CARBON TRADING AND STATE HERITAGE PLACES

Report for the South Australian Heritage Council and Heritage South Australia, Department for Environment and Water and the Architecture Museum, School of Art, Architecture and Design, University of South Australia

Sustainability and Adaptive Reuse Fellowship 2017/18

Carbon Credit Schemes and State Heritage Places

JENNIFER FADDY

2018

Government of South Australia
Department for Environment and Water
University of South Australia
ARCHITECTURE MUSEUM

Carbon Trading and State Heritage Places 2017/18 DEWNR(now DEW) Sustainability and Adaptive Re-use Fellowship

Table of Contents

Introduction

Since mid-2005, the South Australian Department of Environment, Water and Natural Resources (DEWNR) – now Department for Environment and Water SA (DEW) - and the South Australian Heritage Council (SAHC) have funded a South Australian Built Heritage Research Fellowship at the Architecture Museum, School of Art, Architecture and Design, University of South Australia.

The purpose of this report

The brief for the fellowship report proposed a scoping study intended to summarise relevant Australian and international literature and to identify topics/directions for future research, focussing in particular on:

- the current carbon credit environment in Australia and overseas including relevant definitions, and a summary of the current carbon credit climate in Australia;
- voluntary schemes or programs; National Carbon Offset Scheme, Adelaide City Council/SA Government initiative, Green Star, the future of carbon credit trading;
- the potential to recognise carbon credit values inherent in heritage buildings;
- the potential for a Carbon Credit/Offset trading scheme to recognise and trade upon the embodied energy inherent in heritage listed places;
- frameworks and models for setting the value of offset credits associated with heritage buildings; and
- identifying relevant Australian and international case studies.

The focus of the report

With both climate change impacts and the implications of the Paris Agreement requiring a radical change in the rate of renewal and upgrade of existing building stock world-wide, this paper reviews Australia's response and proposed actions, including the role of Carbon Trading as a mechanism to offset carbon produced with carbon sequestered.

In addition, Australia's actions towards heritage conservation as part of this international effort to avoid global warming by reducing carbon are reviewed.

The key concepts of recognising embodied energy in existing buildings, the role of Life Cycle Assessment, and the challenges of minimising waste and achieving net zero are discussed. Current research including comparative studies of embodied energy calculations for historic building types and studies based on assessing the suitability of various building typologies for retrofitting. Recent projects are analysed for their potential to demonstrate the quantum of avoided carbon emissions by retention of existing fabric. Finally, the potential for heritage conservation to be recognised in the new carbon economy, and specifically in Carbon Trading, are analysed, with future actions recommended.

Acknowledgements

I would like to acknowledge and thank

Dr Christine Garnaut, Associate Research Professor in Planning and Architectural History, Director, Architecture Museum, Director, AHURI Research Centre UniSA, President, International Planning History Society - School of Art, Architecture and Design, University of South Australia

Hamish Angus, Senior Heritage Officer, Heritage South Australia, Economic and Sustainable Development, Department for Environment and Water

Michael Queale, Senior Heritage Conservation Architect, Heritage South Australia, Economic and Sustainable Development, Department for Environment and Water

Dr Alpana Sivam, School of Art, Architecture and Design, University of South Australia

I would also like to thank the many professionals who gave up time to give me the benefit of their expertise during preparation of this report.

01 Introduction to Carbon Trading

Climate Change Science

Eminent scientists assert that the earth, with a 2 degree Celsius warming, is not tenable for many flora and fauna species and will change weather patterns (Cleugh, 2018). Many scientists also assert that even at a 1 degree rise (as has occurred since the start of the 20th century) the earth is experiencing erratic weather behaviour requiring species to adapt. At current emissions levels we are on a trajectory for more than a 3 degree global temperature rise by 2050, with 12 years to go before a 2 degree temperature rise (UNEP 2016).

The greatest cause of global warming is the particulate matter associated with greenhouse gas (GHG) emissions, the most problematic greenhouse gas being Carbon Dioxide (CO_2) because of the volumes released by human activity. The high concentrations of particulate matter comes primarily from burning fossil fuel, and causes global warming by trapping and reradiating the heat from the earth that would otherwise be lost to space (NASA 2018).

$C0_2$ is primarily released by coal, oil and gas extraction and production, with cement production being the fourth largest emitter of CO_2 worldwide (Palutikof, 2018). The production of concrete is estimated to be responsible for around 5% of global greenhouse gas emissions (Susskind, 2018).

There are varying figures estimating the amount of CO_2 emissions relating more broadly to construction, however the Fifth Estate e-publication places the construction industry as contributing 25-40% of the world's carbon emissions (Susskind 2018). Not only is the volume of CO_2 the highest of the five greenhouse gases, the rate of CO_2 emissions is also rising at an accelerated rate (Chiodo, 2012).

The recent global effort to reduce carbon emissions is said (at March 2018) to have taken 10 million tonnes of CO_2 out of the environment which is the equivalent to 3 million cars per year off the road (Kaebernich, 2018). However, there is a lag between the reduction of GHG emissions and the corresponding diminution of particulate matter; therefore it is critical to understand that lower emissions are not yet equating to lower $C0_2$ concentrations (UNEP, 2018). The reduction of carbon emissions seen to date has not yet equated to a lowering of the rate of global warming.

Evidence shows that water more readily stores heat than the land, and that the earth's seas are warming faster than the earth's land masses. As an island, this places Australia in a high risk position in regard to global warming.

International Climate Change Policy

Under the Paris Agreement of December 2015, which was the outcome of the United Nations Council of Parties (COP) 21, 195 countries including Australia have committed to reducing GHG emissions to a level that will see a less than 2 degree temperature rise (compared to pre-industrial levels) by 2050. The Paris Agreement also set an aspirational goal of no more than a 1.5 degree temperature rise by 2050.

Following COP 21 in Paris, at COP 22 in November 2016 Australia submitted its targets for carbon emission reduction via Nationally Determined Contributions (NDCs) which pledge to:

- Reduce emissions by 5% below 2000 levels by 2020.
- Reduce emissions by 26 to 28% below 2005 levels by 2030.

These targets require Australians to halve their emissions per capita (Suckling, 2018).

The Paris Agreement and the subsequent NDCs are not only important for setting emissions reduction goals but also for determining how these may occur. Article 6 of the Paris Agreement allows for nations to choose their own path in achieving emissions reduction, and supports offsetting mechanisms as a tool to combat climate change. Australia and over 60 other countries have confirmed that their emissions reduction goals are conditional to having access to offsetting mechanisms such as international carbon trading markets (Carbon Market Institute et al, 2016). . The concept of carbon offsetting (or carbon trading) is that carbon credits, ie tonnes of $C0_2$ being stored or avoided, are bought and sold.

The Paris Agreement and the signatory nations' responses have therefore firmly established the carbon trading economy (initiated under the Kyoto Protocol[1] in 2005), and have also devised specific accounting rules for carbon trading. There are many critics of this emphasis on carbon trading, such as Carbon Market Watch, who argue that "pure offsetting does not reduce emissions beyond a cap and therefore contributes to neither an overall mitigation in global emissions, nor an increase in ambition " (Carbon Market Watch, 2016). Carbon trading has also been called a "distraction" (Carbon Trade Watch, 2009).

[1] International Treaty signed in 1997 that entered into force in 2005, committing parties to reduce greenhouse gas emissions (www.wikepedia.org/kyotoprotocol, 2018)

At April 2018, 139 countries have framework legislation[2] to address climate change mitigation and adaptation (Grantham Institute, 2018). In September 2018 Australia again rejected the opportunity to implement national emissions reduction legislation, as part of the energy guarantee debate.

International Heritage Policy relating to Climate Change

The International Council on Monuments and Sites (ICOMOS), as a global, non-government advisor to UNESCO, has adopted the United Nations (UN) Sustainable Development Goals (SDGs) as its call to action in regard to heritage and sustainability, The SDGs were adopted in September 2015 (prior to the Paris Agreement) and) replaced the 8 Millennium Development Goals pursued during 2000-2015 with 17 new Sustainable Development Goals (SDGs) for the period 2015 – 30 (ICOMOS, 2017). The SDGs "provide a set of common standards and achievable targets to reduce carbon emissions, manage the risk of climate change and natural disasters, and build back better after a crisis" (UNDP, 2018).

ICOMOS has subsequently developed the *ICOMOS Action Plan: Cultural Heritage and Localizing the UN Sustainable Development Goals (SDGs), July 2017* which supports advocacy of the SDGs and provides actions to align the SDGs with ICOMOS' work. SDG 11 (the "Urban Goal") has been particularly recognised by ICOMOS as a target area for action. This goal aims to "make cities and human settlements inclusive, safe, resilient and sustainable" (ICOMOS, 2017(b)). ICOMOS will focus on Target 11.4 to "strengthen efforts to protect and safeguard the world's cultural and natural heritage to make our cities inclusive, safe, resilient and sustainable" (Ibid, 2017). ICOMOS is currently liaising with its member states to map paths for action.

The federal government is due to undertake a review of progress towards the SDGs this year. The SDGs are not yet incorporated into any national planning policies or strategies. Recognition of the inherent environmental value of heritage places is not a feature of any of the major sustainability initiatives driven by Australia's federal government, and at present there are as yet no major building upgrade initiatives that would specifically benefit and strengthen the role of heritage conservation in a sustainable future.

[2] Framework legislation is defined as a law or executive act with equivalent status, which serves as a comprehensive, unifying basis for climate change policy, addressing multiple aspects or areas of climate change mitigation or adaptation (or both) (Grantham Institute 2018).

Australia’s Federal Climate Change Policy

Australia will meet its commitments under the Paris Agreement NDCs through a combination of policies aimed primarily at reducing emissions at a low cost for the highest emitters, promoting energy efficiency and renewable energy, and funding innovation and technological initiatives. These combined policies are referred to as Australia’s “Direct Action Plan”. The primary mechanism relating to carbon trading and a pillar of the Direct Action Plan is the Emissions Reduction Fund (ERF), established under the Carbon Credits (Carbon Farming Initiative) Act, 2011.

The Emissions Reduction Fund (ERF)

The ERF is the government’s vehicle for buying and selling and regulating carbon credits via approved projects, for use in carbon offsetting. Carbon offsetting is used as a mechanism for Australian companies who are required, or wish to, keep carbon emissions below a certain level. Under the ERF, activities such as renewable energy projects, energy efficiency, reafforestation, and indigenous land management are able to trade their emissions reduction benefits as carbon credits. There are currently no carbon offset projects related to the built environment.

There is an associated ERF Safeguard Mechanism (set up under the National Greenhouse and Energy Reporting Act 2007), designed to ensure that emissions reductions paid for through carbon trading do not encourage significant increases in emissions elsewhere in the economy. One hundred and forty Australian businesses currently use the mechanism to stay below legislated emissions targets.

In Australia, carbon offsetting/trading is governed by financial services law. The federal Department of the Environment and Energy and the Clean Energy Regulator are the two agencies that manage the ERF. Both the ERF and the Safeguard Mechanism are overseen by the Climate Change Authority, (established under the Climate Change Authority Act 2011) which provides independent expert advice on Australian Government climate change mitigation initiatives.

The Voluntary National Carbon Offset Standard

Along with the EFR, another pillar of the Direct Action Plan is the voluntary National Carbon Offset Standard 2017 (NCOS) which provides benchmarks for organisations seeking to make their operations, products, services, buildings, precincts or events carbon neutral. Carbon neutral, according to the Federal government, “means reducing emissions where possible and compensating for the remainder by investing in carbon reduction projects (via offset units) to achieve net zero carbon emissions*"* (Commonwealth of Australia, 2018(n)).

One of the suite of NCOS documents is the *National Carbon Offset Standard for Buildings* - the framework to enable new and existing buildings and precincts to gain accreditation to declare carbon neutrality (also known as Net Zero) under the NCOS standard. (Commonwealth of Australia, 2018(i)). Carbon neutrality can be achieved through the National Australian Built Environment Rating System (NABERS) or the Green Buildings Council of Australia (GBCA) Green Star rating tool.

However, the NCOS for Buildings states that

> "*emissions from energy (including energy embodied in materials) used to construct, fit out, renovate or upgrade the building, are not considered part of a building's operational carbon account and are not covered by the Building Standard. Embodied energy from construction materials and processes may be considered for future versions of the standard"* (Commonwealth of Australia, 2018(r)).

In developing the Standard the consensus was that the new Standard should not include embodied emissions as a requirement, but should explicitly state that they should be re-considered at a later date. The reason for omitting them was mainly the difficulty in measurement. Embodied emissions were also considered to be less material, over the entire life of a building, than operational emissions (Knaggs, 2018).

Voluntary (Secondary) Carbon Trading Market

Apart from the formal compliance carbon trading via the ERF there is also a slightly less formalised market of voluntary/non-compliant carbon credit schemes (ie not licensed by ASIC) that can be bought by both individuals and businesses who are not required to offset emissions under legislation, and can be used to offset emissions and/or achieve carbon neutrality. This voluntary carbon trading market is run by private retail firms, or through third parties such as airlines. Voluntary carbon trading is governed by various Australian or global standards, and projects are also tracked via the various agencies who administer the standards.

The voluntary trading market offers a more diverse range of offset projects and is usually considered more experimental than those discussed above under the ERF, however the projects advertised are still predominately methane removal, renewable energy, energy efficiency, industrial gas, forestry, with some co-beneficial projects (such as provision of fuel efficient charcoal stoves, distributing water purifiers) (Carbon Neutral Pty Ltd, 2017).

Australia’s sub-national (State and Local) government policy

The Paris Agreement strengthened the role of “sub National” governments (in Australia- state governments and local governments) in the challenge to reduce carbon emissions. This has provided an impetus in Australian state and local planning and infrastructure policy for climate change initiatives to be developed, even in the absence of strong federal policy direction.

It was reported in March 2018 that total emissions from the Northern Territory grew by more than a quarter (28 per cent) between 2005 and 2016, while for the same period there was an 18 per cent decrease in emissions from New South Wales, a drop of 14 per cent in Queensland, and Tasmania slashed emissions by more than 100 per cent to become Australia's first net carbon sink (Breen, 2018). Since 1990 SA’s carbon emissions have reduced by 9 per cent (City of Adelaide, 2018).

State government action

South Australia legislated on Climate Change in 2008, however this legislation requires a review of targets to align with the Paris Agreement (Grant, 2018). More recently, the Victorian Government passed the Climate Change Act 2017 which provides a raft of actions aimed at meeting the emissions reduction goals set in the Paris Agreement. It supports the current federal legislative framework for recognition of forestry, soil carbon and carbon sequestration rights on public and private land (Victorian Government, 2017).

Some Australian state governments are setting higher goals than federal policy in two major arenas – renewable energy and carbon neutral/net zero - albeit in policy rather than legislation (other than South Australia and Victoria).

State emissions reduction goals can be summarised as follows:

State/Territory	Goal
South Australia, Victoria and the ACT	have committed to net zero greenhouse gas emissions by 2050
Queensland	has set a target for net zero by 2030
NSW and Tasmania	have committed to an aspirational objective of achieving net carbon emissions by 2050
Western Australia and the Northern Territory	no targets

Most of the State Heritage Councils provide guidance in publications in regard to sustainable upgrading and adaptive reuse of heritage buildings, and do not preclude energy efficiency upgrades in their grants programs, however there are no specific State Heritage Council programs to promote the concept of minimising emissions reductions by retaining heritage buildings.

Local government action

Australian capital cities have a large array of sustainability strategies, action plans, and targeted programs to reduce emissions in the built environment. The most prominent in regard to existing buildings are

- the 1200 Buildings Program in Melbourne (which funds retrofitting projects)).
- the Environmental Upgrade Agreement (EUF) programs for non-residential buildings in NSW, Victoria and South Australia (also called Building Upgrade Finance (BUF)) - run via some of the major City councils, where the fabric itself can be part of the upgrade works funded by a finance provider and paid back at low interest for longer terms via council rates. The EUF/BUF is designed to unlock retrofitting activity, and in NSW it is specified that works that focus on reducing material use, and/or recovering and recycling are included.
- In Tasmania there is an Energy Efficiency fund administered via local councils that provides interest free loans for energy efficiency upgrades.

There are numerous other environmental programmes, policies, schemes and affiliations being promoted by various local governments; however they are generally aimed at providing energy efficiency (primarily to promote carbon reduction from building operations). They include CitySwitch, The Better Buildings Partnership, Waterwise, Smart Green Apartments, and solar rebate schemes. Programs to recognise the inherent embodied energy in existing buildings do not currently exist in any local government jurisdiction in Australia.

The global C40 initiative and the Capital Cities Climate Change Initiative are influential lobby groups advocating for climate change action in cities and working with various local governments in Australia.

Capital city goals in regard to emissions reductions are:

State	Goals.
Melbourne	to become a carbon neutral municipality by 2020, with the City’s operations currently carbon neutral.
Sydney	City municipality to reduce greenhouse gas emissions by 70% , and the City’s operations are carbon neutral. Sydney also has a goal of

	becoming a “zero waste” city by 2021 ,where 95 per cent of construction waste and organic waste from parks is recovered.
Adelaide	City municipality has a target to be carbon neutral by 2020, and a target of zero net carbon emissions from the City of Adelaide’s operations by 2020.
Perth	Perth municipality and the City of Perth’s own operations aim to achieve a reduction in the emissions by 30% below BAU baseline by 2030.
Brisbane	City has an aspiration to reduce carbon emissions in their municipality to 6 tonnes per household by 2031, and the City’s operations achieved carbon neutral status in 2017.
Darwin	City has set detailed reduction aims for the City’s operations and the municipality but has no firm targets.
Hobart	City has committed to a corporate emission reduction of 35% from 2009 levels by 2020 and working towards zero emissions by 2020. It is currently reviewing its municipal climate change strategy.
Canberra	Has set targets for 40% reduction in greenhouse gas emissions on 1990 levels by 2020, 100% renewable energy by 2020 and substantial job creation, and Canberra will be carbon neutral by 2050.

Carbon offsetting is used as necessary by the capital cities to achieve these local government emissions reduction goals.

Australia’s performance

Australia’s emissions began to rise again in 2014 after at least 4 years of years of decline, and have risen every year since then (Slezak, 2017(a)).

In November 2018 Australia was ranked sixth-last in the world in terms of performance, under the Climate Change Performance Index[3]. The Index uses 4 key categories to rank 56 nations plus the EU - Australia was rated as a “very low” performing countries overall and in three categories - for efforts to reduce GHG emissions, improve energy efficiency and to develop credible climate policy (performance against renewable energy was ranked “low”) (Climate Change Performance Index, 2018).

Overall Australia is tracking for a 6.6 per cent rise in 2018 (Slezak, 2017(a)). Total emissions have risen to 580Mt $C0_2$-e (March 2018). Per capita our emissions had fallen[4] to17.2 tonnes per capita in 2016, with the leading industrialised countries around 9 -11 tonnes per capita (Knoema, 2017). When such calculations include carbon reductions from compulsory or

[3] The Climate Change Performance Index is an instrument designed to enhance transparency in International climate politics.

[4] Per capita figures have not risen because of population growth. (ABC, 2018)

voluntary offsets (as it is assumed that these do), they are not actual emissions reduction, but modelled (predicted) emissions reductions.

