BUILDING CODE ENERGY PERFORMANCE TRAJECTORY PROJECT

November 2018

Built to Perform in Northern Australia

An industry led pathway to a zero carbon ready building code

AUSTRALIAN SUSTAINABLE BUILT ENVIRONMENT COUNCIL

ClimateWorks AUSTRALIA

About Us

This report is an addendum to *Built to Perform - An industry led pathway to a zero carbon ready building code*, the report for the Building Code Energy Performance Trajectory Project published in July 2018. A full list of project supporters is provided in *Built to Perform*.

Project partners

The project is a partnership between ASBEC and ClimateWorks Australia.

The **Australian Sustainable Built Environment Council (ASBEC)** is the peak body of key organisations committed to a sustainable built environment in Australia. ASBEC members consist of industry and professional associations, non-government organisations and government and academic observers who are involved in the planning, design, delivery and operation of Australia's built environment.

ASBEC provides a collaborative forum for organisations who champion a vision of sustainable, productive and resilient buildings, communities and cities in Australia.

ClimateWorks Australia is an expert, independent adviser, acting as a bridge between research and action to enable new approaches and solutions to accelerate the transition to net zero emissions by 2050 for Australia and our region. It was co-founded in 2009 by The Myer Foundation and Monash University and works within the Monash Sustainable Development Institute.

In the pursuit of its mission, ClimateWorks looks for innovative opportunities to reduce emissions, analysing their potential then building an evidence-based case through a combination of robust analysis and research, and clear and targeted engagement. They support decision makers with tailored information and the tools they need, as well as work with key stakeholders to remove obstacles and help facilitate conditions that encourage and support the transition to a prosperous, net zero emissions future.

Delivery partners

The analysis for *Built to Perform in Northern Australia* was delivered in partnership with Energy Action and Team Catalyst. Full details of the Northern Australia analysis are provided in the *Building Code Energy Performance Trajectory Technical Report – Northern Australia* prepared by Energy Action and Team Catalyst.

Northern Australia report sponsors

Built to Perform in Northern Australia was made possible through support from the Northern Regional Development Australia Alliance (NRDAA), the Queensland Department of Environment and Science and the Queensland Department of Housing and Public Works.

Project supporters

The broader Building Code Energy Performance Trajectory Project was steered by an ASBEC Task Group comprising government, industry and academic stakeholders and chaired by Prof Tony Arnel, a former long-term Board member of the Australian Building Codes Board (ABCB), President of the Energy Efficiency Council and Global Director of Sustainability at Norman, Disney and Young. The project was supported by a range of industry, non-government and government organisations and departments, including the Cooperative Research Centre for Low Carbon Living and RACV. A full list of project supporters is provided in *Built to Perform*.

The project also established a Northern Australia Technical Advisory Group comprising relevant experts in building design, construction and operation, energy performance in buildings, building energy modelling and societal cost-benefit analysis relevant to the Northern Australia region. ASBEC, ClimateWorks and the delivery partners gratefully acknowledge the generous and highly valuable input they have provided throughout the project.

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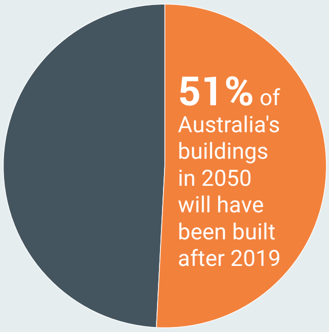
Executive Summary

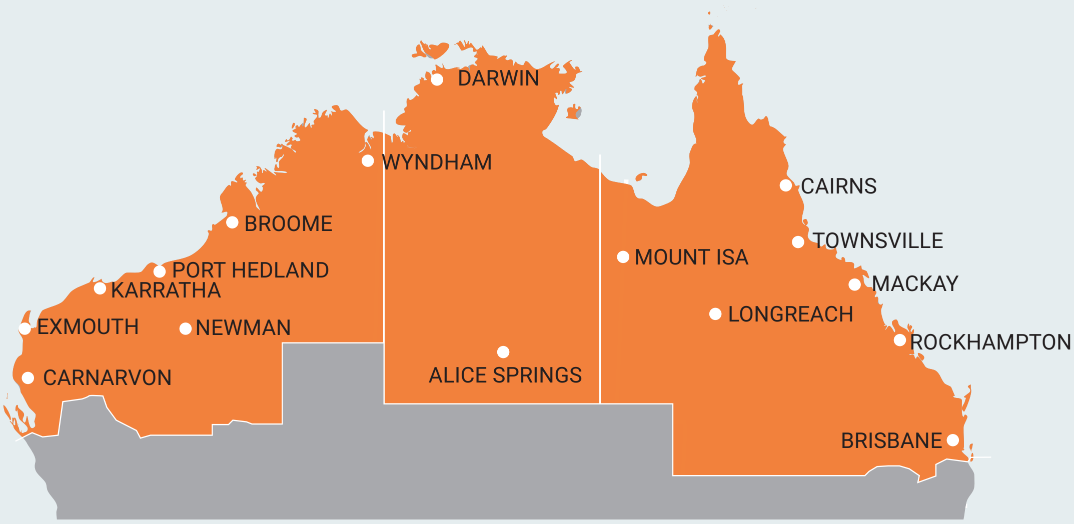
Improved energy performance of buildings presents a win-win-win opportunity, reducing stress on the electricity network, offering bill savings, supporting a least-cost pathway to a zero carbon built environment, and improving health and resilience outcomes for households and businesses.



The National Construction Code is a ready-made policy instrument to influence the operational energy use of new buildings and major renovations. Over time, improvements to the Code can have a significant impact since more than half the buildings expected to be standing in 2050 will be built after the next update of the Code in 2019. Increased minimum energy requirements in the Code are essential to address market failures in the delivery of higher performance buildings that have seen a widening gap between industry leaders and minimum requirements.

A focus on Northern Australia

In July 2018, the Australian Sustainable Built Environment Council (ASBEC) and ClimateWorks Australia released *Built to Perform – An industry led pathway to a zero carbon ready building code*, the report for the Building Code Energy Performance Trajectory Project. This report builds on *Built to Perform* by summarising results most relevant to regions in Northern Australia - broadly defined as Queensland, Northern Territory and regions of Western Australia north of the Gascoyne. New buildings in the Northern Australia region present unique opportunities and challenges, due to factors including a warmer and more humid climate, different construction materials and climate-responsive design practices. These factors have been considered in assessing key opportunities for this region.

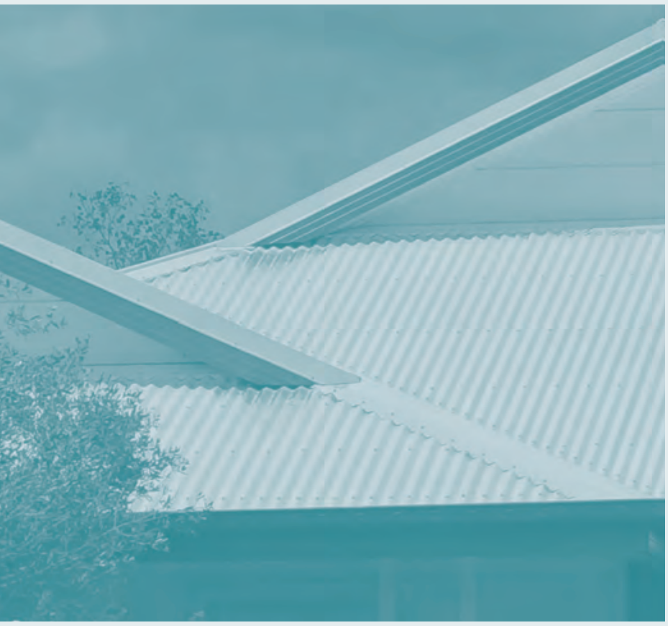


Built to Perform in Northern Australia outlines a set of energy performance targets for different building types across Northern Australian climates, based on societal economic cost-benefit analysis of energy efficiency and on-site renewable energy opportunities. The goal of the analysis was to assess the contribution that the Code could make towards achieving greenhouse gas emissions reductions in line with overarching zero carbon targets.

The analysis shows that by 2030, even conservative improvements in Code energy efficiency requirements for Northern Australia could cost-effectively deliver between 25 and 27 per cent of the energy savings required towards achieving net zero energy in new residential buildings, 22-38 per cent of the required energy savings for commercial sector buildings, and 38-56 per cent for public sector buildings.

Built to Perform in Northern Australia recommends defined targets relevant to the region and a timeline for progressive Code upgrades to reach those targets, as well as an established process for tracking progress and adjusting targets to accommodate future advances in technology and design approaches.

Shifting to this approach would provide the regulatory certainty that industry requires, in order to plan and invest time and effort into research and development, to bring new technologies to market and to deliver higher building energy performance at a lower cost. It would also help unlock the potential for the Code to deliver emissions reductions in line with the international Paris Climate Agreement.



GLOSSARY	
ABCB	Australian Building Codes Board
ASBEC	Australian Sustainable Built Environment Council
BCR	Benefit-cost ratio
CRC	Cooperative Research Centre
COAG	Council of Australian Governments
Code energy requirements	Minimum energy requirements in the National Construction Code
Energy efficiency targets	Targets for energy performance to be included in the Code, excluding any on-site renewable energy generation
NatHERS	National House Energy Rating Scheme
NEEBP	National Energy Efficient Building Project
NEPP	National Energy Productivity Plan
Net energy performance	Annual energy consumption of a building minus the annual on-site renewable energy generation
Net energy targets	Targets for net energy performance to be included in the Code, accounting for on-site renewable energy generation
Net societal benefit	The total social benefits of an action, minus the total social costs, without considering the distribution of benefits and costs (e.g. between the individual taking the action and broader society).
Net zero energy	The annual on-site renewable energy generation is equal to or more than the annual energy consumption
RIA	Regulatory Impact Assessment
Zero carbon	Refers to a building with no net annual greenhouse gas emissions resulting from on-site energy or energy procurement (Scope 1 and Scope 2) from its operation
Zero Carbon Ready Code	A Building Code that maximises the cost-effective potential for new construction to contribute to achieving the overarching zero carbon goal

1. Built to Perform in Northern Australia

ASBEC and ClimateWorks, working with Energy Action and Team Catalyst, have undertaken modelling to determine a set of feasible energy efficiency targets for Code energy requirements and potential net energy targets relevant to new buildings in Northern Australia.

