BENCHMARKING BUILDING EFFICIENCY

LITERATURE REVIEW

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The Red Hill Waste Management Facility Environmental Management System is certified to ISO 14001:2004 standard.

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1 INTRODUCTION

> *"If you cannot measure it, you cannot improve it."*
>
> Lord Kelvin, 1883

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Local council buildings offer a wide range of services and are often vastly different in size, form, function and age. Existing buildings can undergo performance deterioration, change in use, and unexpected faults or malfunctions over time (Ma *et al*. 2012) impacting on energy and water consumption and the effectiveness of existing abatement measures. Research also suggests many building owners and/or operators believe their buildings are more efficient than they actually are (Choi Grande *et al*. 2009).

Energy and water efficiency are valuable performance indicators, yet there is a lack of transparency of building performance in Australia (Leipziger 2013, SPR 2017). Currently, there are no comprehensive, freely available building performance datasets covering the wide variety of building assets managed by a local government, and given that buildings represent a greater than 30% share of energy consumption in the market (**Figure 1**), they present an obvious opportunity for implementation of future abatement measures.

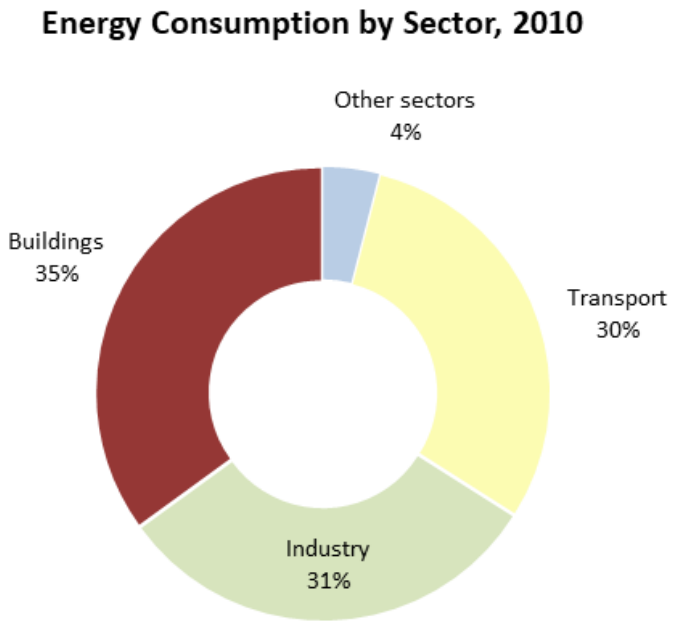

Figure 1 Energy consumption by sector, 2010 (IEA 2013). 'Other Sectors' includes agriculture, forestry, fishing and other non-specified.

2 WHAT IS BENCHMARKING?

> ***"Benchmarking and transparency policies pick up where energy and design codes leave off. After a building is constructed and enters operation."***
>
> \- (Hart 2015)

Benchmarking is a process where an organisation compares a building's energy and water consumption, waste production and/or indoor environment with those of the best performing buildings in a functional category to track and improve its own performance and work towards 'best practice'. Benchmarking can be used to identify priority buildings for energy audits and retrofits, leading to significant saving opportunities. In Western Australia, building performance information is fragmented, limited or unavailable.

Undertaking a building benchmarking assessment will:

- Establish a robust database to better understand key energy performance indicators of buildings.
- Provide evidence for the business case for efficiency investments by quantifying energy and financial savings potential.
- Measure energy and cost savings of retrofit and operation improvements and identify the most cost-effective technology retrofits.
- Support minimum energy performance standards and retrofit policies.
- Support widespread performance improvement to meet energy and carbon targets.

In a sustainable building retrofit, building performance assessment and diagnostics are used to benchmark building energy use, identify system operational problems, and find energy conservation opportunities (Ma *et al*. 2012). An individual council could perform an internal benchmarking process by simply comparing a building's performance from year to year. Trends can be identified by examining data over time, and the impact of performance-improving processes can be assessed. However this has limited value; it does not give an indication of broader community performance and assumes that some buildings in the dataset may already be performing optimally.

A more valuable approach to building benchmarking would be to conduct an external benchmarking study at a regional scale, with 5-10 buildings per functional category. External benchmarking could provide invaluable data about performance successes and/or inefficiencies and provide insight into broader community trends and abatement practices, informing future processes and investment decisions.

