9

Decarbonising Commercial Buildings

Philip Oldfield, Roger Swinbourne and Kriston Symons

Introduction: Current Trends and Performance

Commercial buildings make up an estimated 163 million square metres (net lettable) of building stock in Australia, with growth occurring at around 2.5 million square metres per year between 1999 and 2020 (Commonwealth of Australia 2012). The commercial building sector is also a major contributor to national carbon emissions; while the building sector as a whole is responsible for 23% of Australia's carbon

P. Oldfield (✉)
University of New South Wales, Sydney, NSW, Australia
e-mail: p.oldfield@unsw.edu.au

R. Swinbourne
Arup, Sydney, NSW, Australia
e-mail: roger.swinbourne@arup.com

K. Symons
Arup, Melbourne, VIC, Australia
e-mail: kriston.symons@arup.com

P. Newton et al. (eds.), *Decarbonising the Built Environment*,
https://doi.org/10.1007/978-981-13-7940-6_9

emissions, 44% of this is due to commercial buildings (42% commercial electricity; 2% commercial fuel) (ASBEC 2016).

The commercial office building sector in Australia has long been a global leader in setting itself targets and achieving them. New building standards and improved energy efficiency, for example, is estimated to have contributed to a 32% reduction in carbon emissions from new-build office buildings between 2002 and 2012 (Climateworks 2013). Beyond this, the Australian listed real estate investment trusts are leaders in sustainability across their property portfolios, as recognised by GRESB for the past eight years (Bleby 2018). While codes and standards represent the minimum legal requirements for building design in terms of carbon performance, the private sector very much operates at the opposite end of the spectrum, seeking to continuously improve on previous projects and differentiate their buildings from others in a competitive leasing environment (Fig. 9.1). For example, many of Australia's leading property trusts have committed to being carbon neutral by 2030 across their property portfolios (GBCA 2018a).

This chapter explores the decarbonisation of existing and new Australian commercial office buildings. In doing so, it firstly summarises

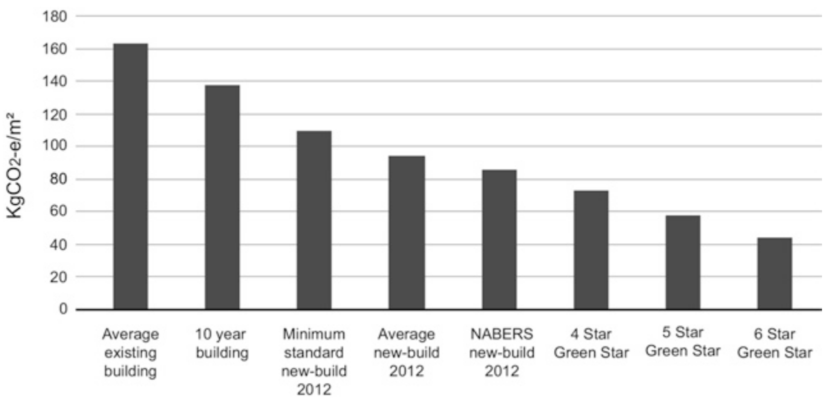

Fig. 9.1 Comparison of Australian office operating carbon emissions in 2012: best performance, fuelled by a competitive market, is achieved far beyond minimum standards (*Source* Author, drawn from data provided in Climateworks 2013)

government frameworks and rating systems to outline targets, pathways and strategies that have already been put in place. It then highlights opportunities for commercial building design teams to reduce operating emissions under the headings of 'energy efficiency', 'active technologies' and 'grid decarbonisation'. Specific challenges to the commercial building industry are presented, along with additional considerations in terms of embodied carbon and precinct level carbon reduction. The chapter concludes by identifying key areas where industry focus is necessary to accelerate the decarbonisation of the commercial building sector beyond current trends.

Government Frameworks

Commercial Building Green Rating Systems: Green Star and NABERS

In 2002 the Green Building Council of Australia (GBCA) created a peer-assessed industry benchmark rating tool for the design of green buildings called Green Star, with the objective of cutting through 'greenwash' and unsubstantiated claims from developers and consultants at the time. Since then, the Green Star rating has become the norm when designing a new office building with over 2000 buildings rated over the 16 years. In 2017, the GBCA and the International WELL Institute agreed to work collaboratively and interest from landlords and tenants in achieving a WELL Rating has increased over recent years. NABERS, the benchmark for assessing the energy consumption and carbon emissions of a building, has evolved from a voluntary rating to being mandated for any office building sale or lease over 1000 m^2. Its impact has been significant as over 20 years of operation, the NABERS rating tool has contributed to the reduction of 830,000 tonnes of carbon emissions (NABERS 2018a).

In 2018, the GCBA released its 'Carbon Positive Roadmap' with industry consultation and support for the next version of Green Star to move towards carbon neutrality. It states 'these requirements will include high levels of energy efficiency, use of 100 percent renewable energy from both on-site and off-site sources; and the avoidance of all fossil fuels' (GBCA 2018b). This applies for new commercial office buildings by 2030 and existing office buildings by 2050. This pathway creates a clear signal for industry on the direction that the GBCA is heading. As shown in the past, industry will respond, innovate and adapt to achieve these targets.

National Construction Code Focus

The National Construction Code (NCC) states minimum requirements for energy efficiency of buildings. This is revised every three years, and a great deal of effort and advocacy has gone into advising the Government that a clear pathway for the Code through to 2030 to achieve carbon neutrality is important for industry, designers, contractors and suppliers, to prepare, respond and deliver.