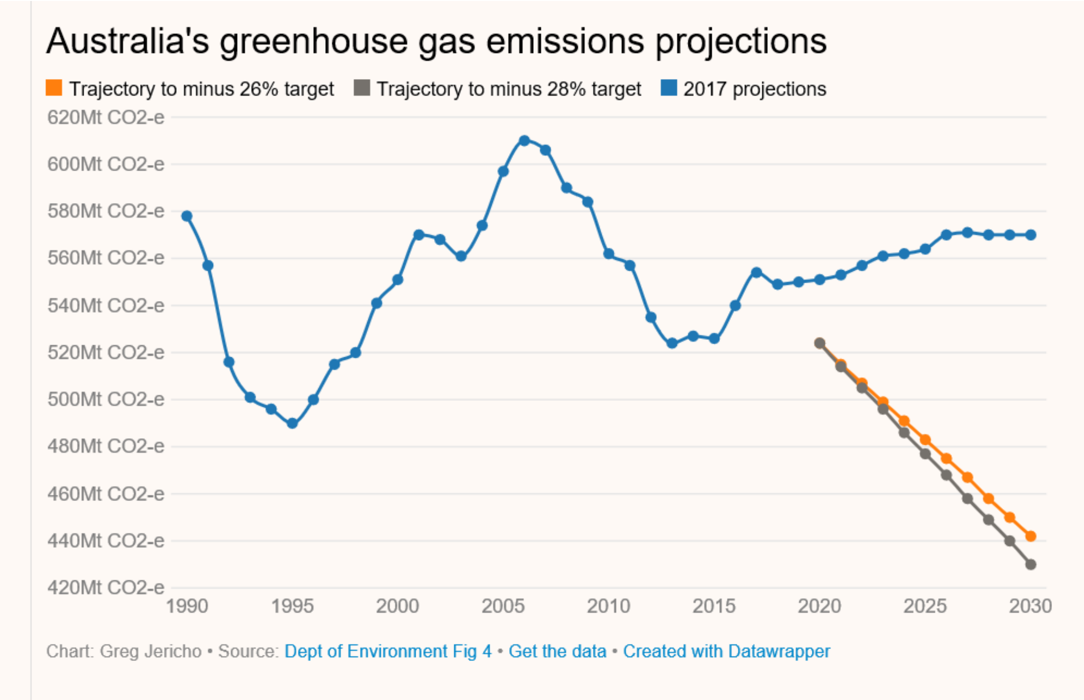

Figure 1 Australia's greenhouse gas emissions projections

Source: Jericho, Greg (2018)

02 The Low Carbon economy

Background

The word carbon is used as an overarching term to encompass carbon (CO_2) emissions, GHG emissions (of the other gases that also cause global warming, often expressed as the "carbon dioxide equivalent"), and embodied carbon. The low carbon economy generally refers to the opportunities and costs associated with decarbonising business by removing fossil fuels from the supply chain). In a low carbon economy the cost of a product with higher embodied carbon is higher, and "goods and services that contain less embodied energy become cheaper, or relatively cheaper as the cost of high carbon products rises" (Blair, no date but pre 2015).

Carbon has become established as a trading commodity due to the Paris Agreement reinforcing the concept of buying carbon offsets as a mechanism to reduce emissions, in order to compensate for carbon emissions that cannot be avoided.

In 2017 the *Australian Prudential Regulation Authority* (APRA), the regulator of the financial services industry, declared that climate change was a foreseeable and actionable risk, establishing mitigation of this risk as a corporate responsibility. There have been warnings that there is currently a systemic risk in financial markets (such as Australia) that are exposed to fossil fuel investment and have not accurately priced the risk of their high carbon assets (Hewson, 2018). At this point in time there are changing investment profiles, and there is high value in low carbon investments (Herd, 2018).

Financial Tools

The low carbon economy has resulted in new financial tools that could, or already do, benefit retrofitting projects.

Green Bonds[5] are used to finance projects undertaken to address climate change. Green bonds were created to fund projects that have positive environmental and/or climate benefits (Climate Bonds Initiative, 2018), and have become a prominent financial tool for investors wishing to invest in sustainable developments.

In 2018 Australia has seven major green bonds, with AUD $360M invested in them (Corke & Moss, 2018). Commentators consider that, "for a country with the world's fourth-largest pool of retirement funds and a high level of awareness of green issues, the [green bond] market is underperforming its potential" due to policy uncertainty (Duran, 2018).

In January 2018 the National Australia Bank launched the country's first ever "green" mortgage bond, designed to finance loans on properties certified as low-carbon buildings. Many of Australia's smaller banks offer green home loans for amounts up to $300k to upgrade homes with energy efficiency features.

[5] a bond is a type of loan which companies, governments, and banks use to finance projects

Ethical investment funds currently invest in companies that create environmentally beneficial projects, for example, wind farms, but it is understood they do not currently invest directly in carbon trading transactions. However, in the future this may be an area of interest, at it aligns with the ethical investment funds' interests in low carbon initiatives. Retaining heritage places could feasibly be an ethical investment opportunity as the activity has an ethical value. However one of the difficulties would be that the success of a project is measured on profitability rather than on added environmental value (Gilbertson & Coelho, 2014).

The Mechanics of Carbon Trading in Australia

Carbon offsets, also called carbon credits (tonnes of $C0_2$-e being stored or avoided, with "e" meaning equivalent), are either purchased to cancel out the carbon emissions that you generate by living or doing business, or sold as carbon credits if your business is to generate carbon abatement. Sellers are typically involved in sequestration activities such as tree planting, indigenous land management, improving energy efficiency, renewable energy and capturing methane from landfill.

The fundamental premise of carbon trading is that it must result in carbon abatement that would not otherwise be achieved. A carbon credit "must deliver abatement that is additional to what would occur in the absence of the project*"* (Clean Energy Regulator, 2018(a)).

In Australia carbon credits are known as Australian Carbon Credit Units (ACCUs). Each ACCU issued represents one tonne of carbon dioxide, or carbon dioxide equivalent stored or avoided by a project. The credits are purchased and issued by the Australian Clean Energy Regulator, and entered into a national registry as part of the emissions reduction activities operating under the ERF. The calculations of ACCUs are highly regulated to measure verifiable carbon abatement. ACCUs are considered a "financial product" under the Corporations Act (2001) and the Australian Securities and Investments Commission Act (2001).

The government purchases emissions reductions at the lowest possible cost by running reverse auctions[6], where a project bids a certain quantity of ACCUs of abatement into the reverse auction. Fixed-price contracts are offered to those who are successful at auction, guaranteeing payment in return for delivery of emissions reductions.

These credits are then able to be purchased to offset emissions against legislated emissions limits or to make voluntary carbon neutral claims and/or become carbon neutral certified (Australian Carbon Marketplace, 2018(a)). The initial value of carbon credits differs, and the entry prices rise and fall. However, carbon credits do not pay ongoing interest or dividends (ASIC, 2017). The trading of carbon credits can occur speculatively meaning that environmental services firms purchase and stockpile ACCUs to sell to their clients. With the NDCs under the Paris Agreement to be reviewed every 5 years, it can be expected that changes could be made to Australia's carbon trading system at these 5-year cycles.

[6] There have been eight reverse auctions since 2014

Purchase of offshore carbon credits by Australian companies has been permitted since December 2017. This is to allow access to cheaper carbon offset options, a move that has been criticised for reducing the impetus to decarbonise our own economy (Koziol, 2017).

Unregulated or voluntary carbon credits, that is, those that are not licensed by ASIC are purchased from suppliers predominately by households and small businesses to voluntarily offset emissions. The providers are specialist consultancy firms. Voluntary carbon credits are regulated under various International Accreditation Standards such as the Verified Carbon Standard (VCS) and the Gold Standard (GS), and can also be ACCUs under Australian Accreditation. Households and businesses chose voluntary emissions schemes largely to match with their own social and environmental goals and values (Carbon Neutral, 2018)

There is speculation that ACCUs are being purchased in the voluntary (secondary) market at a low price to hedge against future carbon offset obligations, for example by state governments (Energetics 2017).

Developing ACCU projects

Carbon abatement projects become "eligible activities" or ACCUs after meeting certain requirements including the criteria in a "methodology determination" (sometimes referred to as the "method" for short). A draft methodology determination is publicly exhibited before being finalised. There is a finalised "Commercial Buildings" method however it relates only to energy efficiency upgrades. There are currently no finalised methodology determinations that relate specifically to conserving heritage buildings (or existing buildings) other than the "Commercial Buildings" method.. Projects are scoped by the Australian Government Department of the Environment and Energy (with scientists, industry, technical experts and potential end users), and must not cause adverse social, environmental or economic impacts.

There is currently a draft "Community Buildings" draft method that was on exhibition in 2016. The draft method

> "*would apply to projects that reduce energy consumption in community buildings, including public buildings, private galleries and museums, schools, hospitals, aged care facilities, common areas of residential apartment complexes and serviced apartment complexes"* (Commonwealth of Australia, 2018(o)).

The draft Community Buildings method emphasises the aim of reduction in the consumption of fossils fuels in energy use, but it does state that "*modifying, installing, removing or replacing .....a building component"* would be considered part of a project. The Commercial Buildings Methodology Determination and the Draft Community Buildings Methodology Determination are attached as Appendix D.

In addition to meeting the method criteria, ACCU projects must meet other eligibility requirements around "newness" and "additionality" and reporting.

The NSW National Parks and Wildlife Service (NPWS) has successfully sought to amend legislation to allow carbon sequestration projects in five reserves under the care of NSW

National Parks, where rehabilitation programs are now being funded by the revenue generated from selling ACCUs (carbon credits). NPWS has successfully argued that this forest restoration would not have occurred in the absence of the project, given funding (rather than technical) constraints, and that it has joint benefits of carbon abatement (80,000 tonnes over 10 years) and improving the environmental values of the land.

Carbon Trading projects are well illustrated in interactive maps on the ERF website (Commonwealth of Australia, 2018(m)). By means of comparison NSW has the highest number of projects at 277, Tasmania the lowest at 14, and SA has 20 projects (one being an energy efficiency project).). In 2016, ASBEC commented on the low rate of development of the energy efficiency (Commercial Buildings) method (ASBEC, 2016).

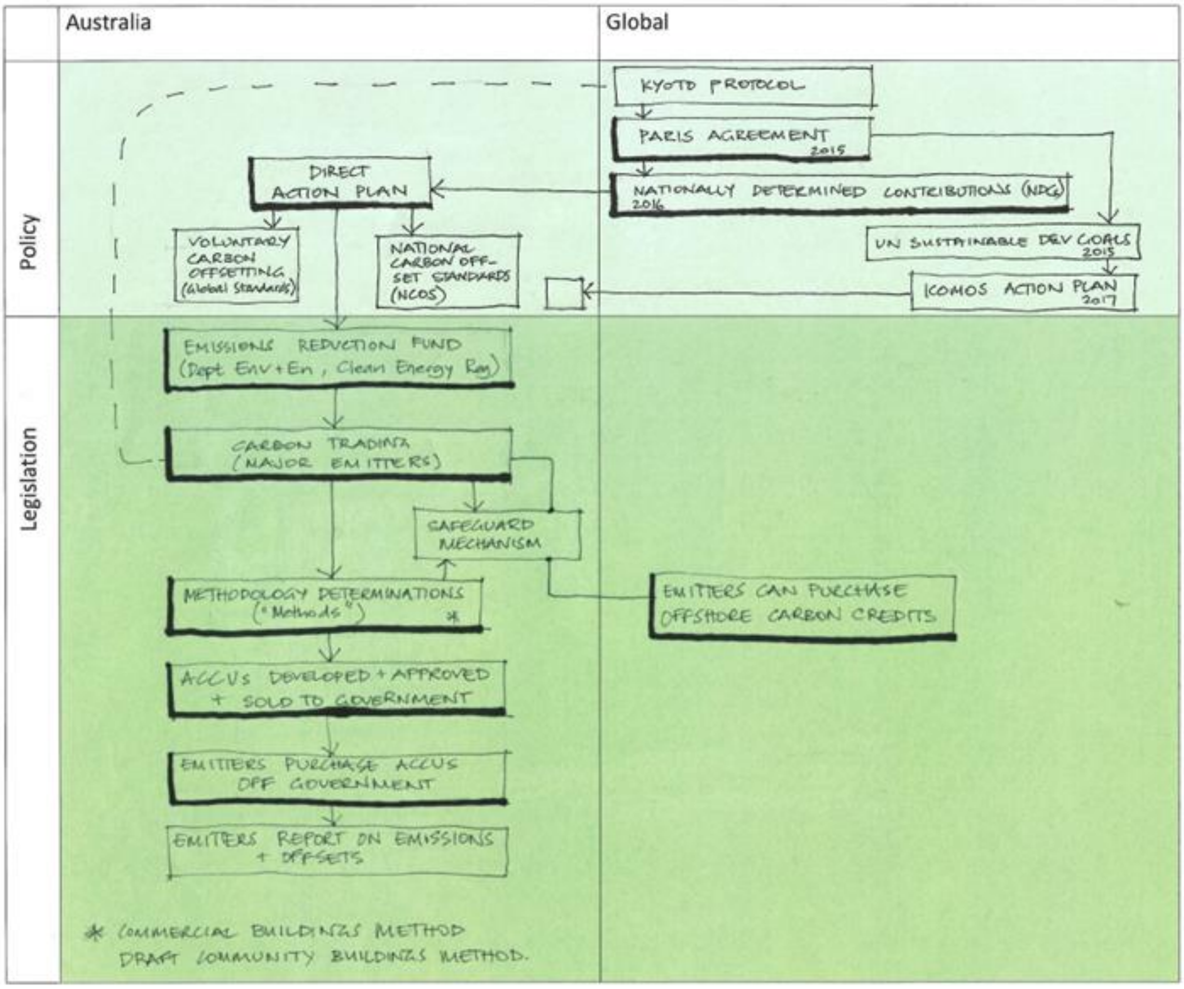

Figure 2 The Mechanics of Carbon Trading

Source: J Faddy

Embodied energy in the low carbon economy

Therefore in the current carbon trading environment in Australia there are no avenues for recognising the embodied energy of existing buildings as a trading commodity.

Embodied energy (also called embodied carbon, inherent embodied energy, sunk embodied energy, embodied global warming potential (GWP), or carbon footprint), includes the direct energy that goes into making a product, and the indirect energy of production, manufacturing, transportation, installation, maintenance and disposal of the product at the end of its life. Embodied energy is the measurement of the carbon and energy emissions associated with making or maintaining building (or product), rather than a measurement of the emissions from the energy used to operate a building or product.

Following popular convention this report uses the term “embodied energy” to include both embodied carbon and embodied energy, except where specified separately, or specified by another source. Strictly speaking the figures for both embodied carbon and embodied energy should be used. Embodied carbon is the carbon density of a product/process (usually measured in tonnes of $C0_2$), and embodied energy is the energy density (usually measures in GJ or MJ). They differ primarily depending on the source of energy during manufacture/construction/transportation.

For buildings in Australia - depending on the size, materials and frequency of refurbishment - the embodied carbon can be equivalent to 10-30 per cent of the operational emissions over the life of the building (Clark, 2017) (whereas in the UK it has been estimated at as much as 50 per cent (WRAP, 2018), and in Sweden 40-45 per cent (Iyer-Raniga & Wong, 2012)). This means that a substantial environmental investment has already been made for each existing building in relation to the ongoing environmental impact of constructing and maintaining the existing building. Yet there are currently no regulations or targets in Australia related to embodied carbon (Clark, 2017) in the built environment, and embodied carbon and embodied energy in the built environment is not a component of the global carbon trading industry.

The embodied energy of materials is one of the values used in undertaking Life Cycle Assessment (LCA), which is used to make decisions about the environmental impact of materials compared to their durability and end-of-life potential. While in some voluntary building rating schemes “such as LEED[7] (US), BREEAM[8] (UK) and Green Star (Australia) the use of low-energy embodied materials, minimisation of waste and reuse of existing components are rewarded” (Chileshe et al, 2014), it is considered that much tougher benchmarks for carbon are required (Clarke, 2017).

Reduction of embodied energy and emissions is one of the nine areas for priority action to achieve the Paris targets as identified in the Global Alliance for Buildings and Construction’s[9] Global Status Report of 2017 (Thorpe, 2017). The 2016 Australian State of the Environment Report made many references to the need to acknowledge the embodied energy (and cultural values) of historic places under the banner of sustainability and suggests that wasted embodied energy is an emerging issue (Commonwealth of Australia, 2016(e)).

Net zero, zero carbon and carbon neutral

[7] Leadership in Energy and Environmental Design (LEED)

[8] Building Research Establishment Environmental Assessment Method (BREEAM)

[9] A group set up at COP21 Paris to implement and accelerate NDCs in relation to the building and construction sector.

Concept

Sustainability literature, professional journals and academic papers acknowledge the need to limit raw material and energy consumption. Net zero, zero carbon and carbon neutral are all terms used to describe the concept of growing, producing and operating the economy, including the built environment, with no carbon emissions being produced. Another common term for this process is “decarbonisation”.

Around a quarter of Australia’s emissions come from buildings (GBCA, 2018(a)). By implementing net zero in buildings, by 2050 emissions savings could meet over half of the national energy productivity target, and more than one quarter of the national emissions target (ASBEC, 2016). As renewable energy becomes more common and improvements in operational energy performance of buildings continues, the embodied energy of materials used in the built environment is likely to be a bigger proportion of total carbon in a low carbon building (GBCA, 2018(a)), increasing *“in importance as the implementation of net-zero energy/emissions concepts become more commonplace”* (Seo et al, 2017).

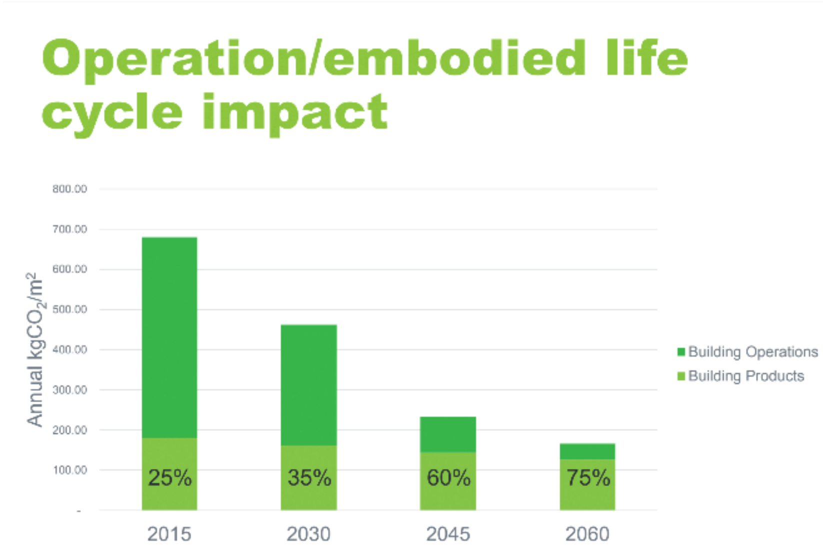

Figure 3 Predicted comparison of operational energy vs embodied life cycle impact

Source: GBCA Nov 2018 – Materials Masterclass presented by J Bengtsson

Buildings use over half of Australia’s electricity (Clark 2017). Australian research has shown that the carbon intensity of the energy supply system is the most important factor in determining the total embodied energy of a structure, meaning that high energy efficiency in material production and transport does not necessarily translate to better environmental performance (Wong et al, 2010) if the energy source is carbon intensive.

The chances of achieving net zero on any scale therefore are low until materials are produced and transported using renewable energy, buildings are powered by renewable energy, and buildings make rather than consume energy.

Policy

In line with most other countries, the federal government’s definition of a carbon neutral building or precinct does not include any calculation of embodied energy, as the National Carbon Offset Standards only measures resource consumption and waste from building operations. The standard states that embodied energy from construction materials and processes may be considered in future versions (Jewell, 2017(b)).

The NSW Government's Net Zero Fact Sheet states that net zero means NSW emissions will be balanced by carbon storage (NSW Government, 2016(a)), effectively acknowledging that in NSW, actual net zero will not be achieved by 2050. In Tasmania, for example, with more than 90 per cent of electricity derived from low emission hydropower, achievement of net zero is more likely.

The GBCA's *Carbon Positive Roadmap* lists a principle to incentivise new buildings to offset their embodied carbon and other emissions, therefore recognising the role of embodied energy in new structures (GBCA (a)2018). The Canada Green Building Council identifies one of the 5 key components of zero carbon buildings as an "Embodied Carbon" metric to recognise the importance of (new) building material life cycle impact, and says that by beginning to track carbon emissions the industry can begin to consistently and accurately measure embodied carbon (CGBC, 2016).

Pathways to Net Zero are still being formulated in rating tools and state and local government planning policy in Australia. Internationally some countries, for example Sweden and the UK, and cities (eg Vancouver, Santa Monica) have Net Zero legislation in their planning regulations, not just in policy. The City of Sydney has issued a "net zero challenge" to developers as an incentive to encourage innovation in the design and construction industry.

03 Quantifying the benefits of existing buildings

Measuring embodied energy

Concept of Measuring Embodied Energy

While there is emerging recognition of the importance of embodied energy in research and policy, there is no established path for acknowledging this as a value attributed to existing buildings. To date, differing terminology, differing methodologies and the challenge of accessing baseline information have been contributing factors to the confusion surrounding the measurement of embodied energy in existing buildings/sites. In Australia the measurement of embodied energy has not previously been standardised and has relied on data from numerous public and private databases, which sometimes make assumptions regarding actual production, transportation and lifespan energy consumption..

Strictly speaking, embodied carbon and embodied energy yield different measurements, although the terms are used as one. Embodied carbon is measured as tonnes of $C0_2$ or $C0_2$ – e (e stands for equivalent), and is the carbon density of a material. Embodied energy is measured as MJ/kg or MJ/m_2, which is the energy density of a material (Designing buildings Wiki, 2018) and is reflective of the energy sources used the various parts of its life.

