PLEA 2017 EDINBURGH
Design to Thrive

REALISING INTENTIONS: An evaluation of green building rating tools for Australian buildings

Leena Thomas[1] and PC Thomas[2]

[1] School of Architecture, Faculty of Design Architecture and Building, University of Technology Sydney, Australia; email Leena.Thomas@uts.edu.au

[2] Team Catalyst Pty Ltd, Sydney, Australia; email pcthomas@teamcatalyst.com.au

Abstract: With growing concerns for enhancing sustainability, much attention has being paid to benchmarking performance in buildings. This paper evaluates the effectiveness of three rating systems that have been widely adopted for over a decade in Australia namely: (i) mandatory compliance under Section J (Energy Efficiency provisions) in the National Construction Code of Australia (NCC), (ii) a voluntary design rating tool - Green Star, and (iii) a voluntary operational rating tool-National Australian Building Environmental Rating Scheme (NABERS). The paper builds on the authors' experience in building performance simulation, rating tool design, practice consultancy and post occupancy evaluations of buildings. It presents a detailed analysis of the rating tools with respect to the alignment between what is being assessed, how it is assessed and administered and the impact on design process and performance outcomes in buildings. The paper assesses the successes and shortcomings of the rating tools to demonstrate the potential for design and post occupancy rating tools to influence market behaviour and building performance and argues for increasingly stringent approaches to get to net zero emissions.

Keywords: rating tools, design targets, actual performance, resilience

Introduction

To meet the Paris 2C target, human greenhouse emissions need to halve each decade for the next three decades (Rockström et al 2017). The US EPA (2008) estimates that buildings are responsible for 38% of all human GHG emissions (20% residential, 18% commercial). The Intergovernmental Panel on Climate Change (IPCC, 2007) states that this sector presents the most cost effective opportunities for GHG reductions, ie., that buildings represent the low hanging fruit. This paper evaluates the effectiveness of three rating systems that have been widely adopted for over a decade in Australia namely: (i) mandatory compliance under Section J (Energy Efficiency provisions) in the National Construction Code of Australia (NCC), (ii) a voluntary design rating tool - Green Star, and (iii) a voluntary operational rating tool-National Australian Building Environmental Rating Scheme (NABERS).

Our emphasis is mainly with respect to questions of mitigation of greenhouse gas emissions and the intersection of these aspects with the ambition of resilience and thriving cities. Consequently this paper goes beyond direct questions of energy consumption in buildings to consider indoor environmental quality and location and transport effects as well as outcomes for occupants. On the other hand this paper does not extend analysis to materials, water, waste and landscape ecology dimensions of thriving cities. The paper builds on the authors' experience in building performance simulation, design, review and

application of rating tools, practice consultancy and post occupancy evaluations of buildings. It presents a detailed analysis of the selected rating tools with respect to the alignment between what is being assessed, how it is assessed and administered and the impact on design process and performance outcomes in buildings. Following an overview of the key rating tools, we present a thematic review of their successes and shortcomings.

Overview of Rating Tools

Section-J (Energy Efficiency provisions) of the National Construction Code (NCC) of Australia

These provisions cover minimum mandatory energy efficiency provisions for all buildings. The stringency limits and choice of measures for the deemed-to-satisfy (DTS) prescriptions were determined through detailed life cycle benefit cost analysis to weigh compliance costs against energy savings. This approach prioritises the efficiency of the building envelope (thermal mass, insulation, glazing and shading) given it typically outlasts changes to services and internal systems. For commercial buildings, compliance can also be achieved using energy simulation to compare with a reference building model (JV3) to give designers some flexibility in trading between different building envelope elements. In the case of residential buildings, the DTS requirements are also hard-coded into the CheNath thermal simulation program. Compliance requires all house designs to meet a minimum level of performance (unconstrained heating and cooling energy) based on the climatic location of the house.