In July 2018, the Australian Sustainable Built Environment Council (ASBEC) and ClimateWorks Australia released *Built to Perform - An industry led pathway to a zero carbon ready building code*[i], the report for the Building Code Energy Performance Trajectory Project. *Built to Perform* outlined a set of energy performance targets for different building types across different climates, based on societal economic cost-benefit analysis of energy efficiency and on-site renewable energy opportunities.

Built to Perform in Northern Australia builds on the original report by summarising results most relevant to regions in Northern Australia (broadly defined as Queensland, Northern Territory and regions of Western Australia north of the Gascoyne). The analysis undertaken for this report explored opportunities and challenges faced by buildings in Northern Australia which are unique to the region. This is due to factors including:

- The warmer and more humid climate. This means that measures such as increased shading and air movement are more important to keep buildings cool;
- Different construction materials. For example, concrete block walls are typical for new housing in much of the region to ease concerns around termites and cyclone safety;
- Climate-responsive design practices, such as including outdoor living areas in houses so that residents can spend less time inside with the air conditioning on; and
- The regional variations in current Code energy requirements compared with the southern states, particularly for residential buildings.

i Available at: https://www.asbec.asn.au/research-items/built-perform/

1.1 Approach to modelling Northern Australian buildings

Eight building 'archetypes' were analysed, each of which was modelled in four orientations. The archetypes were developed to cover a range of typical attributes of common building types as a proxy for the entire building stock, to reflect as broadly as possible the diversity of Northern Australia's buildings. The modelled building archetypes were:

- For residential buildings:
  - Detached, single-storey house;
  - Attached, two-storey townhouse or terrace house; and
  - Apartment.
- For commercial and other non-residential buildings:
  - Office tower;
  - Hotel tower;
  - Medium retail shop;
  - Hospital ward; and
  - School.

The modelling scope in *Built to Perform* (July 2018) was limited to Climate Zones 2, 5, 6 and 7 as defined by the ABCB, most of which relate to climates in the southern half of Australia (see Figure 1).

Northern Australia housing case study:
Innovation House 1, Townsville

Building low-energy housing in Northern Australia requires an understanding of energy demand, solar generation and electricity network performance specific to tropical climates. Townsville's Innovation House was the first 10 star as-designed NatHERS rated house in the Australian tropics. This family home uses simple features to maximise its energy efficiency, such as careful orientation to capture the predominant breezes in the area, large eaves for shading, ceiling fans and a light-coloured roof and walls which reflect much of the sun's heat away from the house. Collectively these design features reduce the overall need for air conditioning. Electricity generation from the 5 kW rooftop solar PV system is more than sufficient to meet the family's air conditioning demand during summer, as well as much of the remaining household electricity consumption.

This case study was contributed by Dr Wendy Miller, Queensland University of Technology, and Rowan Blizzard, Innovation House.

FIGURE 1: Australian Climate Zones

Image source: http://www.yourhome.gov.au/introduction/australian-climate-zones

As shown in Figure 1, the majority of Northern Australia is covered by Climate Zone 1 (hot humid summer, warm winter, e.g. Darwin, Broome, Cairns, Townsville), Climate Zone 2 (warm humid summer, mild winter, e.g. Brisbane, Rockhampton, Mackay) and Climate Zone 3 (hot dry summer, warm winter, e.g. Alice Springs). This report summarises the modelled energy targets relevant to Climate Zones 1 and 2 (for both residential and non-residential buildings) and Climate Zone 3 (for residential buildings only).

The intent of this report is to present illustrative pathways of feasible, cost-effective improvements to minimum Code energy requirements, and to provide recommendations that would enable the implementation of energy targets. Further details on Northern Australia modelling are provided in *Building Code Energy Performance Trajectory Technical Report - Northern Australia* prepared by Energy Action and Team Catalyst, and available on ASBEC and ClimateWorks websites.

1.2 Energy targets for buildings in Northern Australia

This report proposes a set of energy efficiency targets for different building types that could be implemented in the Code. The basis of the analysis is a conservative projection for medium-term trends in construction costs, energy prices, technological changes and other economic factors. The analysis covers the time period over which the next five Code updates will take place, from now until 2034. It sought to answer the following question: "What is the maximum level of energy performance that can be achieved in the future (without fundamental change in building designs) while delivering net economic benefits to society?" for different building types in different climate zones.

For each building archetype in each climate zone, two different sets of targets and forward trajectories were determined as follows:

- **Conservative scenarios:** These include energy efficiency targets and the potential for net energy performance through on-site renewables (assumed to be solar PV, taking into account average consumption profiles and available roof space). All of these targets and performance levels were set at a level where economic benefits to society outweigh capital costs.
* **Accelerated deployment scenarios:** The energy efficiency targets include all measures that are deemed to provide a material energy benefit, and assume faster deployment of energy efficiency technologies. The identified potential for net energy performance in these scenarios assumes that the available roof area of each building archetype is covered with solar PV, allowing for maintenance access and installation angle for panels. Based on our analysis, the benefits of achieving these targets would not outweigh capital costs on current economic projections. However, the cost of achieving these accelerated trajectories could be lower if the industry adapts to energy efficiency measures faster than assumed or if government implements market transformation measures, such as research and development, to reduce the cost of key technologies[ii].

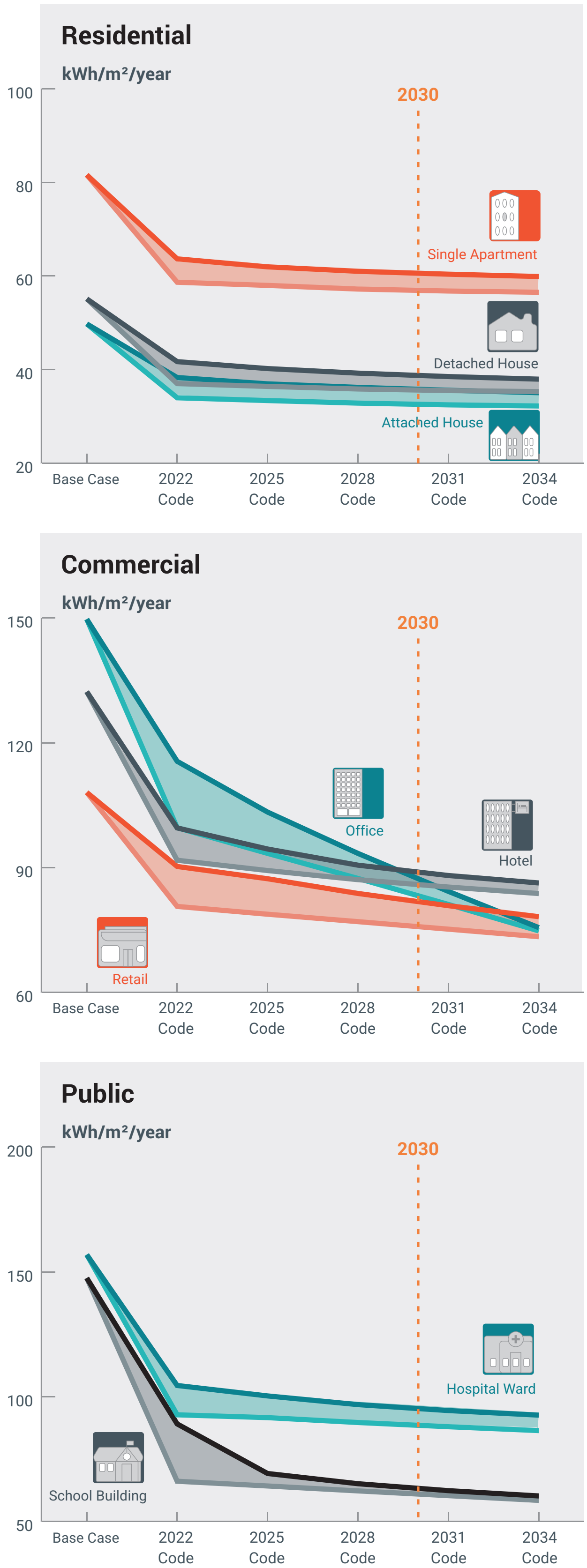
Northern Australia housing case study:
Wunya House, Mary Valley

Wunya House is situated in Queensland's sub-tropical Mary Valley, which experiences large variations in seasonal temperatures. The house is well adapted to this variability, keeping indoor temperatures cool during the summer through features like its light coloured roof to reflect heat, and strategically placed insulation and ceiling fans. Wunya House has proved to be a highly affordable home to run, as its 3 kW rooftop solar system supplies what little electricity the household uses and exports the excess energy to the grid for a profit.

This case study was contributed by Don Parry.

ii See Section 4.6 of *Built to Perform* (July 2018) report for further details.

FIGURE 2: Summaries of proposed energy targets for the Code, under the conservative (darker line) and accelerated deployment (lighter line) scenarios, averaged across modelled climate zones.



The conservative and accelerated deployment energy efficiency scenarios for each building type are illustrated in Figure 2. These summary trajectories are averaged across Climate Zones 1, 2 and 3 (for residential buildings) and Climate Zones 1 and 2 (for commercial and public buildings). Further detail is provided in the body of this section[iii] and in the Appendix to this report. The *Building Code Energy Performance Trajectory Technical Report – Northern Australia* provides technical details underpinning the analysis.