A tonne of carbon dioxide equivalent greenhouse gas would fill 10 backyard swimming pools or 20,000 party balloons (City of Brisbane, 2018). A large tree takes 4kg carbon dioxide out of the atmosphere per year (Gardening Australia, 27/7/18).

A study by Wong et al in 2010 provides comparative embodied energy calculations for different heritage building types, providing relative measurements of embodied energy and embodied carbon. Note that the star rating (Accurate) indicates the energy efficiency of the home which provides an indicator of whether or not substantial additional embodied energy would have to be added to the structure for it to reach an adequate performance level. A few comparative examples from the study are shown below:

Item	Embodied energy (MJ)	Embodied carbon $C0_2$-e (tonnes)	Source
Single skin timber home on stumps, corrugated iron roof (Qld) 1.9 stars	3520 MJ/m2	19.6 t/m2	Wong et al 2010
Brick rendered house with slate roof (Vic) 2.8 stars	4540 MJ/m2	5.45 t/m2	Wong et al 2010
Sandstone home with corrugated iron roof (Tas) 2.4 stars	10200 MJ/m2	6.58 t/m2	Wong et al 2010
Timber walled house corrugated iron roof (NT) 3.2 stars	4690 MJ/m2	70.7 t/m2	Wong et al 2010

Other studies have provided benchmark calculations by building type:

Item	Embodied energy (MJ)	Embodied carbon $C0_2$-e (tonnes)	Source
Typical Australian project home 2013, 4 bedroom brick veneer	2,600,000 MJ (total) (2,600 GJ total)	199 t (total)	Haynes, 2013 Includes recurrent embodied energy of maintenance for 50 years
Late 19th century stone villa (SA) 3 bedroom	980,000 MJ (total) (980 GJ total)	77 t (total)	Pullen & Bennetts, 2011
Average for a new dwelling in Europe in 2008. Av size dwelling in UK is 85 m2	5.34 GJ/m2 454,000 MJ (total)	403 kg/m2 34.255 t (total)	ICE, 2008 14 case studies, most in the UK

Quantifying embodied energy is difficult, and a range of methodologies exist – it is a complex science and is not used in normal practice by owners of small buildings. There have been significant differences demonstrated in research undertaken, with a tendency that early embodied energy calculations may have underestimated the amount of embodied energy in buildings (Ward 2014), (Lenzen et al, 2002), potentially undervaluing the amount of embodied energy in that place.

As embodied energy calculations do not include the calculation of operational energy, the importance of embodied energy for structures such as bridges or stadia is even greater in assessing the total carbon footprint (ICE ,2015).

Standardisation of Embodied Energy Measurements

An International Standard for the carbon footprint of products, ISO 14067, was finalised in July 2018 and is said to be a “gamechanger” for removing the uncertainty and interpretation in measuring embodied carbon, once implemented. It will allow projects to have defendable embodied energy calculations (Aliento, 2018(a)).

Now that there is a standardised method of measurement for new materials, there are calls for the ISO 14067to be adopted for use in green building rating tools, and in) planning policies that have requirements around “sustainable development”, as the standardised method of measurement now allows for projects to have comparable “carbon quotas” (Aliento, 2018(a)).

Embodied energy savings in heritage places

In 1997, English Heritage proposed that “resource value” should be included in the list of heritage values. Twenty-one years later there has been little progress in this regard, despite research substantiating the environmental benefits of retaining heritage places. Another way of measuring the embodied energy saving is that embodied energy could be considered part of the “environmental debt” of an existing structure (Carroon 2010).

A Historic Scotland Technical Paper from 2011 argued that the embodied energy and carbon in an existing building (place) is “sunk”, and therefore of no relevance for mitigating energy consumption today (Menzies, 2011). However, by not demolishing a structure there are savings from not having to demolish, transport, or recycle materials (all energy-intensive processes), therefore this sunk energy and carbon is of relevance for mitigating energy consumption today. This view is echoed by influential groups such as the New Zealand Green Building Council (NZGBC) which has stated that refurbishing an existing building maximises the whole-of-life embodied energy unless the retrofit requires a particularly high carbon solution (NZGBC, 2018).The Australian Government “Your Home” web –based resource encourages reuse of existing buildings and materials to minimise resource use (Commonwealth, 2018(q)).

The case studies referenced in Appendices B and C show the diverse ways that embodied energy calculations can be used to quantify the amount of energy saved by retaining existing buildings. Work to date to measure the embodied energy of heritage places in Australia is limited to a few studies. These are:

- A 2007 study in Adelaide developed a tool for depicting the embodied energy of the Adelaide urban environment (Appendix B);
- A study by RMIT published in 2010 provided a comparison between life cycle energy, greenhouse gas, water and other such environmental impacts for a range of heritage buildings in Australia (1826 to 2000) compared to retrofitted designs (Appendix B);
- A paper in 2010 provided a summary of studies of the environmental performance of existing buildings constructed between 1997 – 2010 (Judson et al 2010);
- A 2011 study of a 1910 South Australian villa compared the GHG emissions/embodied energy savings of renovate/extend option and a demolish rebuild option (Appendix B);
- A 2017 study using data from 60 existing pre-2005 dwellings in Greater Melbourne provided a comparison of energy and carbon intensities for upgrading buildings (Appendix B)

Quantifying the value of existing buildings to argue for retention is not enabled in Australian policy or planning legislation, nor is it undertaken in calculations for ratings under the current suite of green building rating tools. A method of assessment is required to provide a comparison between retaining and refurbishing existing buildings versus rebuilding. To demonstrate the value of existing buildings the true carbon footprint of a replacement structure needs to include the wasted embodied energy expenditure of any existing building proposed for demolition.

The 2016 Australian State of the Environment Report identified the recognition of the embodied energy of historic buildings as one of the challenges of managing historic places, and suggested this could occur via recognition in rating tools, and by using Life Cycle Assessment (LCA) more widely.

The Role of Life Cycle Assessment (LCA)

A LCA is an accounting methodology and an environmental management tool to quantify energy use and carbon emissions for the whole life cycle of a building. The definition of "life cycle" can vary from Cradle to Gate through to Cradle to Cradle (see List of Definitions). In a full LCA the energy and materials used, and pollutants or waste released into the environment as a consequence of the product or activity, are quantified over the whole life cycle (Hammond & Jones, 2008) The LCA methodology follows International Standards ISO 14040 (Judson et al, 2010). However, the methodological framework for LCA on existing buildings is not as clear as for new buildings (Rasmussen et al 2016).

LCA is undertaken to ascertain and minimise the whole of life impacts by comparing carbon emissions and choosing products for their highest and best use. Buildings with carbon intensive products or construction processes can perform well in a LCA if their life cycle is longer, and/or if maintenance is minimal, and if reuse is possible.

It is not useful to simply compare the embodied energy and carbon emissions in producing building materials. Decisions need to consider the longevity and maintenance requirements over the lifespan of the building. Subtleties in measuring embodied carbon include the need to include sequestration of carbon within some building materials (such as timber) or the impact of chemical reactions during the production and/or lifetime of a material (eg concrete) (ICE, 2015), and likely embodied energy to be used in future refurbishment.

A LCA assessment allows comparison and substantiation of material choices in design, usually carried out as part of an assessment for obtaining points under rating tools such Green Star. LCAs are not required under the National Construction Code (NCC), or under for lodging Development Applications (DAs) with local government authorities..LCA can assist in determining when and how to upgrade buildings to maximise the environmental outcome (Judson 2012).

Building Information Modelling (BIM) can use these LCA values to quantify the environmental impacts of building elements to inform design, using colour coded visualisations of the design to express the carbon intensity of each element of the building being considered for use (Menna et al, 2016), as shown below. This has particular application to the assessment of options for existing buildings, as the elements proposed to be demolished can be assessed against the new elements proposed to be constructed (Raimondi & Santicci, 2016), allowing comparison of different construction types and designs, and demonstrating how to minimise embodied carbon through reuse of existing structure. "Therefore the CO_2 footprint can be used as a determining parameter to compare alternative design options", providing quick clear evaluation of different options and the relationships between elements, rather than absolute values" (Raimondi & Santucci, 2016).

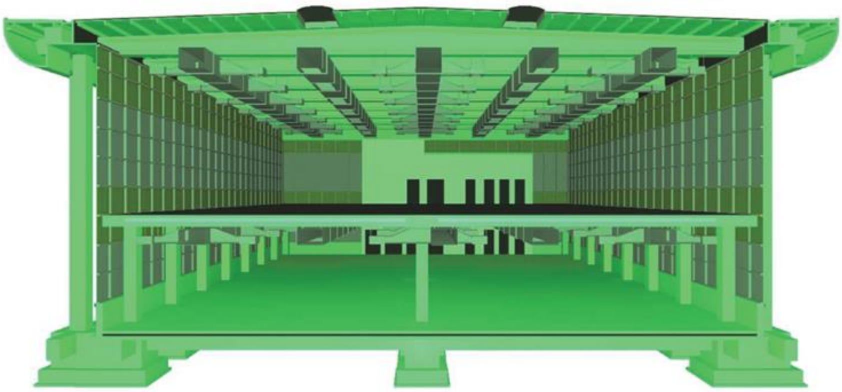

Fig. 5 *BIM model visualization indicating the CO_2 footprint of the different element [8]*

Material	Greenhouse Effect	Rating
1 Kg	(GWP) kg CO 2 eq	da 1 a 5
STEEL	1,24 - 1,70	2
GALVANIZED STEEL	4,8	3
ALUMINIUM	8,0 - 22	5
POLYETHYLENE LAYER	1,82	2
HOLLOWED CLAY BLOCK	0,14 - 0,22	2
CONCRETE SCREED	0,0080	1
LIGHTWEIGHT CONCRETE	0,9900	2
CONCRETE	0,13	1
PRECAST CONCRETE	0,18	1
LAMINATED WOOD BOARD	0	1
BITUMINOUS SEAL	7,4	4
PLASTER	0,25	1
MINERAL WOOL	1,31 - 1,62	2
MORTAR	0,2593	1
PVC BOARDS	2,05	2
CERAMIC TILES	0,00265	1
POLYCARBONATE BOARDS	5,41	3
PAINT	0,13	1
GLASS	0,88 - 0,97	2

Fig. 6 *Extraction from the BIM model of the analytic values for the CO_2 footprint*

Figure 4 BIM model visualisation and data

Source: Raimondi A and Santucci D, CESB 2016

The higher environmental cost of a product with higher embodied carbon may be mitigated by a longer lifespan. Measuring on a 100-year lifespan is common and gives better justification for constructing new buildings, but gives unrealistic results unless the short building cycles we see today, for example as has occurred at Darling Harbour in Sydney, are slowed, and unless we move from a culture of replacement to one of repair.

Appendix B provides recent comparative studies of various embodied energy scenarios, and an introduction to why it is necessary to consider the retention and refurbishment of existing buildings in initial project feasibility considerations.

Appendix C provides a list of recent studies based on understanding building typology and the assumptions that can be drawn from that knowledge.

Minimising Waste and Resource Use

The C40, a global organisation dedicated to tackling climate change in cities, has developed four action areas that have the greatest potential in most global cities to curb emissions, and "improving waste management" is one of these four (C40, 2017).

Construction and demolition waste accounts for 33 per cent of all landfill in Australia. (NSW Government, 2018(b)). Waste reduction policies have been established at all levels of Australian government, and legislative responsibility rests with the states. All states have, at the minimum, waste strategies or strategic waste management plans, with the ACT, NSW, SA and Victoria having more targeted Zero Waste policies in regard to construction and demolition (C & D) waste. South Australia provides a model where landfill disposal of some materials is prohibited unless waste has first been subject to resource recovery efforts (Hyder, 2011), and is the state with the highest recovery and recycling rates (Commonwealth of Australia, 2016(k)).

Australia claims to recycle/recover energy from 2/3 of our waste, however still disposes of an amount only slightly under that of the entire USA (Commonwealth of Australia, 2016(k)). The Australian National Waste Report 2018 states that in 2016-17, out of a total of 67 Mt[10] in total, or 2.7 tonnes of waste per capita in Australia, 20.4 Mt was from the C & D sector (this figure rose over 2 Mt since the 2016 report) (Commonwealth of Australia, 2018(l)).

Significant amounts of new material and potentially reusable material end up as waste, particularly through poor practice and contamination. In Australia, more than 75 per cent of construction waste is clean fill, brick, timber and concrete (NSW Government, 2018(b)). However transport impacts and the fact that environmental (and monetary) values of waste vary across different materials affects the viability of recycling especially in regional areas (Wang 2017). For example, there is a low level of reprocessing glass (20 per cent) compared to a high level of recycling aluminium (95 per cent) (Commonwealth of Australia, 2018(q)).

It is necessary to address waste in all stages of the lifecycle of construction – specification, construction, operation, maintenance and demolition. Waste minimisation in the construction industry is championed primarily through the GBCA Green Star rating tools (requiring measurement and/or consideration of waste management during all of the above phases). Research identifies the lack of markets in Australia in recycled materials as contributing to the high amount of construction and demolition waste, and notes that a national initiative to address this is necessary (Hyder, 2011).

Offsite construction (prefabrication) is considered to be advantageous because of reduced waste and improved waste streams/waste management, however the premise of prefabrication is it's modular configuration which is not always easily integrated into existing buildings.

"Urban mining" is a recent term used to express the concept that an existing building can be used as a resource at the end of its life. It also applies to the concept of using any excavated material of value rather than disposing of it – an example of this is the City of Sydney initiative (commenced in the 1990s) requiring sites that contain a significant quantity of

[10] Mt = Million tonnes

Pyrmont yellowblock sandstone to quarry this stone in a useable form rather than pulverise it, as it is now a rare resource used to repair significant heritage buildings.

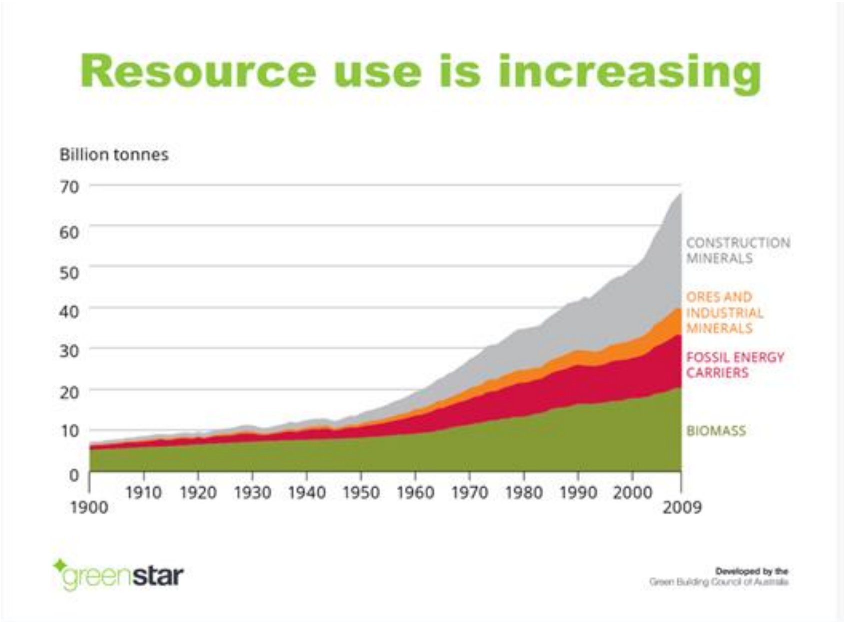

Figure 5 Resource use in construction materials
Source: GBCA Nov 2018 – Materials Masterclass presented by J Bengtsson

Carbon reduction policy and tools relevant to existing buildings

The theory and research into carbon emissions, embodied energy, LCA and waste disposal in construction is immense– but successfully integrating these concepts into the planning, design and construction legislation, guidelines and decision-making processes in the built environment industry is complex and has not been successful in Australia (or in most other countries) for championing retention of existing buildings.

Economic and social sustainability arguments for retaining existing buildings are also strong, as the reduction in carbon emissions for every dollar spent in a retrofit is saving 30-50 per cent of the emissions of a new build, and dollar for dollar refurbishment is weighted towards labour (Carroon 2010).

Current initiatives - International

In most countries legislation and building regulations do not address embodied energy, with the exception of the Netherlands where there is a mandatory calculation of material impacts (although no standards to benchmark against), Sweden (where there is a net-zero target for 2045 in law) and the UK and Austria where there are building regulations under development for the measurement of embodied energy and GHG emissions (Balouktsi et al 2016).

However, there are a number of international initiatives outside of legislation that recognise the carbon reduction inherent in retaining existing buildings:

- The World Green Building Council (WGBC) has decided on a number of principles for its members to follow in promoting a net zero/carbon neutral built environment. The first of these promotes the use of carbon as the key metric (WGBC, 2018(a)), on the basis of needing to monitor against the national NDCs carbon emissions goals resulting from the Paris Agreement. The Green Building Council Canada has also emphasised the need to start measuring impacts, in order to improve decision making. Forecasting now “for future regulation ...will assist in stakeholders towards better practice, and away from conversations only about energy efficiency ..…. and cost criteria”(WGBC, 2018(a)).

- A WGBC initiative known as “Level(s)” - a tool, which can be used by those involved in buildings (such as planners, architects, developers and occupiers) to measure the sustainability performance of them – is under trial in Europe. It provides a framework for measurement that goes beyond energy as the main indicator of sustainable performance, and includes other key aspects of building performance such as greenhouse gas emissions, efficient use of water resources, health and wellbeing, adaptation and resilience to climate change, and cost and value. (WGBC, pre 2017)

- In the United Kingdom (UK) there is the 2016 UK Green Construction Board specification (PAS2080:2016) Carbon Management in Infrastructure – a specification for minimising carbon in infrastructure projects.

- The British Standard EN Standard15643 (2012), “Sustainability of Construction Works”, provides a method for measuring sustainability of construction works including embodied carbon, for new and existing buildings. It defines sustainable construction as having three aspects – social performance, economic performance and environmental performance, and it is intended to be used with the four ISO Standards relating to building service life planning and to ISO 15392:2008 “Sustainability in Building Construction - General Principals”.

- In Italy, the EURAC Institute for Renewable Energy is researching “Renovating Historic Buildings to Zero Energy” (SHC[11] Task 59), focussing on collecting case studies, identifying replicable solutions from case studies, integration of research and development on conservation compatible retrofit solutions, assessing solutions based on both energy and conservation criteria, and developing procedures for multidisciplinary teams to work together.

- The voluntary rating tools used globally – Green Star (Australia), BREEAM (UK) and LEED (USA) – are constantly being updated to reflect improvements in sustainability performance in the built environment. BREEAM currently provides the highest recognition of waste reduction (including construction and demolition waste) at 8.5 per cent of the score. Green Star and BREEAM penalise most heavily for Transport emissions. LEED recognises the reduction in raw material consumption more than other tools (Chehrzad & Sardroud, 2016) - in the current versions (eg v4 New Construction and Major Renovations) by providing (potentially) more points for “building life-cycle impact reduction”[12]. LEED also provides points for “construction demolition and waste management”.

[11] Solar Heating and Cooling (SHC)

[12] In previous versions of LEED (eg v2 Core and Shell) - by providing points for maintaining a percentage of the existing walls, floors and roof

- BREEAM, LEED and Green Star all promote LCA and acknowledge the role of whole-of-lifecycle costing. The new International Standard for measuring the carbon footprint of products (ISO 14067) should assist in ensuring the accuracy of LCA calculations, which have their own international standard (ISO 14040).

- The National Trust USA has developed a set of sustainability initiatives, with Guiding Principle No 1 being to reuse existing buildings (Carroon 2010)

- An emerging area of emissions reduction is the concept of the "circular economy", where materials and products are kept in circulation, using their value for as long as possible, with waste then becoming an input into new products. The Danish government has recently released their plan to transform Danish industry to a circular economy by 2030. Their strategy identifies that there are economic and environmental benefits in a circular economy in the building sector (Danish Ministry of Environment and Food, 2018).

- There are major international efforts underway to accelerate the upgrading of existing buildings, for example :
    - Germany is upgrading all pre 1984 homes by 2020, A and is aiming to double the rate of refurbishment by producing a "municipal toolbox" (called Sandy) aimed at encouraging refurbishment of private homes (Lee et al, 2016)
    - In Albania, Montenegro and Serbia the building stock has been classified into building types, then the potential for ambitious retrofits was determined. Two potential policy packages to overcome barriers were determined, and the potential savings(by 2030) by implementing the policy packages were determined (Szalay et al, 2016)
    - The New York Mandatory Retrofit Programme 2016
    - Europe has many government sponsored retrofit programs, such as the Irish Deep Retrofit Pilot Program 2018.