The state of New South Wales is an interesting case in that it requires compliance with the BASIX (Building Sustainability Index) system, which goes beyond Section-J requirements for the building envelope (assessed as thermal comfort) to legislate for reductions in potable water and assess energy efficiency of installed appliances – (air-conditioning system, washing machine, hotwater) and extent of reliance on rainwater collection and on site renewable energy generation. BASIX targets for detached houses require new construction to deliver 40% reduction in potable water consumption and 40% reduction in greenhouse gas emissions compared to the state average consumption of 3,292 kg of CO_2 per person per year. Interestingly the targets for apartments were set at 25% reduction in greenhouse gas emissions as a benefit cost analysis revealed "that unit dwellings have higher per capita greenhouse emissions than houses and were therefore likely to incur significant additional costs to meet a 40% reduction in emissions" NSW Department of Planning, 2011)

Green Star

Green Star was first introduced to the Australian market in 2003 as a rating system for integrated design of office buildings. Administered by the Green Building Council of Australia, credits in different categories are totalled up achieve 4, 5 and 6 Star building design ratings. It is similar to LEED, sharing the same Intellectual Property and being one of eight national councils which helped to found the World Green Building Council. The rating tools have undergone significant evolution over the years, to encompass more building types such as educational, retail, residential and public and to improve outcomes. There are nine sustainability categories that are rated for Green Star certification: Management, IEQ, Energy, Transport, Water, Materials, Land Use and Ecology, Emissions and Innovation. Currently, there are three Green Star rating tools available, Design & As Built (to certify design & construction), Interiors (to certify interior fit-out), and Communities (to certify plans for precinct level development) that allow developers to ratify projects as they are developed and delivered for occupancy.

A fourth tool Green Star Performance (to certify operational performance), was piloted in 2015 and formally introduced in 2016. Green Star Performance aims to the close the loop on performance and allows existing buildings to be rated actual performance against targets for sustainability across similar categories to the As Built Rating tools.

The National Australian Building Environmental Rating Scheme (NABERS)

Developed in 1999 as the Australian Building Greenhouse Rating (ABGR), the scheme adopted the philosophy that the largest quantum of greenhouse emissions were produced by the existing stock of buildings in developed economies like Australia, and that operational ratings for these buildings were the most effective means of benchmarking and reducing emissions. The rating is "attribute neutral", and does not consider any design features. Inputs towards the rating process are utility bills, leased area, weekly hours of operations, and a correction for climate (postcode) to benchmark the greenhouse gas emissions (Scope 1 and 2 equivalent CO_2/m^2.annum). Subsequently NABERS added Water, Indoor Environmental Quality (IEQ) and Waste benchmarks to its rating suite. The energy and water benchmarks were extended to Shopping Centres and Hotels. Energy benchmarks were also introduced for Data Centres.

The IEQ rating is the most complex and assesses thermal comfort, air quality, acoustic comfort, lighting and office layout through physical measurements for air temperature, mean radiant temperature humidity, air speed ventilation effectiveness, indoor pollutants sound level horizontal light levels and also uses surveys to occupant satisfaction.

Outcomes of Rating Tools in Australia

The role of minimum performance requirements

Mandatory minimum performance requirements as embedded in the NCC have the best opportunity for capturing the bulk of new building stock; as it is developed or refurbished. In order to operationalise reduction of GHG – the current approach emphasises the thermal performance of the building envelope, rather than to drive innovative approaches with respect to building form, layout, alternate environmental control system or even the extent of reliance on HVAC systems for comfort, or push for an absolute target. Starting from a very low baseline in the early 2000's, the energy efficiency provisions have served to lift the thermal performance and ensure that all buildings include basic insulation, thermally efficient glazing and comply to a minimum light power density and system efficiency and have served to educate the building industry on these benefits.

Since its introduction, there have been a number of reviews (Pitt and Sherry 2016) based on revised benefit cost ratios arising from lowering of compliance costs thanks to improvements in technology and best practice standards. These included a shift from 5 star level (equivalent to a thermal energy load of 66 MJ/m2.annum for Sydney) in 2006 to a 6 star in 2010 (51 MJ/m^2.annum) for residential and an increase in building envelope stringencies for commercial buildings. Based on our experience in practice, a DTS compliant office building in Sydney is equivalent to a 4 star NABERS rating (193 $kgCO_2/m^2$ pa – whole building). However as discussed later in this paper, these levels in themselves are unlikely to lead to deep and significant cuts in greenhouse gas emissions.