The latest ASBEC report *Built to Perform* provides a clear trajectory, calling for changes to the NCC in 2019 and the inclusion of a clear pathway for further updates towards carbon neutral buildings (ASBEC 2018). The report suggests designing for energy efficiency through simple strategies such as increased insulation, improved equipment efficiencies, better air-tightness and switching gas heating to electric heat pumps could save between 22 and 32% of a typical office building's energy use by 2030, as compared to the 2016 NCC. The figures are between 34 and 38% in a retail scenario. In addition, it suggests the remaining 'gap to zero' can be met by a mix of best practice design, onsite renewable energy generation, improved appliance efficiency, and the future decarbonisation of grid electricity. For onsite renewables, it is suggested these could meet 28% of the energy needs of a typical office building, and 67% of the needs of a retail building (ASBEC 2018).

Opportunities for Carbon Reduction

Some of the simplest design solutions can have a significant impact on the reduction of carbon emissions in Australian commercial buildings. Since most energy used in commercial buildings comes from HVAC

(43%), followed by lighting (20%) and equipment (13%), strategies to reduce energy loads in these areas are of particular value (ASBEC 2016).

Energy Efficiency

Passive Design Principles

The importance of following 'first design principles' in the creation of commercial buildings is of paramount importance. Designing with solar orientation in mind, use of appropriate insulation for climate, improving air-tightness and shading glazed facades should be first considerations. Given that commercial buildings have high internal heat gains, they are often cooling dominated, so strategies to reduce over-heating, and unwanted heat gains are of value—especially in a warming climate, with increasing heat waves. Once the passive design elements are optimised the active elements should be considered including efficient air conditioning systems, hot water and lighting. Finally, potential renewable energy sources can be explored. Renewable energy in commercial buildings is most commonly provided onsite by solar panels on the roof and offsite through carbon offsets and power purchase agreements.

A framework to consider is the *Carbon Cost Hierarchy Pyramid* (see Fig. 9.2). Effectively, this suggests that key principles such as optimising building form and fabric are more effective at reducing carbon and more cost efficient than renewable technologies in the first instance; as such, form and fabric should be the first design drivers to a low carbon solution (Harrington 2016).

Air-Tightness

The commercial building sector in Australia has been gradually warming to the idea that air tight building envelopes can offer energy savings, air quality and thermal comfort benefits. Increased industry awareness in recent years has been driven by a combination of

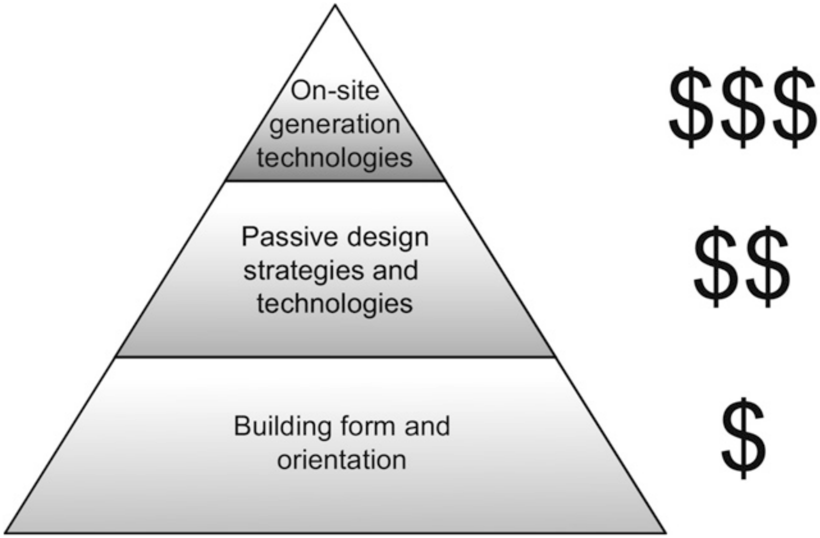

Fig. 9.2 Carbon cost hierarchy pyramid (*Source* Author, adapted from a graphic by Faithful + Gould in Harrington 2016)

minimum compliance, sustainable design ratings and issues with performance.

While there is little research on air-tightness performance in Australian commercial buildings, a sample of seven offices in Victoria provided an average air permeability of 13.4 m^3/hm^2 @ 50 Pa (McLauchlan et al. 2016). Good practice suggests figures in the region of 3.5–7.0 m^3/hm^2, with best practice closer to 2.0–3.5 m^3/hm^2 @ 50 Pa (GBCA 2015)—although this will differ based on both climate zone, and the building's ventilation strategies.

In 2013, Green Star first introduced air leakage testing as an innovation challenge with one point awarded for undertaking a whole building test and sharing the data to educate the industry, with a second innovation point awarded for achieving best practice levels defined in the UK building code. The most recent version of Green Star (Design and As-built v1.2) now requires air tightness tests as part of the commissioning credit.

From 1 May 2019, air-tightness testing will be required to achieve minimum compliance through inclusion in the rewritten National Construction Code, although it is limited to particular climate zones and building types.

Increasing the Range of Temperature Band

Increasing the temperature band one degree each way from a range of 20–24 °C, will reduce energy consumption of the air conditioning system and hence carbon emissions of the building. The rule of thumb is every one-degree reduction in setpoint can save 10% of energy usage. There would also be a need for occupants to dress up or down accordingly with the external ambient conditions. But this benefits in reducing thermal shock between internal and external temperatures as occupants move between buildings.

Use of Mixed Mode Air Conditioning Space

The use of openable windows and the design of tenancy spaces to facilitate zones of winter gardens or mixed mode conditioning areas where occupants can connect with nature and at the same time reduce building energy usage should be considered when designing workspaces. With advances in façade technologies, any building can be designed or retrofitted to include such spaces.