Results presented in this report relating to net energy potential suggest there is a case for introduction of renewable energy requirements in the Code. However, the project team has prioritised energy efficiency to align with the current focus of the Code, and as it can deliver additional comfort, health and resilience benefits over the lifetime of a building. Greater energy efficiency also means that smaller renewable generation systems are needed to meet demand, thereby reducing the cost of investing in such systems.

A number of challenges also need to be resolved in pursuing on-site renewables through the Code, including variability of solar potential, possible exemptions, regulatory barriers to grid connection, grid integration and high upfront costs. Further discussion on these challenges and the significant potential for renewable energy requirements in the Code can be found in Section 4 of *Built to Perform* (July 2018).

Batteries have enormous potential to shift the timing of grid electricity demand, which facilitates integration on-site renewables with the electricity grid. Batteries could also make larger on-site renewable systems more cost-effective, as less electricity is exported to the grid at a rate that is typically lower than retail electricity prices. The analysis in this report shows that it is already cost effective at the building level to fill the available roof area of most modelled build archetypes with solar PV systems. The modelling has not included batteries, and it is unlikely batteries would enable higher levels of solar PV because the analysis shows filling the available roof area is already cost effective.

iii For simplicity, the summary results presented in the body of this report are relevant for new construction in 2030 (i.e. the potential energy efficiency targets in the 2028 Code). This aligns with the timelines for the National Energy Productivity Plan and Australia's 2030 commitment under the Paris Climate Agreement.

1.3 Pathways to achieve energy targets

This project calculated energy efficiency targets by identifying a set of design, technology and construction measures deemed to deliver net societal benefits for the particular building archetypes and climates modelled. The project takes a conservative approach that assumes typical mainstream building designs are retained, without inclusion of best practice design for energy efficiency. Assessing the impacts of best practice design was not within the scope of this project, in keeping with the role of the Code in regulating minimum standards rather than best practice.

Improving the design of a building is often the lowest-cost option to improve energy performance, suggesting that best practice design could enable energy efficiency improvements beyond those modelled in this report. The three case studies profiled in this report exemplify some of the best practice design approaches appropriate to Northern Australia. Potential design approaches beyond measures considered in the analysis include:

- Orienting the building to control its exposure to the sun and best capture prevailing breezes;
- Using 'breezeways' to encourage natural ventilation in important areas of the building, including living rooms;
- Including light-coloured roofs and walls, and extra shading from parasol roofs, which reduces both solar heat entering the building and local urban heat island effects. Urban heat island impacts were not modelled in this project; and
- Designing cool internal spaces away from the exterior walls and windows where building occupants can seek refuge during the hottest days.

Northern Australia housing case study:
Pilbara Vernacular House, Karratha

Keeping homes cool in some of Australia's hottest towns can be challenging and expensive. The Pilbara Vernacular House defies these trends using a number of design features that help keep indoor temperatures comfortable. The house is designed to capture breezes and direct cooler air to bedrooms using 'breezeways', 'wind scoops' and 'wind blades'. The highly reflective roof, deep eaves, and secondary parasol roof over the living area also help keep internal temperatures down. And when temperatures in the Pilbara soar, a central air conditioned living room provides a cool refuge as it's protected by other, external living spaces.

This study was contributed by Landcorp and Josh Byrne & Associates. Image courtesy VAM Media

The measures selected in the modelling and listed on the following pages provide an illustration of how energy efficiency targets could be achieved. These measures suggest potential focus areas (such as insulation and air tightness) for individual projects to cost-effectively improve building performance, or for the ABCB to investigate when considering increased stringency in the Code.

However, the measures listed in this report are not intended as a prescriptive pathway to achieve the energy targets. The targets are intended to be applied in a way that does not favour particular technologies over others. It is recommended that the Code maintains technological neutrality to provide designers and builders with flexibility in their choice of technologies and design approaches to meet the targets. Stronger targets, combined with this flexibility, are expected to encourage best practice design approaches as designers and builders seek the lowest-cost approach to meeting the targets.

Findings for residential buildings in Northern Australia

Detached house, attached house and single apartment archetypes were modelled in Climate Zones 1, 2 and 3.

As an average across the modelled climate zones under the conservative scenario, strengthening the energy efficiency requirements of the Code could deliver between 25 and 27 per cent of the energy savings required to achieve net zero energy in new residential buildings by 2030, compared with the baseline[iv]. This could be achieved through simple measures such as:

- Improved air tightness;
- Higher performance windows (for example, in the order of total window system U-value 4 W/m^{2}K and solar heat gain coefficient 0.5-0.6);
- Increasing insulation;
- Installing adjustable outdoor awnings or larger eaves;
- Light-coloured roofs and walls;
- Increasing internal thermal mass (for example, by using external insulation and cladding to take advantage of the thermal mass of concrete block walls);
- Including ceiling fans; and
- Increasing the energy efficiency of air conditioning, lighting and domestic hot water.

While the energy efficiency strategies that were found to be cost-effective were broadly consistent across Climate Zones 1, 2 and 3, analysis uncovered some minor variations that reflect the diversity between climates across the region. Higher performance windows (with U-value in the order of 2-3 W/m^{2}K) were included in the modelled Climate Zone 2 archetypes compared with the Climate Zone 1 and 3 scenarios. On the other hand, measures that increase the ventilation of roof spaces to reduce build-up of heat were more likely to be cost effective in the Climate Zone 1 and 3 models. There was no distinct climate dependency for increased internal thermal mass as it depends on building type, orientation and the other energy efficiency measures. In considering variation within Climate Zone 1, modelling results suggest that housing in the Northern Territory's Top End is likely to consume more energy than comparable buildings in far north Queensland due greater demand for cooling. Despite this, the overall strategies to improve energy performance are broadly consistent across the hot and humid Climate Zone 1.

There was significant variation in the percentage improvement opportunities for different climate zones. Larger short-term opportunities were present for Top End buildings (in the order of 30-40 per cent improvement) compared with Queensland buildings (5-20 per cent). This may reflect the different baselines used; the residential building models in Climate Zone 2 started from a higher performance baseline than Climate Zones 1 and 3. But while there is significant variation in the baseline energy performance, the gap in whole-building energy consumption between climate zones reduces by half by the end of the modelled forward trajectory period.

Assuming minimal industry learning and conservative projections of technology cost and performance improvements, the upfront cost associated with these improvements (averaged across Climate Zones 1, 2 and 3) would be approximately $121 per square metre for the modelled apartment archetype, $91 per square metre for the attached house archetype and $90 per square metre for the detached houase archetype. These upfront costs would be more than offset by energy bill savings, reduced spend on heating, cooling and ventilation equipment, and electricity network savings.

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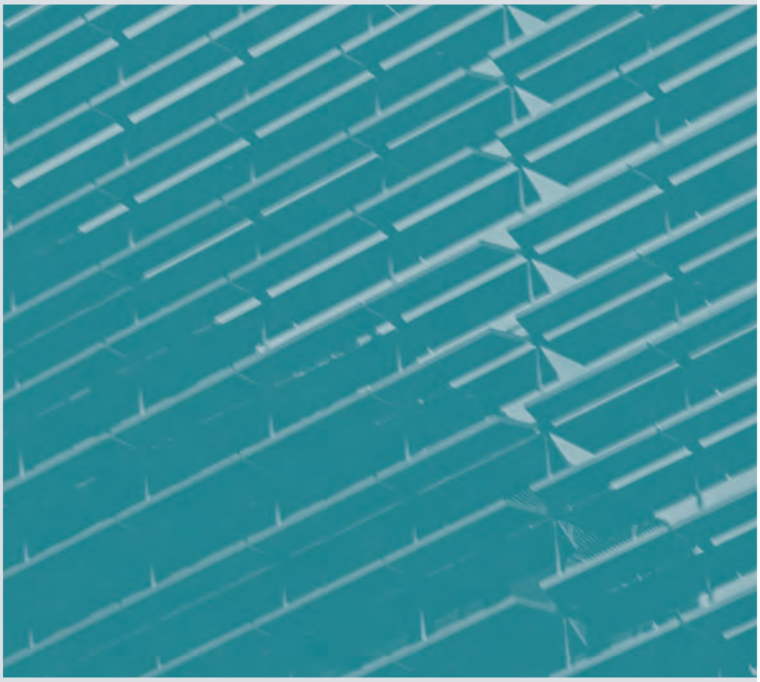
iv The baseline for Climate Zone 2 is 6 Star NatHERS equivalent, as per *Built to Perform* (July 2018). The baseline for Climate Zone 1 and Climate Zone 3 is set to correspond with the minimum requirements across Northern Australia, taking into account state/territory variations: 5 Star NatHERS equivalent for the detached and attached house, and 3.5 Star NatHERS equivalent for the single apartment.

Under the accelerated deployment scenarios, changes to the Code energy requirements could deliver 30-34 per cent of the required energy savings. This could be achieved through accelerated deployment of higher performance windows (with total system U-value in the order of 2 W/m^2K and solar heat gain 0.24) and more efficient air conditioning, lighting and domestic hot water.

The remaining task of reaching net zero energy in residential buildings would need to be addressed through a combination of best practice design, on-site renewable energy, complementary measures such as mandatory disclosure, voluntary measures to improve energy efficiency, strengthened standards for items outside the Code (such as plug-in appliances) and decarbonised electricity supply.

Analysis of on-site renewable energy potential shows that there is the potential for both detached and attached housing to reach net zero energy through a combination of strengthened Code energy requirements and rooftop solar PV generation as early as 2022. By 2030, with projected cost reductions in solar PV, the potential would increase further; if grid integration and other challenges can be resolved, there is the potential for a single-storey detached house to generate over three times its annual energy use through solar PV, while a two-storey attached house could generate one-and-a-half times its energy use.

The potential for apartments is less significant; by 2030 an apartment in a mid-rise building could potentially generate one-tenth of its annual energy use via rooftop solar PV, although accelerated commercialisation of building-integrated solar PV could unlock additional opportunity for apartment buildings (this was not considered in analysis for this report).