The EMRC is aware of a number of councils and organisations in the Perth Metropolitan Region who are undertaking, or have undertaken a process of building benchmarking. There may be opportunities to co-ordinate with these entities to share information and expand datasets for more extensive benchmarking.

3 WHY SHOULD WE BENCHMARK BUILDING PERFORMANCE?

Buildings use large amounts of energy, with significant short-term economic costs, and long-term environmental impacts. The majority of existing building stocks were built prior to the introduction of sustainability benchmarks and are energy inefficient (Alam *et al*. 2016). Improving the efficiency of buildings, particularly their use of energy, is one of the fastest and most cost-effective ways of reducing carbon emissions, improving local economic development, air quality and public health (Becque *et al*. 2016).

There are many policies and strategies at a global, national and regional scale that highlight the importance of emissions reduction (see Error! Reference source not found.) as well as considerable amount of research in academia that provides cost-benefit analysis of building retrofits. In the local context, resource use efficiency is driven by long-term strategic objectives relating to environmental conservation, sensitive use of resources, emissions reduction, the rising cost of electricity and the scarcity of water.

3.1 Rising cost of electricity

The cost of electricity in Western Australia has been steadily increasing to eventually reflect the true cost of generation and delivery to consumers. In 2016-2017 alone, there has been a 10% increase in the L1 Business Tariff, and this is set to increase further through to 2020.

3.2 Scarcity of water

The inflow into surface water reservoirs has declined as our climate continues to dry. This trend is predicted to continue into the future. Groundwater levels have declined significantly over the past 30 years as a result of multiple factors, including water abstraction, changes in land use and declining rainfall (DoW 2014).

In most areas, ground water use is being reduced to rebalance abstraction with changing rainfall. While future groundwater availability across the region is generally limited, managed aquifer recharge with treated wastewater will be increasingly used to offset additional public water supply. Water use efficiency, water sharing and alternative sources will continue to be essential to increase reliability and enable expansion (DoW 2014).

Perth currently supplements groundwater and surface water runoff with water sourced from the two desalination plants; the Southern Seawater desalination plant which supplies approximately one third of Perth's total water needs, and the Perth Seawater desalination plant in Kwinana, which produces approximately 18% of Perth's water supply needs (Water Corporation 2018). Whilst this water supply is not climate dependant, it comes at a greater cost to the consumer, which is being reflected in the rising cost of water announced in the Western Australian 2018 budget.

3.3 Emissions reduction targets

Buildings account for 40 per cent of the world's energy consumption and one third of global greenhouse gas emissions (CSIRO 2015). Australia has ratified the Paris Agreement 2015 with an unconditional commitment to reduce emissions 26-28% below 2005 levels by 2030. Global average building energy use per person since 1990 has remained constant at 5 MWh per person per year. An estimated 77% reduction in total CO_2 emissions in the buildings sector is required by 2050 to maintain global emissions reduction targets. (IEA 2013)

The IEA in their *Tracking Clean Energy Progress 2017* report identified a need for Organisation for Economic Co-operation and Development (OECD) nations, of which Australia is a member, to address energy performance of existing buildings and to rapidly expand, strengthen and enforce building energy policies.

4 BENEFITS OF BENCHMARKING

Retrofit initiatives often focus predominantly on installing more efficient equipment; however, simply installing energy efficient design elements is often not sufficient to achieve lasting energy efficiency (SBEnrc 2013). Understanding the potential optimal performance of a building, observing performance over time and comparing the building performance against other similar structures allows an organisation to identify and monitor possible inefficiencies.

The benchmarking process quantifies building performance and enables an organisation to set scientifically based, realistic targets for improvement that can be monitored and reviewed regularly.

4.1 Barriers to investing in energy efficiency

Retrofitting a building is subject to many barriers, Alam *et al.* (2016) (**Table 1**) divides these challenges into four main categories; economic, regulatory, knowledge and social barriers. Understanding of potential barriers will aid in the development of a robust communication plan for the development of a building benchmarking business case.

Governments face further challenges and scrutiny when financing retrofitting projects. Payback periods of retrofitting projects may be greater than four years and can be up to seven years. Investment in these projects increases net debt over the forward estimates period. Although the long-term benefits of building efficiency retrofitting is well understood, governments often give a higher priority to reducing the amount of net debt over the forward estimate period resulting in building retrofitting projects being seen as a cost rather than a saving (Zou *et al.* 2017).