Agile Working, Flexible Working or Activity-Based Working

The adoption of various forms of flexible working by employers, along with advances in mobile phone and internet technologies provides a great opportunity for office space to be designed differently. With more employees working from home, staggering employee hours, or choosing furniture and desk solutions that suit their work needs, there is less reliance on traditional layouts permitting more flexible spaces to be created, such as common areas and winter gardens.

Active Design Technologies

Air Conditioning Ventilation Systems

Air conditioning solutions have evolved over the past ten years with many new office buildings utilising active and passive chilled beams or underfloor displacement air conditioning. Initially these systems were required in order to obtain high NABERS ratings above 4.5 stars. However, over time it has been realised through energy modelling and operation that variable air volume air conditioning systems are more than capable of achieving 5.5 stars and beyond. Any risk in achieving the rating has been met with back-up micro-turbine cogeneration systems for minimal cost—less than the cost difference for chilled beam solutions or underfloor displacement systems.

Thermal Plant

Cooled chilled water systems have been the preferred solution for greatest energy efficiency. However, depending on the overall NABERS aspirations of the building, high technology screw chillers and air-cooled plant are capable of comfortably meeting 5 Star NABERS. The need for greater aspirations in targeting high NABERS ratings, either through tenant demand or government guidelines, will continue to ensure the most efficient thermal cooling plant is utilised, maximising the ability for onsite renewables to offset building electrical loads.

There is a trend towards considering all electric buildings and either designing for all electric energy, taking advantage of a decarbonised grid, or having a pathway to replace gas plant at the end of its commercial life with electric plant. In commercial office buildings, this is focused on the hot water boiler plant that serves both the heating system and domestic hot water used in sinks and basins.

Lighting Systems

LED lighting has become the norm for office lighting with increased functionality over the years in terms of controls and dimming. Many older buildings are having lighting upgrades undertaken to replace fluorescent lights with LED benefitting from short payback periods. The future trend is towards more task-based lighting solutions that give users more control over their preferred lighting solutions. In addition, the use of motion and daylight sensors result in lighting levels turning down or off when not required, saving energy and associated carbon.

Renewable Systems at the Building Scale

The primary use of renewables on commercial buildings has been solar photovoltaic (PV) panels or solar hot water panels on the roof. Many new buildings integrate these technologies, while many existing buildings have them retrofitted.

The cost reduction of PV cells across the industry has led to commercially acceptable short payback periods for buildings owners and accelerated uptake. This provides a point of difference for the building in attracting tenants but also enables industry designers and contractors to become familiar with the technology and installation strategies. Familiarity is important in the construction industry and less uncertainty is met with less pricing risk and hence better value pricing assisting payback period and cost-based justifications for the application of new technologies.

It is worth noting, that generally, roof mounted solar photovoltaic systems can only supply enough electricity to serve three floors of a building, so commercial buildings of any greater height will require different renewable energy solutions and most likely use offsite carbon offsets solutions.

There have been a few instances of roof mounted wind turbines however cost and performance has meant to date that take-up of this type of building technology has not become widespread.

Decarbonisation of the Electricity Grid

The decarbonisation of the electricity grid is an important consideration in the design and retrofit of commercial office buildings. Figure 9.3 shows the reduction in carbon intensity of the electricity grid over the

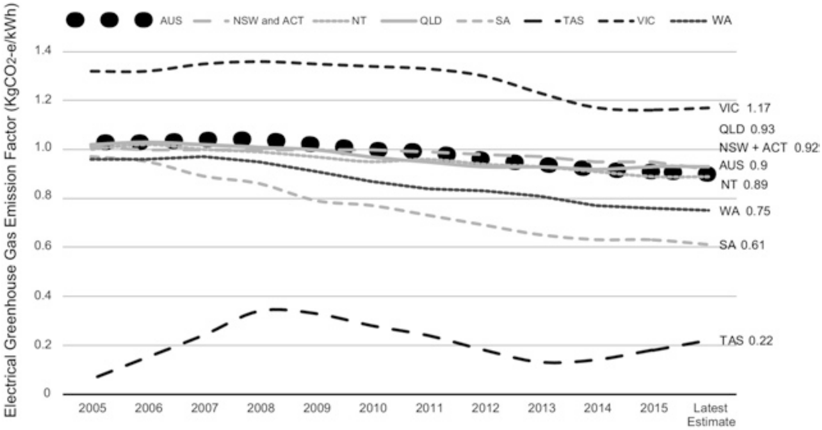

Fig. 9.3 Carbon intensity of delivered electricity (*Source* Author, drawn from data provided in Commonwealth of Australia 2018)

past ten years by state. It is expected that the carbon intensity of electricity will drop rapidly across many states in the coming years, as substantial wind and other renewable energy sources comes online.

As the electricity grid decarbonises the use of gas for heating and other purposes in a building becomes more carbon intensive than utilising electricity. Hence many buildings are being designed as all electric, moving away from gas as a fuel; or are at least providing provision for future conversion from gas to electric at a suitable point in time.

Figure 9.4 shows the tipping point has been reached across Australia (noting that some variation does exist by state) where the carbon intensity of air source heat pumps is lower than natural gas condensing boilers; hence from a carbon perspective, moving away from using gas for hot water generation can achieve the optimum outcome.