In the absence of mandatory reporting of post occupancy emissions it remains difficult to gain proper accounts as to actual savings in energy and greenhouse gas emissions as a consequence of the code. Typically simulation models for compliance use idealised conditions and estimated outcomes are optimistic. Moreover isolation of the NCC regulated attributes (building envelope, installed heating and cooling systems and equipment from

other plug loads during the actual monitoring of houses is incredibly difficult. This is compounded by variation in occupancy (schedule and area) as well as occupant behaviour and appliance efficiency. Even in commercial buildings where more detailed monitoring of end uses is available, our experience suggests that the simulation conducted for purposes of compliance are rarely comparable with the reality of operation.

Incentivisation of the top end buildings through voluntary design based tools

Since its introduction in 2003, the Green Star tool has been used to rate over 1500 buildings served to embed the conversation around green buildings and sustainability within the major players of the building industry. A large number of developers and building owners use the tool to validate their flagship projects and others committing to achieve minimum 5 Star Green Star – Design & As Built ratings for all new industrial, commercial and retail projects.

The tool is also called up in the design brief of many projects and used by industry as a surrogate for ensuring design quality and environmental design. Its emphasis on the occupant comfort, well-being and broader questions of sustainability as meant that well versed good design practices such as access to views, daylight and increased access to fresh air, used of forest certified timber, low VOCs and no PVC, access to public transport are entrenched in the tool as attributes that can be rewarded with scoreable points. While the Green Star tool adopts fairly ambitious targets under all categories, it allows industry stakeholders to gain credibility for good practice measures even if the ultimate goal is not reached. For example, in the case of greenhouse gas emissions the minimum compliance is set above industry benchmarks at a 4.5 star (equivalent to 164 kg CO_2/m^2.annum in Sydney) NABERS equivalent simulated rating with rewards for progressive reduction from this baseline. However, maximum points (20/20) are only achievable for a net zero emissions. This is in contrast to tools such as Living Building Challenge, where compliance requires a pass or fail for the top level target that demands net positive energy and on energy storage for resiliency.

Incentivisation of the top end buildings through Commitment to Performance

The attribute neutral report cards offered under NABERS prioritises performance and real outcomes. In a science target hungry property market, this has caused a number of assets holders to report their historical operational performance for energy/greenhouse emissions, water consumption, IEQ and waste. Within this framework it must be said that Water and Energy have gained early and wider adoption as these are easy to assess being a single metric, whereas ratings for Indoor Environmental Quality and Waste that require measurement of multiple attributes and include aspects perceived to be intrusive such as occupant surveys are adopted only by a smaller group of buildings.

Table 1: Average reduction in energy intensity over multiple consecutive NABERS Energy star ratings for office buildings (source: NSW Office of Energy and Heritage)

Repeat number of NABERS Energy ratings	Average reduction in energy intensity
2	7%
4	16%
6	24%
8	29%

It can be argued that the requirement to ensure and maintain a minimum, monitored, operational performance for energy/GHG via NABERS, has improved the performance of the stock of office buildings impacted. Table 1 shows the impact of ongoing monitoring where, on average, office buildings captured under the NABERS scheme have been shown to reduce

energy use by 7% on their second rating and 29% by the eighth rating. It is important to note that this is not the performance improvement for a small number of non-representative top performers, but the average improvement of hundreds of buildings in the NABERS database.

The ability to benchmark their asset portfolio over a wider range of categories for sustainability is also gaining traction. The success of Green Star at the top end of the property market (http://www.architectureanddesign.com.au/news/gbca-ends-the-year-on-a-high-with-80-more-green-st) where ratings increased from 223 projects in 2015 to 401 in 2016 was attributed to a sharp uptake of the Green Star Performance tool. However at this stage, that tool is in its infancy and its impact in influencing change is not easy to assess as yet.

Policy measures that influence market behaviour and performance

Figure1 documents the take up of NABERS Energy (Greenhouse) Star ratings in Australia. There was little uptake until 2003 when the NSW State Government mandated that all their buildings were to be rated for annual performance. Further increases in uptake can be seen in 2006 and 2007 when Federal and then State Governments introduced requirements that buildings owned or leased office spaces be 4.5 stars, and again in 2010 when the Commercial Building Disclosure (CBD) Act requiring all office buildings with more than 2,000 m^2 to report their emissions at the time of lease or sale was introduced by the Commonwealth.

