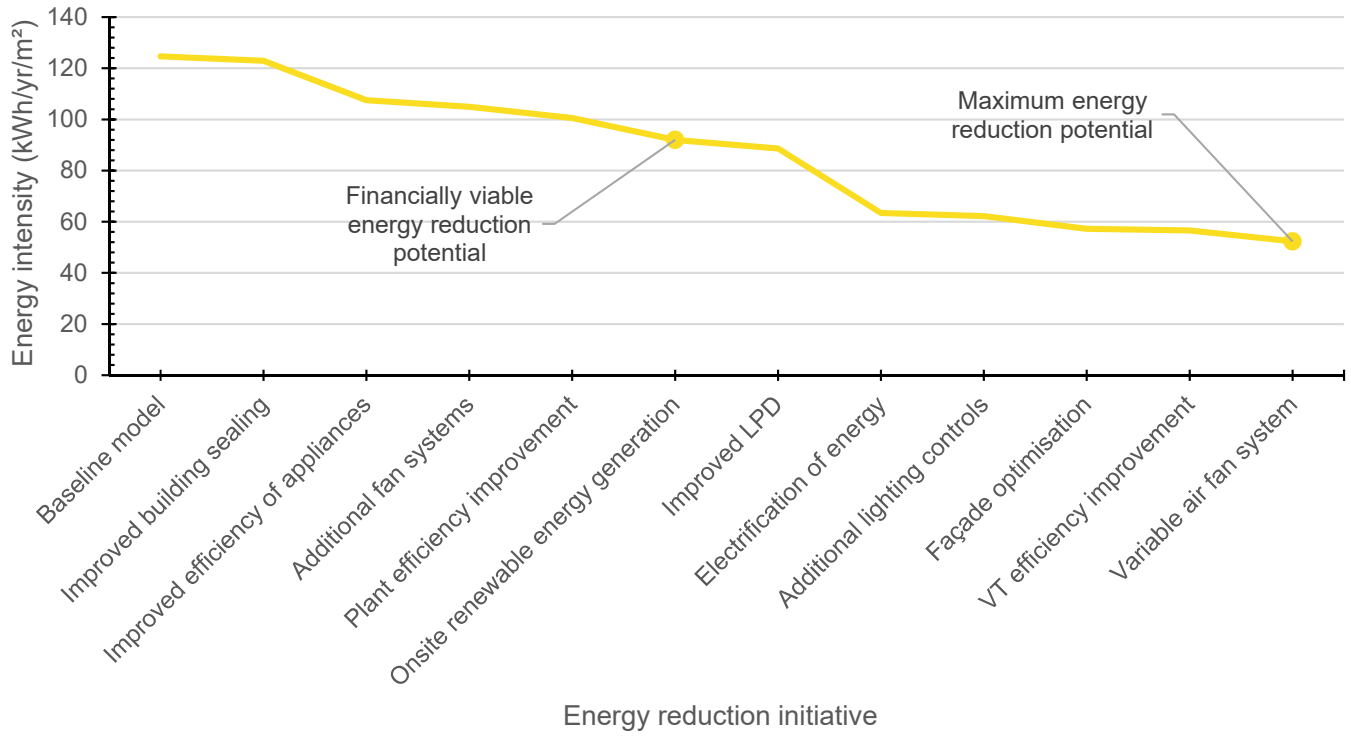
Energy reduction measure	NCC 2019 energy reduction	IRR (15 years)	IRR (25 years)	Capital cost increase
Façade optimisation	3.8% - 6.9%	(-21%) - (-17%)	(-10%) - (-7%)	2.86% - 4.84%
Improved building sealing	0.6% - 1.8%	CAPEX Decrease	CAPEX Decrease	(-0.22%) - (-0.02%)
Variable air fan system	4.3% - 5.7%	(-20%) - (-2%)	(-20%) - (-2%)	0.36% - 1.19%
Additional fan systems	1.8% - 2.5%	4% - 10%	8% - 13%	0.15% - 0.24%
Plant efficiency improvement	2.7% - 4.8%	(-1%) - 30%	0% - 31%	0.12% - 0.95%
Electrification of energy	16.7% - 21.4%	0% - 10%	1% - 10%	0.24% - 0.44%
Improved lighting power density	2.0% - 2.7%	3% - 11%	3% - 11%	0.07% - 0.12%
Additional lighting controls	0.9% - 1.5%	(-13%) - 1%	(-13%) - 1%	0.05% - 0.08%
Vertical transport efficiency improvement	0.7% - 0.8%	(-18%) - (-6%)	(-16%) - (-5%)	0.12% - 0.30%
Improved efficiency of appliances	11.1% - 12.1%	12% - 15%	12% - 15%	0.19% - 0.33%
Onsite renewable energy generation	4.2% - 12.2%	0% - 0%	5% - 6%	0.25% - 1.08%

The cumulative reductions in order of financial viability have been plotted in Figure 7 below. These indicate the cumulative reduction in energy intensity when measures are aggregated. The limit of financial viability occurs at approximately 95 kWh/yr/m^2 and the maximum energy reduction potential occurs at approximately 55 kWh/yr/m^2.