Challenges to Carbon Reduction

There are a number of challenges in the commercial building sector that make achieving greater reduction in carbon emissions difficult. We highlight a few of these below:

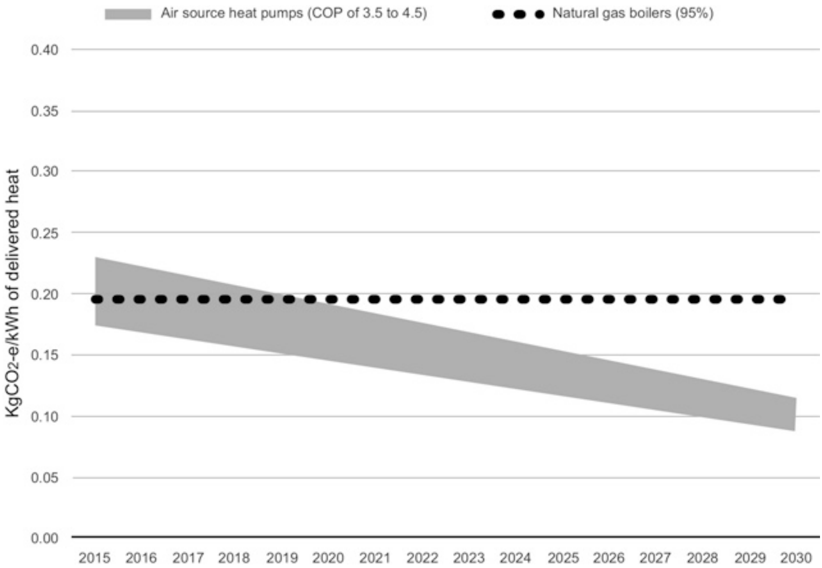

Fig. 9.4 Carbon intensity of air source heat pumps versus natural gas condensing boilers

Split Incentive Between Tenants and Landlords

The nature of the commercial office building sector is that landlords develop and own buildings and seek tenants for the available net lettable area in the building. However, once the lease is signed between the tenant and the landlord, normally for an industry standard duration of ten years, there is little incentive for each party to improve the building efficiency or reduce carbon emissions. This leads to locked in performance of the building for at least a decade. Initiatives such as the Cityswitch programs (which educate tenants on what they can do to improve their carbon emissions) and Environmental Upgrade Agreements (EUAs) (a building upgrade finance mechanism that allows a landlord to agree with the tenant to upgrade parts of the building and provides a low interest rate secured on the property statutory title) have assisted in undertaking building upgrades. EUA's enable the building owner to benefit from the savings with protection for the tenant through a 'no worse off' mechanism.

Regular communication between landlords and tenants around a joint vision to reduce carbon emissions and discuss each party's respective mechanisms under their control is important. Some upgrade initiatives such as air conditioning controls, lighting systems, metering and solar panel installations can benefit both the tenant and the landlord if discussed and worked through with a common vision for the building.

Green Leases

Many building tenants require the landlord to provide a base building that achieves a certain NABERS rating in relation to energy usage. However, few of these leases exert onus on the tenants to achieve a tenancy NABERS rating. With the introduction of the Commercial Building Disclosure program, most landlords will be required to report the NABERS rating of the building on an annual basis. However, there is no such requirement for tenants who generally use around 50% of the building's electricity. Improving tenant awareness and embedding a variety of environmental initiatives in the workplace including energy efficiency will assist in reducing overall carbon reduction initiatives of the commercial building sector.

Air Conditioning—Heating and Cooling

Air conditioning is the most energy-intensive part of a commercial building, and as such, the design of the air conditioning system is a critical component to achieving the buildings NABERS rating but also to occupant comfort.

The use of mixed mode ventilated spaces has not been taken up to any significant extent in commercial office buildings in Australia; however, that is starting to change. The more flexible, interactive and openable the facades of buildings are, the easier it is to design for mixed mode air conditioning. Creating spaces on the perimeter of a floor plate that allows the heating and cooling to be turned off when ambient conditions are suitable, not only reduces emissions but also provides an opportunity for occupants to connect with the external environment.

These spaces tend to be great locations for planting, improving occupants' wellbeing and satisfaction with the buildings they occupy during working hours.

The challenge is current trends in commercial building design are towards larger floorplates meaning there is greater internal areas versus perimeter envelope, and hence less opportunity for mixed mode air conditioning. In addition, leases between landlords and tenants have a fixation for temperature control bands generally in the region of 21.5 °C ± 1.5 °C. Relaxing this one lease clause creates a great opportunity for the commercial building space across Australia to reduce carbon emissions.

Existing Small and Medium Commercial Office Building Stock

Retrofitting existing commercial buildings represents very different challenges to the design of new buildings. A report by City of Melbourne in 2013 titled *The Next Wave* and an update in 2018 titled *The Next Wave Refresh* highlights the opportunity that upgrading small- and medium-sized commercial building stock has in reducing carbon emissions. Acknowledging that the large listed property trusts generally have achieved higher levels of energy performance across Premium and A-Grade PCA rated commercial office space, the B, C and D Grade stock has not achieved the same outcomes (Sustainability Victoria 2018).

Embodied Carbon Emissions in Commercial Buildings

The carbon impact of buildings is not only due to their operation—their heating, lighting, ventilation and appliances. Buildings also contribute towards significant GHG emissions through their materials, construction and eventual demolition. This is known as embodied carbon. A building's *initial embodied carbon* refers to the carbon emissions caused by the extraction of the raw materials, their fabrication, transportation and installation in the initial creation of the building. *Recurring embodied carbon* refers to the emissions from maintaining, replacing and retrofitting the building over its effective lifecycle (for more on this, see Chapter 7).

The materials we use in commercial buildings have a significant impact on the environment. Cement, for example, is responsible for 8% of all global carbon emissions—a figure which is higher than total emissions from every country, bar the USA and China (Andrew 2018; Rodgers 2018). Historically, most environmental design thinking has considered embodied carbon to contribute around 20% of a building's total carbon footprint, with 80% from operations (Kestner 2009). However, in more recent years research has suggested this can be much higher—closer to 45% embodied and 55% operational for a high-performance office building (Sturgis and Roberts 2010). The problem is reducing a building's operational carbon emissions almost always requires additional embodied carbon. This can be in the form of extra insulation, aluminium to create solar shading, additional layers of glazing, etc.