Ideally implementing a risk assessment process as part of the retrofitting decision making process will help to identify the best option for retrofitting investment and reduce exposure to some of the risks identified above. To further aid the business case for efficient building retrofits, **Figure 2** details some of the measurable benefits, but also highlight benefits that can be difficult to quantify, and are often disregarded in the decision-making process, resulting in an underestimation of the value of a project.

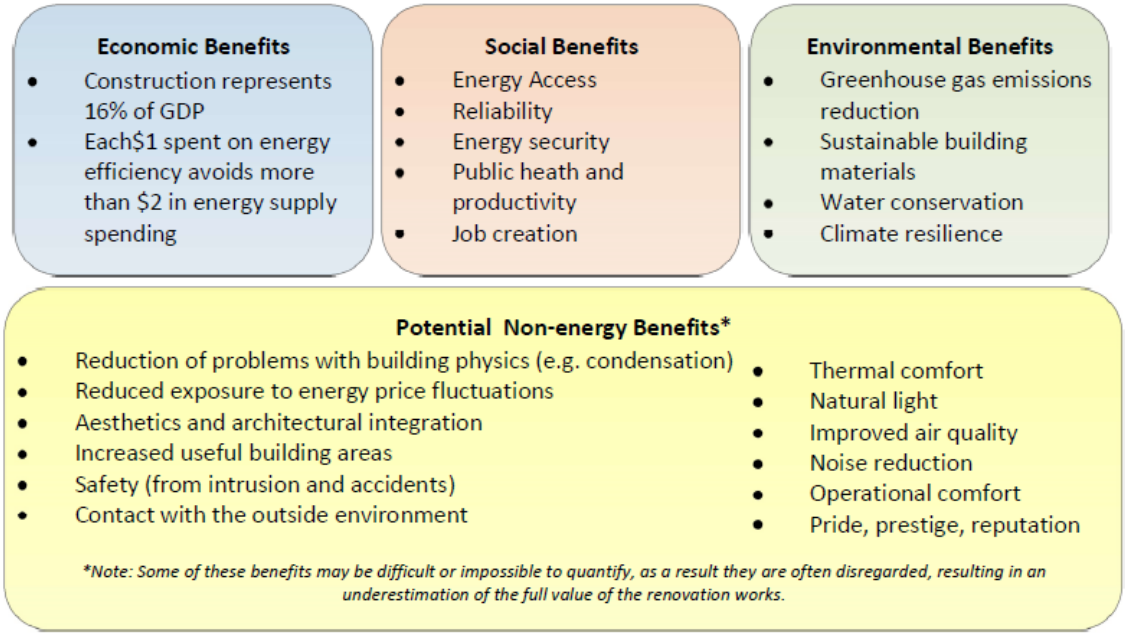

Figure 2: Possible benefits of building efficiency retrofits (Almeida *et al* 2016)

Table 1: Barriers to uptake of building energy retrofitting, Alam *et al*. 2016, Pg 2-3, Table 1

Economic Barriers	
Lack of finance	Building owners or consumers do not have access to sufficient fund for retrofitting
High upfront costs and payback expectations	Retrofitting existing buildings requires high upfront costs and the benefits accrue gradually overtime which sometimes result in longer payback period
Priorities in investments	Interested to invest the capital in higher earning investments
Price signals	Have a higher propensity to undertake energy retrofit investments, if the financial incentive associated with it is sufficiently large
Split-incentives	Not interested to retrofit when the person who would pay the cost of retrofitting would not receive the full benefit of them
Minimize cost	Cutting the funds for energy efficiency generally comes first if cost minimization is required
Uncertainties over financial gain	The difference between actual and predicted energy savings from retrofit influence cost savings and hence payback period
Lack of attention and materiality	Incremental savings from retrofitting are quite small compared to the benefits from other investments and hence less attention is given
Regulatory Barriers	
Fragmented market	In most cases, none of the involved professionals (during design, construction and operation stage) are expert in building efficiency, but the responsibility for achieving it is diffused among them which present a coordination challenge
Institutional	There is a bias among institutional investors more familiar and comfortable with supply-side investments and large-scale financing, rather than generally smaller (and “more risky”) projects on the demand side
Structural	Average age of the building stock is increasing because of a low demolition rate. Because of the age of buildings, the landlord-tenant dilemma makes it difficult to ameliorate the existing building stock
Multi-stakeholder issues	It can be very difficult to agree on energy saving investments in multi-owner buildings if the owners have to either approve a decision or make a financial contribution
Government not a strong driver	If the government demonstrates a strong commitment to policies that encourage sustainability, as well as lead by example, this can create a long-term positive impact on industry
Knowledge Barriers	
Lack of information and awareness	Sustainability is not usually understood well by owners or consumers. In some cases, they are not aware of current best practice or do not fully comprehend the effectiveness of energy efficient technologies
Awareness of savings potential	While there is a general appreciation that energy saving is a “good thing”, there remains a lack of understanding of the energy, cost and carbon savings from different measures