The CBA demonstrates that only five of the analysed measures achieve a positive IRR and could be implemented on a cost neutral basis and return a 23 to 34 per cent improvement on energy performance over the BASIX baseline:

- improved building sealing
- improved efficiency of appliances
- additional fan systems
- plant efficiency improvement
- on-site renewable energy generation.

Figure 7: Multi-unit residential cumulative energy intensity reduction by energy efficiency reduction measure



The financially viable energy reduction measures were aggregated, and the results translated into the planning and design tools (Table 15-16). Percentage values in the NABERS Energy rating column refer to the percentage above the NABERS star band.

Table 15: Multi-unit residential energy results for financially viable measures

6-10 Storeys

Energy reduction model	Energy intensity kWh/yr/m²	BASIX 25 energy reduction	BASIX score	Green Star Buildings certified rating and Credit 22 criteria
BASIX baseline model	123.1 - 123.9	0.0%	25	-
Financially viable model without onsite renewable energy generation	96.4 - 97.2	21.0% - 22.2%	40	Credit Achievement
Financially viable model with onsite renewable energy generation	81.6 - 82.2	33.2% - 34.2%	63	Exceptional Performance
Maximum energy potential without onsite renewable energy generation	66.9 - 67.4	45.6% - 45.7%	43	Exceptional Performance
Maximum energy potential with onsite renewable energy generation	51.9 - 52.5	57.6% - 57.9%	66	Exceptional Performance

11-20 Storeys

Energy reduction model	Energy intensity kWh/yr/m²	BASIX 25 energy reduction	BASIX score	Green Star Buildings certified rating and Credit 22 criteria
BASIX baseline model	122.5 - 122.9	0.0%	25	-
Financially viable model without onsite renewable energy generation	98.9 - 100.0	18.4% - 19.5%	34	Minimum Expectation
Financially viable model with onsite renewable energy generation	90.0 - 90.9	25.7% - 26.7%	47	Credit Achievement
Maximum energy potential without onsite renewable energy generation	65.8 - 66.3	46.0% - 46.3%	40	Exceptional Performance
Maximum energy potential with onsite renewable energy generation	56.8 - 57.4	53.3% - 53.6%	54	Exceptional Performance

21-30 Storeys

Energy reduction model	Energy intensity kWh/yr/m²	BASIX 25 energy reduction	BASIX score	Green Star Buildings certified rating and Credit 22 criteria
BASIX baseline model	127.4 - 128.2	0.0%	25	-
Financially viable model without onsite renewable energy generation	100.0 - 102.6	18.4% - 20.0%	31	Minimum Expectation - Credit Achievement
Financially viable model with onsite renewable energy generation	90.9 - 97.1	24.2% - 25.7%	40	Credit Achievement
Maximum energy potential without onsite renewable energy generation	63.3 - 65.8	46.3% - 50.6%	39	Exceptional Performance
Maximum energy potential with onsite renewable energy generation	56.8 - 57.9	53.6% - 54.9%	47	Exceptional Performance

Table 16: Multi-unit residential CBA results for financially viable measures

6-10 Storeys

Energy reduction model	IRR (15 years)	IRR (25 years)	Capital cost increase
Financially viable model without onsite renewable energy generation	17% - 18%	17% - 18%	0.76%
Financially viable model with onsite renewable energy generation	5% - 6%	5% - 6%	1.84%
Maximum energy potential without onsite renewable energy generation	(-6%) – (-6%)	(-3%) – (-3%)	8.52%
Maximum energy potential with onsite renewable energy generation	(-8%) – (-8%)	(-7%) – (-6%)	7.44%

11-20 Storeys

Energy reduction model	IRR (15 years)	IRR (25 years)	Capital cost increase
Financially viable model without onsite renewable energy generation	13% - 15%	13% - 15%	0.48%
Financially viable model with onsite renewable energy generation	5% - 6%	5% - 6%	0.90%
Maximum energy potential without onsite renewable energy generation	(-8%) - (-8%)	(-5%) - (-5%)	5.82%
Maximum energy potential with onsite renewable energy generation	(-9%) - (-9%)	(-7%) - (-7%)	5.40%

21-30 Storeys

Energy reduction model	IRR (15 years)	IRR (25 years)	Capital cost increase
Financially viable model without onsite renewable energy generation	14% - 14%	14% - 14%	0.52%
Financially viable model with onsite renewable energy generation	9% - 9%	9% - 9%	0.77%
Maximum energy potential without onsite renewable energy generation	(-6%) - (-5%)	(-4% - (-3%)	4.61%
Maximum energy potential with onsite renewable energy generation	(-7%) - (-5%)	(-6% - (-3%)	4.36%

It is financially viable to achieve a 18 to 22 per cent reduction on BASIX NSW Government Energy targets for high rise apartments as defined by BASIX in Greater Sydney without renewable energy generation and a 24 to 34 per cent reduction with onsite renewable energy generation, depending on the ratio of roof area to floor area.