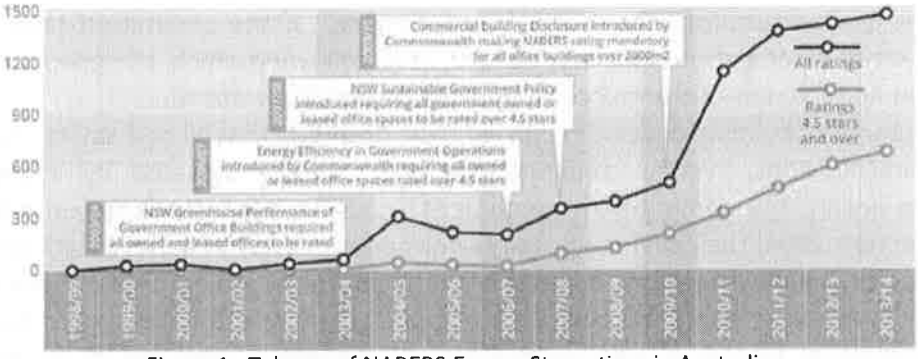

Figure 1: Take up of NABERS Energy Star ratings in Australia

Figure 1 also points to a significant increase in the number of annual ratings at 4.5 star or better after the 2010 CBD Act. This can be traced to a number of factors. The NABERS energy/GHG rating scale originally comprised 5 stars. At the inception of the scheme the top 5 star level, was expected to only ever be achieved by 5% of the target building population. However, once governments mandated a 4.5 star level performance for base buildings (landlord operation equivalent to 87 kg CO_2/m^2.annum in Sydney), industry quickly rose to the challenge. By 2010 almost every new building was committing to (and achieving) NABERS Energy 4.5 star, and more than 5% were performing at or above 5 stars (base building equivalent to 71 kg CO_2/m^2.annum in Sydney). This led to a review of NABERS Energy benchmarks (RMS and Team Catalyst, 2010) which proposed an extension to the scale to 6 or even 7 stars (net zero). A sixth star was added in 2012. Equivalent to 72 kg CO_2/m^2.annum whole building and 35 kg CO_2/m^2.annum base building in Sydney, a 6 star level is a 50% reduction in GHG emissions compared to 5 star performance. Adding a seventh star to the NABERS scale offers a readymade mechanism for zero carbon performance.

Interestingly, Federal and State governments have not reviewed their 4.5 NABERS Energy star performance criterion for the buildings they own or lease. Consequently, the 4.5 star level continues to be the de facto minimum performance standard for all office buildings greater than 2,000m^2 NLA.

Risk and responsibility driving performance, choices and outcomes

The emphasis on actual performance has resulted in a number of market behaviours.

The speculative nature of the Australian building market contributes to an industry practice that attributes and isolates responsibility for performance to different end users. To accommodate this the NABERS tools offer separate ratings for base building (landlord) and tenancy in addition to whole building ratings (base building+tenancy). However the separate ratings do not portray the full story of the building performance. In the area of IEQ for example, the base building is assessed by measurement of physical attributes of IEQ. Even though the building shell (base building) also has a significant impact on the quality of occupant experience, responsibility of occupant satisfaction ratings for IEQ is isolated only to the tenancy rating. In the case of energy, the base building ratings of many large office buildings and shopping centres do not reflect the energy use of the tenants - for instance many larger stores often run independent HVAC systems separate from the base building.

The Commitment Agreement process is an interesting mechanism established within NABERS to enable developers to market the future performance of the building before commencing construction. It requires the developer to legally commit to achieving a post construction performance target at development application stage. The developer is given a specific time period, usually 18 months after start of normal operation, to have an independent assessor confirm the level of performance. If the committed target is not achieved, a series of mitigation steps may be instigated, following which, all signed up tenants are informed and the non-conformance is reported on a public website.