One of the challenges with our current thinking in terms of getting 'down to zero', is that most definitions of 'net zero energy', or 'carbon neutral' exclude embodied emissions. For example, the *Australian National Carbon Offset Standard for Buildings* only considers operational carbon emissions, and not embodied carbon—although this may be considered in future versions (Commonwealth of Australia 2017). A building that achieves carbon neutrality in operations will still have a significant carbon impact due to its embodied emissions; in fact, its embodied carbon will likely be much higher than a typical building due to the additional materials and systems needed to achieve such a high performance. It is therefore vital for the design team to holistically consider carbon emissions across the full *lifecycle* of a commercial building. For example, changing a building's structure from a concrete frame to mass timber at the design stage would likely significantly reduce its carbon footprint—but this would not contribute towards its ability to meet carbon neutrality under current definitions. On the other hand, installing building integrated wind turbines would contribute towards achieving carbon neutral status, even if only a little. Yet wind turbines would likely save far less carbon than the use of structural timber if considered holistically over a building's life (Oldfield 2019).

While there are very few building regulations that govern the reduction of embodied carbon emissions, standards and definitions are changing. In Norway proposals have emerged to consider embodied carbon emissions as part of a new framework for defining zero energy performance in buildings (Fufa et al. 2016). In Australia, *The Carbon Positive Roadmap* proposes that all new 6 Star Greenstar rated buildings will need to demonstrate a reduction of embodied carbon of 10% against a reference building by 2020, and 20% by 2023. The aim is for this to be expanded to all new buildings by 2030 and 2035 respectively (GBCA 2018b).

While figures of embodied carbon can vary significantly based on geography, building type, materials and calculation methodology, a new office building in Australia will likely have an initial embodied carbon in the order of 400–1200 $KgCO_2$-e/m^2GFA. One benefit of reducing this is that carbon savings would be instant, made prior to the building being built—as opposed to operational savings which can take years to accumulate. Some key strategies to reduce embodied carbon in commercial buildings include:

Structural Optimisation

Structural materials are the greatest contributor to embodied carbon in most commercial buildings. As such, strategies to optimise a building structure and dematerialise its concrete and steel can contribute to significant savings. A growing trend is the use of timber as a structural material in Australian commercial buildings, with examples including International House in Sydney and 25 King in Brisbane (see Fig. 9.5). This trend will likely accelerate with a 2016 change to the National Construction Code (NCC) allowing timber buildings up to eight storeys without the need for costly additional approvals. Timber has a benefit over steel and concrete given that wood sequests carbon during its lifecycle; a cubic metre of wood will absorb on average 787 kg of CO_2-e

Fig. 9.5 International House, Barangaroo. Timber as a low carbon structural material in multistorey commercial buildings (*Source* Tzannes Associates, with permission)

during its life. If sustainably sourced, timber can therefore significantly reduce building emissions. Research by Teh et al. (2016), found that if all new commercial buildings built in Australia used timber, by 2050 carbon savings would be in the order of 13 $MtCO_2$-e without sequestration, or 28 $MtCO_2$-e including sequestration.

Passive Design

Mechanical systems and services are often the second greatest contributor to embodied carbon in commercial buildings (Oldfield 2012). While embracing passive design can have an embodied carbon cost—i.e. through additional insulation, shading, layers of façade, etc.—passive design can reduce air conditioning and other servicing requirements, along with plant machinery and ducting. This can therefore reduce carbon intensive materials such as steel, copper and aluminium.

Cement Replacement

Given the large carbon impact of cement, strategies to replace this in commercial buildings are beneficial. Replacement products including the use of Fly Ash or Ground Granulated Blast Furnace Slag (GGBFS) are commonplace.

Adaptive Reuse

While 51% of the building stock standing in Australia in 2050 will be completed after 2019 (ASBEC 2018), existing buildings still need to be retrofitted and upcycled rather than demolished. A radical reimagining of the commercial building stock is possible, not only to improve operational carbon performance and thermal comfort, but to save embodied carbon too. The Quay Quarter Tower in Sydney, for example, will retain two-thirds of the existing AMP Tower, originally built in 1976. Floorplates will be extended to the north to create additional lettable area, but thousands of tonnes of concrete will also be saved by reusing the existing concrete core, columns and slabs over 50 storeys.

Low Carbon Finishes and Fittings

Finishes and fittings also contribute significantly to embodied carbon in commercial buildings, due to their high replacement rate (i.e. recurring embodied carbon). The use of low carbon finishes (i.e. timber, recycled material products, etc.) and durable materials with a longer lifespan can reduce carbon impacts in this category.

Low Carbon Retrofitting of CBD Precincts

Precincts are typified by physical proximity, diverse uses, similar key stakeholders, regulatory context, governance frameworks and service infrastructure. However, they are inherently complex and characterised by multilayered interactions between institutions, people, regulatory, financial and policy frameworks, and technological systems like water and energy. Precincts provide a unique opportunity for flexible, dynamic and local responses and value creation. Stakeholders can benefit from economies of scale to access technological innovations if they can enable collective action and recognise collective value. How we harness this opportunity is unlocked through an effective understanding of stakeholders' needs, existing assets and social and economic drivers as well as technical and physical drivers.

For this reason, to enable an existing precinct to consider collective action towards carbon reduction there is a need to understand the economic, stakeholder, governance, economic and financial barriers and drivers as well as the technical barriers and drivers. Due to the complexity of decision-making and value differentials at a precinct scale it is not a matter of identifying a single technology or project, but instead critical to think in terms of a program of collective actions that need to be taken. The challenge is how to break this down into manageable scales without losing sight of the need for the integrated system outcomes we desire.