POTENTIAL 2030 ENERGY TARGETS - Residential buildings

Single Apartment*

Conservative scenario

Baseline energy use (2016 Code)

81.6 kWh/m2/year

Controlled by the Code (Heating, cooling, lighting, hot water)

43.2

Outside scope of current Code (Plug-in appliances)

0

Net zero energy

25% via energy efficiency^

Could be met by using:

- > Eaves or adjustable awnings
- > Ceiling fans
- > Better air tightness
- > Higher performance windows
- > Increased insulation
- > Increased thermal mass
- > Efficiency improvements in air conditioning equipment, lighting and domestic hot water

Accelerated deployment scenario

30% via energy efficiency^

Could be met by using:

- > All measures in conservative scenario, plus:
- > Market-leading higher performance windows
- > Accelerated efficiency improvements in air conditioning equipment, lighting and domestic hot water

Attached House*

Conservative scenario

Baseline energy use (2016 Code)

55.1 kWh/m2/year

Controlled by the Code (Heating, cooling, lighting, hot water)

25.8

Outside scope of current Code (Plug-in appliances)

0

Net zero energy

29% via energy efficiency^

Could be met by using:

- > Adjustable outdoor awnings or larger eaves
- > Ceiling fans
- > Better air tightness
- > Higher performance windows
- > Increased insulation
- > Increased thermal mass
- > Increased ventilation of roof space
- > Efficiency improvements in air conditioning equipment, lighting and domestic hot water

Accelerated deployment scenario

35% via energy efficiency^

Could be met by using:

- > All measures in conservative scenario, plus:
- > Market-leading higher performance windows
- > Accelerated efficiency improvements in air conditioning equipment, lighting and domestic hot water

Detached House*

Conservative scenario

Baseline energy use (2016 Code)

49.8 kWh/m2/year

Controlled by the Code (Heating, cooling, lighting, hot water)

21.9

Outside scope of current Code (Plug-in appliances)

0

Net zero energy

27% via energy efficiency^

Could be met by using:

- > Adjustable outdoor awnings
- > Ceiling fans
- > Better air tightness
- > Higher performance windows
- > Increased insulation
- > Increased thermal mass
- > Increased ventilation of roof space
- > Efficiency improvements in air conditioning equipment, lighting and domestic hot water

Accelerated deployment scenario

34% via energy efficiency^

Could be met by using:

- > All the measures in the conservative scenario, plus:
- > Market-leading higher performance windows
- > Larger eaves
- > Accelerated efficiency improvements air conditioning equipment, lighting and domestic hot water

The gap to net zero energy can be met by a combination of best practice design, on-site renewable energy, improved appliance efficiency and decarbonised grid electricity supply.

Analysis of on-site renewable energy potential shows it could meet approximately:
12 % of remaining energy use for apartments
Greater than 100% of remaining energy use for attached homes
Greater than 100% of remaining energy use for detached homes

* Data presented here is an average for this building archetype across Climate Zones 1, 2, and 3

^ Percentage reduction is a proportion of whole building energy (or in the case of the apartment, whole-dwelling energy excluding central services), including energy that is currently not in the scope of the Code and needs to be addressed by measures outside the Code

Findings for commercial buildings in Northern Australia

Hotel, office and retail shop archetypes were modelled in Climate Zones 1 and 2.

As an average across the modelled climate zones under the conservative scenario, strengthening the energy efficiency requirements of the Code could deliver between 22 and 38 per cent of the energy savings required to achieve net zero energy in new commercial buildings by 2030, compared with a baseline that complies with the energy requirements proposed for the 2019 Code. This could be achieved through simple measures such as:

- Installing adjustable outdoor shading;
- Using light-coloured external walls;
- Increasing thermal mass; and
- Increasing the efficiency of air conditioning and lighting.

While energy efficiency strategies that were found to be cost-effective were broadly consistent across Climate Zones 1 and 2, analysis uncovered some minor variations that reflect the diverse climates present across the region. Increased wall insulation was generally found to be more cost effective in the more temperate Climate Zone 2, compared with Climate Zone 1. Measures that take advantage of cooling from outdoor air were also generally more effective in the modelled office building in Climate Zone 2. With respect to the percentage improvement compared with the baseline, less opportunity was found in Climate Zone 1 for the modelled hotel archetype (around 10 percentage points) but there was relatively little variation between climate zones for office and retail archetypes (up to three percentage points).

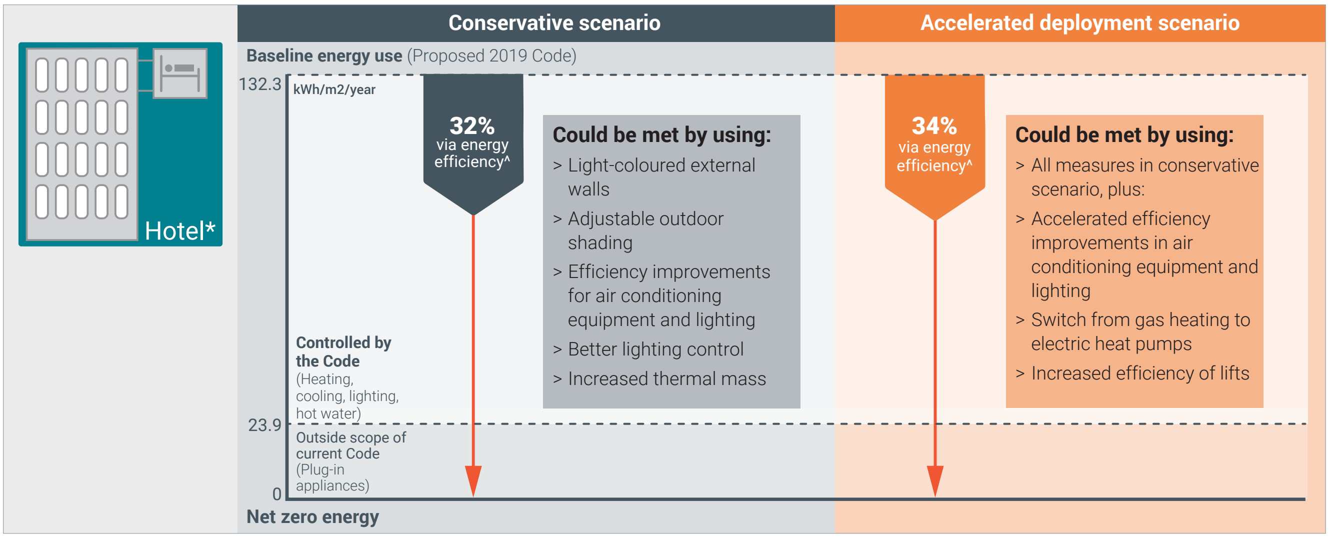
Assuming minimal industry learning and conservative projections of technology cost and performance improvements, the upfront cost associated with these improvements (averaged across Climate Zones 1 and 2) would be approximately $145 per square metre for the modelled hotel archetype, $105 per square meter for the office archetype and $215 per square metre for the retail archetype. These upfront costs would be more than offset by energy bill savings, reduced spend on heating, cooling and ventilation equipment, and electricity network savings.

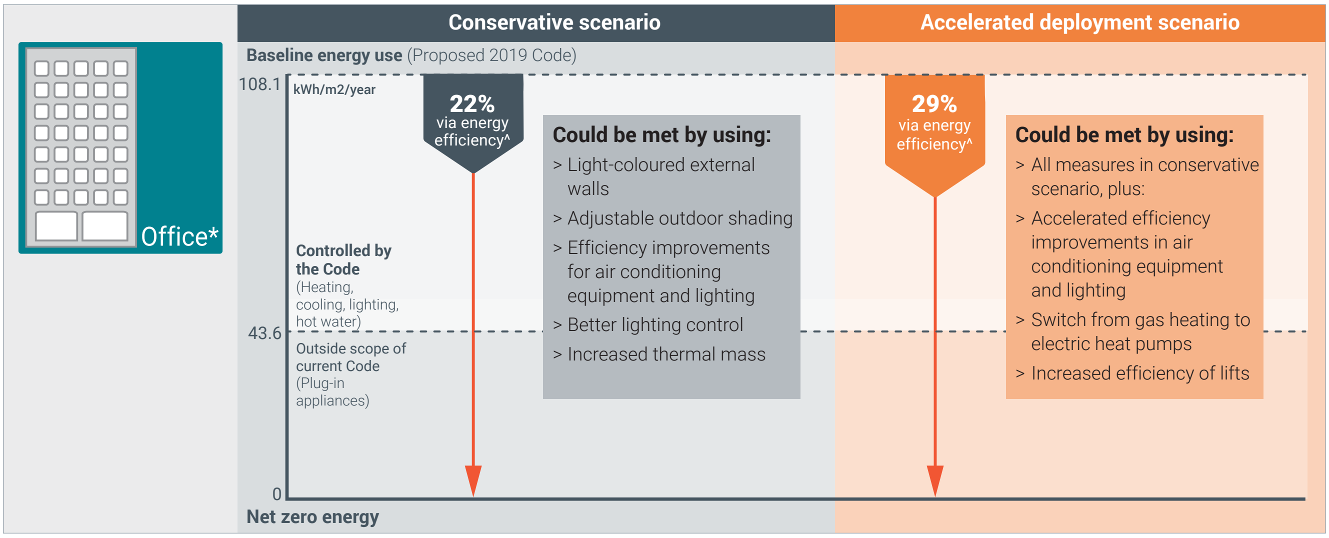
Under the accelerated deployment scenarios, changes to the Code energy requirements could deliver 29-42 per cent of required energy savings. This could be achieved through accelerated deployment of more efficient chillers, lighting, lifts and commercial-scale electric heat pumps.