Current Initiatives – Australia

Initiatives relating to carbon reduction in existing buildings in Australia include:

- Ongoing review of the National Construction Code (NCC) which is often criticised for focussing on operational energy and for not setting high enough standards. A 2013 study found that "new commercial office buildings with a (voluntary) Green Star Rating had on average half the emissions intensity of new office buildings built to minimum [NCC] Code energy requirements" (ASBEC, 2018 p11). ASBEC's[13] Building Code Energy Performance Trajectory Project promotes the need for a Zero Carbon Ready construction NCC and recommends expanding the scope of the Code and progress of complimentary measures – progressing the code towards "addressing future sustainability challenges ...such as ... embodied carbon and address zero carbon in existing buildings by integrating embodied energy and emissions into the code in future" (ASBEC, 2018 p37)

[13] ASBEC is the Australian Sustainable Built Environment Council

- The ASBEC project recognises that standards may need to differ to account for variations in climate. The need for variation is echoed by the Australian Building Codes Board (ABCB) who acknowledge that *"*a balanced approach needs to be taken when assessing an existing building and ... when developing a scope of remedial works" (ABCB, 2016).
  The ASBEC study recommends a range of complimentary policies to compliment the incremental Code changes, flagging future minimum standards for existing buildings and rental properties, and calling for financial incentives to accelerate progress such as green depreciation and stamp duty concessions.

- In 2016 Sustainability Victoria produced *Energy Efficient Office Buildings: Transforming the Mid-Tier Sector* which provides numerous examples of small scale which, although focussed on energy efficiency upgrades, provides numerous examples with specific upgrade information, in some cases recognising that envelope refurbishments would have improved the outcome (Sustainability Victoria 2016).

- Green Star continues to be dominant in Australia and it is more holistic in its measurement of emissions impact than other rating tools such as BASIX, NABERS or NATHers. Green Star provides points for waste reduction, life cycle assessment, use of low emission steel, timber or concrete, and has added a recent requirement to test airtightness. Green Star has an Innovation Challenge for "Culture, Heritage and Identity" which provides recognition for projects that demonstrate that a place is heritage listed, that its character has been celebrated in a refurbishment, and that there is interpretive information available.

- The GBCA has issued two other Green Star Innovation Challenges called "Responsible Carbon Impact" and "Carbon Positive". These Challenges provide Green Star credits for projects using reduced carbon, carbon offsetting, use of carbon neutral certified products and/or registering of a building as carbon neutral for a minimum of six years. However Green Star is voluntary, and predominantly used for new buildings, and with no specific emphasis on encouraging re-use of existing buildings the impact of these two Green Star challenges on existing buildings is expected to be minimal.

- In a 2017 submission to the GBCA on proposed changes to Green Star the Australia ICOMOS National Scientific Committee on Energy Efficiency and Sustainability asserted that the only way to achieve the maximum six star rating should be to include the refurbishment of an existing building in the development.

- In Australia, voluntary initiatives can be partly credited with the fact that "for the eighth successive year the Australia and New Zealand real estate sector has outperformed other regions in ...the Global ESG (environmental, social and governance) Benchmark for real estate*"* (Property Council, 2018).

Although all states and territories in Australia except WA and the NT have net zero goals and objectives, each has as a minimum waste strategy or waste management plan. With numerous local councils having water and waste reduction and energy efficiency policies, there is no legislated planning requirement for LCA assessment, minimum carbon emissions standards in construction, or justification for demolition of existing buildings on environmental grounds.

Carbon Reduction and Design Life

The Paris Agreement “fundamentally recasts the valuation of existing buildings” (Elefante 2017), yet there is no legislative requirement in Australia to demonstrate the need to demolish, and the carbon emissions merits can often be argued either way.

There are examples of major redevelopments such as the Waterloo Housing Estate, the Sirius Building, Moore Park Stadium and Darling Harbour (all in Sydney) where large iconic buildings have been or are proposed for demolition well short of their lifespan, with no environmental repercussions, and with the ability for the new structures to claim high environmental credentials. The key carbon reduction policy that seems unpalatable in Australia is the need to slow down the demolition cycle, and to cease demolishing serviceable buildings before the end of their design life.

Historic Scotland states that “a new building would have to use many times less energy than an existing one to justify replacement” (Historic Scotland, 2011, p 35). In addition, a UK study highlights the advantages of refurbishing existing buildings compared to demolition and concludes the positives of refurbishment (reduction in transport costs, reduced landfill, greater reuse of material, reduced new land uptake, retention of community infrastructure, benefits of neighbourhood renewal) outweigh negatives (costs of demolition and rebuilding, materials wastage, greater embodied carbon inputs, pollution associated with demolition and rebuilding, greater transport for materials and waste, use of natural resources, noise and disruption) (Power, 2008). This indicates that increasing the rate of retention of existing buildings would assist in meeting climate change targets.

Carbon Reduction and Decision Making

Martin Boesch is an influential Swiss teacher and author who advocates re-use of existing building and reinforcement of their character as a first assumption in projects – not ruling out demolition and replacement but advocating that this should only follow “serious analysis of the potential for meaningful re-use” (Boesch 2017). He believes that “one cannot talk of architecture today without talking about the process of reactivating existing buildings …. whether they are listed buildings or not”, to extend the lifespan of existing structures as a sustainability strategy.

In Australia, a recent study of senior building professionals and decision makers into the use of Evidence Based Decision Making found that decision makers used and trusted “feedback from previous projects” as their primary sources of knowledge. As the report points out, using ad hoc information collected from previous projects can perpetuate bad decision making, and using these sources of information as a default position often results from short lead times in the design development phase that do not allow for exploring unfamiliar solutions (Low Carbon Living CRC, 2018). The study confirms that there is a disconnect between academic research and other research and development and the access and use of this information by building professionals. This is a concern that has been echoed in Europe (Preiss, 2017).

UN and Australian research has concluded "that conventional economic measures are ineffective in reducing building's emissions when compared to regulation of building performance through mandatory setting of energy performance standards" (Enker, 2016).

04 Conclusion – Recognising the environmental Contribution of Heritage

In order to meet the targets of the Paris Agreement, Australia must halve its emissions per capita. As much as 25 per cent of Australia's emissions come from buildings, and retrofitting existing buildings could provide 100Mt of carbon savings by 2050 (ASBEC, 2016). 33 per cent of waste is from the Construction & Demolition (C&D) sector. The Global Alliance for Building and Construction reports that current renovation rates amount to 1 per cent of the existing building stock, and that it must increase to 3 per cent per year to achieve net zero carbon by 2050 (Thorpe 2017).

The new low carbon economy looks likely to become a force in determining the cost of doing business. There is potential that low carbon solutions to providing buildings/floorspace in Australia will cost less than high carbon solutions. Incentives to encourage and accelerate the reuse of existing buildings could contribute to this reduction in carbon emissions, and increase the value of existing buildings in a low carbon economy. Success depends on how benefits are to be measured. Payback periods must be considered for the environmental cost of an activity, rather than for monetary cost.

Much of this report has presented evidence as to why existing buildings generally must be considered a more valuable resource. The following section considers heritage places as a subset of the general resource. The following recommendations address the question of how the environmental value of heritage places could be best recognised..

Carbon savings – making the case for State Heritage Places

The role of the Conservation Management Plan (CMP)

State heritage listing in Australia affords a place protection under the various state planning acts, and signifies a high level of heritage significance. This generally means minimal alteration is possible for the most significant parts of the place, and that the building will be largely retained. It sets an expectation that there is a value in keeping and reusing the place in its setting.

The level of change possible for a state heritage listed place is determined by a Conservation Management Plan (CMP) prepared in accordance with the articles of the ICOMOS Burra Charter. A CMP makes a subjective assessment on a number of different heritage criteria and ranks them in importance. However, a CMP could do a lot more to direct the future of a state heritage place.

The heritage community could send an immediate signal that environmental benefits are derived from conserving state heritage places by lobbying ICOMOS to include 'resource value' or 'environmental value' as a criteria for assessment in the Burra Charter (as suggested by English Heritage in 1997). This aspect should be considered as part of the significance of a place during the initial assessment, before it is too late to consider it further along in the development cycle.

"Resource value" could simply be an initial assessment of the inherent embodied energy existing in the place – an estimate of the embodied energy that would be spent in providing the resource today. Some work to inform embodied energy calculations of Australian building typologies has already been undertaken in– (Pullen & Bennetts, 2011;, Wong et al, 2010). Further work to express the embodied energy of heritage building typologies (for an initial rule of thumb assessment) would not be difficult.

While CMPs already assess the condition of a listed place, they could specifically also assess the degree of disrepair and potential for reuse in a more active way (eg in a simplified table such as that below which would provide a snapshot of the amount of work required to optimise the use of the place). They could also assess the types of interventions that would improve energy efficiency and continue the life of the structure (as is recorded in Scottish heritage databases).

Interventions to extend the life of the place

Potential useable area

%	minor	major	reconstruction	demolition
x				
y				
z				

Technologies and techniques are available that are now standard practice in building design that could be used in the preparation of CMPs to assess and demonstrate the environmental value of a state heritage place. Significant building projects today will employ point cloud/(3D) modelling which could be used by the heritage architect to determine quantities of material, and laser scanning can be used to determine the precise condition of fabric. Accurate embodied energy calculations could be obtained from sustainability consultants undertaking LCA assessments as part of the project if there is an intent for a Green Star, LEED or BREEAM rating. These embodied energy values can be used in BIM tools to demonstrate in 3D the life cycle impacts of each of the major building elements (new and existing). Various waste calculator tools are available to determine the volumes of waste that are generated by the demolition of different materials, and data on the success (or otherwise) of recycling and/or reuse of different materials is available.

Finally, CMPs should consider not only planning legislation, but also relevant sustainability legislation where applicable. This might include referencing state and local government climate change and zero carbon strategies, waste minimisation strategies, and sustainability provisions in Local Environmental Plans (LEPs) and Development Control Plans (DCPs). Heritage assessments should demonstrate how important state heritage places are in achieving the three pillars of sustainability (economic, social and environmental).

In summary, the CMP process, which is now well embedded in the planning process, should become at the same time broader to consider environmental (or resource) value, and more rigorous in its approach to assessing the sustainability values and where they exist. Every relevant tool available should be employed to demonstrate in a CMP that a state heritage place has a level of environmental value, in addition to a heritage value.

Including a resource value in a CMP will not have a statutory implication until such time as this criterion becomes embedded in planning legislation. However, to achieve that goal it is essential to commence the dialogue and become familiar with the language used in the low-carbon environment.

Carbon Trading for State Heritage places – likelihood of success

A heritage conservation industry versed in the language of sustainability is also essential to a future where the reuse of state heritage places could be part of the carbon trading environment.

The key elements of the formal carbon trading process have been detailed in Section 2 of this report. Carbon trading of the tonnes of embodied energy inherent in a retained State heritage place and in a structure needed to replace it would align with the stated aim of "sustainable land management". It would also achieve carbon "abatement"[14] as required as emissions have been avoided by retaining the place rather than creating a new place or structure to perform a function.

Both the NCOS for buildings and the NCOS for precincts refer to the carbon offset integrity principles that a carbon offset must be additional, permanent, measureable, transparent, address leakage, and be independently audited and regulated (CCCLM, 2017) In terms of demonstrating that retention of a state heritage place reduces emissions below a baseline of what would have been expected to occur in the absence of retention, the credit could include the embodied energy value of what you do not have to build because there is already an existing building performing the function.

The introduction of carbon abatement projects into some NSW National Parks is a potential comparative model – if best practice land management is to rehabilitate by planting trees in a National Park, then arguably this should have happened anyway. The carbon trading environment has enabled this abatement to be accelerated. The argument that state heritage buildings should be conserved and upgraded anyway could be equally applicable, yet the benefit (abatement) is in the structure that does not have to be built, accelerating the upgrading and ful occupation of an existing building.

The opportunities and barriers of entering into the formal carbon trading environment are seen to be as follows:

Opportunities		Barriers
Carbon Trading market is open to looking for options and more diversity.		You can buy into offshore projects so the market will likely expand offshore rather than in Aust
The opportunity for the contribution of existing buildings in the carbon trading environment has been recognised by ASBEC.		
There is a high amount of investment in carbon trading and more to come as net zero becomes more mainstream		This is disputed by some – there is an alternate view that it is too expensive to reduce emissions via this market and that it is not moving
Recognising heritage places in carbon trading aligns with the governments goals of measuring carbon abatement		Government direction may change

[14] the action of ending, lessening, easing (off), decrease, diminishing

Carbon savings can also be measured as a function of what you don't have to build – in addition to the embodied energy calculations of an existing structure		
There are no standards already agreed for measuring and understanding the benefits		There are no standards already agreed for measuring and understanding the benefits
Can be demonstrated to accelerate reduction in carbon emissions (by using something already built)		
		A Govt portfolio or a large investor portfolio would be more likely candidates than a small scale operator
There is a Draft Community Buildings methodology determination that can be used as a model		It is complicated, highly regulated system, and will take a lot of organisation to a get new initiative across the line
		Rigid timing – limited and controlled by reverse auction cycle
		Volumes of carbon probably too small
		Hard to argue why it should be restricted to heritage and not all existing buildings.
		Would likely favour city over rural situations – no benefit if you cannot fully occupy or reuse the building or place

The market for Carbon Trading will grow commensurate with the inability of government and business to meet their legislated emissions reductions and the NDCs. Given that the NDCs made globally following the Paris Agreement only pledge to deliver one third of the emissions reductions needed to meet the goals of the Agreement (UNEP, 2016), and that Australia is one of the G20 countries singled out as requiring "further action" to meet their NDCs (UNEP, 2017) it could be anticipated that the formal carbon trading market will grow.

The voluntary carbon trading process has also been discussed in Section 2. One view is that a key role of the voluntary offset market is to shape the rules, that it "can be used as a testing ground for procedures, methodologies and technologies" (WWF, 2008).

The opportunities and barriers of entering into the voluntary carbon trading environment are seen to be as follows:

Opportunities		Barriers
Carbon Trading market is open to looking for options and more diversity – the voluntary market is more open to		

experimentation		
There is a high amount of investment in carbon trading and more to come as net zero becomes more mainstream		This is disputed by some – there is an alternate view that it is too expensive to reduce emissions via this market and that it is not moving
Voluntary market is not necessarily tied to government policy		
Carbon savings can also be measured as a function of what you don't have to build – in addition to the embodied energy calculations of an existing structure		
There are no standards already agreed for measuring and understanding the benefits		There are no standards already agreed for measuring and understanding the benefits
Can be demonstrated to accelerate reduction in carbon emissions (by using something already built)		
		Even though voluntary, it is complicated, highly regulated, and will take a lot of organisation to get across the line
Can trade small volumes – the minimum is 1 tonne in the voluntary market		
Not enough projects to meet current demand		
		Hard to argue why it should be restricted to heritage rather than all existing buildings
		Would likely favour city over rural situations – no benefit if you can't fully occupy or reuse the building or place
		Privately owned buildings unlikely to be organised enough to follow through on the process for small amounts of carbon to be traded

Confidence in carbon trading has ebbed and flowed over the last decade - with political and economic uncertainty and coordinated approaches to regulations cited as concerns (Perdan et al, 2011). Recent commentary observes that innovation is stimulating voluntary offset demand while at the same time uncertainty over future obligations is holding the market back (Energetics, 2017).

Other potential mechanisms/possible avenues for offsetting the unrealised potential of heritage buildings

The need to address the value of existing buildings in planning and sustainability legislation, rating tools and financial incentives has been discussed above. The need for urgent accelerated action to reduce carbon emission, particularly in the short term, has been identified by prominent agencies (UNEP 2017, C40 2017). Cities in particular must prioritise the retrofitting of existing building stock in the next three years (C40, 2017). Many studies have shown that a retrofitted building will have far less carbon emissions than an equivalent new building (Carroon2010)

The ideal would be that there is positive discrimination (Tomsic et al 2016) when assessing the environmental value of heritage buildings in other words to develop an “active policy” to extend the lifespan of existing buildings (Fuertes, 2017) The aim is to stimulate investment in refurbishing heritage buildings, as part of a suite of tools for retaining and accelerating the upgrade of existing buildings. The Australian Research Centre (ARC) has called for an alternative building code to be developed for existing buildings (Udawatta et al, 2018(a)), while the LEED rating tool pioneers credits for reuse of existing structure and materials.

Research has posed that environmental consciousness is the main driver for adaptation and conversion of buildings in Australia (Remoy et al cited in Udawatta et al, 2018(a)). However the identified barriers, many of which are technical in nature (Bullen and Love, 2011) must be overcome by increasing the environmental value of existing buildings and engendering a culture of repair and reuse.

Approaches (in addition to the changes proposed to the CMP process) to accelerate the highest and best use of state heritage buildings could be:

Changes to voluntary rating tools

- to use LCA to determine whether any existing buildings on the site should be reused;
- to penalise (in the rating tools point system) a site where a building is being demolished before the end of its design life;
- to ensure you can’t get the highest rating unless you reuse an existing building on the site;
- to set carbon and waste budgets based on the proposed amount of floor area;
- to severely penalise (in the point system) the generation of waste which arises from demolition of structures existing on the site;
- to allow heritage buildings to claim another star or higher level of rating for sustainability attributes such as waste avoidance and using existing infrastructure (Balderstone 2012)
- to provide realistic lifecycles, not base every LCA on 100 years which is not the norm for new buildings (there are LCAs for 35-100 years, resulting in vastly different outcomes)
- ensure that changes to the rating tools do not favour new construction over adaptive reuse

Changes to the National Construction Code (NCC)

- to require life cycle assessment when demolition of certain types of buildings are proposed (eg over a certain floor area, or over a certain tonnage of waste)
- provide a separate NCC for existing buildings (Udawatta et al,) 2018(b))

- require recognition of existing embodied energy and/or avoided embodied energy in Section J
- require detailed waste stream assessment in Section J
- prepare for tightening of requirements for air leakage, increased thermal mass and increased insulation – study the best approaches for different types of heritage buildings.

Changes to Planning/Building Practices

- LEPs to require consideration of reuse options
- all DAS should come with the design life clearly stated on the DA approval form, especially if approval is based on an LCA assessment with an assumed design life
- the waste stream for unused building materials needs to become more sophisticated
- Local (?) government needs to map/record empty buildings
- Planning tools should promote (in the first instance) the idea of setting carbon and waste budgets based on the proposed amount of floor area;
- the building industry needs to develop a repair capability – this is new area for job growth
- the concept of a circular economy needs to be accelerated by research & development

Incentive schemes

- incentives are needed to reduce the demolition cycle in cities
- consider using the Heritage Floorspace model – unrealised embodied energy from floorspace which isn't built because an existing building is upgraded rather than demolished can be sold to someone else to use to build floorspace – ie a Transferable Sustainable Floorspace scheme
- a system of embodied energy credits – could be a sq m rule of thumb embodied energy rating combined with a longevity rating to demonstrate the environmental contribution of an existing building,
- "eco points" schemes have been suggested however it seems more worthwhile to tap into existing initiatives rather than invent something new

Financial incentive schemes

- conserving heritage places could in the future be part of the ethical investment environment as low carbon investments become highly prized
- waste needs to and will become more expensive
- slowing demolition cycle is essential but will be resisted because it will have knock on effects for the development industry, employment etc
- there are calls for "green depreciation" and tax incentives for environmental upgrades (ASBEC, 2018).

In summary, for the barriers and opportunities for recognising the environmental benefit of heritage places in the formal and informal carbon trading environment to be overcome, a concerted effort to engage with the federal government must be made by the heritage industry (in particular with the Department of Environment and Energy, the Climate Change

Authority and the Emissions Reduction Fund). The key stakeholders in this project development and liaison would be the federal Department of the Environment, each of the State Heritage Councils, and Australia ICOMOS.

To prepare for such engagement, pilot projects could be developed for the voluntary carbon trading market, in consultation with companies that identify as being likely to purchase such carbon credits (eg large development of building companies), and the Australian and global authorities that register such voluntary carbon trading projects. Stakeholders in addition to those above would be the companies who sell the voluntary carbon abatement products.

In regard to the suggested actions around changes to the CMP process, and changes to Green Star, the NCC, planning practices and incentive schemes to recognise the environmental benefits of retaining heritage buildings, it is acknowledged that there is a great deal of work to be done on many fronts. A key aspect of success would be to develop a forum for researchers and practitioners to engage more closely.

