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Residential building sustainability rating tools in Australia

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Cover image. Jacob & Jade's House Renovation, ACT, by Cooee Architecture provides a case study in optimising the thermal improvement opportunities for the project (Image: Ben King)

Abstract

The residential building sector is a significant contributor to carbon footprint and climate change. This is primarily due to operational energy consumption derived from fossil fuels, and the impact of embodied carbon in materials that are used in construction and maintenance during a building's life cycle. In the context of transitioning to a low or zero-carbon housing future, building rating tools will play a critical role in improving the environmental performance of new and existing housing. This note examines key residential rating tools relevant to the Australian context, including some international tools. It aims to provide design practitioners with an understanding of these tools, including considerations to identify where best to apply them in the design process. This note updates information from earlier articles (Iyer-Raniga et al. 2007; Iyer-Raniga et al. 2014).

A case study written by Sarah Lebner, Cooee Architecture, is included in Appendix B of the note to highlight how project optimisation was applied to a house renovation.

Introduction

The residential building sector globally accounts for 19% of worldwide energy consumption and 17% of energy-related greenhouse gas emissions (IEA 2020, 2021). The sector also consumes up to 50% of all raw and recycled materials with the total amount of material consumption expected to increase over coming years (Marinova et al. 2020). In Australia, the residential sector consumes 26% of the nation's energy (House Energy 2023) and emits 12% of total carbon emissions (Australian Government 2023). Building construction is responsible for 1% of national energy and water consumption (Soonsawad et al. 2022). Transitioning to a low-carbon future and achieving net-zero emissions as set nationally by 2050 requires significant action and improvement from the residential building sector. Residential rating tools will play a critical role in achieving this outcome.

This note examines key residential rating tools to provide practitioners with an understanding of their operation, including ways to identify the most suitable application in different project scenarios. The first section introduces residential rating tools. The note then examines the tools on the Australian market, followed by an overview of key tools aligned internationally. Finally, a comparative summary is provided so that design practitioners can easily determine which tool is the most appropriate for their location, assessment type and requirements.

Rating tools: an overview

Rating tools are important for allowing residential design practitioners to systematically quantify and optimise the environmental performance of housing in terms of materials, technology, design and occupancy outcomes.

There have been significant improvements in the environmental performance of new residential stock, and to a lesser degree the existing housing stock, in many developed countries over recent decades. Several jurisdictions currently have policy requirements that new housing is required to achieve a zero (or near zero) emission performance outcome. For example, the European Union has, since 2021, required that all new dwellings achieve a near-zero energy performance standard (European Commission 2021).

Low-emission residential standards require a departure from typical minimum performance regulations, which have focused primarily on addressing heating and cooling energy requirements (Moore & Holdsworth 2019). Beyond reductions in energy use, sustainability considerations include renewable energy technologies, water efficiency, water conservation, and the selection and use of materials from both a performance perspective and their embodied carbon impact.

A range of residential rating tools are available to assist decision making and assessment at various stages of the design process, including planning, construction and post-occupancy as well as for various building aspects such as materials, operational energy use and whole-of-building performance (Iyer-Raniga & Wasiluk 2007, Iyer-Raniga et al. 2014). Building rating tools use complex calculation engines to interpret building characteristics into scientific scenarios which subsequently provide predicted environmental performance and impacts. Some tools can be used in the design process to estimate the (comparative) performance of a building based on a set of occupancy assumptions, usually set as a baseline from the National Construction Code (NCC). Other tools measure the actual performance of the building (and its use) during occupancy. Some tools can do both. Software operators can simulate performance based on regulatory standards, stipulated or voluntary, thereby encouraging the industry to move beyond minimum benchmarks (Doyon & Moore 2020). Several local councils stipulate additional tools for new buildings (including housing) for environmentally sustainable design planning such as BESS, FirstRate5 and NABERS required by City of Bendigo and City of Yarra (City of Bendigo 2023, City of Yarra 2023).

Typically, tools that predict performance are used for demonstrating compliance with, or exceeding, minimum regulatory requirements. The measured performance of buildings is generally found in voluntary assessment tools. Parameters typically covered within the tools to generate a residential sustainability rating include:

- greenhouse gas emissions
- annual thermal temperature performance
- energy consumption, generation and storage
- water consumption
- water-sensitive design
- waste reduction
- transportation elements
- material impacts
- biodiversity
- indoor environment quality, and occupant health and productivity
- building management system.

The next section discusses commonly used Australian and key international residential rating tools.