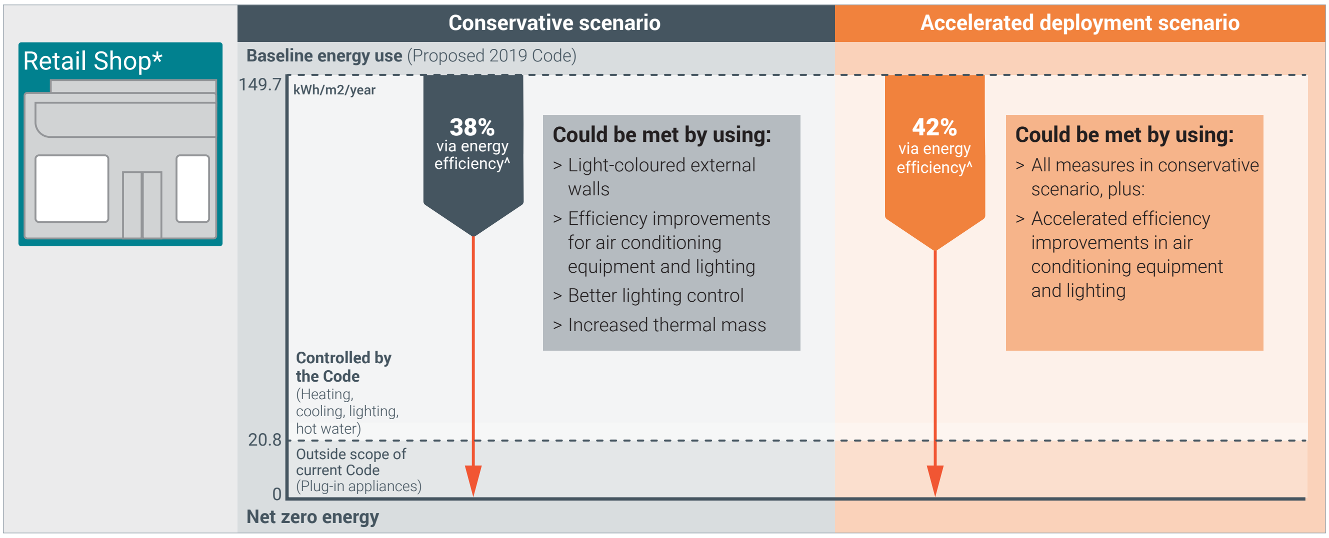
The remaining task of reaching net zero energy in commercial buildings would need to be addressed through a combination of best practice design, on-site renewable energy, complementary measures such as mandatory disclosure, voluntary measures to improve energy efficiency, strengthened standards for items outside the Code (such as plug-in appliances) and decarbonised electricity supply.

Analysis of on-site renewable energy potential shows that by 2030, when combined with strengthened Code energy requirements, there is potential for a low-rise hotel or a mid-rise office building to generate approximately 20 per cent of its annual energy use through rooftop solar and building integrated PV. A medium-sized single-storey retail building could potentially generate approximately two-thirds of its energy use.

POTENTIAL 2030 ENERGY TARGETS - Commercial buildings







The gap to net zero energy can be met by a combination of best practice design, on-site renewable energy, improved appliance efficiency and decarbonised grid electricity supply.

Analysis of on-site renewable energy potential shows it could meet approximately:
22% of the remaining energy use for a hotel
22% of the remaining energy use for an office
66% of the remaining energy use for retail

* Data presented here is an average for this building archetype across Climate Zones 1 and 2

^ Percentage reduction is a proportion of whole building energy, including energy that is currently not in the scope of the Code and needs to be addressed by measures outside the Code

Findings for public buildings in Northern Australia

Hospital ward and school building archetypes were modelled in Climate Zones 1 and 2.

As an average across the modelled climate zones under the conservative scenario, strengthening the energy efficiency requirements of the Code could deliver between 38 and 56 per cent of energy savings required to achieve net zero energy in new hospital wards and school buildings by 2030, compared with a baseline that complies with energy requirements proposed for the 2019 Code. This could be achieved through simple measures such as:

- Installing adjustable outdoor shading;
- Using light-coloured external walls;
- Increasing thermal mass;
- Increased insulation; and
- Increasing the efficiency of air conditioning and lighting.

While the energy efficiency strategies that were found to be cost-effective were broadly consistent across Climate Zones 1 and 2, the analysis uncovered one minor variation: measures that optimise the intake of outdoor air based on internal carbon dioxide levels were also generally more effective in Climate Zone 1. With respect to the percentage improvement compared with the baseline, there was relatively little variation between climate zones (up to six percentage points).

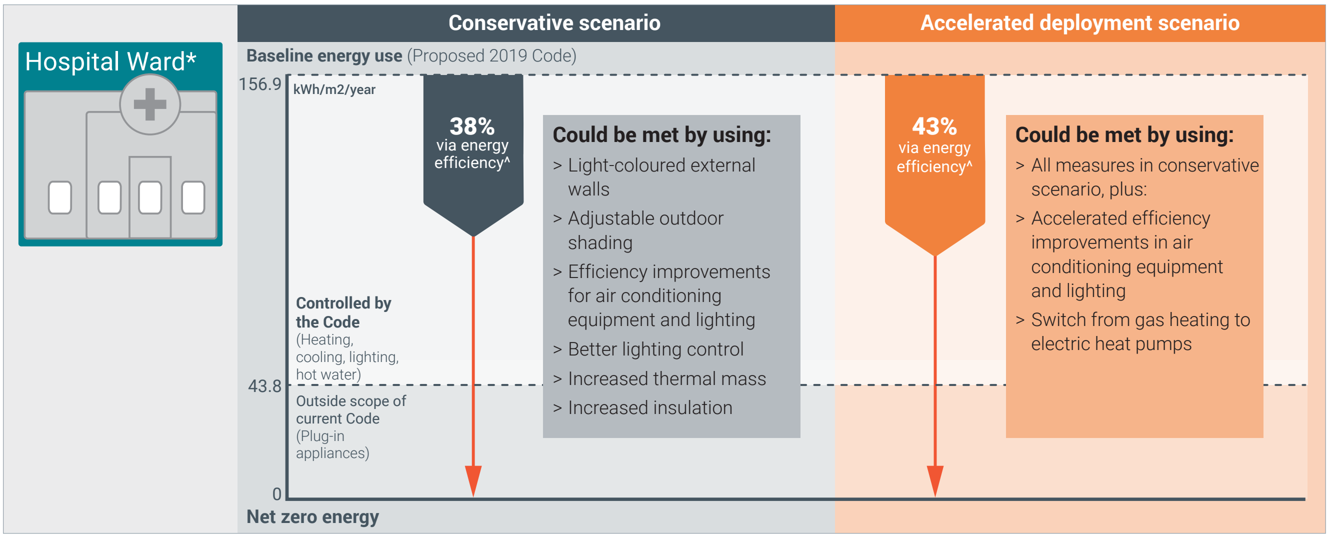
Assuming minimal industry learning and conservative projections of technology cost and performance improvements, the upfront cost associated with these improvements (averaged across Climate Zones 1 and 2) would be approximately $207 per square metre for the modelled hospital ward archetype and $323 per square metre for the school building archetype. These upfront costs would be more than offset by energy bill savings, reduced spend on heating, cooling and ventilation equipment, and electricity network savings.

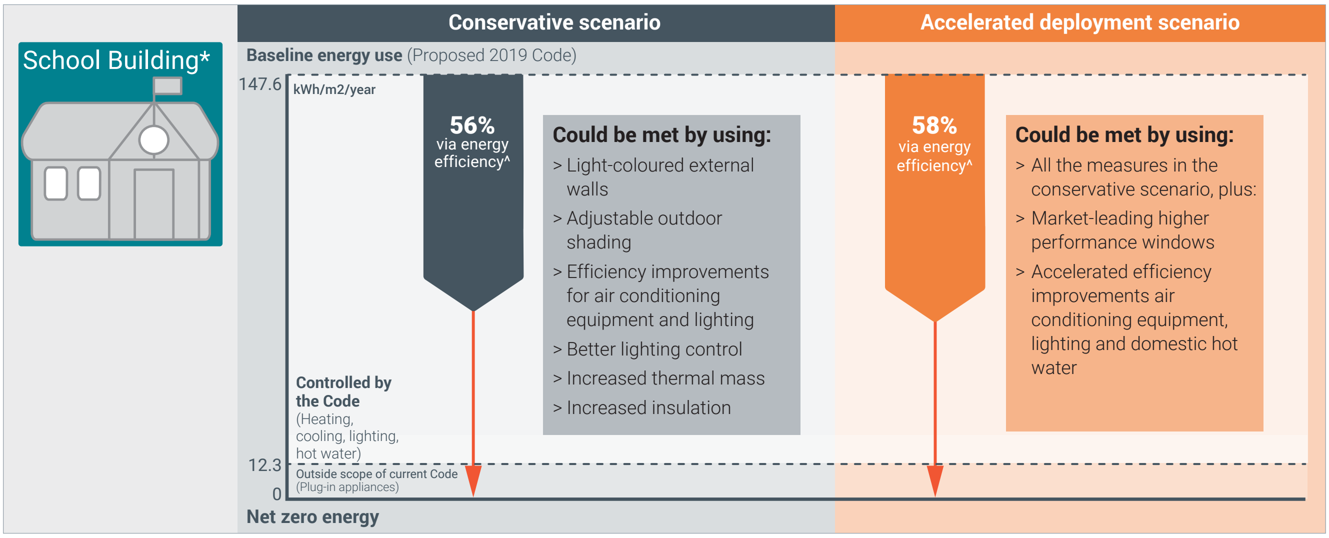
Under the accelerated deployment scenarios, changes to the Code energy requirements could deliver 43-58 per cent of required energy savings. This could be achieved through accelerated deployment of more efficient chillers, lighting and commercial-scale electric heat pumps.