Sydney's Broadway Precinct

The Empowering Broadway research (Swinbourne, Hilson & Yeomans 2016), developed with the CRC for Low Carbon Living, focused on an existing precinct to explore how a low carbon transition could be enabled at a precinct scale. The research focussed on the existing and emerging technical, governance, financial and policy frameworks both reviewing international best practice as well as setting up a Living Laboratory through stakeholder engagement, research and analysis of the Broadway study area.

The Broadway Study area is within Sydney's CBD and includes the Central Park development (a new mixed-use precinct), The University of Technology Sydney (university campus) and NSW TAFE (tertiary training campus)—see Fig. 9.6. The public domain is managed by City of Sydney (Local Government) and the energy distributor is Ausgrid (distribution network). The precinct was identified as each of

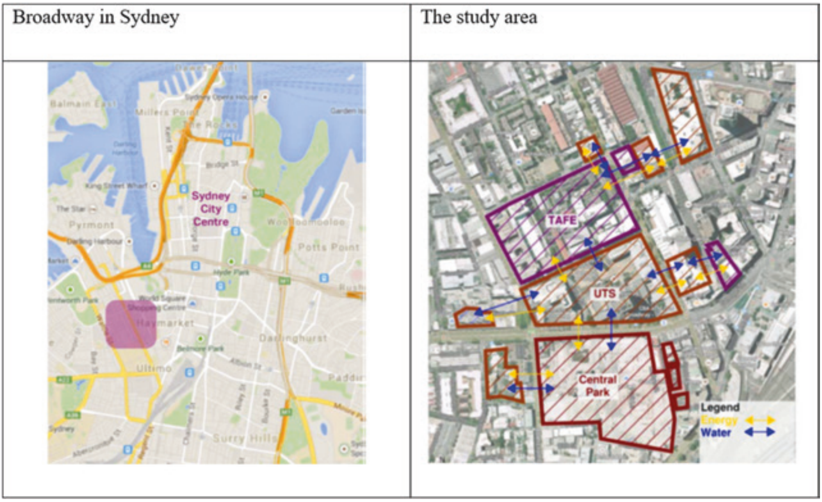

Fig. 9.6 Sydney Broadway precinct (*Source* Swinbourne, Hilson and Yeomans 2016; CRC for low carbon living, with permission)

the stakeholders were already operating precinct systems and all were motivated to become more sustainable and reduce carbon emissions. Between them, these stakeholders hold a range of assets of different ages and uses including retail, educational, residential, commercial and public domain.

Key Learning

The following points outline some of the key findings from the Empowering Broadway research that are important considerations when looking at transitioning precincts to a low carbon future.

Stakeholders

At a precinct level, a multitude of stakeholders control the short-, medium- and long-term decisions being made within the precinct which will collectively over the long-term impact its ability to transition towards a low carbon future. Therefore, at the outset, there needs to be an understanding and engagement with the key stakeholders, to understand their motivations and drivers as well as their level of control, influence or interest in energy and carbon outcomes. It was found that there are significant challenges in engaging with a diverse stakeholder group with wide-ranging levels of knowledge, values, engagement and perceptions on energy and carbon within a precinct. However, this phase of the process is important to realise a collective vision and effective governance to progress a precinct's transition. In a nutshell, the value of effective stakeholder engagement at a precinct level improves legitimacy, transparency, relevance and credibility, to support implementation.

Governance

Precincts have fragmented governance through a range of ownership, management, financial, policy and regulatory considerations. This creates the need for a shared vision and understanding of the governance mechanisms required to enable this vision to be realised. The study found that for precinct scale projects, business and governance models are innovating very quickly, often faster than the technologies. Put simply, a level of collective governance is required and emerging technologies are enabling this both at a social, financial, asset and utility level.

Existing Assets

Existing precincts have a varied asset mix with different maintenance and renewal strategies. These assets include the building envelopes, energy infrastructure, water infrastructure and fixtures and fittings. This creates challenges with timing and coordination as existing infrastructure and assets are at multiple stages of replacement and renewal. For example, for an air conditioner unit with a design life of 20 years on an asset register indicating 10 years since installation, the cost of replacing it 10 years early from an accounting perspective is effectively a loss of

10 years off the asset value and embodied carbon. The sunk cost of early replacement is an important consideration and therefore an understanding of the ownership, lifecycle and influence of these assets is important in enabling a precinct transition. For this reason, it is valuable to understand the relative and collective opportunities within the asset cycles as well as the current decision-making processes in asset replacement.

Risk/Resilience

Risk is a significant driver for decision-makers both in behavioural and economic decision-making. The perceived and actual risk of engaging with your neighbours at a precinct scale can be a significant barrier to enabling precinct level transition. In addition to this, there is risk in relation to the uncertainty of regulatory, political, economic, growth and technology change that needs to be considered and addressed if precinct scale initiatives are applied. However, collaborating at a precinct scale can break down those risk perceptions and can also create a sense of shared value and trust. Rapidly developing technologies and practices such as peer-to-peer energy trading, blockchain and offsite renewable energy are quickly changing the dynamics and investment risks for precinct action, collective action, collective risk and collective benefit.

Financing

In order to transition a precinct, investment or investment coordination is often needed. There is significant innovation occurring in financing models that can enable precinct energy and carbon transitions. There are several factors driving this innovation. One of these is the increasing ability to use technology and data to manage assets as well as to trade utilities, efficiencies, renewable energy, peak consumption or trade reduction in consumption. The emergence of blockchain and other crypto platforms also facilitate greater transparency and trade of services and risk. Another factor driving change in financial markets is identifying investments that have a positive environmental or social benefit as well as a positive financial return. This has been found to decrease risk and increase investment value. This is being realised in the emerging green bonds and ESG investment markets. Other financial opportunities exist where there are tax benefits, grants, low interest loans (green loans or environmental upgrade agreements) which can unlock capital or operational finance for precincts.