Other key actions would be:

To engage with the federal government Department of the Environment and Energy to

- accelerate actions around developing a circular economy

- recognise embodied energy in the NCC and NCOS

- development of “positive discrimination” policies for retention of existing buildings

To engage with the state government Planning departments to

- recognise the value of existing buildings in policies and planning instruments, and to develop a floorspace incentive scheme

- develop ways of introducing embodied energy credits and setting of carbon budgets for major developments

Appendix A Definitions

Name	Acronym	Definition
Australian carbon credit units	ACCUs	Issued by the Aust Gov Clean Energy Regulator in recognition of emissions reductions. One ACCU is earned for each tonne of carbon dioxide equivalent (tCO2-e) stored or avoided by a project. ACCUs can be sold to generate income, either to the government through a carbon abatement contract, or in the secondary market
Australian Securities Investment Commission	ASIC	Regulates Australian Carbon Credit Units (ACCUs) and Eligible International Emissions Units (EIEUs – also known as ERS (Emissions Reduction Units))
Building Information Modelling	BIM	Software that generates and manages digital representations of physical and functional characteristics of places in a 3D format
C40		C40 is a network of the world's megacities committed to addressing climate change. C40 supports cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change
Carbon		A carbon-containing gas, notably carbon dioxide, or a collection of such gases, especially when considered as a contributor to the greenhouse effect: plans for capturing and sequestering carbon produced by power plants
Carbon abatement		The reduction of the amount of carbon dioxide that is produced when coal and oil are burned
Carbon Credit		A permit which allows a country or organization to produce a certain amount of carbon emissions and which can be traded if the full allowance is not used
Carbon emissions		The release of carbon into the atmosphere
Carbon Footprint		The total emissions caused by an individual, event, organization, or product, expressed as carbon dioxide equivalent
Carbon Neutral (also called Net Zero?	_	Reducing emissions where possible and compensating for the remainder by investing in carbon reduction projects (via offset units) to achieve net zero carbon emissions
Carbon Offsets		Mechanism by which one pays for someone else to reduce GHG elsewhere, so the purchaser of the carbon offset can compensate for, or "offset", their own emissions

		Carbon offsets are specific projects or activities that reduce, avoid or sequester emissions.
Carbon positive		A building or precinct that produces more energy than it uses
Carbon Trading		A mechanism to compensate for not annually reducing emissions to zero by allowing the emitter to invest in carbon reduction projects (via offset units) to achieve net zero carbon emissions
Circular Economy		An economy in which materials and products are kept in circulation, using their value for as long as possible, with waste then becoming an input into new products
Council of Parties	COP	The COP is the supreme decision-making body of the United Nations Framework Convention on Climate Change (UNFCCC).
Decarbonisation		Actions to take carbon emissions out of the atmosphere
Ecopoints		A measure of the overall environmental impact of a product or process covering environmental impacts of climate change, fossil fuel depletion, ozone depletion, freight, human toxicity (air and water),waste disposal and water extraction, acid deposition, eco toxicity, eutrophication, smog, minerals extraction –using the weighted Ecopoint methodology developed by the UK Building Research Establishment (BRE)
Embodied carbon		The greenhouse gas emissions associated with the non-operational phase of a project, ie extraction, manufacture, transport, assembly, maintenance, replacement, deconstruction, disposal, reuse, recycling – expressed as kg or tonnes of $C0_2$
Embodied energy (sometimes called embedded energy)		Sometimes used in reference to embodied carbon, but is technically different. It is the quantity of non-renewable energy per unit of building material - expressed in KJ or MJ, ie in an existing place - the carbon emissions that have already occurred.
Emissions Reduction Fund	ERF	Australian Government's legal vehicle (est under the Carbon Farming Initiative Amendment Bill 2014) for buying and selling and regulating carbon credits via approved projects for use in carbon offsetting. The Department of the Environment and Energy and the Clean Energy Regulator are the two agencies that manage the ERF

		Under the Fund, a range of activities are eligible to earn ACCUs. Projects must comply with an approved method that measures verifiable reductions in emissions and sets out the rules for activities which can earn carbon credits. The Government purchases ACCUs through a reverse auction system Certain high emitting businesses are legally obliged to offset their carbon emissions by purchasing ACCUs. Others may purchase them voluntarily
Emissions Reduction Fund Methods		The “methods” determine emissions reduction activities available through the ERF scheme, developed and legislated by The Department of the Environment and Energy. They are a set of criteria for developing ACCUs
Ethical Investment (also known as socially responsible investment (SRI))		An investment process that incorporates environmental and social factors when selecting investments, in addition to the objective of achieving a competitive financial return
Green Bonds		A segment of financial instruments issued by companies looking to demonstrate their ethical and social responsibility credentials. They are often issued for major renewable energy infrastructure projects, constructing low-carbon residential buildings, etc
Greenhouse gas	GHC	Gas produced from anthropogenic activities including primarily carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and natrium trifluoride (NF_3)
Global Warning Potential	GWP	Another way of expressing embodied carbon - an index representing the combined effect of the differing time GHG remain in the atmosphere and their relative effectiveness in absorbing outgoing infrared radiation
International Council on Monuments and Sites	ICOMOS	Global non-government organisation working to promote the conservation, protection, use and enhancement of cultural heritage sites, and working as an advisory body to UNESCO on the cultural sites of World Heritage List.
Intergovernmental Panel on Climate Change	IPCC	Global authority on Climate Change issues
International Council on Monuments and Sites	ICOMOS	A network of experts that form a global non-government organisation which is dedicated to promoting the application of theory, methodology,

		and scientific techniques to the conservation of the architectural and archaeological heritage.
Life Cycle Assessment	LCA	The predicted overall energy use of the building (construction and operation) over its lifespan
Life Cycle – Cradle to Gate		Assessment of impacts associated with raw materials, , materials or processes to the point where the products are packaged and ready for delivery to site.
Life Cycle – Cradle to Site		Assessment of above impacts plus impacts of transportation to site including processing on site to make use of the product or component.
Life Cycle – Cradle to Grave		Assessment of the above plus use and then final disposal of the product – it assumes no end-of-life residual value.
Life Cycle – Cradle to Cradle		Assessment of the above plus assessment of residual value of materials for reuse or recycling as raw material for the same or a different product.
Low Carbon Economy		An economy where high carbon emitters are considered poor assets
National Carbon Offset Standard	NCOS	A voluntary standard that provides benchmarks for organisations seeking to make their operations, products, services, buildings, precincts or events carbon neutral. The Carbon Neutral Program provides a framework for certifying carbon neutrality against the National Carbon Offset Standards
Nationally Determined Contributions	NDCs	National Governments stated goals to meet the emissions reductions as pledged in the Paris Agreement
National Construction Code	NCC	a uniform set of technical provisions for the design, construction and performance of buildings throughout Australia. It is published and maintained by the Australian Building Codes Board, on behalf of and in collaboration with the Australian Government and each State and Territory Government
Net Energy		Determined by calculating embodied energy and operational energy over the the expected lifespan of a building or process
Net Zero (also called Carbon Neutral)		Reducing emissions to zero, or balancing emissions by an equal amount of carbon storage. An asset that has eliminated or offset all annual carbon emissions to balance energy consumed with energy produced. An asset that has been certified against the Australian Government's National Carbon Offset Standard for Buildings

Paris Agreement		Outcome of the UN Council of Parties (ie Countries) (COP21) Dec 2015 summit held in Paris, where world leaders agreed to limit global warming to well below 2 degrees C
Primary Energy		The total energy needed to produce a final energy service, including inputs and losses along the energy chain
Rating Tools		Certification used to assess and recognise buildings which meet certain green requirements or standards
Renewable Energy Target	RET	An Australian Government scheme designed to reduce emissions of greenhouse gases in the electricity sector and encourage the additional generation of electricity from sustainable and renewable sources
Safeguard Mechanism		The Safeguard Mechanism is part of the Emissions Reduction Fund. It puts limits (baselines) on the emissions of facilities that emit more than 100,000 tonnes of emissions a year. These baselines cover around half of Australia's emissions, including facilities in the manufacturing, electricity, mining, oil and gas, transport and waste sectors. A single sectoral baseline applies to grid connected electricity generators
Sequestration		The storage of carbon in plants (or artificially) by the absorption of $C0_2$ from the air and conversion of the carbon in the form of carbohydrates (sugars) Also called CCS - Carbon Capture/Storage.
Sustainable Development Goals	SDGs	17 Sustainable Development Goals adopted by the UN for 2015-30, in their "New Urban Agenda" (which replaces "UN Agenda 2030")
Sunk Carbon/Sunk Embodied Energy		Energy (ie carbon emissions) spent or used in the past, eg to create an existing building. Also called Inherent Embodied Energy
The Clean Energy Regulator		The government agency that administers the ERF. This includes project assessment and registration, running of the auctions, issuing Australian carbon credit units (ACCUs), as well as safeguard mechanism compliance.
Urban mining		extracting existing raw materials from buildings scheduled for demolition or refurbishment
Operational energy		The "Operational Energy" is the amount of energy required to run the building over its design life and includes appliances such as Air-Conditioners, Hot

		Water systems, Refridgeration and Lighting.
Zero Carbon		See Carbon Neutral
Zero Waste		Design of a product’s life cycle so that all resources are reused (including energy and materials)

Appendix B

Comparative studies of embodied energy calculations - an Annotated Bibliography

Dublin City and the Heritage Council (2004) "Built To Last – The Sustainable Reuse of Buildings – an action of the Dublin City Heritage Plan" Dublin City and the Heritage Council (2004) http://www.dublincity.ie/sites/default/files/content/Planning/HeritageConservation/Documents/sustainable_reuse_buildings_athusaid_inbhuanaithe_foirgneamh.pdf accessed 7 September 2018:

- The 2004 study from Ireland used five actual refurbishment projects and compared them with 5 hypothetical equivalent new buildings in relation to cost, environmental analysis and whole-of-life costs. While the expenditure was more advantageous in 4 out of the 5 scenarios, all refurbished existing buildings performed better in terms of environmental impact than the hypothetical redeveloped buildings.

Pullen, Stephen (2007) "A Tool for Depicting the Embodied Energy or the Adelaide Urban Environment", https://www.researchgate.net/publication/242275899_A_Tool_for_Depicting_the_Embodied_Energy_of_the_Adelaide_Urban_Environment accessed 30/7/18:

- The 2007 study in Adelaide developed a tool for depicting the embodied energy of the Adelaide urban environment, the aim being to depict the embodied energy of residential buildings in a spatial format to allow comparison of the energy performance of new housing developments with existing.

Carroon, Jean (2010) "Sustainable Preservation - Greening Existing Buildings", John Wiley & Sons, p8:

- A UK study in 2008 compared C02 emissions in new construction with the refurbishment of existing homes and concluded that new, energy efficient homes recover the carbon expended in their construction only after 35-50 years of energy operation.

Power, Anna (2008) "Does demolition or refurbishment of old and inefficient homes help to increase our environmental, social and economic viability?" Energy Policy, Vol 36 Issue 12 Dec 2008 https:/www.sciencedirect.com/science/article/pii/S0301421508004709 accessed 4 March 2018:

- This other study from the UK in 2008 looked at new-build compared to upgrade scenarios over 50 years, taking embodied energy and operational energy into account, and determined that the worst performing refurbished property performed better for 28 years than the average new-build, before its cumulative impact became worse than the new-build.

Carroon, Jean (2010) “Sustainable Preservation - Greening Existing Buildings”, John Wiley & Sons, p261:

- A 2009 study from Canada assessed the embodied energy of four historic buildings of various sizes against the embodied energy of these buildings should they be reconstructed, and determined the avoided $C0_2$ from refurbishment was between 85-1591 years of the operational energy use.

Carroon, Jean (2010) “Sustainable Preservation - Greening Existing Buildings”, John Wiley & Sons, p6:

- A US study determined that the percentage of transportation energy use [for materials] exceeds the operational energy use for the construction of an office building by 137%.

Bin, Guoshu and Parker, Paul (2012) “Measuring buildings for sustainability: Comparing the initial and retrofit ecological footprint of a century home – The REEP House”, Applied Energy 93 (2012), pp24-32:

- This Canadian study in 2010 reviewed the retrofit of an early 20th century detached house, assessing that the embodied carbon per unit area is 240kg/m2 initially, with a further 110kg/m2 added by the subject substantial renovation. Examining the life cycle energy, carbon and ecological footprint with a 50 year life span the study determined that the environmental cost of the retrofit will be offset in two years.

Pullen, Stephen & Bennetts Helen (2011) “Valuing embodied energy in the conservation of historic residential buildings”, Australian Architectural Science Association, 2011 http://anzasca.net/wp-content/uploads/2014/02/31P57.pdf accessed 10 February 2018:

- This 2011 study of a 1910 South Australian villa compared the GHG emissions/embodied energy savings of renovate/extend option and a demolish rebuild option, with the result that the renovate and extended villa yields 26% less life cycle emissions than the demolished and rebuilt house (Pullen & Bennetts 2011). The lifecycle measured was 50 years and excluded the sunk env energy of the existing building. However, if the sunk environmental energy of the house, or the embodied energy value of a typical replacement house was included, one would expect a higher result for avoided emissions.

Iyer-Raniga & Wong Everlasting Shelters: Life cycle Energy assessment for heritage buildings, Historic Environment 24, Number 2, 2012:

- This 2012 Australian study proposed a life cycle framework to assess the highest average reduction of lifecycle primary energy in 8 heritage buildings typical of the period 1880’s- 1970s, and found that the heritage buildings did not all perform badly in terms of energy consumption (which included primary energy consumption).

Wong, JPC; Iyer-Raniga, U; Sivaraman, D “Energy efficiency and environmental impacts of buildings with heritage values in Australia”, Heritage and Sustainable Development, 2010:

- A study by RMIT published in 2010 provided *a comparison between life cycle energy, greenhouse gas, water and other such environmental impacts* for a range of heritage buildings in Australia (1826 to 2000) compared to retrofitted designs where performance was improved and heritage values retained (Wong et al, 2010). It found that *the cumulative primary energy associated with embodied* [energy], *materials replacement and construction ranged from 5-20% of the total lifecycle primary energy consumption*. The lifecycle measured was 100 years. This is reflective of the low embodied energy of the heritage structures.

Liljenstrom, Carolina and Malmqvist, Tove (2016) "Resource use and greenhouse gas emissions of office fitouts – a case study", Central Europe Towards Sustainable Building CESB 2016 pp 182-189:

- A Swedish study compared the embodied energy and carbon for a new office fitout with the embodied energy and carbon of the building itself. The total embodied carbon (GWP) of the fitout was 74.5 kg CO2-e/m2 and the total embodied energy was 1.7 GJ/m2. Given the embodied energy and carbon were calculated at 200 – 800kg CO2 – e/m2 and 3 – 9 GJ/m2 for the initial construction of such a building, the conclusion was that fitouts can have a dramatic environmental impact over the lifecycle of a building.

Seo, Seongwon; Foliente, Greg; Zhengan, Ren (2017) "considering embodied impacts of retrofitting existing dwelling stock in Greater Melbourne", Journal of Cleaner Production 170, 2018, pp1238-1304:

- A complex 2017 study using data from 60 existing pre-2005 dwellings in Greater Melbourne provided a comparison of energy and carbon intensities for upgrading buildings by local government area, with methodologies for comparing the operational benefits of retrofitting against the energy used in the retrofit.

Rasmussen, Freja; Nygaard & Birgisdottir, Harpa (2016) "Life Cycle environmental impacts from refurbishment projects – a case study", Central Europe Towards Sustainable Building (CESB) 2016, pp 277-284:

- This 2016 Danish study used LCA to compare the refurbishment of three 1960s 14 storey residential towers, comparing it to reference values for the equivalent new construction under two scenarios – one where the existing structures are already offset (the existing structure has no environmental impact), and one where a % of the embodied impact of the existing structures are included (based on a 100 year lifecycle) – under the 1st scenario the embodied impacts of the refurbishment generally correspond to 20-30% of the reference building's impact, and under the second scenario the embodied impacts of refurbishment generally correspond to 40-50% (Rasmussen, 2016), indicating a greater environmental footprint for refurbishment however still much less than that of 3 new buildings.

Balouktsi, Maria; Lutzkendorf, Thomas; Seo, Seongwon; Foliente, Greg; (2016a) "Embodied Energy and Global Warming Potential in Construction – Perspectives and interpretations", Central Europe Towards Sustainable Building (CESB) 2016, p 661-668:

- An Australian/German collaboration investigated whether there is any difference in measuring embodied energy when designing a building compared to the embodied energy of an existing building. They observed that the embodied energy in existing buildings *is an "ecological value" that is preserved through building maintenance and modernization (sic) or unlocked through demolition and recycling*.

Berg, Frederik & Fuglseth, Mie (2018) "Life Cycle Assessment and Historic Buildings: energy efficiency refurbishment vs new construction in Norway", Journal of Architectural Conservation 24:2, pp 152-167:

- This 2018 study from Norway undertook a LCA with a 60 year life cycle comparing the net "climate benefits"..between refurbishment of a 1930s residential building and construction of a new building in accordance with modern codes. It concluded that for the new building it takes more than 50 years for the initial emissions from new construction to be outweighed by the efficient energy consumption of the new build. It also determined that with the upgrade accounting for 2% of the total lifetime emissions of the refurbished building, the emissions related to the construction of the new building are 12 times higher than the refurbishment.

Tokede, O; Udawatta, N; Luther, M (2018) "Retrofitting Heritage Office Buildings in the UK: a case study", Built Environment, Project & Asset Management Vol 8, Issue 1, pp 39-50:

- A 2018 study compared the base cases of energy consumption and carbon emissions between retrofitting an office building in Scotland (a converted 1930s school) with retrofitting a heritage listed office building in the UK (no info provided).This was modelled under 4 different levels of intervention including the use of a commercial insulation package, over a life cycle of 60 years. It found that the *differential in annual energy savings achieved, based on the proportion of capital cost to operational cost, is 14.6% in the heritage building compared to 24.6% in the non heritage building*. It is worth noting that the capital costs of each of the four levels of interventions were lower in the heritage building.

Edge Environment, (2018). "New Build vs Refurb – The Life Cycle answer".
https://edgeenvironment.com/new-build-vs-refurb-life-cycle-answer/ accessed 1/11/18

- This 2018 Australian study compared the carbon emissions of refurbishing an existing building (to 5 star NABERS) with those of demolishing and rebuilding to 3 star NABERS), over a 15 year life cycle. The option to refurbish the existing building has 36% less carbon emissions, and saved 34,740,000 kg CO_2 over 15 years.

Langston, Craig; Chan, Edwin H W; Langston, Craig; Chan, Edwin H W; Yung, Esther H K "Embodied Carbon and Construction Cost Differences between Hong Kong and Melbourne Buildings", *Construction Economics and Building*, Vol 18, No 4, December 2018, pp 84-102:

- This study compared embodied emissions from both refurbished projects and new buildings in Hong Kong and Melbourne. It found that in Hong Kong the mean embodied carbon for refurbished buildings is 33-39% lower (per/m^2)than new build projects, while in Melbourne it is 22-50% lower. The report recommended that waste from building demolition of existing structures must be given more consideration, to ensure recycling and adaptive reuse strategies are achieved.

Appendix C

Relevant studies based on building typology – an annotated bibliography

Lei, M and Roders, AP (2018) “Building typology, energy efficiency and historical preservation: a literature review, Heritage 2018 – 6^{th} International Conference on Heritage and Sustainable Development, pp 63-70:

- This literature review into research based on understanding retrofit options through studies of building typology referenced a 2014 study in Italy that developed a methodology to determine appropriate energy upgrades of historical buildings based on building morphology (by De Berandinis et al).

Kleeman, Frizt; Lederer, Jakob; Fellner, Johann (2015) “Buildings as an urban mine – the case study of Vienna”, in Proceedings: International Workshop “Mining the Technosphere – Drivers and Barriers, Challenges and Opportunities” TU Wien Oct 2015 pp 105-108:

- This 2015 study reviewed the material composition of buildings in Vienna, to map the distribution of material composition in buildings and likely demolition activity, in order to facilitate higher quality recycling by predicting the volume and type of materials likely to become available. A summary of the date of construction, use, material intensity (kg/m^3) of organic and inorganic materials of the buildings was tabulated and mapped.