In a number of building developments we have observed that all cost saving measures, alternate specifications, system configurations are carefully assessed by independent assessors to ensure the commitment agreement is not at risk. As discussed elsewhere (Thomas and Hall, 2004) the goal for a 5 star performance ensured that advanced ventilation system via solar chimneys was not deleted in the face of mid project value engineering in Building A. On the other hand, the push back of capital costs where buildings are developed only to aspirational targets is also noteworthy. In Building B, the use of an HVAC air distribution component designed to improve airflow in low load situations was initially refused by the project manager as it was thrice the cost of the standard product. This was until the electrical contractor realised that installation of this newer device would not require electrical wiring and reheat coils. At this point the displaced capital cost enabled the newer device to be incorporated to capture the GHG savings.

A large number of office buildings are delivered via a design and construct mechanism based around least cost tenders. In our practice, we have observed the risk of demonstrating the initial NABERS Energy performance as per the Commitment Agreement is increasingly being passed onto the head contractor. Legal contracts are being written around "builder retentions", where a percentage of the head contractor fees are retained by the owner/ developer until the NABERS Energy star performance is proven within a stipulated time frame.

Questions of long term resilience

The mandatory energy efficiency provisions of the NCC do not go beyond the emphasis on greenhouse gas mitigation to questions of energy sources, or reliance on energy based systems. In the past, the use of simulated performance of heating and cooling was predominantly used as a surrogate measure for the thermal energy load in residential buildings. However, the reality is that more and more residential buildings are actually resorting to air-conditioning for their heating and cooling needs - thanks to increased

expectations for standardised comfort conditions and further compounded by poor designs of apartment buildings where deep plans and poor ventilation make buildings uncomfortable fairly quickly. This situation is further exacerbated during heat waves such as the recent hottest summer of 2016-2017 which resulted in city wide shortages of pedestal fans and air-conditioning units for sale. These aspects further emphasise the need for higher stringency within existing mandatory measures but also highlight the need to ensure aspects such as natural ventilation and passive operability continue to be maintained in residential buildings.

Another area that needs to be tackled is the manner in which the metric for efficiency emphasises unit area meter is masking the total consumption or the consumption per capita of many of these houses (see Thomas and Thomas, 2001) – especially as the average Australia house at over 200m^2 or 90m^2/person is one of the largest in the world (Wilson, 2014).

In the context of increased potential for energy brownouts and blackouts in the face of extreme weather events and grid stress, measures such as switching off non-essential loads, and/or relaxing comfort tolerances and further attention to on-site generation and storage becomes crucial in both residential and non-residential buildings. Some of these aspects fold into requirements for a Climate Change Adaptation Plan that gains credits under Green Star. While this paper tackles the measures at building level, the opportunities for precinct wide strategies in this respect are gaining attention through tools such as Green Star Communities.

Most non-residential buildings are designed to very narrow temperature conditions (20-24°C) which reinforces the assumption of year round air-conditioning. Under normal conditions, targets for 4.5 and 5 star performance are routinely achieved using energy efficient buildings that are sealed and air-conditioned all year round. Under current rating tools, moving performance of such buildings towards zero carbon could be achieved through a techno-centric focus through huge arrays of PV panels. However a more cost effective and arguably resilient approach could come from a philosophical shift to building comfort that questions standard reliance on year round air-conditioning, and seeks to reinstate mixed mode conditioning through spatial and temporal diversity in buildings (Thomas, 2107).

Conclusions – A regulatory pathway towards zero carbon

As discussed in this paper, Australia has seen a number of effective regulatory and voluntary initiatives to improve the sustainability of buildings with particular emphasis to mitigate greenhouse gas emissions in the past decade. These tools have been primarily developed to influence and work with market forces, and have brought these questions to the front and centre of building practice. The findings above demonstrate the value of setting aspirational targets within Green Star and the value of setting operational targets that are annually assessed under the Commitment Agreement protocols of NABERS to shift the performance of the office building sector. Furthermore as discussed, the use of design ratings and commitment agreements have encouraged the market to mature and rise to the challenge and actually deliver buildings to meet ambitious targets.

However in terms of new buildings, the only regulatory framework that covers GHG of ALL buildings is the NCC. We argue that currently the NCC is not stringent enough and remains a market oriented framework where planetary costs are not driving the stringency limits. In contrast, if we consider these from the perspective of keeping Australia's commitments to get to no more than 2 degree global warming by 2050, as discussed above, we need to halve our emissions every decade and get to zero carbon in three decades (Rockström et al, 2017). While this is in keeping with the commitments of three of the states (NSW Victoria and South Australia), in the country, buildings will need to play their part.