In BASIX Energy this translates to a score between 31 - 40 without renewable energy generation and 40 - 63 with onsite renewable energy generation. In Green Star buildings the financially viable model will achieve credit achievement in Credit 22.

The multi-unit residential asset class has similar energy results compared to the hotel asset class. However, as the compliance stringency for multi-unit residential developments was not increased in the latest update to NCC 2019 many of the energy reduction measures investigated had more positive financial outcomes.

Multi-unit residential development (South City District). Image by Greater Sydney Commission.

Mixed use

To ensure the applicability of the analysis, combinations of the four asset classes were analysed as mixed-use developments and assessed similarly to each of the previous classes as per the typologies identified in Table 17.

Table 18 shows that due to the different combinations of asset classes, the results are more variable than for each individual asset class both in energy reduction and in CBA. The largest energy reduction is achieved through onsite renewable energy with a positive IRR and less than a one per cent increase in capital cost.

Table 17: Mixed use typologies

Typology	Description	Gross Floor Area	Scope
Office and shopping centre	Regional shopping centre with A Grade office - 12 storeys total	57,222m² shopping centre 17,818m² office 75,040m² total	Base building only
Office and hotel	4 Star hotel with A Grade office - 12 storeys total	1,498m² hotel 17,818m² office 19,316m² total	Base building for office and whole building for hotel
Office and multi-unit residential	High rise multi-unit residential with A Grade office - 22 storeys total	5,941m² multi-unit residential 17,818m² office 23,579m² total	Base building for office and whole building for multi-unit residential

Table 18: Mixed use results

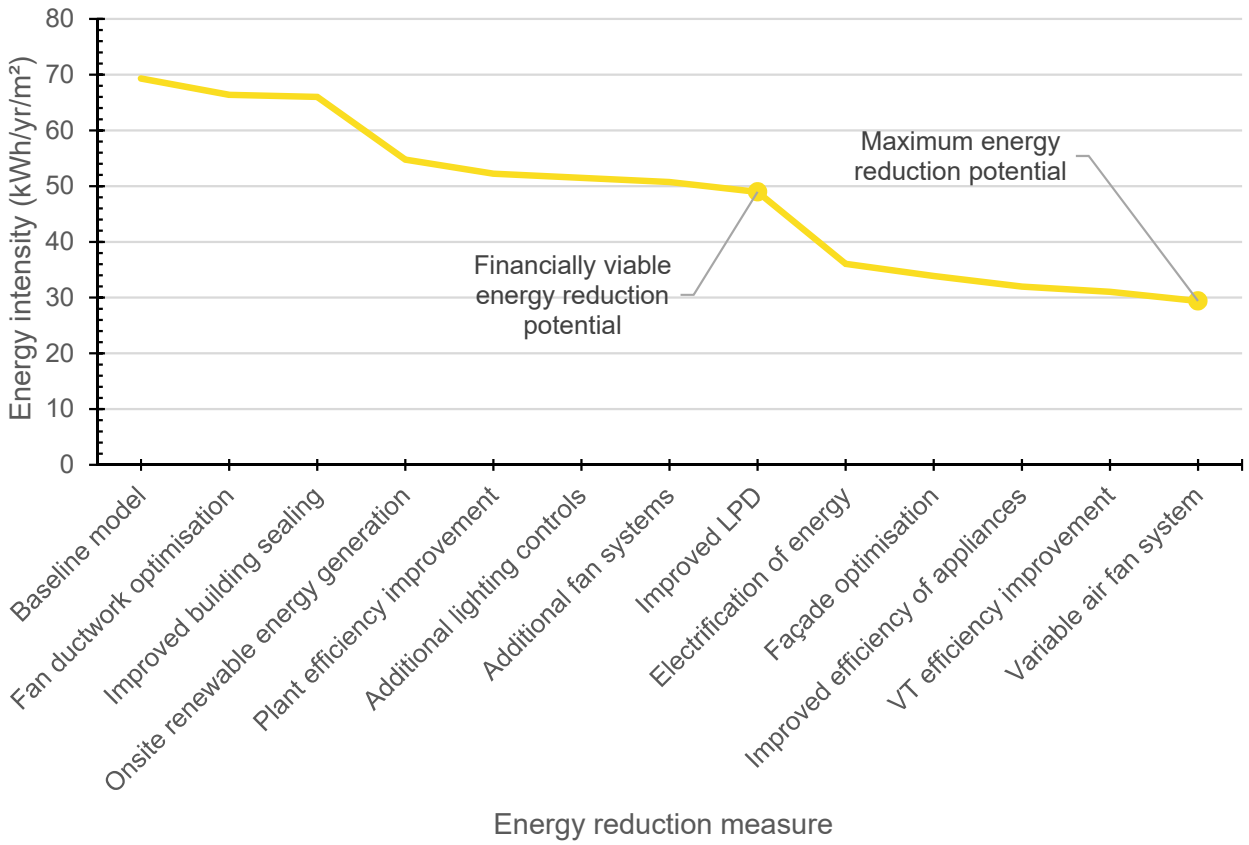
Energy reduction measure	NCC 2019 energy reduction	IRR (15 years)	IRR (25 years)	Capital cost increase
Façade optimisation	1.9% - 5.5%	(-16%) - (-15%)	(-6%) - (-5%)	0.66% - 0.66%
Improved building sealing	0.4% - 0.7%	2% - 32%	7% - 33%	0.01% - 0.01%
Fan ductwork optimisation	2.2% - 5.9%	19% - 24%	21% - 25%	0.05% - 0.06%
Variable air fan system	0.6% - 8.6%	(-31%) - (-21%)	(-31%) - (-21%)	0.14% - 0.16%
Additional fan systems	1.0% - 1.1%	0% - 1%	5% - 6%	0.00% - 0.04%
Plant efficiency improvement	4.3% - 4.8%	2% - 9%	3% - 9%	0.13% - 0.20%
Electrification of energy	14.8% - 23.4%	(-10%) - 1%	(-9%) - 2%	0.34% - 0.37%
Improved lighting power density	2.1% - 3.2%	(-13%) - 10%	(-13%) - 10%	0.03% - 0.26%
Additional lighting controls	1.0% - 1.7%	3% - 12%	0% - 12%	0.01% - 0.02%
Vertical transport efficiency improvement	1.9% - 2.2%	(-14%) - (-11%)	(-12%) - (-9%)	0.21% - 0.21%
Improved efficiency of appliances	3.0% - 4.9%	(-9%) - (-3%)	(-9%) - (-3%)	0.05% - 0.07%
Onsite renewable energy generation	9.8% - 29.6%	2% - 4%	7% - 9%	0.19% - 0.84%