The remaining task of reaching net zero energy in public buildings would need to be addressed through a combination of best practice design, on-site renewable energy, voluntary measures to improve energy efficiency, strengthened standards for items outside the Code (such as plug-in appliances) and decarbonised electricity supply.

Analysis of on-site renewable energy potential shows that by 2030, when combined with strengthened Code energy requirements, there is potential for a single-storey hospital ward to generate approximately 40 per cent of its annual energy use through rooftop solar PV, while a single-storey school building could generate almost 90 per cent of its energy use.

POTENTIAL 2030 ENERGY TARGETS - Public buildings





The gap to net zero energy can be met by a combination of best practice design, on-site renewable energy, improved appliance efficiency and decarbonised grid electricity supply.

Analysis of on-site renewable energy potential shows it could meet approximately:
44% of the remaining energy use for a hospital ward
87% of the remaining energy use for a school building

* Data presented here is an average for this building archetype across Climate Zones 1 and 2
^ Percentage reduction is a proportion of whole building energy, including energy that is currently not in the scope of the Code and needs to be addressed by measures outside the Code

2. Recommendations

Urgent action is needed to unlock the opportunities presented in this report. This report recommends three actions, listed below. Full details on these recommendations can be found in *Built to Perform.*

RECOMMENDATION 1: Commit to a forward plan for the Building Code.

By the first quarter of 2019, the COAG Energy Council and Building Ministers Forum should commit to a forward plan for Code energy requirements to deliver higher performing buildings, resulting in energy cost savings for Australian households, energy productivity improvements for businesses, improved occupant health and resilience, improved energy system reliability, and emissions reductions. This would provide the regulatory certainty needed to stimulate investment and innovation by industry to deliver higher performance buildings at lower cost.

High performance buildings support a least-cost pathway to a zero carbon built environment. Australia is a signatory to the Paris Climate Agreement, and it is widely-accepted that to meet obligations under this Agreement, developed countries must reach net zero emissions by 2050. A forward plan for Code energy requirements is recommended to make the Code 'Zero Carbon Ready'. A Zero Carbon Ready Code would maximise the potential for new construction to cost-effectively contribute to achieving the economy-wide zero carbon goal, and prepare buildings built today for the 2050 zero carbon environment in which they will ultimately be operating.

A Zero Carbon Ready Building Code would include energy efficiency targets in the Code which are at least as stringent as the conservative energy efficiency targets in this report (excluding renewable energy potential), introduce net energy targets (including renewable energy potential), and establish a clear set of rules and processes for implementation and adjustment of the targets in the Code.

RECOMMENDATION 2: Deliver a step change in 2022.

By the first quarter of 2019, the COAG Energy Council and Building Ministers Forum should jointly agree to task the ABCB to deliver a step change in energy requirements in the 2022 Code, with a strong focus on residential standards and a further incremental increase in non-residential standards.

Work is already in progress to increase the stringency of non-residential energy requirements in the 2019 Code update, along with improvements to residential requirements (but no increase in stringency). The analysis in this report shows that a step change in energy performance is possible today for residential buildings, and further gains for non-residential buildings are possible beyond the proposed 2019 Code changes.

RECOMMENDATION 3: Continue to enable climate-responsive building design and construction practices

State and Territory Governments should progress measures that build capacity in the region to deliver higher performing residential and non-residential buildings at lower cost, using design and construction practices appropriate to the climate.

Northern Australia is a diverse region, and different design and construction practices are suited to different climates and building types. There has been a call for stronger Code energy requirements in Northern Australia that could encourage greater take-up of traditional climate-responsive housing design techniques suited to each region (with features such as effective cross-ventilation and larger awnings) as this would be a cheaper strategy for higher performance buildings compared with southern Australian-style designs[v]. Improving industry capacity to deliver comfortable, resilient and higher energy performance buildings in both residential and non-residential sectors would reduce the cost of meeting stronger Code energy requirements.

RECOMMENDATION 4: Expand the scope of the Code and progress complementary measures.

The COAG Energy Council and Building Ministers Forum should jointly establish work programs that investigate expanding the scope of the Code to prepare for future challenges and opportunities relating to economic and environmental sustainability and resilience. This could include investigation of health, peak demand and design for maintainability requirements for inclusion in the Code. The Building Ministers Forum and COAG Energy Council should also progress measures to complement the Code and drive towards zero carbon new and existing buildings.

v See page 46 of The Application of NatHERS Software in Northern Australia Climates (2017) by Isaacs, Plunkett and Fogolyan. Available at: http://www.nathers.gov.au/sites/prod.nathers/files/u20/Final%20ANSNAC.docx [Accessed 3 October 2018]

Implementation considerations

The following key issues need to be considered when pursuing the recommendations of this report:

1. A clear, rules-based process for Code updates and target adjustments is essential to fully capture potential benefits and provide the policy stability required by industry.
2. Pursuing the potential for on-site renewables through the Code presents significant opportunities but also challenges that will need to be resolved. These challenges include the variability of solar potential across different sites and building types, the potential need for exemptions, barriers to grid connection, grid integration issues and the high upfront costs. These issues are likely to be solvable, and other jurisdictions have already begun to introduce specific on-site renewable energy requirements into building codes.
3. Improving compliance and enforcement regimes is paramount. While it is recognised that improvements to the energy efficiency requirements of the Code must be matched by improvements in compliance and enforcement, the fact that some operators are failing to comply with the regulations should not prevent implementation of cost-beneficial and achievable strengthening of the energy requirements.
4. Code requirements for infiltration and ventilation must ensure that occupant health outcomes are maintained or improved when pursuing increased energy efficiency. This is particularly important in humid climates where inadequate treatment of humidity inside buildings can lead to issues such as condensation and mould[vi]. Education and training would be critical alongside minimum standards to share the understanding that a more airtight building does not imply a 'sealed, insulated box'; appropriate consideration of both infiltration and ventilation can enable buildings to be naturally ventilated when weather conditions are appropriate, while efficiently protecting occupants from uncomfortable temperatures and humidity when needed.
5. Natural gas use in buildings needs to be phased out to meet long-term emissions targets. Further work is required to assess the best approach to transitioning away from gas (in particular natural gas), especially in areas where gas is the dominant fuel for heating and cooking, and in specific applications such as commercial kitchens where gas may continue to be demanded. Further work is also needed to explore the role of zero carbon gas sources such as biogas in a future zero carbon built environment.
6. Research, development and deployment policies targeting key technologies, and design practices can help accelerate energy performance trajectories, while generating significant benefits. The accelerated deployment scenarios highlight that additional energy savings could be achieved if cost reductions can be delivered for a range of technologies that are not currently cost-effective, or not projected to be cost-effective until later years. These include market-leading higher performance windows, large-scale electric heat pumps, and accelerated improvements in the efficiency of air conditioning, lighting and domestic hot water systems.
7. The Code is one part of the solution to transitioning buildings to zero carbon - other complementary policies targeting building energy performance are required. ASBEC's *Low Carbon, High Performance* report[vii] recommended a broad suite of policy measures to support the transition to a zero carbon built environment.

Full details on these implementation considerations can be found in *Built to Perform*.

vi For further details on considerations for air tightness in tropical climates, refer to Improving Australian Housing Envelope Integrity, a 2016 report by the Australian Institute for Refrigeration Air Conditioning and Heating (AIRAH)

vii Available at: https://www.asbec.asn.au/research-items/low-carbon-high-performance-report/

Appendix

Detailed summary of results

The main body of this report provides results as an average across Climate Zones 1, 2 and 3. This appendix provides a more detailed summary of the key modelling results relating to Trajectory Project analysis. Further details on methodology and results are provided in Appendix A of *Built to Perform* and the Northern Australia Technical Report (available on ASBEC and ClimateWorks websites).

Modelled climate zones

ASBEC and ClimateWorks, in partnership with Energy Action and Team Catalyst, undertook the following additional modelling beyond the modelling conducted for the *Built to Perform* report:

- Residential buildings were modelled for Climate Zone 1 and Climate Zone 3; and
- Commercial and other non-residential buildings were modelled for Climate Zone 1.

Results from the this additional analysis were combined with existing Climate Zone 2 results to form the results presented in this report.

Northern Australia captures a broad diversity of climates, including the dry arid interior and both the wet and dry tropics[viii]. This diversity can be observed even within climate zones as defined by the ABCB. For example, Climate Zone 1 covers:

- The **tropical 'Top End' including Darwin and the northern tip of Western Australia**, with higher average temperatures than other regions and less variation between summer and winter - the mean daily summer temperature around Darwin is between 27-30 degrees Celsius, which only drops to 24-27 degrees in winter, though this seasonal variation increases in locations south of Darwin. The hotter and more humid conditions with lower temperature variability generally translate to higher demand for cooling buildings, so measures to reduce heat transfer into buildings using shading and insulation are more likely to be favoured for energy efficiency. Analysis undertaken for this report shows that the energy required for cooling in the Top End is likely to be significantly higher than for other regions within Climate Zone 1. This region also experiences higher rainfall totals during the wet season than some dry tropical Queensland locations (e.g. Townsville);
- The **'dry tropics', including Townsville**, which is exposed to moist south-easterly trade winds and experiences greater temperature variability between summer (mean daily temperature around 27-30 degrees Celsius) and winter (18-21 degrees). Feedback from Northern Australia stakeholders for this project suggest that, anecdotally, the dry tropics feel less humid than other parts of the region with relief from the heat in the evenings even on hot days. Measures to encourage ventilation in buildings are likely to be more effective in this region, though because of the high daytime temperatures, efforts to reduce heat transfer are still important; and

viii A summary of the climate in specific regions across Australia at a level of detail beyond the ABCB definitions, based on Natural Resource Management clusters, can be found in the Cluster Reports on Climate Change in Australia (CSIRO and Bureau of Meteorology): https://www.climatechangeinaustralia.gov.au/en/publications-library/cluster-reports/ [Accessed 1 October 2018]

- The **'wet tropics', including Cairns and Cape York**, which is exposed to prevailing north-easterly winds during the wet season and south-easterly winds during the dry season. Seasonal temperature variations between summer and winter on Cape York are comparable to the Top End, while seasonal temperature observations for Cairns are comparable to Townsville (though the combination of high humidity and strong prevailing winds make this region unique compared with other tropical regions). Analysis undertaken for this report suggests that the cooling energy required for buildings in this region is likely to be significantly less than a comparable building in the Top End.