Data/Information

To manage a precinct scale carbon transition, it is critical to understand the nature of consumption, supply and distribution within the precinct as well as an appreciation of who or what can impact or influence carbon emissions. It is also important to understand what the decision-making processes are and what assets and building occupants are responsible for in terms of consumption. This can enable more effective decision-making to have the greatest impact and prioritise programs and projects to realise positive outcomes. One of the challenges of data gathering was found to be the diverse range of quality, quantity and data collection standards that exists across different assets. There were also significant challenges in the willingness to share this data due to privacy and commercial concerns. This requires effective understanding of what data is needed to enable precinct level decisions, data recording and sharing protocols as well as governance and privacy standards. In summary, precinct level data is critical to prioritise precinct level action and business cases; however, this needs to be carefully managed to ensure quality, quantity and privacy standards can be realised.

Change and Uncertainty

The declining cost of renewable technologies and energy storage in the face of rising network costs are creating significant opportunities for precincts to consider energy system supply optimisation. The current utility systems are also exposed to significant national and state regulatory controls, incentives and disincentives which creates a difficult investment environment.

Potential Model Typologies to Enable Transition

The following provides some examples of models that can help enable precinct transition:

Precinct Microgrid/Precinct Utility

This is where the precinct energy or utility infrastructure is owned by a third party who operates the distribution, and potentially some of the generation or storage within the precinct. This model will seek to drive system efficiencies and allow for renewable energy integration and bulk purchasing discount benefits to the community of building owners. One of the challenges with this model is to recognise the low carbon incentive in transition as the model can rely on selling utilities to achieve its financial commitments.

Energy Services Companies (ESCO)

This is a model where energy is provided as a service, selling the service benefit rather than the kWh. This can be commercial, not for profit or consumer owned. It comes with a level of service guarantee and lower cost profiles. Unlike a commercial microgrid it is also incentivised to drive efficiencies to reduce costs.

Bulk Precinct Retrofit Model

This may be through environmental upgrade agreements where the funding for the upgrades are borrowed off future rates/utilities. It could also include agreements to bulk purchase or upgrade physical infrastructure to reduce the cost and enable precinct initiatives to be optimised.

Centralised and Outsourcing Facilities Management

This provides for focussed precinct level asset coordination and management, allowing greater economies of scale and increasing the depth in experience across the facilities teams to drive efficiencies.

Membership Model

Building owners and managers receive assistance with energy efficiency retrofits in return for providing service providers with access to data or meeting council sustainability objectives. Friendly competition leads to greater uptake of energy savings projects. For example, the Better Buildings Partnership is a membership model where the building owners and managers receive assistance with energy efficiency retrofits in return for fees and shared experience. This can be realised within a precinct but in the case of the NSW Better Buildings Partnership, has been achieved across an asset class.

Conclusions

There are very few examples of carbon neutral office buildings in Australia of significant scale. The first was Pixel, in Melbourne, completed in 2010 with a floor area of 1136 m^2 (Fig. 9.7). The building is designed to dramatically reduce its energy demand through a shaded façade, water cooled exposed slabs facilitating radiant cooling, night purge ventilation, heat exchange and high levels of insulation. Onsite energy generation includes wind turbines, fixed and trackable PVs and an anerobic digester. The building's carbon impact is not only reduced at an operations level though; reusable façade panels provide future adaptability, while a specialised concrete mix called pixelcrete was used with almost half the embodied carbon of traditional concrete.

Since then other buildings and precincts have sought carbon neutrality through a mixture of efficient performance and carbon offsets or power purchase agreements that utilise offsite renewable generation

Fig. 9.7 Pixel building, Melbourne

such as large-scale wind or solar farms. Examples include Barangaroo by Lendlease at a precinct scale in Sydney (Barangaroo 2018) and the Australian Institute of Architects Headquarters (41 Exhibition Street) in Melbourne (Architecture 2018).

Recently Frasers Property obtained the first Certified Carbon Neutral Commercial Office building called Building F in Rhodes, Sydney. Building F achieved a NABERS Energy rating of 5.5 stars using a combination of energy efficiency measures, including building monitoring and tuning, along with a 100 kW solar system to minimise energy use onsite. The building also uses 20% GreenPower on its remaining energy demand (NABERS 2018b).

Building scale is important to consider when targeting carbon neutrality, and here commercial office buildings can be at a disadvantage. Some commercial buildings such as libraries and civic centres have large roof spaces relative to their total floor areas, thus ample space for integrated PV systems to offset energy demand. Larger scale offices though tend to have multiple storeys on tight urban sites, limiting the area available for integrated photovoltaic panels, or other onsite energy systems—which are more effective on the roof than vertically aligned on facades. At present, this means most office buildings aiming for carbon neutrality in Australia do so through a mix of energy efficiency and carbon offsetting. However, given developments in onsite energy generation technologies, and reducing costs, this could change in the future. As we move towards a greater decarbonisation of the commercial building sector, there are a number of areas where increased focus will accelerate this change. These include:

- Given the large commercial building footprint occupied by government at all levels, an increase in Government Office Accommodation Standards, particularly around existing buildings is important. This applies both to the tenancy space and how it is operated, but also the base buildings that government tenancies occupy.
- Increased awareness, information sharing and training of commercial tenants of various sizes to make more informed decisions when selecting tenancy space. But, also to inform tenants as to how they can continue to optimise and improve the energy efficiency of their space and improve awareness and behaviours on how they use the space.
- Dramatically enhancing the National Construction Code through lifting minimum standards and providing a clear trajectory of future three-yearly amendments towards carbon neutral performance, so that industry can respond and plan accordingly.
- With a decarbonised electricity grid alongside improved passive design and construction features of commercial buildings, large scale buildings will still need to rely on technological advances in buildings integrated photovoltaic (BIPV) renewables to achieve carbon neutrality along with precinct solutions, demand management and carbon offsetting.
- An evolution of the scope of 'carbon neutral' to not only include carbon emissions associated with building operations, but also to consider embodied carbon. This will allow for a holistic carbon performance of commercial buildings to be realised. It will also allow for greater consideration of the carbon impact of technologies and

strategies designed to reduce operational emissions, on building's embodied carbon performance, providing an understanding of trade-offs over time.