In the case of new commercial buildings we contend that the mandatory target for all buildings (not just government owned or leased) would need to rise from 4.5 star NABERS to 5 star in the next decade and then to the 6 star level in the following decade and zero carbon in the decade after. Such deep cuts and commitments to actual performance would need to extend beyond office buildings to include retail, industrial buildings, and mandate whole building ratings rather than only base-building or tenancy ratings to ensure no potentials for mitigating GHG are lost. The relatively lenient energy targets in the residential sector must also shift towards zero carbon emissions by 2050 especially in multi residential apartment buildings, given the increase in the construction of apartment buildings coupled with the concerns for resilience of such buildings as discussed above. Similar to commercial buildings, these should include some mechanism for commitment operational performance between the developer/contractor and tenant association.

The bulk of the buildings that will exist in 2050 are already with us. Increasing heatwaves are causing a sharp uptake of air-conditioning over summer and exacerbating energy use in these existing buildings - an aspect that is completely escaping the attention of the building monitoring or regulations in place. Based on the success of the building disclosure in office buildings (CBD), we recommend that similar schemes to reveal and document actual performance need to be mandated for all existing building types, in conjunction with incentives to retrofit and improve performance.

The regulatory frameworks and ratings tools in Australia offer the necessary mechanisms to bring about the change. That said, increased stringencies and significantly more ambitious targets and a commitment to performance rating is required to ensure buildings play their role in meeting the Paris 2C GHG emission reduction targets.

References

Rockström J., Gaffney O., Rogelj J., Meinshausen M., Nakicenovic N., Schellnhuber H.J., Science, A roadmap to rapid decarbonisation, 24 Mar 2017, Vol. 355, Issue 6331, pp. 1269-1271

U.S. EPA. 2008, Inventory of U.S. Greenhouse Gases Emissions and Sinks: 1990-2006, p. ES8.

ABCB (Australian Building Codes Board) 2016, National Construction Code (NCC) Vol 1, Section-J Energy Efficiency, and Vol 2, Section 2, Part 2.6; (downloadable at http://www.abcb.gov.au/Resources/NCC)

IPCC 2007. Climate Change 2007 Synthesis Report, p. 59.

GBCA (Green Building Council of Australia), Green Star Ratings, gbca.org.au/green-star/

OEH (NSW Office of Environment and Heritage), nabers.com.au

NSW Planning and Environment, 2004, BASIX, Building Sustainability Index, www.planningportal.nsw.gov.au/planning-tools/basix

Pitt & Sherry, 10 May 2016, Pathway to 2020 for Increased Stringency in New Building Energy Efficiency Standards: Benefit Cost Analysis: Commercial Buildings: 2016 Update

Thomas, L.E. & Hall, M.R. 2004, 'Implementing ESD in Architectural Practice - An investigation of effective design Strategies and Environmental Outcomes', Proc. PLEA Conference, Technische Universiteit Eindhoven, Netherlands, pp. 415-420.

Thomas, L.E. 2017, 'Combating overheating: mixed-mode conditioning for workplace comfort', Building Research and Information, vol. 45, no. 1-2, pp. 176-194.

Thomas, P.C., Venkatesan, A. & Thomas, L.E. 2014, 'Effective natural ventilation in modern apartment buildings', Proc. 30th International PLEA Conference, CEPT UNIVERSITY PRESS, Ahmedabad, India, pp. 353-360.

Thomas, L.E. and Thomas PC 2000, 'A Study of an Energy Consumption Index Normalised for Area in House Energy Rating Schemes', 38th Annual Conference of the Australian and New Zealand Solar Energy Society

Resource Management Solutions and Team Catalyst, 2008, Review of Benchmarks, Australian Building Greenhouse Rating, for NSW Dept of Environment and Climate Change

Wilson, L. How big is a house? Average house size by country, shrinkthatfootprint.com/how-big-is-a-house#wXGCmEpDXBfdlb4s.99