The cumulative reductions in order of financial viability are plotted in Figure 8. The limit of financial viability occurs at approximately 50 kWh/yr/m^2. and the maximum energy intensity reduction potential is approximately 30 kWh/yr/m^2.

The CBA demonstrates that seven of the analysed measures are economically viable and could be implemented on a cost-effective basis and return a 22 to 40 per cent improvement on energy performance over the NCC 2019 / BASIX 25 baseline:

- fan ductwork optimisation
- improved building sealing
- onsite renewable energy generation
- plant efficiency improvement
- additional lighting controls
- additional fan systems
- improved lighting power density.

Figure 8: Mixed use cumulative energy intensity reduction by financial viability per energy efficiency reduction measure



The financially viable energy reduction measures were aggregated and the results translated into the planning and design tools (Tables 19 and 20). Percentage values in the NABERS Energy rating column refer to the percentage above the NABERS star band.

Table 19: Mixed use energy results for financially viable measures

Energy reduction model	Energy intensity kWh/yr/ m^2	NCC 2019 BASIX 25 energy reduction	NABERS Energy rating	BASIX score	Green Star Buildings certified rating and Credit 22 criteria
NCC 2019 / BASIX compliant baseline model	64.4 - 72.9	0.0%	3.5 star (+10%) - 5.5 star (+28%)	25	-
Financially viable model without on-site renewable energy generation	58.0 - 64.0	10.0% - 13.0%	4.5 star (+8%) - 6.0 star (+9%)	30	Minimum Expectation
Financially viable model with on-site renewable energy generation	38.9 - 56.9	21.8% - 39.6%	5.0 star (+20%) - 6.0 star (+22%)	44	Credit Achievement - Exceptional Performance
Maximum energy potential without on-site renewable energy generation	34.8 - 44.5	37.1% - 46.4%	4.0 star (+1%) - 6.0 star (+22%)	40	Exceptional Performance
Maximum energy potential with on-site renewable energy generation	15.8 - 37.3	48.8% - 75.8%	4.5 star (+3%) - 6.0 star (+45%)	54	Exceptional Performance

Table 20: Mixed use CBA results for financially viable measures

Energy reduction model	IRR (15 years)	IRR (25 years)	Capital cost increase
Financially viable model without on-site renewable energy generation	0% - 9%	3% - 15%	0.24% - 1.50%
Financially viable model with on-site renewable energy generation	3% - 15%	0% - 9%	0.48% - 2.58%
Maximum energy potential without on-site renewable energy generation	(-8%) - (-5%)	(-8%) - (-3%)	3.95% - 8.47%
Maximum energy potential with on-site renewable energy generation	(-9%) - (-5%)	(-5%) - (-3%)	4.19% - 9.55%

Appendix 3

Proposed DCP and LEP clauses

DCP control - net zero energy buildings

Definitions

The following definitions are applicable to these controls only.

Net zero energy development means a development that consumes no more energy than is provided by a combination of:

- renewable energy generated onsite, or
- renewable energy procured from offsite sources for a period of 5 years.

In this definition, energy includes gas, electricity and thermal energy, and excludes diesel used for emergency back-up generation. Other emissions, such as those from refrigerants, are not included.

Renewable energy means energy that comes from natural resources such as sunlight, wind and rain that are renewable (naturally replenished).