Knowledge Barriers	
Lack of Motivation	Some building owners are not interested in improving their buildings unless the equipment is about to break or there is a concerning high level of vacancy that is affecting rental income
Skills & knowledge related to building professionals	Skill shortages exist in both the contractor market responsible for the effective installation of energy saving measures, as well as in professional services, with few architects and designers familiar with energy efficient renovation
Confusion in choosing the best option	If two or more professionals give supposedly conflicting advice as to the best way to renovate, this may lead to scepticism amongst the consumer over the installation of energy efficient measures
Perception regarding energy efficiency	Some building owners have the perception that energy efficiency investment would not yield a return and see it as compliance and cost burden
Social Barrier	
Interruption to building operation	The usual operation of a building is interrupted when a renovation is being undertaken. In the case of deep renovation, the entire building may need to be vacated which will involve practical and financial barriers associated with re-locating the occupant for the period of the retrofit

4.2 Overcoming barriers and accelerating building efficiency

Benchmarking building performance is a process that has been widely adopted in other countries and numerous case studies highlighting barriers to change and measures to overcome these barriers have been completed. In particular, work has been conducted at the local government level to inform proposals to conduct benchmarking and performance assessments. It is important to take the opportunity to learn from past experience. **Table 2** highlights the common success factors and challenges to implementing benchmarking and energy efficiency programs at the local government level on more than 40 projects globally.

Table 2: Lessons learned from cities designing and implementing building efficiency programs or initiatives (Becque *et al.* 2016).

Success Factors	Common Challenges
Stakeholder engagement	Data accuracy – incorrect data stemming from human error
Partner support from key industry groups or utilities	Aggregated whole-building data can be difficult for building owners and managers to obtain
Buy-in and recognition from mayors and elected officials	Moving to implementation can be a big step
Flexibility in implementation (e.g. compliance can be encouraged through extended grace periods rather than issuing fines)	Staffing limitations - some cities have overcome this by pooling resources and expertise with other government departments
Targeted strategies	Tenant engagement
Well-designed linkages between regulatory and voluntary programs	Outreach and marketing may require significant effort and time to adapt to specific groups or building functions

5 AUSTRALIAN ASSESSMENT TOOLS

In Australia, two ratings tools are commonly used to assess and benchmark building performance; Green Star, a design rating tool, and the National Australian Built Environment Rating System (NABERS), a performance rating tool.

5.1 NABERS

NABERS is a nationally endorsed building rating system managed by the NSW Office of Environment and Heritage on behalf of Federal, State and Territory governments. NABERS offers a benchmarking assessment as part of their ratings process, however they offer only a limited range of building categories for assessment; offices, shopping centres, hotels, homes and data centres.

NABERS does have a number of freely available online calculators, and reverse calculators. However, they are restricted by the functional category of the building and apart from the administration buildings, local governments are unable to apply these tools.

5.2 Green Star

Green Star assesses sustainable design, construction and predicted operation of buildings. The Green Star process encourages sustainable decision-making at the design stage, predicting performance and efficiencies upon completion and operation. Green Star does not address actual performance during operation. Green Star ratings must be awarded within 24 months of the completion of a building or refurbishment.

6 REGIONAL BENCHMARKING PROJECT

Conducting a benchmarking project on a regional scale would provide invaluable insight into current building performance and popular abatement measures, whilst overcoming the difficulties of finding a freely available dataset of comparative building functions. There will also be economies of scale and reduced individual procurement costs by undertaking a regional scale project. A thorough understanding of building performance can assist local governments to:

- Measure and verify existing efficiency measures implemented and provide a gap analysis of areas where greater improvement can be made and guide future retrofitting decisions.
- Put local governments in a prime position to capture future funding opportunities as they arise, because they have proactively identified their goals and priority actions.
- Provide a cleaner environment and a more liveable city.