Huuhka, Satu (2016) “Demolished Buildings: empirical evidence on types, ages and construction materials”, Central Europe Towards Sustainable Building (CESB) 2016, pp 1105-1112:

- A 2016 study looked at the service life of buildings demolished in Finland between 2000-2012, comparing the average life of buildings and of their different materials and typologies. 50,818 buildings were examined and it was determined that on average, the demolished buildings were 51 years old, well below their design life (the minimum average of 19 years was for steel buildings and the maximum average of 50 years was for brick buildings).

Szlalay, Zsuza; Novikova, Aleksandra; Csoknyai, Tamas; Feiler Jozef (2016) “Low Carbon Scenarios for South East Europe: Case Study of Albania”, Central Europe Towards Sustainable Building (CESB) 2016, pp 299-306:

- A 2016 study prepared an assessment of building typologies in Albania, Montenegro and Serbia. It reviewed the likely retrofit option for each typology, developed best and worst case scenarios for each typology and retrofit option and then calculated the potential energy savings under three scenarios – BAU, moderate and ambitious.

Martinez-Molina, Antonio; Ausina, Isabel Tort; Cho, Soolyeon; Vivancos, Jose-Luis (2016) “Energy Efficiency and Thermal Comfort in historic buildings: a review”, *Renewable and Sustainable Energy Reviews*,61:70, August 2016

- This 2016 literature review summarised techniques used to achieve performance refurbishments , focussing on grouping different building types used as case studies. The aim is to demonstrate the feasibility of maintaining the built heritage values of historic buildings while achieving significant improvements in energy efficiency.

Seo, Seongwon; Foliente, Greg; Zhengan, Ren (2017) “considering embodied impacts of retrofitting existing dwelling stock in Greater Melbourne”, Journal of Cleaner Production 170, 2018, pp1238-1304:

- A 2017 study considered the embodied impacts of retrofitting existing dwelling stock in greater Melbourne, by looking at a life cycle approach (25 years) of energy use and GHG emissions of upgrading of building stock at an urban scale. It used data collected by the Victorian government which examined 60 existing houses (pre 2005) to determine the average energy efficiency of their existing envelopes. It concluded that all the pre 2005 dwellings in the study area can be practically retrofitted or upgraded from 3 to up to 6 stars (NatHERS). When all pre 2005 dwellings are upgraded to 3-star there is 36% less energy consumption compared to BAU, with the embodied energy needed for this upgrade equivalent to 7% of the annual operational consumption. When all pre 2005 dwellings are upgraded to 6-star there is 76% less energy consumption compared to BAU, with the embodied energy needed for this upgrade equivalent to 50.3% of the annual operational consumption.

Lei, M and Roders, AP (2018) “Building typology, energy efficiency and historical preservation: a literature review, Heritage 2018 – 6th International Conference on Heritage and Sustainable Development, pp 63-70:

- This literature review into research based on understanding retrofit options through studies of building typology referenced a 2018 study in Spain that reviewed the typology of historical housing and developed an information sheet to analyse performance and recommend actions based on protecting cultural values (by Pozas and Gonzales).

Berg, Frederik & Fuglseth, Mie (2018) “Life Cycle Assessment and Historic Buildings: energy efficiency refurbishment vs new construction in Norway”, Journal of Architectural Conservation 24:2, pp 152-167:

- Green Lab study (NT for Historic Preservation) compared the potential savings offered by reusing or retrofitting heritage buildings to replacing them with new buildings over a certain period using LCA and results showed that it took between 10 and 80 years for a new energy efficient building to pay bay emissions caused during construction through reduced emissions in operation.

Appendix D

The Commercial Buildings Methodology Determination & the Draft Community Buildings Methodology Determination

Commercial Buildings Method.pdf

community-buildings-draft-determination.pdf

Appendix E Case Studies

Country	Site/Name	Key Features	Potential to demonstrate….	Contact/s
Australia SA	Royal Adelaide Hospital, Adelaide	Seven heritage buildings are being retained and repurposed. A creatively up-cycled building that was originally slated for demolition set to be refurbished rather than demolished because costs stack up. As part of the adaptive re-use of the first two heritage listed buildings on the old Royal Adelaide Hospital site carbon accounting is being undertaken, as the SA State Government are looking for the precinct to be NCOS carbon neutral certified at some point.	Embodied energy statistics for large scale heritage conservation and building reuse	Suzanne Ridling Silver Thomas Hanley DesignInc Colleen McDonnell Renewal SA Colleen.McDonnell@sa.gov.au Paul Davy - D^2 paul@dsquaredconsulting.com.au
	Main Assembly Building, colloquially known as 'the MAB', Tonsley, Adelaide	A five-hectare floor plate under the umbrella of the refurbished roof with other retained structural elements and the original factory floor. A variety of tenancy spaces have been developed including prefabricated, modular buildings that can be deployed in highly flexible configurations to suit a variety of uses and expanded to suit growing businesses. The MAB has abundant natural sunlight and ventilation, thanks to skylights and open 'walls' and offers public areas such as the Town Square, two 'urban forests', plus cafés and meeting places that all create collision spaces to foster serendipitous networking for collaboration and innovation. The urban forests sit under open sections of the MAB	Architects re-evaluated initial assumptions to demolish the building The project embodies 90,000 tonnes of retained carbon, equivalent to taking 25,000 cars off the road for a year. 6-Star Green Star Communities rating "It's about repurposing existing built resources and not relying on using up more of the earth's resources or releasing embodied carbon," Highlights the importance of	Woods Bagot (Milos Milutinovic), with Tridente Architects and Oxigen

		roof providing naturally shaded green spaces, while cooling the air and reducing the sun's thermal load on the roof. 2017 Urban Design Institute of Aust National Award for Excellence.	environmental rehabilitation in architectural practice. Featured in Venice Biennale 2018	
	DEWR Adelaide offices	Upgraded existing office building (c1980s?) Work done on modelling and quantifying the embodied carbon present in the existing building, and in particular the relative merits of retaining it or demolishing it in terms of life cycle environmental impact.	Environmental comparison on keeping and upgrading vs demolishing existing building	Paul Davy D^2 paul@dsquaredconsulting.com.au
	Plant 4, Bowden	Constructed in 1963 and extended a number of times over the years, the former Clipsal light manufacturing building had laid empty since 2009. Constructed at a time before air-conditioning was commonplace, the double brick façade provides great thermal mass. The saw-tooth roof and soaring ceilings flood the building with natural light and promote good air flow. The project team was determined to maintain as much of the manufacturing character as possible. Many of the building's industrial elements – such as cable trays and lifting hoists – have remained intact as design features, while other building elements have been repurposed into new staircases. Plant 4 had high thermal mass but limited insulation; it had fans and HVAC, but they weren't efficient.	5 star design as built v1, 2015 Challenge was making the building code compliant in a cost effective manner. The urban design guidelines for Bowden specify that even new buildings must respond to the industrial heritage of the area, and new residential buildings are incorporating bricks, sleepers and timber from demolished buildings in Adelaide. Each building on the 16.3 hectare site must achieve a 5 Star Green Star rating – or above. Renewal SA has raised the bar further by committing to achieve a Green Star – Communities rating for the entire precinct.	Paul Davy & Deborah Davidson D^2 paul@dsquaredconsulting.com.au Renewal SA's Manager Sustainability Project Delivery at Bowden, Andrew Bishop.

		Some of the existing building evaporative cooling systems and some ventilation has been reused, while new services include direct and indirect evaporative cooling systems, lighting, potable and recycled water supplies, metering and building management systems. A new 60kW PV array is also being installed on the roof.		
Australia NSW	Quarantine Station	Redeveloped as a hotel, 2000, in a National Park	Upgraded heritage building complex, now used as a hotel. A large number of timber buildings. Some National Parks have now been approved to accommodate carbon sequestration projects. The Quarantine Station could be investigated as the first example of an urban sequestration project in an urban National Park, given the number of timber buildings.	J Faddy
	The Beehive, Surry Hills	New office building using recycled materials and passive design – recent AIA sustainability award winner Reused 2000 roof tiles – some as a bris-soleil and some internally (eg for bookshelves) Australian Institute of Architects NSW Architecture Awards 2018: Small Project Architecture – Award Sustainable Architecture – Award Commercial Architecture – Commendation	Shows reuse of waste products for passive design benefits, conscious reduction of embodied energy in the materials of the new-build.	Luigi Roselli Architects
	Greenland, Sydney	1965 former Waterboard office building - steel	Differing anecdotes as to why steel	J Faddy

		structure kept, many storeys will be added to accommodate apartments.	structure was retained – demolition was protracted and noisy as a result (social impacts)	
	Money Box Building, Martin Place	Major Green Star refurbishment and adaptive reuse of an iconic 10 storey steel structure completed in 1916, with additional storeys added (now 19 storeys). Green Star credits as 96% of demolition and construction waste diverted from landfill. “Heritage buildings offer up great opportunities for the Green Star accreditation process, thanks to their embodied energy” (Briggs)	Achieved both a 5 Star Green Star Office Design rating and a 5 Star Green Star As Built rating	JPW & TKD Architects Grocon National Services Manager, Geoff Briggs
	39 Hunter St, Sydney	First 6 star Green Star certified heritage building. The current GBCA Green Star Design & as- built rating tool v 1.2 uses up to 4 stars (75+ points) to measure performance. The recognition of reuse of existing structures is achieved by 2 points being available for façade reuse and 2 points available for reuse of structure.	Recognition of reduction of amount of materials and waste and for heritage conservation in Green Star rating tool	Peter McKenzie Jackson Teece
	Legion House/ANZ complex	Carbon Neutral retrofit of heritage listed building with new building constructed on the site	New buildings constructed on the site allowed the retrofit of Legion House to be carbon neutral, as new buildings contain all the renewable energy infrastructure	Sarah Kalenta sarahkalenta@grocon.com.au 03 9631 8833
	Sirius building	78-apartment brutalist building (1979) Exposed off-form concrete walls and floors combined with acid-etched precast concrete	Building under threat. Ability to reuse existing structure has been demonstrated, which would avoid	Save Our Sirius http://saveoursirius.org/

		window frames, early prefabrication, high quality design and construction.	material and carbon emissions waste, and truck movements through a residential area.	
Australia WA	Engineering Pavilion Complex “building 216”, Curtin University WA - a new building	LCA assessment and embodied energy assessment	The percentage saving of GHG emissions has been estimated to be about 60% compared to the construction of a traditional building to serve the same function	Curtin University WA
Italy 2010 – 2018	M9 Museum District, Venice – Mestre	Former military institutional site. Comprises seven buildings - retains buildings including a converted 16th century convent, a 1970s office. Includes a new museum and pedestrian links to weave into existing urban fabric. Built as urban renewal to address disparity of cultural wealth between Venice and Venice Mestre.	Floors of the historic convent strengthened to increase load capacity Site is LEED Gold rated Preservation and reuse of building structures, retention of passive ventilation for convent, recycling of some historic fabric that was demolished.	Sauerbruch Hutton (architects) Venice Biennale 2018
UK	University of the Arts, Kings Cross (London) 2000 - 2011	A regeneration scheme of former railway land and structures which brought 10 buildings back into use, including listed 1852 former granaries, and generated 20 new businesses, 26,000 new jobs and 8,000 sq m of new public realm.	Developer (Argent) who reuses buildings instead of demolishing BREEAM rating of “very good”	Stanton Williams (architects)
UK Scotland	Fairfield Shipyard Drawing Offices, Glasgow	The Fairfield office building, which opened in 1890, was designed by architect John Keppie. The refurbishment created a modern office complex of 12 suites amounting to 18,000 sq ft plus 3,000 sq ft	Used baseline to determine impacts if a new building has to provide the function instead	Mark Watson, Historic Scotland

		of heritage space that will tell the story of shipbuilding in Govan.		
	Liam Muldoon (architect) Bonnington Bond, Leith (Edinburgh)	Brick and steel whisky warehouse 1908, sugar refinery and sugar warehouse c 1860s, and a stone malting, conversion to mixed use mainly residential. Although a lot of demolition in some parts, using the Mary T Watts carbon calculator (which works by calculating energy saved by not taking fabric away), it was calculated that the conversion has saved 182,830,000 MBTU (million British Thermal Units). If the building was to be demolished 116,400,000 MBTU embodied energy invested would have been wasted.	Idea of a carbon calculator that uses generic measurements eg heavy construction, providing an actual numeric assessment. 1 million BTU=1055.06 MJ	Mark Watson, Historic Scotland
	Tower Mill, Hawick	Built in 1851 for wool spinning, was derelict, now contains commercial, cafe and cinema. Extant embodied energy is 29,856,300 MBTU If it had been demolished energy taken up by demolition would have been 201,209,592 BTU New work to provide equivalent building would be 20,986,377 MBTU	New building could have been built with a lower carbon footprint than the old, but the energy in demolition would have been enormous.	Mark Watson, Historic Scotland
Ireland	Battersea Power Station Ramsay Cox & Assoc	Demo would have equalled c 150 petrol tankers. Bricks alone would have added another 250 trucks. Replacing new would increase embodied energy by as	Used system of “eco points” to assess	ICOMOS Ireland Peter Cox

		much as 40%.		
	Building 2 *Built To Last* study, 2004 The Heritage Council and Dublin City Council	4 storey plus basement terraced 18th century brick building. Refurbished as offices, as was previous use. Is a Protected Structure. Low level intervention. Ecopoints per sq m for reuse = 27.17 Ecopoints per sq m for rebuild = 33.07	Use of eco points system to determine "Environmental Impact" Not a great difference between environmental impact of building and redevelopment because embodied energy of existing structure is not counted	ICOMOS Ireland Peter Cox
Spain	Sala Beckett Theatre and Drama Centre, Barcelona	Workers cooperative built 1924, abandoned for 30 years, now theatre complex. Use of natural light in theatre inspired by ruinous state of building prior to refurbishment.	Design process commenced with environmental assessment Featured in Venice Biennale 2018	Flores and Prats (architects)
France	Bois-le-Pretre Tower – Paris - 2008-11.	Former residential tower reused for residential Rather than demolishing a 1959 apartment block on the outskirts of Paris, it was reused. Residents could decide whether to stay, occupancy of the buildings retained during works. "A sustainable project must take into consideration the impact on the environment, on the production of new structures, and obviously on people's lives." Poorly detailed c1980s façade was replaced, interior layouts altered and a new prefabricated wintergarden/balcony layer added.	"For the money needed to tear down 1 existing apartment and to build a new one, you can renovate and expand 3 to 4 existing apartments."	Druot, Lacaton & Vassal (architects)
Switzerland	St Gotthard Old Hospice- St Gotthard-Pass, 2008-2010	16th century hospice converted into a hotel, with additions including a new level. As works could only	Combined approached of prefab and heritage	Miller & Maranta (architects)

		take place during summer, and combination of fabric retention and new prefabricated elements was employed.		
Denmark	“Sorgenfrivang”, Viirum	3 x 14 storey residential blocks 1960, total gross floor area of 41,911 sq m. New roof covering , insulation, new facade elements low energy windows, new balconies, residents remained in block, new stairwells, elevators, refurbished interiors of apartments, solar, new HAVC, new electrical	Measure of embodied energy - compared reference values of refurbishment with demolition and new construction over 50 years. Example of debate as to whether you account for the environmental investment of the existing building. Explored the concept of burden sharing between first and second lifespans in LCA calculations.	Freja Nygaard Rasmussen & Harpa Birgisdottir – Danish Building Research Institute
New Zealand	Mason Bros building, Auckland, 2018	1920s warehouse turned office 5700 sq m. Full life cycle assessment , 5 star NABERS rating	Use of BIM for decisions – advanced energy and daylight analysis in design phase to determine architectural design, decision to retain large portions of original structure even though building was at the end of its serviceable life (based on LCA which determined 50% decrease in global warming potential among other environmental benefits).	Anthony Calderone Mott MacDonald GBC NZ
Finland	Finlayson Mill, Tampere	Former cotton spinning mill 1820s-1990, now shops, offices, cinemas, museums and residential Only 10% of floor area was lost in the conversion.	If it had been demolished and the new uses put in a similar new building the energy spent would drive a small car 3 times from earth to mars and back (1,595,040,880 MBTU) Keeping the remaining buildings resulted in a development 55% less costly in terms of embodied energy	Mark Watson Historic Scotland

			than if everything sheltered within the complex had been built anew.	
UK	122 to 126 Chancery Lane , London, 2012	In the late 1980's the buildings were demolished and rebuilt behind the retained listed facade to provide new office accommodation over the five upper floors. The current redevelopment includes conversion of office space into high quality dwellings whilst the existing retail and restaurant units that occupy the ground and basement floors remain in use. It makes the most of the old and the new, celebrating the heritage of the area with the Victorian façade and providing exemplary 21st century living space. BREEAM rating: Excellent (version: Domestic Refurbishment 2012) Due to the careful retention and reuse of materials, coupled with the procurement of new materials with a low environmental impact (including embodied carbon) over the full life cycle of the building, the development design has achieved 23 out of the 25 available BREEAM credits for 'Mat 01 Environmental Impact of Materials'.	The dwellings are designed to achieve carbon savings of over 30% against the notional new construction building, mainly via renewable energy, planning report says 12% will be achieved. Example of redevelopment of 1980's structures with an historic listed facade.	City of Westminster
	Coal Drops Yard in King's Cross 2018	A new major shopping district in King's Cross, repurposing two heritage rail buildings from the 1850's. Now home to stores, restaurants and cafés,. The pair of elongated Victorian coal drops are reimagined as public spaces.	Thomas Heatherwick : "We believed there was an opportunity to celebrate the heritage of the existing structures rather than destroy them."	Heatherwick Studio
Africa	Zeitz Museum of Contemporary Art (Zeitz MOCAA), , Cape Town,	The world's largest museum dedicated to contemporary art from Africa and its diaspora. The museum is housed in 9,500 sq metres of custom	Reuse of an existing building with significant constraints and embodied energy.	Heatherwick Studio Van der Merwe Miszewski

	South Africa 2017	designed space, spread over nine floors, carved out of the monumental structure of the historic Grain Silo Complex. The silo, disused since 1990, stands as a monument to the industrial past of Cape Town, at one time the tallest building in South Africa. The galleries and the atrium space at the centre of the museum have been carved from the silos' dense cellular structure of forty-two tubes that pack the building. The development includes 6,000 sq metres of exhibition space in 80 gallery spaces, a rooftop sculpture garden, state of the art storage and conservation areas, a bookshop, a restaurant, bar, and reading rooms and cultural centre.		Architects (VDMMA), Jacobs Parkers Architects, Rick Brown + Associates

Bibliography

A

Aliento, Willow (2017) “The pros and cons of building upgrade grants”' The Fifth Estate e-news, 17 August 2017
https://www.thefifthestate.com.au/innovation/commercial/the-pros-and-cons-of-building-upgrade-grants/94696 accessed 11/03/18

Aliento, Willow (2018a) “A level playing field at last for embodied carbon in goods and services”, The Fifth Estate e-news, 12 July 2018
https://www.thefifthestate.com.au/energy-lead/business-energy-lead/level-playing-field-for-embodied-carbon/ accessed 13 July 2018

Aliento, Willow (2018b) “Turning a beast of a building into a beautiful high performer”, The Fifth Estate e-news, 17 May 2018
https://www.thefifthestate.com.au/innovation/case-studies/turning-a-beast-of-a-building-into-a-beautiful-high-performer/ accessed 13 July 2018

Aliento, Willow (2018c) “WA industry in push for building upgrade finance”15 March 2018
https://www.thefifthestate.com.au/business/finance/wa-industry-in-push-for-building-upgrade-finance/ accessed 3 August 2018

Alwan, Zaid & Jones, Paul (2014) “The importance of embodied energy in carbon footprint assessment”, Structural Survey, Vol 32, Issue 1, 2014
hhttps://www.emeraldinsight.com/doi/full//10.1108/SS-01-2013-0012 accessed 1 May 2018

Athena Sustainable Materials Institute (2018) “ Who Does LCA & Why?”
http://www.athenasmi.org/resources/about-lca/who-does-lca-why/ accessed 7 July 2018

Australian Building Codes Board (2016) “Upgrading Existing Buildings Handbook”
https://www.abcb.gov.au/Resources/Publications/Education-Training/Upgrading-existing-buildings
accessed 2 March 2018

Australian Ethical (2018) https://www.australianethical.com.au/what-is-ethical-investment/
accessed 5/5/18

Australian Broadcasting Commission (2018) “Fact Check: Are carbon emissions coming down in Australia?” 10 Dec 2018
https://www.abc.net.au/news/2018-12-17/emissions-amanda-vanstone-verdict/10621820
accessed 12 Dec 2018