Shopping centre means two or more retail premises within a building that has shared plant and services which are managed by a single person or entity. This does not include specialised retail premises, garden centres, hardware and building supplies, landscaping material supplies, plant nurseries, roadside stalls, rural supplies, timber yards or vehicle sales or hire premises.

Refurbishment means carrying out of works to an existing building where the works affect at least half the total volume of the building measured over its external roof and walls and where there is no increase in the gross floor area. In calculating the extent of the building's volume that is being changed, the proposed works and all other building work completed or authorised within the previous three years is to be included.

Controls:

(1) Development identified in Table 1: Development thresholds and energy performance standards is to be capable of achieving the performance standards in that table and:

(a) Applications are to include an Energy Assessment Report prepared by a suitably qualified person, who is also a NABERS accredited assessor, demonstrating that the building is capable of achieving the performance standards identified in Table 1: Development size thresholds and energy performance standards.

(b) Where development proposes to achieve the energy intensity performance standard (kWh/yr/m^2), an assessor from the NABERS Independent Design Review Panel is to formally verify energy modelling.

(c) Where it is a refurbishment of or addition to a heritage item, a reduction in the performance standards in Table 1: Development size thresholds and energy performance standards may be considered if it is clearly demonstrated that compliance with the standards cannot be reasonably achieved without unacceptable impact on the heritage item and that energy efficiency and use of renewables is reasonably maximised. The application for a reduction in the standards must be supported by:

i. a Heritage Impact Statement, prepared by an appropriately experienced heritage consultant

ii. energy modelling prepared by a suitably qualified person.

Table 1: Development thresholds and energy performance standards

Proposed land use	Development threshold for performance standards	Energy performance standards Applications submitted between 1 January 2023 – 31 December 2025	Energy performance standards Applications submitted from 1 January 2026 onwards
Office (base building)	A new office building containing a net lettable area (NLA) of 1,000m² or more A refurbishment to an existing office building that contains a NLA of 1,000m² or more An existing office building of 1,000m² NLA or more with an addition of 50% or more NLA	Maximum 45 kWh/yr/m² of Gross Floor Area (GFA), or 5.5 Star NABERS Energy Commitment Agreement (CA) + 25%, or Certified Green Star Buildings rating with a "credit achievement" in Credit 22: Energy Use, or equivalent	Maximum 45 kWh/yr/m² of GFA, or 5.5 Star NABERS Energy CA + 25%, or Certified Green Star Buildings rating with a "credit achievement" in Credit 22: Energy Use, or equivalent and Renewable energy procurement equivalent to "net zero energy" or a maximum of 45 kWh/yr/m² of GFA
Retail (applies to shopping centre base building only)	A new shopping centre containing a gross lettable area – retail (GLAR) of 5,000m² or more An existing shopping centre of 5,000m² GLAR or more with an addition of 50% or more GLAR	Maximum 55 kWh/yr/m² of GFA, or 4 star NABERS Energy CA, or Certified Green Star Buildings rating achieving the "minimum expectation" in Credit 22: Energy Use, or equivalent	Maximum 45 kWh/yr/m² of GFA, or 5 star NABERS Energy CA, or Certified Green Star Buildings rating with "exceptional performance" in Credit 22: Energy Use, or equivalent and Renewable energy procurement equivalent to "net zero energy" or a maximum of 45 kWh/yr/m² of GFA
Hotel (whole of building)	A new hotel of 100 rooms or more A refurbishment to an existing hotel that contains 100 rooms or more An existing hotel of 100 rooms or more with an addition of 50% or more hotel rooms	Maximum 245 kWh/yr/m² of GFA, or 4 star NABERS Energy CA, or Certified Green Star Buildings rating achieving the "minimum expectation" in Credit 22: Energy Use, or equivalent	Maximum 240 kWh/yr/m² of GFA, or 4 star NABERS Energy CA + 10%, or Certified Green Star Buildings rating with a "credit achievement" in Credit 22: Energy Use, or equivalent and Renewable energy procurement equivalent to "net zero energy" or a maximum of 240 kWh/yr/m² of GFA
Mixed use	Where one or more of the above thresholds for each proposed use apply	The above performance standards apply for each proposed use	The above performance standards apply for each proposed use

LEP Provision – Net zero energy buildings

(1) The objective of this clause is to reduce the production of greenhouse gas emissions from development and contribute to the resilience of development to climate change.

(2) This clause applies to the following development in Table 2.

(3) Development consent must not be granted to development to which this clause applies unless the consent authority is satisfied that:

(a) for applications lodged on and between 1 January 2023 and 31 December 2025 the development is highly efficient and reduces energy use through energy efficiency and the use of on-site renewables, and

(b) for applications lodged on or after 1 January 2026 that the development is capable of achieving net zero energy.

(4) The consent authority must have regard to the extent to which the development will achieve any relevant standards identified in a development control plan made by the Council in respect of the land when considering whether development:

(a) is highly efficient and reduces energy use through energy efficiency and the use of on-site renewables, and

(b) is capable of achieving net zero energy.