Climate Zone 3 is generally dryer and more arid than Climate Zone 1, though there is still variation in climates within Climate Zone 3. Regions in the centre of Australia (e.g. Alice Springs) experience greater temperature variation between summer and winter and within the same day, than areas further north (e.g. Mt Isa, Tennant Creek). Central Australia also experiences significantly cooler evenings, particularly in winter. This means measures to keep buildings warm at night through insulation are more likely to be important in Central Australia.

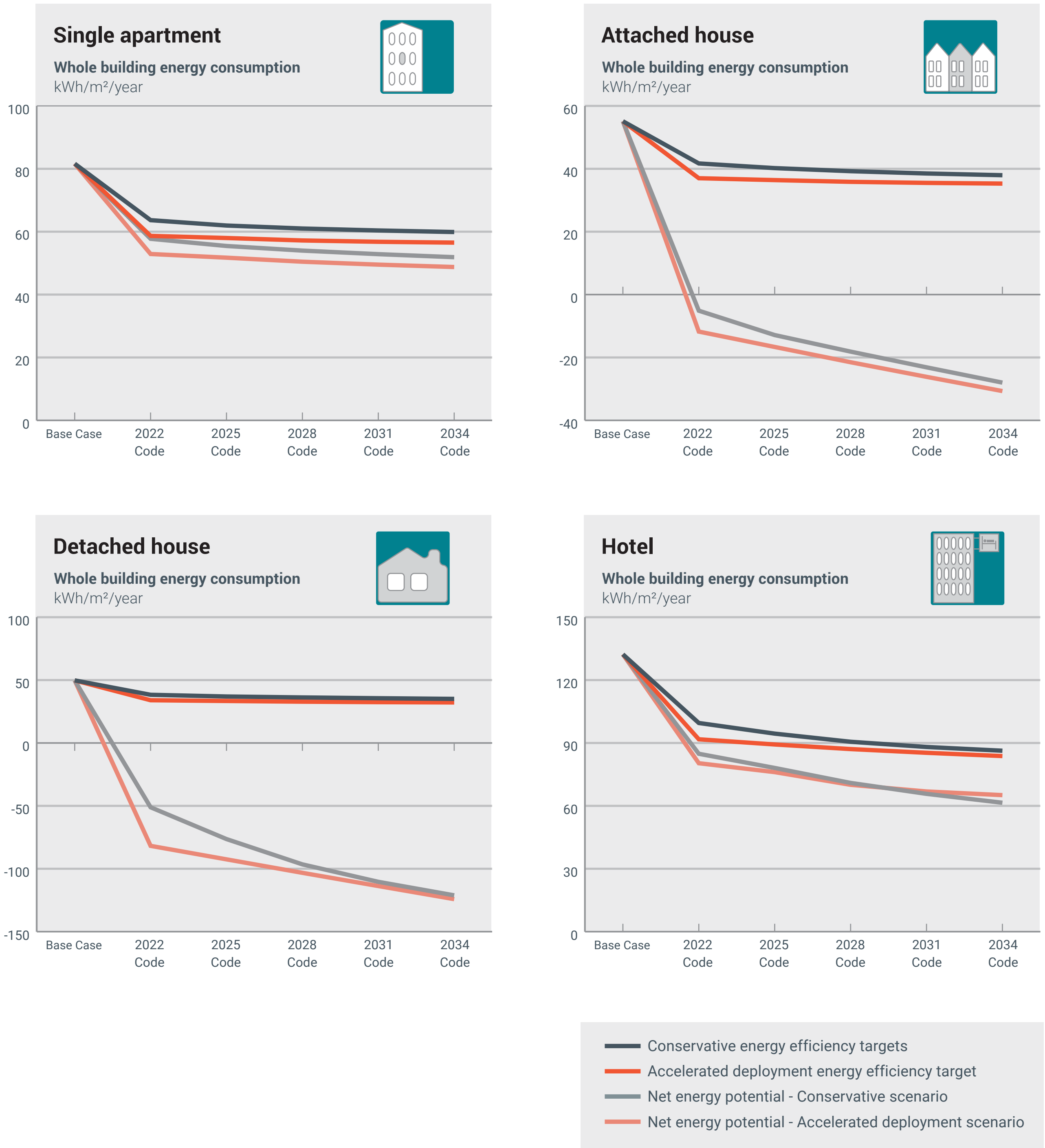
The climate variation across Northern Australia means that specific energy targets will vary for different locations even within climate zones. For example, modelling undertaken for this report suggests that numeric targets for far north Queensland buildings are likely to be lower than comparable buildings in the Top End, as the milder climate is more conducive to natural ventilation which leads to lower cooling energy demand. Tables A1 and A2 provide further details on the targets relevant to these regions.

Despite this variation across and within climate zones, feedback from stakeholders suggests that design principles for energy efficient buildings across Northern Australia are relatively consistent. These principles are generally focused on reducing heat transfer into buildings through shading, insulation and lighter material colours, and encouraging air movement through ceiling fans and natural ventilation. This qualitative feedback from Northern Australia stakeholders is reflected in the modelling results, which does not suggest significant variation between Climate Zone 1, Climate Zone 2 and Climate Zone 3 in the indicative pathways for higher performance buildings.

Summary of energy results

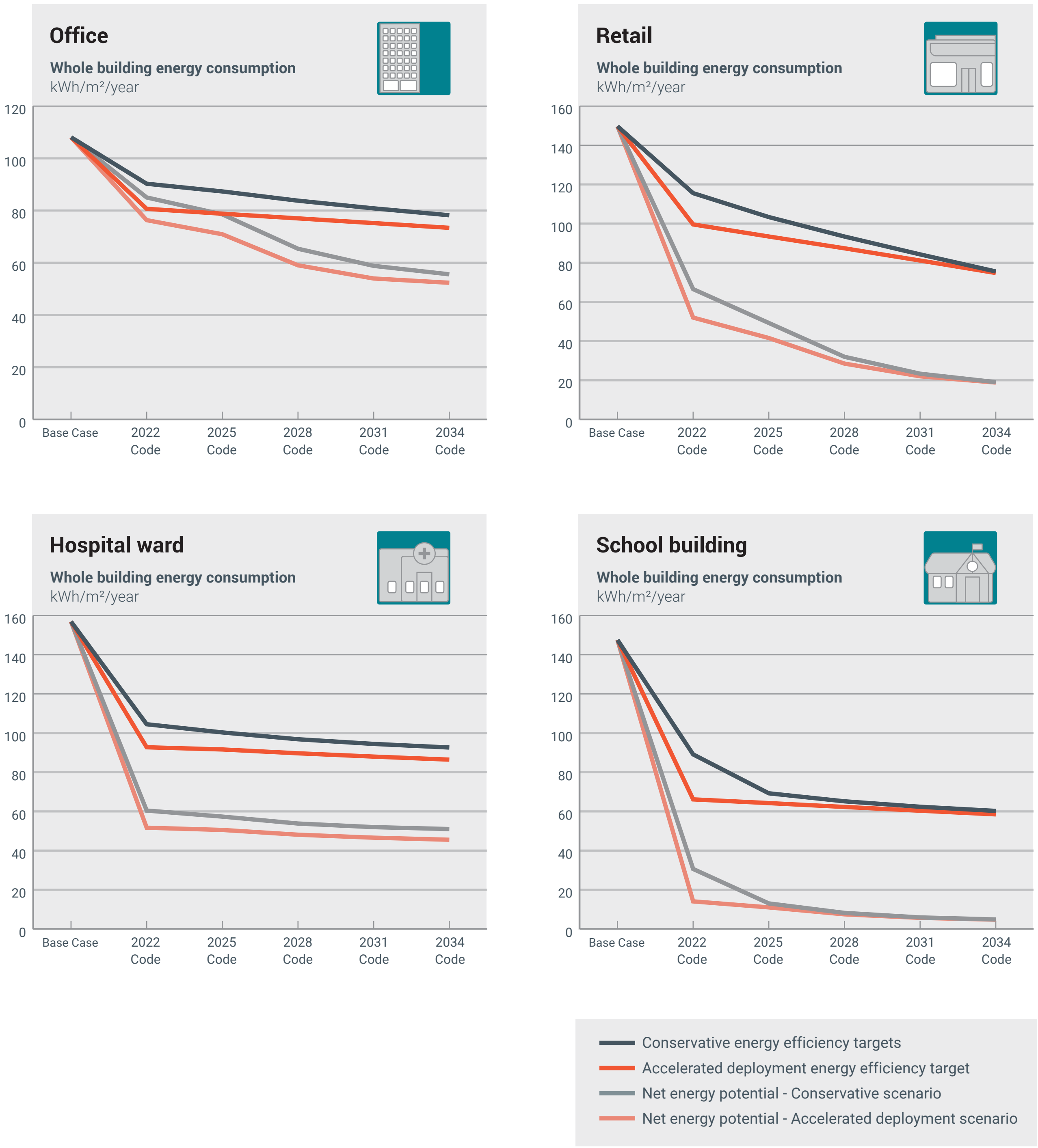
Figure A1 summarises the energy efficiency targets and net energy potential, averaged across Climate Zones 1, 2 and 3 (for the single apartment, attached house and detached house[ix]) and Climate Zones 1 and 2 only (for the hotel, office, retail, hospital ward and school building).