A regional building benchmarking process would occur in a number of stages as outlined in **Figure 3**.

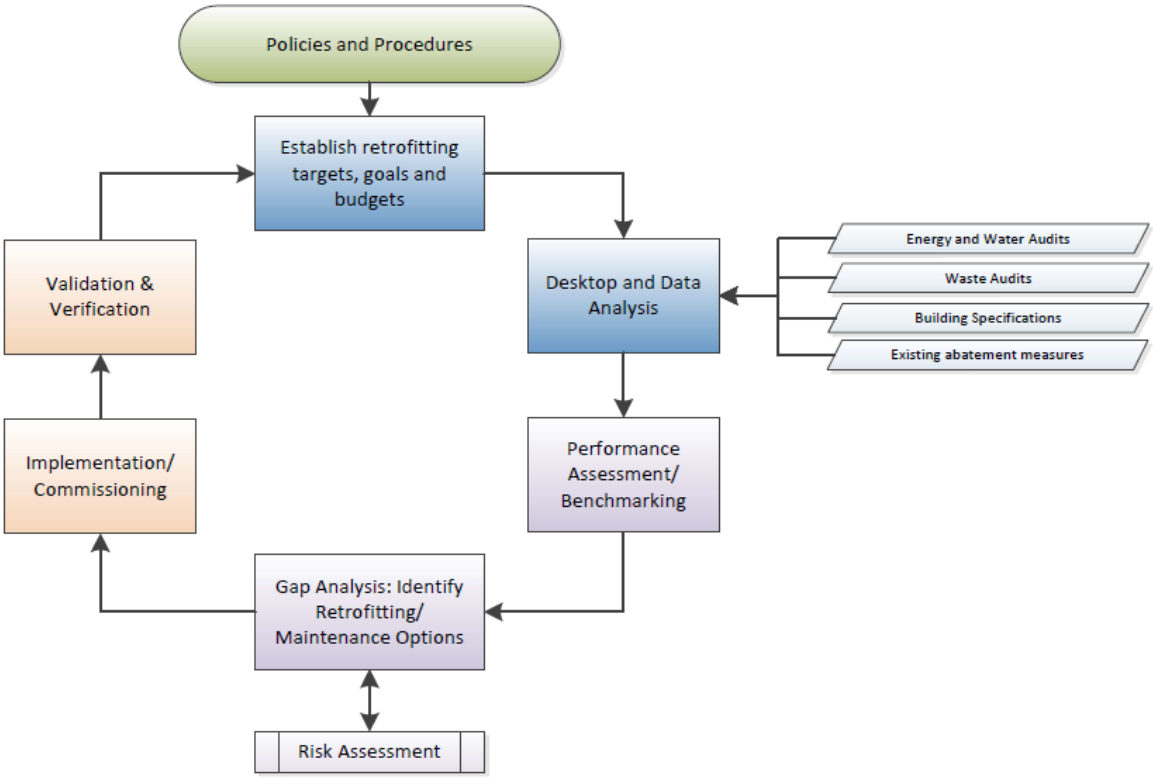

Figure 3: Proposed regional building benchmarking process

6.1 Establishing targets, goals and budgets

The first step in the benchmarking process is an analysis of existing policies and programs (including effectiveness) and assessment of key issues (barriers) impeding

uptake of efficiency measures. This stage in the process will establish the scope and scale of the benchmarking process and should result in the development of SMART targets (Specific, Measureable, Attainable, Relevant and Time-based).

6.2 Desktop and data analysis

6.2.1 Baseline building data

Understanding a council's building stock is an important step in crafting policies and programs for reducing energy consumption. An inventory of building stock will identify key building types, building age, and energy consumption. It will identify existing datasets on building characteristics and reveal how complete and comprehensive they are.

In order to conduct a benchmarking process building data needs to be compiled for statistical analysis and to normalise the data. At a minimum, the following is required:

- Building Function/Category (e.g. office, aquatic centre, hall, childcare centre), age and location.
- Hours of operation, usage data and/or occupancy rates (an office may only be operational Monday-Friday 8am-6pm).
- Floor area (this would need to be defined as either nett or gross area and would need to be consistent across all buildings).
- A list of key pieces of equipment (e.g. pool pumps, air conditioning units, number of computers).
- 12 months of electricity and water consumption data.*
- Consider 'business as usual' life-cycle costs of the building if practicable.