References

Andrew, RM 2018, 'Global CO_2 emissions from cement production', *Earth System Science Data*, vol. 10, pp. 195–217.

ASBEC 2016, *Low carbon, high performance. How buildings can make a major contribution to Australia's emissions and productivity goals*, Melbourne, Australia.

ASBEC 2018, *Built to perform: an industry led pathway to a zero carbon ready building code*, Melbourne, Australia.

Architecture 2018, *Sustainability*, Australian Institute of Architects, viewed 27 January 2019, <http://www.architecture.com.au/architecture/national/sustainability#41x>.

Barangaroo 2018, *Sustainability*, Barangaroo Delivery Authority, viewed 27 January 2019, <https://www.barangaroo.com/the-project/progress/sustainability/>.

Bleby, M 2018, 'Lendlease, Frasers, Stockland top GRESB sustainable property ranking', *Australian Financial Review*, 12 September, <https://www.afr.com/real-estate/lendlease-frasers-stockland-top-gresb-sustainable-property-ranking-20180912-h1599q>.

Climateworks 2013, *Tracking progress towards a low carbon economy. Part 4, buildings*, Melbourne, Australia.

Commonwealth of Australia 2012, *Baseline energy consumption and greenhouse gas emissions in commercial buildings in Australia, part 1—report*, November, <https://www.energy.gov.au/sites/default/files/baseline-energy-consumption-part_1-report-2012.pdf>.

Commonwealth of Australia 2017, *National carbon offset standard for buildings*, Canberra, Australia, <http://www.environment.gov.au/system/files/resources/88f3280a-ebc9-47f3-8f28-7537dafd7056/files/ncos-buildings.pdf>.

Commonwealth of Australia 2018, *National greenhouse gas account factors*, July 2018, Canberra, Australia, <http://www.environment.gov.au/system/files/

resources/80f603e7-175b-4f97-8a9b-2d207f46594a/files/national-greenhouse-accounts-factors-july-2018.pdf>.

Fufa, SM, Schlanbusch, RD, Sørnes, K, Inman, M & Andresen, I 2016, *A Norwegian ZEB definition guideline, ZEB project report 29-2016*, SINTEF Academic Press, Oslo.

GBCA 2015, *Greenstar: design as built v1.1. Submission guidelines*, Green Building Council of Australia, Sydney.

GBCA 2018a, *Global commitment for net zero carbon buildings*, Green Building Council of Australia, viewed 27 January 2019, <https://new.gbca.org.au/news/industry-news/global-commitment-net-zero-carbon-buildings/>.

GBCA 2018b, *A carbon positive roadmap for the built environment—stage 1: commercial, institutional, and government buildings and fitout*, <https://gbca-web.s3.amazonaws.com/media/documents/carbon-positive-roadmap-discussion-paper-fa.pdf>.

Harrington, P 2016, *Accelerating net-zero high-rise residential buildings in Australia. Final report*, Pitt & Sherry, Melbourne.

Kestner, D 2009, 'Sustainability: thinking beyond the checklist', *Structure Magazine*, June, p. 5.

McLauchlan, C, Ledo, L, Kokogiannakis, G & Cooper, P 2016, *Feasibility study on Australian commercial buildings airtightness*, Sustainable Buildings Research Centre, Wollongong, NSW, Australia.

NABERS 2018a, *Our story*, Office of Environment and Heritage, <https://www.nabers.gov.au/about/our-story>.

NABERS 2018b, *Frasers Building F, Rhodes, Sydney*, Office of Environment and Heritage, <https://www.nabers.gov.au/about/news/australias-first-carbon-neutral-building>.

Oldfield, P 2012, 'Embodied carbon and high-rise', *Proceedings of the CTBUH 2012 Conference,* Shanghai, pp. 614–622.

Oldfield, P 2019, *The sustainable tall building: a design primer*, Routledge, New York and London.

Rodgers, L 2018, 'Climate change: the massive CO_2 emitter you did not know about', *BBC Science and Environment*, 17 December 2018, <https://www.bbc.com/news/science-environment-46455844>.

Sturgis, S & Roberts, G 2010, *RICS research—Redefining zero: carbon profiling as a solution to whole life carbon emission measurement in buildings*, RICS, London.

Sustainability Victoria 2018, *The next wave: refresh*, prepared by Aecom, Melbourne, <https://www.sustainability.vic.gov.au/About-Us/Publications/Commercial-Buildings-The-Next-Wave-Refresh-2018>.

Swinbourne, R, Hilson, D & Yeomans, W 2016, *Empowering Broadway Phase 1 report*, prepared for the Cooperative Research Centre for Low Carbon Living, Sydney, Australia, <http://www.lowcarbonlivingcrc.com.au/resources/crc-publications/crclcl-project-reports/rp2018-empowering-broadway-phase-1-report>.

Teh, SH, Wiedmann, T, Schinabeck, J & Moore, S 2016, 'Replacement scenario for construction materials based on economy-wide hybrid LCA', in proceedings of *International High-Performance Built Environment Conference: A Sustainable Built Environment Conference*, Series iHBE 2016, Sydney, Australia.