Table 2: Net zero energy emissions development

Development	Development thresholds for performance standards
Office	A new office building containing a net lettable area (NLA) of 1,000m^2 or more
	A refurbishment to an existing office building that contains a NLA of 1,000m^2 or more
	An existing office building of 1,000m^2 NLA or more with an addition of 50% or more NLA
Retail (applies to shopping centre only)	A new shopping centre containing a gross lettable area – retail (GLAR) of 5,000m^2 or more
	An existing shopping centre of 5,000m^2 GLAR or more with an addition of 50% or more GLAR
Hotel	A new hotel of 100 rooms or more
	A refurbishment to an existing hotel that contains 100 rooms or more
	An existing hotel of 100 rooms or more with an addition of 50% or more hotel rooms
Mixed use	Where one or more of the above thresholds for each proposed use apply

(5) In this clause—

Net zero energy means the development consumes no more energy than is provided by a combination of:

- renewable energy generated on-site, or
- renewable energy procured from off-site sources for a period of five years.

In this definition, energy includes gas, electricity and thermal energy, and excludes diesel used for emergency back-up generation. Other emissions, such as those from refrigerants, are not included.

Shopping centre means two or more retail premises within a building that has shared plant and services which are managed by a single person or entity. This does not include specialised retail premises, garden centres, hardware and building supplies, landscaping material supplies, plant nurseries, roadside stalls, rural supplies, timber yards or vehicle sales or hire premises.

Refurbishment means carrying out of works to an existing building where the works affect at least half the total volume of the building measured over its external roof and walls and where there is no increase in the gross floor area. In calculating the extent of the building's volume that is being changed, the proposed works and all other building work completed or authorised within the previous three years is to be included.

Appendix 4

Planning and design tool appraisal

NABERS

NABERS Energy is a voluntary benchmarking tool that uses recorded energy usage data to rate building performance. NABERS Energy is part of a suite of NABERS tools including Water, Waste and Indoor Environment.

NABERS Energy can be agreed at the design stage of new buildings through a commitment agreement that binds a development to a level of performance that is verified post occupancy. A commitment agreement involves an independent review of the building and system design and energy system modelling to ensure it can achieve the targeted NABERS rating. This ensures the early consideration and implementation of design strategies.

NABERS ratings are benchmarked in half-star increments from 0 stars to 6.0 stars, where a zero-star rating indicates the building is performing well below average, while a six-star rating indicates the building is market-leading.

NABERS Energy can be used for the following asset classes:

- Office - base building, tenancy and whole building
- Shopping centre - base building only
- Apartment - common areas only
- Hotel - whole building only.

Strengths

NABERS has the following strengths in supporting the performance standards:

- third party verification of inputs and results, which supports improved performance outcomes and credibility associated with performance claims
- recognised and understood throughout the industry – this means that it is readily accepted by industry
- robust processes with clearly defined rules and well understood in the office sector and to a lesser extent in shopping centres and hotels
- drives ongoing improvement in energy consumption through annual reporting and measurement where a commitment agreement is in place
- assesses performance both in operation and during the design phase through a commitment agreement
- recognises contribution from onsite renewable energy and renewable energy procurement while still encouraging improved energy efficiency.

Considerations

The following needs to be considered in relation to NABERS in supporting the performance standards:

All asset classes (excluding residential)

- Benchmarks are notionally based on greenhouse gas emissions however the emission factors are not updated regularly and do not currently reflect shifts in emissions intensity of different energy sources.
- Submetering needs to be provided to enable proper accounting of the energy uses in buildings with complex systems or mixed-use buildings that share energy systems.
- NABERS for shopping centre and hotels is not as widely used as NABERS for offices and as a result not all participants will be comfortable with its application.
- While the incremental performance bands between star ratings is consistent between 0 and 5 Stars, the scale increases significantly between 5 and 6 Stars. So, to improve a Star rating beyond a 5 Star rating, the building's performance must be improved by an increasingly higher level than for ratings of 0 to 5 Stars. This can provide confusion to building owners and designers.
- In some cases, NABERS targets could potentially lead to less efficient building design overall, due to the metering requirements. This is particularly obvious in mixed use buildings or integrated fit-outs where central systems are less compatible with the standard metering arrangements employed to divide building occupiers. A central system may require much more detailed metering design and more expensive metering technology in order to adequately divide the energy uses in a building between base building and individual tenants. This may occasionally result in a non-centralised system being designed to avoid this outcome in spite of any potential savings.
- NABERS assesses efficiency through greenhouse gas emissions, not energy. Emissions do not directly align to energy efficiency improvements due to different emissions factors associated with different fuels. For instance. while electrification can increase energy efficiency, it is currently a more emissions intensive fuel and so negatively impacts the NABERS Energy Rating.