**A comprehensive benchmarking study would include waste management. Waste audits are a considerable extra process and cost. This has been excluded from this scope of work. The EMRC waste audtiting consultancy services if councils would like to consider this separately or at a later date.*

Lessons learned from benchmarking projects around the world have identified the time required to obtain all the necessary building baseline data to be a common challenge faced by local governments. The EMRC could offer the assistance of a Project Officer to work with the Council in-house to source and compile the data in a consistent manner across the Region.

During this stage the project team will assess the building stock available in the participating councils, identify priority targets and select a subset of buildings to be targeted for level 2 audits.

6.3 Level 2 audits

It is not financially viable to conduct level 2 audits based on AS/NZ 3598:2014 on all buildings within a local government area. At a minimum Level 2 audits would be completed on:

- aquatic centres (priced separately)
- childcare centres

- council administration facilities and depots
- high resource consuming public open spaces
- large sporting/recreation complexes
- large community centres
- large irrigation reserves
- libraries

The EMRC does not currently have a qualified auditor in-house to conduct Level 2 Audits. However the EMRC can assist participating councils to prepare scopes of work for tendering. Councils should investigate if there may be financial savings by tendering as a Region.

As part of the audit outcomes, each of the facilities would be analysed to consider retrofitting opportunities assessing financial returns including energy benefits, maintenance and carbon emission reduction benefits.

Further detail about the project process and a scope of works to undertake a regional building benchmarking project will be provided at a later date.

7 BUILDING MOMENTUM - NEXT STEPS

Benchmarking building efficiency equips local governments with the analysis and data to help develop business cases for efficient building retrofits. The comparisons and outcomes will aid team members in the development of priority buildings to target for retrofitting projects and take a strategic approach to the implementation of retrofitting programs.

Conducting the benchmarking project will be a carefully staged process, but there are tasks that can be undertaken in preparation for the kick-off of a regional project each of these activities will aid in making the process smoother and more efficient:

- Develop a short-term plan identifying current issues with buildings and other operations and what to do about them. Include energy-saving solutions wherever practicable.
- Track and evaluate success of existing energy efficient upgrades and communicate these back to leaders.
- Work to assure that comprehensive long-term savings (not just for initial cost) is factored into decision making for projects. Consider the life-cycle cost of the building/s.
- Search for influential champions who understand the value of strategic planning and/or prioritise tangential issues, like economic development.
- Be sure that energy saving is a part of the decision-making process for individual projects such as infrastructure or building improvements and development plans.

- Look for leadership in the broader community, people who are willing and able to spearhead energy planning.
- Recruit others to help keep the energy issue a focus; set up volunteer activities such as energy-saving challenges.

8 REFERENCES

AEMC – see Australia Energy Market Commission

Alam, M, Zou, PXW, Sanjayan, J, Stewart, R, Sahin, O, Bertone, E, Wilson, J 2016. *Guidelines for Building Energy Efficiency Retrofitting*. Sustainability in Public Works Conference 24-26 August 2016. http://sbenrc.com.au/app/uploads/2015/11/GuidelinesBuildingEnergyEfficiencyRetrofitting_PublicWorksConf_Patrick-Zou1.pdf. [03 July 2018].

Almeida M, Venus D, Morick O & Rodriguez-Maribona I, 2016. Renovating Buildings with Cost-Effective Reductions in Energy and Carbon Emissions – Findings from the IEA EBC Annex 56 (Webinar 08/11/2016). http://kms.energyefficiencycentre.org/elearning/renovating-buildings-cost-effective-reductions-energy-and-carbon-emissions-findings-from-iea-ebc-annex-56. [07 August 2018]

Australia Energy Market Commission (AEMC) 2017. *Residential electricity price trends report 2017*. www.aemc.gov.au. [11 July 2018]

Becque R., Mackeres E., Layke J., Aden N., Liu S., Managan K., Nesler C., Mazur-Stommen S., Petrichenko K., and Graham P. 2016. *Accelerating Building Efficiency – Eight Actions for Urban Leaders*. World Resources Institute. https://www.globalabc.org/uploads/media/default/0001/01/663799d3710192148244619bb5f309452c6f443d.pdf. [13 July 2018]