FIGURE A1: Summary of energy efficiency targets and net energy potential, averaged across modelled climate zones



ix The residential archetypes were modelled in two locations in Climate Zone 1: the Top End (of Northern Territory and Western Australia) and Far North Queensland. The conservative energy efficiency targets, accelerated deployment energy efficiency targets and base case energy consumption used throughout this report incorporate results from both locations.

FIGURE A1: Summary of energy efficiency targets and net energy potential, averaged across modelled climate zones... continued



Results for each archetype and climate zone

Table A1 provides a high-level summary of results for different climate zones for the conservative and accelerated deployment scenarios, relevant to the 2022 Code. Table A2 present results relevant to the 2028 Code. Complete results relevant to each three-yearly Code upgrade from 2022 to 2034 inclusive are published in the *Building Code Energy Performance Trajectory Technical Report – Northern Australia*.

An improvement to building energy performance is deemed 'cost-effective' if societal benefits outweigh costs over a 40-year building lifetime. For example, modelled improvements to the detached house archetype in Climate Zone 2 (built 5 years from now - i.e. between the 2022 and 2025 Codes - and in the nominal 'zero-degree' orientation) have a calculated capital cost of $7,265. This cost is outweighed by $6,021 in lifetime energy cost savings, $1,150 from reduced heating cooling equipment size and $1,673 in electricity network investment savings. Estimated annual energy cost savings are not directly translatable to lifetime energy cost savings because the lifetime energy costs incorporate projected changes in electricity prices and a discount rate of seven per cent. Further details on benefits and costs for all modelled scenarios are provided in the Technical Report.

TABLE A1: Results for each building archetype in each climate zone, relevant to the 2022 Code.

		Base Case	2022 Code				
Climate Zone	Archetype	Energy use (kWh/m²/year)	Energy efficiency target (kWh/m²/year)	Up-front additional capital cost – Energy efficiency ($/m²)	Annual energy bill savings, averaged over 15 years ($/year)	Net energy potential (kWh/m²/year)	On-site solar PV system size (kWh)– includes rooftop and BIPV
Conservative scenario							
CZ 1 Top End NT and WA	**Apartment**	111.4	74.6	$149	$297	69.0	0.3
	Attached	79.8	52.5	$142	$438	3.3	4.1
	Detached	75.4	50.7	$124	$586	-58.2	13.5
	Hotel	134.3	109.4	$85	$6,513	97.2	28.2
	Office	116.5	97.3	$76	$25,069	91.7	26.2
	Retail	170.4	131.3	$138	$5,493	78.7	26.2
	Hospital ward	175.4	123.1	$170	$3,586	70.2	31.0
	School building	201.7	120.4	$277	$2,285	47.7	12.0
CZ 1 Far North QLD	**Apartment**	75.5	64.2	$62	$108		
	Attached	48.9	41.0	$44	$127		
	Detached	38.9	36.3	$57	$232		
CZ 2	**Apartment**	63.4	56.0	$48	$198	50.6	0.3
	Attached	41.3	35.2	$46	$270	-3.5	3.6
	Detached	37.4	31.8	$42	$397	-17.0	6.6
	Hotel	130.3	89.7	$132	$10,990	72.5	28.2
	Office	99.6	83.2	$59	$50,342	78.3	26.2
	Retail	129.0	99.8	$98	$11,430	54.4	26.2
	Hospital ward	138.5	85.9	$144	$6,519	50.7	31.0
	School building	93.5	57.8	$149	$2,529	13.6	12.0
CZ 3	**Apartment**	76.2	59.9	$98	$157	53.6	0.3
	Attached	50.5	38.2	$70	$198	-15.2	4.1
	Detached	47.3	34.4	$74	$306	-78.2	12.8

TABLE A1: **Results for each building archetype in each climate zone, relevant to the 2022 Code**... continued.

		Base Case	2022 Code				
Climate Zone	Archetype	Energy use (kWh/m²/year)	Energy efficiency target (kWh/m²/year)	Up-front additional capital cost – Energy efficiency ($/m²)	Annual energy bill savings, averaged over 15 years ($/year)	Net energy potential (kWh/m²/year)	On-site solar PV system size (kWh)– includes rooftop and BIPV
Accelerated deployment scenario							
CZ 1 Top End NT and WA	**Apartment**	111.4	65.7	$269	$365	60.0	0.3
	Attached	79.8	44.5	$152	$547	-4.6	4.1
	Detached	75.4	41.6	$176	$757	-74.5	14.4
	Hotel	134.3	102.2	$85	$8,341	91.6	28.2
	Office	116.5	88.9	$76	$35,856	87.1	26.2
	Retail	170.4	110.1	$148	$8,257	58.4	26.2
	Hospital ward	175.4	115.4	$180	$4,089	65.3	31.0
	School building	201.7	90.3	$333	$3,036	22.3	12.0
CZ 1 Far North QLD	**Apartment**	75.5	58.7	$170	$148		
	Attached	48.9	36.3	$115	$189		
	Detached	38.9	33.8	$126	$308		
CZ 2	**Apartment**	63.4	54.8	$278	$205	49.4	0.3
	Attached	41.3	33.7	$234	$266	-10.7	4.1
	Detached	37.4	30.1	$296	$436	-75.0	14.4
	Hotel	130.3	81.4	$139	$22,343	69.1	28.2
	Office	99.6	72.4	$308	$70,752	65.6	26.2
	Retail	129.0	89.0	$109	$12,961	45.7	26.2
	Hospital ward	138.5	70.2	$165	$7,242	38.1	31.0
	School building	93.5	42.0	$943	$2,777	5.9	12.0
CZ 3	**Apartment**	76.2	55.5	$256	$191	49.2	0.3
	Attached	50.5	33.5	$139	$256	-20.0	4.1
	Detached	47.3	30.4	$135	$384	-95.9	14.4

TABLE A2: Results for each building archetype in each climate zone, relevant to the 2028 Code.

		Base Case	2028 Code				
Climate Zone	Archetype	Energy use (kWh/m²/year)	Energy efficiency target (kWh/m²/year)	Up-front additional capital cost – Energy efficiency ($/m²)	Annual energy bill savings, averaged over 15 years ($/year)	Net energy potential (kWh/m²/year)	On-site solar PV system size (kWh)– includes rooftop and BIPV
Conservative scenario							
CZ 1 Top End NT and WA	**Apartment**	111.4	70.1	$203	$340	63.5	0.3
	Attached	79.8	48.5	$164	$502	-9.3	4.8
	Detached	75.4	46.5	$143	$687	-90.0	16.9
	Hotel	134.3	98.8	$119	$10,998	80.7	89.9
	Office	116.5	89.5	$117	$41,878	73.6	307.5
	Retail	170.4	104.3	$224	$10,826	37.9	103.2
	Hospital ward	175.4	113.0	$247	$5,093	61.0	53.0
	School building	201.7	86.2	$445	$3,767	12.2	22.8
CZ 1 Far North QLD	**Apartment**	75.5	61.8	$90	$131		
	Attached	48.9	38.6	$60	$166		
	Detached	38.9	35.1	$77	$279		
CZ 2	**Apartment**	63.4	54.9	$72	$287	48.6	0.3
	Attached	41.3	34.1	$51	$385	-18.1	4.8
	Detached	37.4	30.7	$50	$597	-83.6	15.7
	Hotel	130.3	82.4	$170	$26,408	61.2	89.9
	Office	99.6	78.0	$94	$72,033	57.2	307.5
	Retail	129.0	82.5	$207	$18,401	26.1	103.2
	Hospital ward	138.5	80.7	$168	$7,992	46.6	53.0
	School building	93.5	44.1	$202	$3,164	4.1	22.8
CZ 3	**Apartment**	76.2	57.2	$120	$182	49.9	0.3
	Attached	50.5	35.8	$91	$236	-27.0	4.8
	Detached	47.3	32.5	$90	$352	-115.9	16.9

TABLE A2: Results for each building archetype in each climate zone, relevant to the 2028 Code… continued**.**

		Base Case	2028 Code				
Climate Zone	Archetype	Energy use (kWh/m²/year)	Energy efficiency target (kWh/m²/year)	Up-front additional capital cost – Energy efficiency ($/m²)	Annual energy bill savings, averaged over 15 years ($/year)	Net energy potential (kWh/m²/year)	On-site solar PV system size (kWh)– includes rooftop and BIPV
Accelerated deployment scenario							
CZ 1 Top End NT and WA	**Apartment**	111.4	63.3	$262	$384	56.7	0.3
	Attached	79.8	42.4	$148	$571	-15.3	4.8
	Detached	75.4	39.5	$172	$806	-97.0	16.9
	Hotel	134.3	96.1	$120	$11,810	79.7	89.9
	Office	116.5	83.8	$114	$50,706	71.6	307.5
	Retail	170.4	97.2	$234	$11,953	33.3	103.2
	Hospital ward	175.4	111.6	$257	$5,204	61.0	53.0
	School building	201.7	84.8	$446	$3,808	11.4	22.8
CZ 1 Far North QLD	**Apartment**	75.5	57.2	$166	$161		
	Attached	48.9	35.2	$112	$204		
	Detached	38.9	32.7	$123	$332		
CZ 2	**Apartment**	63.4	53.9	$282	$262	47.6	0.3
	Attached	41.3	33.1	$236	$334	-19.1	4.8
	Detached	37.4	29.4	$297	$550	-94.1	16.9
	Hotel	130.3	78.1	$176	$27,516	60.4	89.9
	Office	99.6	70.2	$315	$90,086	46.5	307.5
	Retail	129.0	77.6	$219	$18,635	23.7	103.2
	Hospital ward	138.5	67.8	$189	$8,657	35.2	53.0
	School building	93.5	39.7	$941	$3,383	3.5	22.8
CZ 3	**Apartment**	76.2	54.4	$249	$199	47.1	0.3
	Attached	50.5	32.7	$134	$272	-30.1	4.8
	Detached	47.3	29.7	$131	$401	-118.7	16.9

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