Hotels

- Achieving a higher NABERS Hotel rating is not directly related to lower operational costs, since factors influencing the final rating do not have a direct impact on operational energy (e.g. number of conference seats). This impacts on the NABERS Energy of Hotel ratings more so than office or shopping centre ratings.
- Significant consumption within the NABERS energy scope includes energy loads outside of a developer's control (e.g. appliances in rooms and restaurant consumption). As such, it is currently challenging to design a building to achieve a specific rating as many of these large energy contributions rely on fit-out specifications (which are determined typically after development consent).

Shopping centres

- The NABERS benchmark is currently only aligned to work with shopping centres with an area greater than 5,000m^2.

Opportunities for Improvement

There are opportunities to improve the NABERS Energy rating tool to further support the implementation of the performance standards. Key opportunities include:

- amending the performance bands by which stars are awarded so that equal recognition is given for achieving performance improvements above 5 Stars and towards net zero energy
- introducing mechanisms to increase the uptake of NABERS Energy ratings for Hotels. This could include incentives such as subsidies covering the cost of ratings or marketing support for NABERS rated.

Green star

Green Star Design and As Built is a voluntary rating tool and covers the design, construction and commissioning phase of a building. It is one of several Green Star rating tools developed by the GBCA. Green Star Design and As Built is the relevant tool for the performance standards It has been developed for any type of building and covers a vast range of sustainable design elements with energy consumption representing only a portion of the overall credits. It rewards projects for reducing greenhouse gas emissions and uses various pathways:

- prescriptive pathway: points awarded where operational greenhouse gas emissions are reduced through specific best-practice building attributes
- alternative pathways based on building use: points awarded where NatHERS, BASIX or a NABERS commitment agreement is used to demonstrate that predicted greenhouse gas emissions will be reduced compared to a typical building
- reference building pathway: points awarded from achieving the minimum conditional requirement of a 10 per cent improvement on a Green Star reference building to achieving maximum carbon neutral operations. The reference building is derived from the Section J minimum requirement for non-residential buildings or BASIX/NatHERS for residential buildings

Green Star also recognises projects for specific initiatives such as the provision of on-site renewable systems and off-site renewable energy through the ability to purchase LGCs, GreenPower and PPAs.

A new version of Green Star Design and As Built has recently been released called Green Star for New Buildings. There have been a range of updates and advancements made in the new tool, with one of the key changes being the development of the 'Energy use' credit in the Positive category. This credit more closely aligns with the performance standards and awards developments achieving 20% and 30% improvement with 'Credit achievement' and 'Exceptional performance' respectively and a 10% improvement in energy stipulated as the 'Minimum expectation'. Green Star for new Buildings must be used for new Green Star applications from 1 January 2022.

Strengths

Green Star has the following strengths in supporting the performance standards:

- third party verification of energy modelling and as built documentation, which supports improved performance outcomes and credibility associated with performance claims
- the industry is familiar with Green Star - this means that it is readily accepted by industry
- flexibility in its use for different building types and sizes
- provides recognition for improvements beyond NCC / BASIX compliance
- recognises contribution from onsite renewable energy with provision for commitment to purchasing offsite renewables or credits based on contract documentation
- a Green Star pathway to net zero carbon has been defined, with the requirement in the new tool that net zero performance is required for all projects seeking a 6 star certification. The industry is aware of upcoming changes and can prepare accordingly.

Considerations

The following needs to be considered in relation to Green Star in supporting the performance standards:

- Green Star is explicitly designed as a holistic tool to assess a variety of sustainability outcomes. As such, if Green Star is used for the performance standards, specific minimum points would need to be dictated for certain credits
- credits for specific energy efficiency initiatives do not provide full flexibility for achieving the lowest overall cost pathway to net zero energy buildings and needs to be reviewed on a project by project basis
- Green Star often has increased cost associated with reporting and certification when compared to other design and planning tools. This is due to many more elements than energy use
- Green Star assesses energy improvements in terms of emissions, this is not aligned with the net zero energy building performance standards scope.

Opportunities for improvement

There are several opportunities to improve the Green Star tools to further support the implementation of the performance standards. Key opportunities include:

- certification of the energy credit independently from the remainder of the credits in the tool, which could reduce the cost and time spent to get certification
- mandatory requirement for Green Star Performance associated with the Energy credit would allow for operational performance to be monitored and verified to ensure best practice construction and commissioning practices.

BASIX

The BASIX Energy tool sets minimum compliance requirements(targets), for residential development at all scales from single dwellings to high rise apartments under the NSW legislated Building Sustainability Index (BASIX). BASIX Energy covers the minimum acceptable energy efficiency performance.

BASIX Energy scores are a percentage expression of residential greenhouse gas emission savings per person (excluding transport emissions) compared to NSW benchmarks.

Thermal comfort, which is factored into the BASIX Energy score is modelled using tools approved under the federal government NatHERS scheme. It assesses the performance of passive design elements in minimising theoretical energy demand for space heating and cooling within apartment dwellings. Passive design elements include fabric and glazing, shading, orientation and natural ventilation.

The estimated energy demand related to thermal comfort (i.e. estimated annual mechanical space heating and cooling demands) is then combined with other building services for lighting, domestic water heating, ventilation, and other equipment within the Energy section of BASIX to calculate a percentage improvement against a specific benchmark. Different target scores must be achieved depending on the number of storeys and climate zone.