Choi Grande, H, Creyts, J, Derkach, A, Farese, P, Nyquist, S, Ostrowski, K, 2009. Unlocking Energy Efficiency in the U.S. Economy. McKinsey Global Energy and Materials. https://www.mckinsey.com/client_service/electric_power_and_natural_gas/latest_thinking/~/media/204463A4D27A419BA8D05A6C280A97DC.ashx. [23 July 2018]

CSIRO 2015. Mapping energy consumption in our cities. https://www.csiro.au/en/Research/LWF/Areas/Resilient-cities-21C/Energy-cities/Mapping-energy-use. [13 July 2018]

Commonwealth of Australia, Department of Foreign Affairs and Trade 2017. *2017 Foreign Policy White Paper*. www.fpwhitepaper.gov.au [11 July 2018]

Commonwealth of Australia, Department of Foreign Affairs and Trade, 2018. *Report on the Implementation of the Sustainable Development Goals 2018.* http://dfat.gov.au/aid/topics/development-issues/2030-agenda/Documents/sdg-voluntary-national-review.pdf. [19 June 2018]

DOE – see U.S. Department of Energy

Government of Western Australia, Department of Water (DoW) 2014. WAter resources inventory 2014 – Water availability, quality and trends. Government of Western Australia. www.water.wa.gov.au. [12 July 2018].

DFAT – see Commonwealth of Australia, Department of Foreign Affairs and Trade

DoW – see Government of Western Australia, Department of Water (Now the Department of Water and Environmental Regulation)

Green Star, https://new.gbca.org.au/green-star, Green Building Council Australia, [21 June 2018].

Hart, Z, 2015, *The Benefits of Benchmarking Building Performance.* IMT and Pacific Coast Collaborative. https://www.imt.org/resources/the-benefits-of-benchmarking-building-performance/ [06 July 2018]

IEA – see International Energy Agency

International Energy Agency. 2013. *Transition to Sustainable Buildings: Strategies and Opportunities to 2050*. https://www.iea.org/publications/freepublications/publication/Building2013_free.pdf. [29 June 2018]

International Energy Agency 2017. Tracking Clean Energy Progress 2017 excerpt *Energy Technology Perspectives 2017 Informing Energy Sector Transformations*. OECD/IEA https://www.iea.org/publications/freepublications/publication/TrackingCleanEnergyProgress2017.pdf [13 July 2018]

Leipziger, D 2013, *Comparing Building Energy Performance Measurement – A framework for international energy efficiency assessment systems*. Institute for Market Transformation. https://www.imt.org/resources/comparing-building-energy-performance-measurement/. [21 June 2018]

Ma Z, Cooper P, Daly D, Ledo L. 2012 Existing building retrofits: Methodology and state-of-the-art. Energy and Buildings. 55(12):889-902

NABERS – see National Australia Built Environment Rating System

National Australia Built Environment Rating System, https://www.nabers.gov.au, NSW Office of Environment and Heritage on behalf of Commonwealth, state and territory governments [21 June 2018].

Office of Energy Efficiency & Renewable Energy, 2013, *Designing a Benchmarking Plan*. https://www.energy.gov/eere/slsc/downloads/designing-benchmarking-plan, [25 June 2018]

SBEnrc – see Sustainable Built Environment National Research Centre

SPR – see Strategy. Policy. Research.

Strategy Policy. Research. (SPR) Pty Ltd 2017, Emissions and energy savings from potential changes to National Construction Code energy performance requirements – the Code Calculator, from http://www.energy.gov.au/sites/g/files/net3411/f/code_calculator-final_report_jun_2017_pdf_1.76mb.pdf, [03 July 2018]

Sustainable Built Environment National Research Centre 2013, *The 'Performance Nexus for Existing Commercial Buildings*. Literature review by Curtin University and the Queensland University of Technology. http://sbenrc.com.au/app/uploads/2013/10/SBEnrc-Project-1.1-Energy-Performance-Nexus-Workbook.pdf. [12 July 2017]

United States Department of Energy, 2013. Guide to Community Strategic Energy Planning. https://www.energy.gov/sites/prod/files/2014/05/f15/cesp_guide.pdf [25 July 2018]

Zou, PXW, Stewart, RA, Alam, M, Vertone, E, Sahin, O 2017, *Retrofitting public buildings for energy and water efficiency*. Sustainable Built Environment National Research Centre (SBEnrc), Melbourne, Brisbane and Perth, Australia. http://sbenrc.com.au/app/uploads/2015/11/SBEnrc-1.43-Industry-ReportWEB.pdf. [09 July 2018]