Australia’s Carbon Marketplace (a) (2018)
https://marketplace.carbonmarketinstitute.org/projects/credit-types/ accessed 21 April 2018

Australia's Carbon Marketplace (b) (2018) http://marketplace.carbonmarketinstitute.org/policy-landscape/ accessed 18 December 2018

Australian Securities and Investment Commission (ASIC) (2017) https://www.moneysmart.gov.au/investing/complex-investments/carbon-trading accessed 7 July 2018

Australian Securities and Investment Commission (ASIC) (2018), http://asic.gov.au/regulatory-resources/financial-services/carbon-markets/ accessed 14 April 2018

Australian Sustainable Built Environment Council (ASBEC) (2016) "Low Carbon, High Performance How buildings can make a major contribution to Australia's emissions and productivity goals", May 2016, https://www.asbec.asn.au/wordpress//wp-content/uploads/2016/05/160509-ASBEC-Low-Carbon-High-Performance-Summary-Report.pdf accessed 25 February 2018

Australian Sustainable Built Environment Council (ASBEC) (2018) "Building Code Energy Performance Trajectory Project – Final Report", http://apo.org.au/node/199346 accessed 22 September 2018

Australian Sustainable Development Guidelines Summit (2018) "Message from the Co-Chairs", 12 March 2018 http://ap-undsn.org/category/events/past-events accessed 23 April 2018

B

Balderstone, Susan (2012) "Sustainable Heritage: How does it rate?"
Historic Environment Vol 24 No2 2012

Balouktsi, Maria; Lutzkendorf, Thomas; Seo, Seongwon; Foliente, Greg; (2016a) "Embodied Energy and Global Warming Potential in Construction – Perspectives and interpretations", Central Europe Towards Sustainable Building (CESB) 2016, p 661-668

Balouktsi, Maria; Lutzkendorf, Thomas; Foliente, Greg; (2016b) "Embodied impacts in stakeholder decision-making in the construction sector", International Conference on Sustainable Built Environment, March 2016, p 458-467

Berg, Frederik & Fuglseth, Mie (2018) "Life Cycle Assessment and Historic Buildings: energy efficiency refurbishment vs new construction in Norway", Journal of Architectural Conservation 24:2, pp 152-167

Bin, Guoshu and Parker, Paul (2012) "Measuring buildings for sustainability: Comparing the initial and retrofit ecological footprint of a century home – The REEP House", Applied Energy 93 (2012), 24-32

Blair, Ross (pre 2015) “Embodied energy in a carbon market”, McKean Park Lawyers, no date but pre 2015 http://www.mckeanpark.com.au/wpcontent/uploads/2015/10/Embodiedenergyinacarbonmarket.pdf accessed 21 April 2018

BRANZ (2014) “Embodied Energy” http://www.level.org.nz/material-use/embodied-energy/
accessed 7 April 2018

Breen, Jacqueline (2018) “Call for NT climate policy as greenhouse gas emissions rise”, 22 Mar 2018 http://www.abc.net.au/news/2018-03-22/green-groups-call-for-nt-climate-policy-as-emissions-rise/9573404 accessed 5 May 2018

Boesch, Martin and Machado, Joao F “Yellowred – on reused architecture”, March 2017, La Biennale di Venezia, July 2018

Broccoli, Anthony (2018) “Earth's temperature has risen by a degree. It matters”, podcast https://www.yaleclimateconnections.org/2017/04/why-a-1-degree-temperature-rise-matters/ accessed 14 April 2018

Bullen, Peter and Love, Peter (2011) “Factors influencing the adaptive re-use of buildings” , Journal of Engineering, Design and Technology, Vol 9 Issue 1, pp32-46

Burke, Paul (2016) “Direct Action not giving us bang for our buck on climate change”, May 16, 2016 https://theconversation.com/direct-action-not-giving-us-bang-for-our-buck-on-climate-change-59308 accessed 15 April 2018

C

C40 (2017) “Focussed acceleration: A strategic approach to climate action in cities to 2030”, November 2017, McKinsey Centre for Business and Environment, https://www.c40.org/other/deadline_2020 accessed 11 March 2018

Canada Green Building Council (CGBC) (2016) “Zero Carbon Buildings Framework”, November 2016
https://www.cagbc.org/cagbcdocs/NetZero/2016_CaGBC_Zero_Carbon_Framework_Exec_Summary.pdf accessed May 2018

Carbon Farmers of Australia (2018) “Future of Carbon Trade Policy”, https://carbonfarmersofaustralia.com.au/carbon-trading/future-of-carbon-trade-policy/ accessed 7 September 2018

Carbon Market Institute, IETA and Baker McKenzie (2016) “Optimising Australia’s Position in international carbon markets”, http://carbonmarketinstitute.org/optimising-australias-position-in-international-carbon markets 2016 accessed 12 March 2018

Carbon Market Institute (2018)
http://marketplace.carbonmarketinstitute.org/participate/#offsetting accessed 7 July 2018

Carbon Market Watch (2016) "Views on rules, modalities and procedures for the mechanism established by Article 6, paragraph 4, of the Paris Agreement", September 2016 https://unfccc.int/files/parties_observers/submissions_from_observers/application/pdf/691.pdf accessed 14 April 2018

Carbon Neutral Pty Ltd (2017) https://carbonneutral.com.au/carbon-offsets/, accessed 28 April 2018

Carbon Neutral Pty Ltd (2018) https://carbonneutral.com.au/carbon-offsets/ accessed 10 December 2018

Carbon Trade Watch (2009) "Carbon Offsets Fact Sheet 2, Carbon Offsets" https://carbontradewatch.org accessed 14 January 2018

Carroon, Jean (2010) "Sustainable Preservation - Greening Existing Buildings", John Wiley & Sons

Chang, Charis (2017) "We've come up short in an important world ranking of more than 50 countries in what has been described as embarrassing", 17 Nov 2017 http://www.news.com.au/technology/environment/climate-change/australia-almost-comes-last-in-world-ranking/news-story/ded327a877298c36059c757e8387b7af accessed 14 April 2018

Chehrzad, Mohamad & Sardroud, Javad Majrouhi (2016) ""Understanding selection criteria in green building rating tools by a closer look at ten major standards, CESB Abstracts 2016, p 223-226

Chileshe, Nicolas: Zuo, Juan; Pullen, S; Zillante,G (2014) "Construction Management and a State of Zero Waste", in "Designing for Zero Waste" ed. By Lehmann, Steffen and Crocker, Robert, p284-306

Chiodo, Jennifer (2012) "What does a tonne of C02 look like" https://buildingenergy.cx-associates.com/2012/06/what-does-a-ton-of-co2-look-like accessed 10 January 2018.

ACT (2018) https://www.act.gov.au/carbon-zero-cities accessed 10 December 2018

City of Adelaide (2018) https://www.cityofadelaide.com.au/city-living/sustainable-adelaide/carbon-neutral-adelaide/carbon-neutral-adelaide-policy-and-strategy/ accessed 4 May 2018

City of Brisbane (2018) https://www.brisbane.qld.gov.au/about-council/governance-strategy/vision-strategy/reducing-brisbanes-emissions accessed 4 May 2018

City of Hobart (2018) https://www.hobartcity.com.au/Council/Strategies-and-plans/Hobarts-Climate-Change-Strategy accessed 5 May 2018

City of Melbourne website (2018) http://www.melbourne.vic.gov.au/about-council/vision-goals/eco-city/pages/zero-net-emissions-strategy.aspx accessed 28/4/18

http://www.melbourne.vic.gov.au/about-council/vision-goals/eco-city/Pages/emissions-reduction-plan.aspx accessed 4 May 2018

City of Perth (2018) https://www.perth.wa.gov.au/sites/default/files/documents/City%20of%20Perth%20Environment%20Strategy.pdf accessed 3/5/18

City of Sydney (2018) http://www.cityofsydney.nsw.gov.au/vision/towards-2030/sustainability/carbon-reduction accessed 4/5/18 and http://www.cityofsydney.nsw.gov.au/vision/towards-2030/sustainability/carbon-reduction/carbon-neutral accessed 4 May 2018

City of Vancouver (20154) "Vancouver's Energy Retrofit Strategy for existing buildings" https://vancouver.ca/files/cov/Energy-Retrofit-Strategy-for-Buildings-Presentation-for-Council-June-2014.pdf accessed 7 July 2018

Clark, David (2017) The Fifth Estate e publication, "Green Star rises to the decarbonisation challenge", 31 October 2017 https://www.thefifthestate.com.au/columns/spinifex/green-star-rises-to-the-decarbonisation-challenge/ accessed 12/02/18

Cleugh, Dr Helen (2018) "Climate Change Science and Solutions", Adapt NSW and NSW Office of Environment and Heritage Climate Leadership Conference, 15-16 March 2018

Climate Bonds Initiative (2018) https://www.climatebonds.net/market/explaining-green-bonds and https://www.climatebonds.net/resources/overview/climate-bonds-for-beginners accessed 5 May 2018

Climate Change Performance Index (2018) "Results 2018" https://www.climate-change-performance-index.org/the-climate-change-performance-index-2018 accessed 10 December 2018

Commonwealth of Australia (2018a) Clean Energy Regulator http://www.cleanenergyregulator.gov.au/OSR/ANREU/types-of-emissions-units/australian-carbon-credit-units accessed 11 March 2018

Commonwealth of Australia (2018b) Clean Energy Regulator http://www.cleanenergyregulator.gov.au/RET accessed 25 March 2018

Commonwealth of Australia (2018c) Climate Change Authority http://www.climatechangeauthority.gov.au/ accessed 14 April 2018

Commonwealth of Australia (2017d) Department of the Environment and Energy "2017 Review of Climate Change Policies", December 2017, http://www.environment.gov.au/system/files/resources/18690271-59ac-43c8-aee1-92d930141f54/files/2017-review-of-climate-change-policies.pdf accessed 15 April 2018

Commonwealth of Australia (2016e) Department of the Environment and Energy "State of the Environment 2016, Heritage: key findings" https://soe.environment.gov.au/key-findings-all accessed 4 May 2018

Commonwealth of Australia (2018f) Department of the Environment and Energy http://www.environment.gov.au/climate-change/government accessed 11 March 2018

Commonwealth of Australia (2018g) Department of the Environment and Energy https://www.environment.nsw.gov.au/business/upgrade-agreements.htm accessed 3 August 2018

Commonwealth of Australia (2018h) Department of the Environment and Energy "Making methods under the Emissions Reduction Fund" http://www.environment.gov.au/climate-change/emissions-reduction-fund/publications/erf-methods-development accessed 7 July 2018

Commonwealth of Australia (2018i) Department of the Environment and Energy "Carbon Offset Standards" http://www.environment.gov.au/climate-change/government/carbon-neutral/ncos accessed 11 March 2018

Commonwealth of Australia (2018j) Department of the Environment and Energy http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/about accessed 11 March 2018, 21 April 2018

Commonwealth of Australia (2016k) Department of the Environment and Energy "Australian National Waste Report - Final 2016" https://www.environment.gov.au/system/files/resources/d075c9bc-45b3-4ac0-a8f2-6494c7d1fa0d/files/national-waste-report-2016.pdf accessed 7 May 2018, 27 July 2018

Commonwealth of Australia (2018l) Department of the Environment and Energy "Australian National Waste Report 2018" http://www.environment.gov.au/protection/waste-resource-recovery/national-waste-reports/national-waste-report-2018 accessed 12 December 2018

Commonwealth of Australia (2018m) Department of the Environment and Energy "Emissions Reduction fund projects map"common http://www.cleanenergyregulator.gov.au/ERF/project-and-contracts-registers/interactive-map accessed 15/4/18, 12 December 2018

Commonwealth of Australia (2018n) Department of the Environment and Energy (2018) http://www.environment.gov.au/climate-change/government/carbon-neutral accessed 21/04/18

Commonwealth of Australia (2018o) Department of the Environment and Energy Community Buildings http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods/community-buildings accessed 3 June 2018

Commonwealth of Australia (2018p) Department of the Environment and Energy Commercial Buildings http://www.environment.gov.au/climate-change/government/emissions-reduction-fund/methods/commercial-building-energy-efficiency accessed 3 June 2018

Commonwealth of Australia (2018q), “Your Home” website http://yourhome.gov.au/materials/embodied-energy accessed 29 July 2018

Commonwealth of Australia (2018r) Department of the Environment and Energy, “NCOS for Buildings” http://www.environment.gov.au/climate-change/government/carbon-neutral/ncos/building accessed 5 February 2018

Corke, Clare and Moss, Steven (2018) “Green Bond Market: an Australian focus”, 5 April 2018 https://www.corrs.com.au/thinking/insights/green-bond-market-an-australian-focus/ accessed 12 May 2018

Council of Australian Governments (COAG) (2013) Business Advisory Forum “Review of Carbon Reduction and Energy Efficiency Measures”, March 2013. https://www.coag.gov.au/sites/default/files/communique/BAF-Review-Carbon-Reduction-Energy-Efficiency-Measures.pdf accessed 3 June 2017

Council of Capital Cities Lord Mayors (CCLM) (2017) “Feedback on National Carbon Offset Strategy”, https://www.lordmayors.org/?p=862 accessed 7 July 2018

D

Danish Government (2017) Advisory Board for Circular Economy “Reduce, Reuse, Recycle, Rethink” https://en.mfvm.dk/fileadmin/user_upload/MFVM/Miljoe/Cirkulaer_oekonomi/Advisory-Board-for-Circular-Economy-Report-2017-Content_Single_pages_WEB.pdf accessed August 2018

Danish Ministry of Environment and Food (2018) “National Danish strategy for a Circular Economy – State of Green” https://stateofgreen.com/en/partners/state-of-green/news/new-national-danish-strategy-for-circular-economy/ accessed 12 July 2018

Designing buildings Wiki (2018) “Embodied Energy and Carbon” www.designingbuildings.co.uk/wiki/Embodied_energy_in_construction accessed 4 May 2018

Droege, Peter (2006) “Renewable City: A Comprehensive Guide to an Urban Revolution”, John Wiley & Sons, 2006

Duffy, Aidan (2009) “Land use planning in Ireland: a lifecycle energy analysis of residential development in the Greater Dublin area”, Dublin Institute of Technology http://www.academia.edu/1430330/Land_use_planning_in_Ireland_-_a_life_cycle_energy_analysis_of_recent_residential_development_in_the_Greater_Dublin_Area accessed 27 July 2017

Dublin City and the Heritage Council (2004) “Built To Last – The Sustainable Reuse of Buildings – an action of the Dublin City Heritage Plan” http://www.dublincity.ie/sites/default/files/content/Planning/HeritageConservation/Documents/sustainable_reuse_buildings_athusaid_inbhuanaithe_foirgneamh.pdf accessed 7 September 2018

Duran, Paulina (2018) “Australia green bond market muzzled by policy uncertainty” 5 February 2018 https://www.reuters.com/article/us-australia-bonds-green/australia-green-bond-market-muzzled-by-policy-uncertainty-idUSKBN1FP0OS accessed 5/5/18

E

Edge Environment, (2018). “New Build vs Refurb – The Life Cycle answer”. https://edgeenvironment.com/new-build-vs-refurb-life-cycle-answer/ accessed 1/11/18

Elefante, Carl (2017) “Changing World, Evolving Value: A Historic Preservation Roadmap Toward 2050”, APT Bulletin – Journal of Preservation Technology 48.2.3, 2017 pp 9-12.

Energetics (2017) “Global Carbon Offset Markets Analysis” https://www.energetics.com.au/insights/knowledge-centres/carbon-offsets-information-centre/ accessed 25 February 2018

English Heritage (1997) “Sustaining the historic environment: new perspectives on the future” https://www.thenbs.com/PublicationIndex/Documents/Details?DocId=259207 accessed 25 March 2018

English Heritage website (2018) https://www.climatechangeandyourhome.org.uk/english-heritage-climate-change-your-home-sustainable-development/ accessed 22/03/18

Enker, Robert (2016) “Energy Policy for Buildings: Why Economic Interventions may be Ineffective”, Conference Paper, Central Europe Towards Sustainable Building (CESB) 2016 pp 1366-1373

European Union (2018) http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics_-_emission_inventories accessed 11/03/18

EURAC Research Institute for Renewable Energy “Energy Retrofit of Historic Buildings” http://www.eurac.edu/en/research/technologies/renewableenergy/researchfields/Pages/Energy-Retrofit-Of-Historic-Buildings.aspx accessed 11 March 2018

F

Faddy, Jennifer (2011) "Sustainable heritage....as rating tools improve the Case for Conservation could outweigh Demolition", Architecture Bulletin - Sustainable Heritage, March/April 2011

Fuertes, Pere (2017) "Embodied Energy Policies to Retain Existing Buildings", Alternate Renewable Energy Quest (Conference), February 2017 https://www.sciencedirect.com/science/article/pii/S1876610217322397 accessed 8 August 2018

G

Gardening Australia (2018), episode on ABC on 27 July 2018

Galvin, Ray & Sunikka-Blank, Minna (2013) "German retrofit policy in Context" , Green Energy and Technology Book Series, 26 July 2013, pp29-46 https://rd.springer.com/chapter/10.1007/978-1-4471-5367-2_3 accessed 5 May 2018

Garnaut, Ross (2011) "Climate Change Review 2011" http://www.garnautreview.org.au/update-2011/garnaut-review-2011/summary-garnaut-review-2011.html accessed 21 Jan 2018

Germanwatch, Climate Action Network Europe and the NewClimate Institute (2017) "The Climate Change Performance Index Report 2017" https://germanwatch.org/en/13042 accessed 11/3/18

Gilbertson & Coelho (2014) "The Natural Capital Facility A window into the "green" economy" http://www.carbontradewatch.org/downloads/publications/a-window-into-the-green-economy.pdf accessed Feb 2018

Grant, Julia (2018) "Leading the Way – Putting the Climate Leadership Declaration into Practice", Adapt NSW and NSW Office of Environment and Heritage Climate Leadership Conference, 15-16 March 2018

Grantham Institute (2016) "The Global Climate Legislation Study Summary of key trends 2016", COP22, Marrakesh, November 2016 http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2016/11/The-Global-Climate-Legislation-Study_2016-update.pdf accessed 14/4/18

Grantham Institute (2018) "Global trends in climate change legislation and litigation: 2018 snapshot", 30 April 2018 http://www.lse.ac.uk/GranthamInstitute/publication/global-trends-in-climate-change-legislation-and-litigation-2018-snapshot/ accessed 29/7/18

Green Building Council Australia (GBCA) (a) (2018) "Carbon Positive Roadmap" June 2018 https://gbca-web.s3.amazonaws.com/media/documents/carbon-positive-roadmap-discussion-paper-fa.pdf accessed 29/7/18

Green Building Council Australia (GBCA) (b) (2018) Innovation and Leadership through Green Star https://gbca-web.s3.amazonaws.com/media/documents/carbon-neutral-and-innovation-challenges-201117.pdf accessed 5 April 2018

Green Building Council Australia (GBCA) (c) (2018) Carbon Neutral press release https://new.gbca.org.au/news/gbca-media-releases/carbon-neutral-buildings-and-precincts-are-step-closer/ accessed 29/7/18

Green Building Council Australia (GBCA) (d) (2018) "Which company will achieve Australia's first carbon neutral portfolio?" https://new.gbca.org.au/news/gbca-media-releases/which-company-will-achieve-australias-first-carbon-neutral-portfolio/ accessed 27 February 2018

H

Haynes, Richard (2013) "Embodied Energy Calculations within Life Cycle Analysis of Residential Buildings", 2010 revised 2013, http://www.etoolglobal.com/wp-content/uploads/2012/10/Embodied-Energy-Paper-Richard-Haynes.pdf accessed 4 April 2018

Hammond, GP and Jones, C I (2008) "Embodied energy and carbon in construction materials", Institution of Civil Engineers, May 2008, Energy 161 Issue EN2 pp87-98

Herd, Emma (2018) "The Power of Investment to Influence Climate Action Decision", Adapt NSW and NSW Office of Environment and Heritage Climate Leadership Conference, 15-16 March 2018

Hewson, Dr John (2018) "Taking a proactive approach to carbon disclosure", Adapt NSW and NSW Office of Environment and Heritage Climate Leadership Conference, 15-16 March 2018

Historic Scotland presentation (no date) courtesy of Mark Watson

Hyder Consulting Pty Ltd (2011) "Construction and Demolition Waste Status Report" https://www.environment.gov.au/system/files/resources/.../construction-waste.docx accessed 4 Aug 2018

Huuhka, Satu (2016) "Demolished Buildings: empirical evidence on types, ages and construction materials", Central Europe Towards Sustainable Building (CESB) 2016, pp 1105-1112