Strengths

BASIX has the following strengths in supporting the performance standards:

- accepted and well understood by the property industry in NSW
- providing BASIX certificates is an existing requirement for the planning assessment process
- BASIX promotes the installation of high efficiency appliances and equipment, improved building fabric and, to a degree, passive design elements
- the BASIX tool supports performance beyond minimum compliance when planning incentives are used
- there are governance checks in the BASIX scheme that is part of the planning assessment process - this occurs at development assessment, construction and occupation certification.

Considerations

The following needs to be considered in relation to BASIX in supporting the performance standards:

Overall

- Benchmarks are notionally based on greenhouse gas emissions, however the emission factors used do not adequately reflect ongoing shifts to emissions intensity of different energy sources, only being updated occasionally and, currently, not with great transparency.
- Assesses energy improvements in terms of greenhouse gas emissions. This is not aligned with the performance standards scope and can result in challenges achieving higher scores when electrification is pursued under current BASIX scoring methods (which is under review).
- Inability to model typical floors or dwellings. Using it as a tool to assess energy efficiency improvements and net zero energy options for individual initiatives would be an inefficient and time-consuming approach
- Total energy consumption or greenhouse gas emissions of each project assessed in BASIX is not provided to the modeller, therefore it would not be possible to estimate the quantity of offsite renewables or offsets required to meet the performance standards following the onsite initiatives.

Renewable energy

- Only onsite renewable energy sources can be considered in the tool's current form.

Mechanical services

- The option to have ceiling fans combined with central heating and cooling systems is not available for apartments.
- The option to have fan coil units with central systems is not available.
- It is not possible to account for reduced fan pressure drops.

Vertical transportation

- Recent improvements to the calculation of energy use by lifts has limited impact on the overall energy score.

Appliances

- The impact of the star rating for the fridges is higher than expected.

Opportunities for Improvement

There are several opportunities to improve BASIX to further support the implementation of the performance standards. Key opportunities include:

- development of a trajectory for updates to the BASIX tool and targets on a regular cycle with increased stringency in line with the ABCBs trajectory for the Section J provisions
- the BASIX tool applies a broad range of factors to its scoring algorithm. This algorithm is understandably hidden from the front-end interface of the tool, to reduce complexity for user input. However, because it runs in the background and the nature and values of the algorithm factors used are not obvious to the user, it can be difficult to understand the value that individual initiatives contribute toward the final score. Improved transparency of the BASIX calculations would allow the design team to quantify the benefit of each energy saving initiative
- the purpose of BASIX is a compliance tool, not a design tool, and therefore its suitability to provide advice to the design team on achieving a low energy consuming building should be reviewed
- current BASIX targets for some residential projects result in higher emissions than business as usual designs. BASIX targets should be updated to reflect current design standards
- refresh emission factors used for BASIX every 2-3 years based on the National Greenhouse Gas Accounts
- update the algorithms and expand the available selections for mechanical, electrical, vertical transportation and hydraulic service
- introduce a mechanism to allow the use of off-site renewables to be recognised in achieving targets.

Appendix 5

Green star energy credit comparison

The GBCA undertook a comprehensive review of all the Green Star tools during 2019-2020, including Green Star Design and As Built (used for new buildings and major refurbishments). This resulted in the Green Star Design and As Built tool undergoing a restructure at the same time as the development of the performance standards.

In late 2020, GBCA released Green Star Buildings to replace Green Star Design and As Built. Green Star registrations throughout 2021 can use either the old tool or the new tool. From January 2022, all applications will need to use Green Star Buildings.

Green Star Buildings has two key differences from Green Star Design and As Built when applied to the performance standards:

- Design and As Built used a credit points approach and Buildings uses three levels, *Minimum Expectation, Credit Achievement and Exceptional Performance*
- percentage improvement levels in Design and As Built were awarded on a continuous scale between 10% and 100%, however Buildings has increment bands of 10%, up to 30%.

Credit 22: Energy Use is the relevant section in Green Star Buildings for the performance standards. Tables 1 and 2 below show the required reductions for the first and second targets respectively.

Table 1: Energy reductions for the first target

Asset class	Approximate energy improvement required - existing Green Star Design & As Built	Certified Green Star Buildings v1 rating with the following achievement level in Credit 22: Energy Use	Equivalent energy improvement under Credit 22 - Green Star Buildings
Office	20%	Credit Achievement	20%
Shopping centre	10%	Minimum Expectation	10%
Hotel	10%	Minimum Expectation	10%

Table 2: Shows the required reductions for the second target

Asset class	Approximate energy improvement required - existing Green Star Design & As Built	Certified Green Star Buildings v1 rating with the following achievement level in Credit 22: Energy Use	Equivalent energy improvement under Credit 22 - Green Star Buildings
Office	20%	Credit Achievement	20%
Shopping centre	30%	Exceptional Performance	30%
Hotel	15%	Minimum Expectation	10%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