I

Institute of Civil Engineers (ICE) (2018) http://ice.org.uk accessed 15 January 2018

Institution of Civil Engineers (ICE) (2015), Embodied Energy and Carbon briefing sheet, https://www.ice.org.uk/knowledge-and-resources/briefing-sheet/embodied-energy-and-carbon accessed 20/3/2018

International Council on Monuments and Sites (ICOMOS) (2017a), documents from the Coordination meeting on the United Nations Sustainable Development Goals (SDGs), February 2017

International Council on Monuments and Sites (ICOMOS) (2017b), *ICOMOS Action Plan: Cultural Heritage and Localizing (sic) the UN Sustainable Development Goals (SDGs), July 2017*

ICOMOS Ireland & Ramsey & Cox Associates (no date), "Built to Last" (Battersea Power Station), courtesy Peter Cox

Iyer-Raniga & Wong *Everlasting Shelters: Life cycle Energy assessment for heritage buildings*, Historic Environment 24, Number 2, 2012

J

Jericho, Greg (2018), "Australia's emissions are rising. It's time for this government to quit pretending" www.theguardian.com/business/grogonomics/2018/jan/09/australias-emissions-are-rising-its-time-for-this-government-to-quit-pretending 9 January 2018, accessed 17 August 2018

Jewell, Cameron (a) (2017) "How states and territories compare on climate action"**,** Fifth Esate e-newsletter**,** https://www.thefifthestate.com.au/urbanism/climate-change-news/how-states-and-territories-compare-on-climate-action, 31 Jan 2017 accessed 5/5/18

Jewell, Cameron (b) (2017) "Australia now has a official definition of carbon neutral buildings and precincts", Fifth Estate e–newsletter 10 Oct 2017 https://www.thefifthestate.com.au/business/government/australia-now-has-an-official-definition-of-carbon-neutral-buildings-and-precincts/ accessed 7 November 2018

Jeyaretnam, Terence (2018) "Creating Business and Economic Opportunity Through Climate Leadership"' Adapt NSW and NSW Office of Environment and Heritage Climate Leadership Conference, 15-16 March 2018

Judson, Ellis P, (2012) "Reconciling Environmental Performance and Heritage Significance", Historic Environment Vol 24 No 2, 2012 pp19-24

Judson, P and Iyer-Raniga, U (2010) "Reinterpreting the value of built heritage for sustainable development", Heritage 2010, Volume 1, 2010

K

Kaebernich, M (2018) "The Power of Choices – Creating Momentum for Voluntary Action", Adapt NSW and NSW Office of Environment and Heritage Climate Leadership Conference, 15-16 March 2018

Kelly, Paul (2007) "Carbon, the currency of a new world order", *The Australian* 21 March 2007

Kleeman, Fritz; Lederer, Jakob; Fellner, Johann (2015) "Buildings as an urban mine – the case study of Vienna", in Proceedings: International Workshop "Mining the Technosphere – Drivers and Barriers, Challenges and Opportunities" TU Wien Oct 2015 pp 105-108

Knaggs, Charlie (2018) personal comment

Knight Frank (2018) Sustainability Announcement (http://www.knightfrank.com.au/resources/commercial/brochure/eua-announcement(2).pdf accessed 24/4/18

Knoema, World Data Atlas (2017) https://knoema.com/atlas/Australia/CO2-emissions-per-capita accessed 5/5/18

Koziol, Michael (2017) "Big business cleared to buy foreign carbon credits", *The Sydney Morning Herald*, 20 December 2017

L

Langston, Craig; Chan, Edwin H W; Langston, Craig; Chan, Edwin H W; Yung, Esther H K "Embodied Carbon and Construction Cost Differences between Hong Kong and Melbourne Buildings", *Construction Economics and Building*, Vol 18, No 4, December 2018, pp 84-102

Lee, Johanna; Hiete, Michael; Kockler, Heike; Stengel, Julian (2016) "Increasing energy refurbishments of residential buildings via more targeted instruments", CESB Abstracts, p 63-64

Lehmann, Steffen (2014) :Sustainable building design and systems integration – Combining Energy Efficiency with material efficiency" (Ch 11) Designing for Zero Waste: Consumption, Technologies and the Built Environment ed. Steffan Lehmann and Robert Crocker, Taylor & Francis Group, 2014

Lei, M and Roders, AP (2018) "Building typology, energy efficiency and historical preservation: a literature review, Heritage 2018 – 6th International Conference on Heritage and Sustainable Development, pp 63-70

Lenzen et al (2002) cited in "Embodied Energy Considerations for existing buildings", Historic Scotland Technical Paper 13, 2011 www.historic-scotland.gov.uk/technicalpapers p17, accessed 23 March 2018.

Lloyd, Graham (2018) "Carbon Trading is the great Green Gamble", *The Weekend Australian* 9 Jan 2018 https://www.theaustralian.com.au/news/inquirer/carbon-trading-is-the-great-green-gamble/news-story/8a0b999fb59c322d4bcd0c11a28f0d81 accessed 21/04/18

Low Carbon Living Cooperative Research Centre (CRC) (2018) "Building Better Decisions", March 2018 http://www.lowcarbonlivingcrc.com.au/sites/all/files/publications_file_attachments/building_better_decisions_final_230318.pdf accessed 10 May 2018

Luciano Michael (2017) "Net-Zero Energy: What States Are Leading The Way?" 26 April 2017 https://www.wirelessdesignmag.com/blog/2017/04/net-zero-energy-what-states-are-leading-way accessed 10 July 2018

M

Martinez-Molina, Antonio; Ausina, Isabel Tort; Cho, Soolyeon; Vivancos, Jose-Luis (2016) “Energy Efficiency and Thermal Comfort in historic buildings: a review”, *Renewable and Sustainable Energy Reviews*,61:70, August 2016

Menna, Costantin;, Caruso, Maria Chiara; Asprone, Domenic, Prota, Andrea (2016) “LCA based methodological framework for comparative environmental assessment of new buildings”, Central Europe Towards Sustainable Building (CESB) 2016 pp1424-1429

Menzies, Gillian F (2011) “Embodied Energy Considerations for existing buildings”, Historic Scotland Technical Paper 13, 2011 www.historic-scotland.gov.uk/technicalpapers accessed 23 March 2018

McDowell, Clayton; Kokogiannakis, Georgios; Cooper, Paul; Tibbs, Michael (2016) “A bottom-up data collection methodology for characterising the residential building stock in Australia”, Central Europe Towards Sustainable Building (CESB) 2016, pp 221-228

Moncaster A M, Song J-Y (2012) “A comparative review of existing data and methodologies for calculating embodied energy and carbon of buildings”, International Journal of Sustainable building Technology and Urban Development , 3:1 p26-36, 2012

Murray, James (2018) “Net Zero: Government hints at 2050 target date for CCC review” Business Green 4 May 2018 https://www.businessgreen.com/bg/news-analysis/3031681/net-zero-government-hints-at-2050-target-date-for-ccc-review accessed 7 May 2018

N

National American Space Agency (NASA) (2018) Global Climate Change “Vital Signs of the Planet, A blanket around the earth” https://climate.nasa.gov/causes accessed 11 /4/18

Nature Conservation Council (2018) “Where’s the plan? NSW Government falling behind in race to repower with renewables” https://www.nature.org.au/media-releases/2018/03/where-s-the-plan-nsw-government-falling-behind-in-race-to-repower-with-renewables/ 22 March 2018 accessed 22/4/18

NSW Government (a)(2016) Office of Environment and Heritage Fact Sheet “Achieving Net Zero Emissions by 2050” (Nov 2016) https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Climate-change/achieving-net-zero-emissions-by-2050-fact-sheet-160604.pdf accessed 22 February 2018

NSW Government Office of Environment and Heritage (b)(2016) “More than 200,000 new trees for NSW national parks”, 5 May 2016 https://www.environment.nsw.gov.au/news/more-than-200000-new-trees-for-nsw-national-parks accessed 32 April 2018

NSW Government (a) (2018) Office of Environment and Heritage http://climatechange.environment.nsw.gov.au/About-climate-change-in-NSW/NSW-emissions accessed 5/5/18

NSW Government (2018b) Environmental Protection Authority "Construction Waste Reforms 2018" https://www.epa.nsw.gov.au/your-environment/waste/industrial-waste/construction-demolition/construction-and-demolition-waste accessed 4 Aug 2018

NSW Government (2018c) Office of Environment and Heritage, Heritage Division "Draft Design Guide For Heritage, 2018" http://www.environment.nsw.gov.au/research-and-publications/publications-search/better-placed-heritage-design-guide accessed 26 May 2018

New York City, NYC retrofit accelerator program https://retrofitaccelerator.cityofnewyork.us/ accessed 7 July 2018

New Zealand Green Building Council (2018) https://www.nzgbc.org.nz/Story?Action=View&Story_id=280 accessed 12 April 2018

O

P

Palutikof, Jean (2018) "New Approaches to Climate Thinking and Risk Management", Adapt NSW and NSW Office of Environment and Heritage Climate Leadership Conference, 15-16 March 2018

Pangolin Associates, http://pangolinassociates.com/sustainability_services/carbon-credits accessed 31 July 2018

Perdan, Slobodan & Azapagic, Adisa (2011) "Carbon Trading: Current schemes and future developments", Journal of Energy Policy 39, 2011, pp 6040-6054

Property Council of Australia (2018) "Australian property companies top the GRESB table again in 2018" https://www.propertycouncil.com.au/Web/Content/Media_Release/National/2018/Australian_property_companies_top_the_GRESB_table_again_in_2018.aspx accessed 15/9/18

Power, Anna (2008) "Does demolition or refurbishment of old and inefficient homes help to increase our environmental, social and economic viability?" Energy Policy, Vol 36 Issue 12 Dec 2008 https:/www.sciencedirect.com/science/article/pii/S0301421508004709 accessed 4 March 2018

Preiss, Jurgen (2017) Welcome address, ENVIBUILD 2017, Vienna

Pullen, Stephen (2007) "A Tool for Depicting the Embodied Energy or the Adelaide Urban Environment", https://www.researchgate.net/publication/242275899_A_Tool_for_Depicting_the_Embodied_Energy_of_the_Adelaide_Urban_Environment accessed 30/7/18

Pullen, Stephen & Bennetts Helen (2011) "Valuing embodied energy in the conservation of historic residential buildings", Australian Architectural Science Association, 2011 http://anzasca.net/wp-content/uploads/2014/02/31P57.pdf accessed 10 February 2018

Q

Queensland Government Department of Environment and Heritage Protection, "Global carbon offset markets analysis" https://www.qld.gov.au/environment/assets/documents/climate/global-offset-markets-analysis-report.pdf accessed 25 July 2017

R

Raimondi, Alberto & Santucci, Daniele (2016) Resistance to transformation: synthetic visual indicators to evaluate the environmental impact of building refurbishment through the use of BIM models, Central Europe Towards Sustainable Building (CESB) 2016, pp 1445-1452

Rasmussen, Freja; Nygaard & Birgisdottir, Harpa (2016) "Life Cycle environmental impacts from refurbishment projects – a case study", Central Europe Towards Sustainable Building (CESB) 2016, pp 277-284

Redden, Ruth (2018) "Valuing the Environmental Performance of Existing Buildings", Draft Conference paper

Rood, Richard B (2017) "If we stopped emitting greenhouse gases right now would we stop climate change?", *The Conversation* e-news, https://theconversation.com/if-we-stopped-emitting-greenhouse-gases-right-now-would-we-stop-climate-change-78882 2017, accessed 14/4/18

Royal Society of New Zealand (2016) "Transition to a low-carbon economy for New Zealand" April 2016, http://www.royalsociety.org.nz accessed 5 April 2018

S

Seo, Seongwon; Foliente, Greg; Zhengan, Ren (2017) "considering embodied impacts of retrofitting existing dwelling stock in Greater Melbourne", Journal of Cleaner Production 170, 2018, pp1238-1304

Sheftalovich, Zoya (2018) "Should you trust carbon offsets?" *Choice* magazine, https://www.choice.com.au/home-improvement/energy-saving/reducing-your-carbon-footprint/articles/carbon-offsets accessed 28/04/18

Slezak, Michael (2017a) “Australia's greenhouse gas emissions soar in latest figures”, *The Guardian*, 4 Aug 2017 https://www.theguardian.com/australia-news/2017/aug/04/australias-greenhouse-gas-emissions-soar-in-latest-figures accessed 5/5/18

Slezak, Michael (2017b) “Australia’s greenhouse gas emissions highest on record”, *The Guardian*, 10 December 2017 https://www.theguardian.com/environment/2017/dec/11/australias-transport-emissions-in-past-year-the-highest-on-record accessed .30/7/18

South Australian Government (2018a)http://ourenergyplan.sa.gov.au/ accessed 22/4/18

South Australian Government (2018b) http://www.climatechange.sa.gov.au/target-zero accesssed 5/5/18

South Australian Government (2018c) https://renewalsa.sa.gov.au/tonsley-to-represent-australia-at-venice-biennale/ accessed 3 June 2018

South Australian Government (2018d) “Royal Adelaide Hospital”, https://renewalsa.sa.gov.au/vision-former-royal-adelaide-hospital-site/ accessed 25/7/18

South Australian Government Department for Environment and Water (2018) “Building Upgrade Finance” https://www.environment.sa.gov.au/topics/climate-change/programs-and-initiatives/building-upgrade-finance Accessed 26 July 2018

Suckling Patrick, (2018) “Australia and the Paris Agreement”, Adapt NSW and NSW Office of Environment and Heritage Climate Leadership Conference, 15-16 March 2018

Susskind, Anne (2018) “55 Sustainable Investment options for a brave new world” Fifth Estate e-newsletter, 22 March 2018, https://www.thefifthestate.com.au/business/public-community/55-sustainable-investment-options-for-a-brave-new-world accessed 22/3/18).

Sustainability Victoria (2016), “Energy Efficient Office Buildings: Transforming the Mid-Tier Sector” www.sustainability.vic.gov.au/eeob accessed 25 July 2018

Szlalay, Zsuza; Novikova, Aleksandra; Csoknyai, Tamas; Feiler Jozef (2016) “Low Carbon Scenarios for South East Europe: Case Study of Albania”, Central Europe Towards Sustainable Building (CESB) 2016, pp 299-306

T

The 2030 Districts Network (2018) “American cities striving to be carbon neutral” http://www.2030districts.org/districts accessed 19 July 2018

The Prince’s Regeneration Trust (2010) “The Green Guide for Historic Buildings – How to improve the environmental performance of listed and historic buildings”, published by The Stationary Office

Titley, David (2017) “Why is climate change’s 2 degrees Celcius of warming limit so important?”, *The Conversation*, 22 August 2017 http://theconversation.com/why-is-climate-changes-2-degrees-celsius-of-warming-limit-so-important-82058 accessed 14/4/18

Thorpe, David (2017) “UN and IEA deliver wake-up call to the building sector”, The Fifth Estate e news, 12 December 2017, https://www.thefifthestate.com.au/urbanism/climate-change-news/un-and-iea-deliver-wake-up-call-to-the-building-sector/ accessed 12 July 2018

Tokede, O; Udawatta, N; Luther, M (2018) “Retrofitting Heritage Office Buildings in the UK: a case study”, Built Environment, Project & Asset Management Vol 8, Issue 1, pp 39-50

U

Udawatta, Nilupa; Zillante, George; Elmualim, A; Rameezdeen, Raufdeen; Zuo, Jian. (2018a).” Adaptive Reuse of Inner-City Buildings: Methods for Minimising Waste and Stimulating the Economy”. 141-152. 10.1007/978-981-10-6190-5_14. https://www.researchgate.net/publication/321916672_Adaptive_Reuse_of_Inner-City_Buildings_Methods_for_Minimising_Waste_and_Stimulating_the_Economy accessed 24/08/18

Udawatta, N; Zuo, J; Chiveralls K; Yuan, H; Zillante, G; Elmualim, A (2018 b) “Major factors impeding the implementation of waste management in Australian construction project” July 2018 Journal of Green Building 13(3):101-121 http://www.journalofgreenbuilding.com accessed 10 September 2018

United Nations Development Program (UNDP) (2018) Sustainable Development Goals http://www.undp.org/content/undp/en/home/sustainable-development-goals/background.html accessed 12 December 2018

United Nations Division for Sustainable Development Goals (DESA) (2012) “Back to Our Common Future - Sustainable Development in the 21st century (SD21) - project Summary for policymakers” https://sustainabledevelopment.un.org/content/documents/UN-DESA_Back_Common_Future_En.pdf accessed 20 January 2018

United Nations Division for Sustainable Development Goals (DESA) (2018) https://sustainabledevelopment.un.org/resources/sd21 accessed 20 January 2018

United Nations Environment Programme (UNEP) (2016) “The Emissions Gap Report 2016”: A UNEP Synthesis Report https://europa.eu/capacity4dev/unep/document/emissions-gap-report-2016-unep-synthesis-report accessed 14/4/18

United Nations Environment Programme (UNEP) (2017) “The Emissions Gap Report 2017”, A UN Environment Synthesis Report November 2017 http://wedocs.unep.org/bitstream/handle/20.500.11822/22070/EGR_2017.pdf?sequence=1&isAllowed=y accessed 20/7/18

United Nations Environment Programme (UNEP) (2018) "Global Warming of 1.5 degree Celcius – a special report" https://report.ipcc.ch/sr15/pdf/sr15_spm_final.pdf Accessed 10 December 2018

United Nations Framework Convention on Climate Change (UNFCCC) (2018) "Global Climate Action Reports" https://unfccc.int/ accessed 14/4/18

United Nations Global Compact (2018) "Global Opportunity Report 2018 https://www.unglobalcompact.org/docs/publications/Global_Opportunity_Report_2018.pdf accessed 23/3/18

V

Victorian Government (2017) Department of Environment, Land, Water and Planning, "Climate Change Act 2017 Overview – Fact Sheet" https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0022/55282/CC-Act-2017_Fact-Sheet_Overview_v2.pdf accessed11/3/18)

Victorian Government (2018) Environmental Upgrade Finance https://www.energy.vic.gov.au/energy-efficiency/environmental-upgrade-agreements accessed 3 August 2018

W

Wang, Jiayuan; Wu, Huanyu; Duan, Huabo (2017)"Combining Life Cycle Assessment and Building Information Modelling to account for carbon emission of building demolition waste: a case study", November 2017, Journal of Cleaner Production 172 https://www.sciencedirect.com/science/article/pii/S0959652617327476 accessed 12 May 2018

Ward (2014), "Breathing Life into the Corpse – Upcycling through Adaptive Re-use", in "Designing for Zero Waste: Consumption, Technologies and the Built Environment" ed. Steffan Lehmann and Robert Crocker, Taylor & Francis Group, 2014, pp246-265
Waste and Resources Action Program (WRAP), "Cutting embodied carbon in construction projects", Information Sheet (no date) www.wrap.org.uk/construction accessed 11/3/18

Watson, Mark (2016) "Rewarding the Green", Central Europe Towards Sustainable Building (CESB) 2016, pp x147

Wikipedia, 2018 www.wikepedia.org/kyotoprotocol

Wong, JPC; Iyer-Raniga, U; Sivaraman, D "Energy efficiency and environmental impacts of buildings with heritage values in Australia", Heritage and Sustainable Development, 2010.

World Green Building Council (pre 2017) "From Thousands to Billions – Coordinated Action towards 100% Net Zero Buildings by 2050" (no date, but pre 2017) https://www.worldgbc.org/sites/default/files/From%20Thousands%20To%20Billions%20WorldGBC%20report_FINAL%20issue%20310517.compressed.pdf accessed 12/5/18

World Green Building Council (2018a) “Advancing Net Zero Principles” https://worldgbc.org/advancing-net-zero accessed 28 August 2018

World Green Building Council (2018b) Introducing Level(s): A common language to understand sustainability in European buildings http://www.worldgbc.org/news-media/introducing-levels-common-language-understand-sustainability-european-buildings accessed 24/8/18

World Resources Institute (WRI) (2016) “NDCs One Year On An Overview Of G20 Countries’ Action On Reducing Greenhouse Gas Emissions” Nov 2016 http://www.wri.org/sites/default/files/uploads/NDCs_One_Year_On.pdf accessed 12/4/18

World Wildlife Fund (WWF) Germany (2008) “Making Sense of the Voluntary Carbon Market A Comparison of Carbon Offset Standards” https://sei-us.org/Publications.PDF/SEI-WWF-Comparison CarbonOffest-08.pdf accessed 4 March 2018