Australian rating tools

Nationwide House Energy Rating Scheme (NatHERS)

From 2023, most states and territories in Australia will raise the minimum mandatory performance requirements in the National Construction Code (NCC) from 6 star to 7 star (out of ten) for new housing and significant renovations as assessed under the Nationwide House Energy Rating Scheme (NatHERS). However, not all states and territories are introducing NCC 2022 energy efficiency requirements and transition arrangements apply for some requirements. Refer NCC 2022 state and territory adoption dates for more information on your jurisdiction (ABCB 2023). To align with these changes, NatHERS has been updated in the following key areas:

- **Climate files:** used to best represent median weather conditions in a multiple-year period, the climate files have been updated with more recent and accurate weather data. The historical weather data was from 1960s to 2004; the updated weather data is from 1990 to 2015 and covers nine climate zones. Future climate files for 2030 and 2050 have been developed by CSIRO to reflect climate change. Refer Case study resources for download link to these files.
- **Star bands:** the star bands have been revised based on new climate files.
- **New heating and cooling load limits:** the new load limits are provided in NCC 2022 and differ from those released in August 2021. These limits are for new 7 star stringency in NatHERS star bands. They differ for Class 1 and Class 2, as well as between floor types (concrete slab on ground and suspended floors).
- **Thermal bridging:** change in the inclusion of thermal bridging when calculating R-values will make the prediction of thermal resistance of the building envelope more accurate as per new NCC 2022 requirements. Thermal bridging is 'the heat movement across an object with a higher thermal conductivity than the materials around it' (NatHERS 2022).
- **Whole of Home energy ratings:** have been introduced to assess 'the energy performance of appliances such as hot water, heating and cooling, pool and spa pumps as well as solar energy generated onsite and battery storage' (NatHERS 2022). This is to encourage the use of more efficient appliances to achieve energy savings and home comfort (see Figure 1).

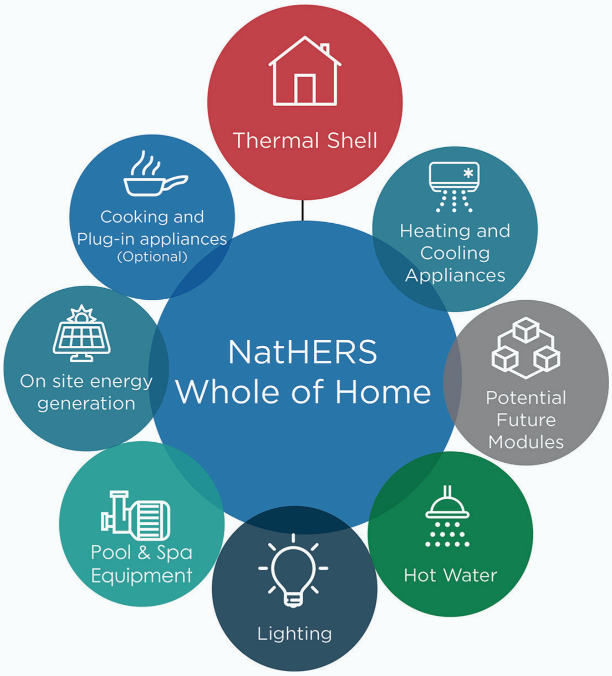

Figure 1. Energy performance of various aspects in Whole of Home (Source: Australian Government 2020, © Commonwealth of Australia, 2022. Your Home is licensed under CC BY 4.0.)

There are two main types of residential building rating tools: thermal (or energy) rating tools and Environmentally Sustainable Design (ESD) rating tools. Key Australian building rating tools are examined in these two themes.

Thermal rating tools

- AccuRate Home (Benchmark tool)
- BERS Pro
- FirstRate5
- HERO

AccuRate Home (which supersedes AccuRate Sustainability), BERS Pro, FirstRate5 and HERO are simulation tools for modelling the thermal performance of a building enclosure. These rating tools can be used to optimise design and meet, or exceed, code compliance as accredited by NatHERS. NatHERS recognises this suite of tools as part of the Australian Government's actions to regulate energy and resource use in the residential building sector. All tools are now required to be operated with inputs aligning to the NCC 2022 changes. For residential building designers to meet the NCC, they must use software modelling to estimate the building fabric thermal performance of their design or demonstrate Deemed-to-Satisfy (prescriptive) criteria.

ESD rating tools

- BASIX
- BESS
- eTool
- Green Star
- NABERS apartment buildings
- Residential Efficiency Scorecard

The above tools address energy performance and wider parameters including water performance and environmental impacts from material selection. They are generally voluntary but some jurisdictions may make them mandatory. It is worth noting that local jurisdictions may have their own tools. The key observations are summarised below and in Appendix A.

Thermal rating tools

The following thermal rating tools can be used to demonstrate compliance with the NCC and to test different design, material and technology considerations on overall performance. This helps optimise outcomes before certification.

AccuRate Home (Benchmark tool)

AccuRate Home (which replaces AccuRate Sustainability) is developed for the Whole of Home assessment and ratings as part of the expansion of NatHERS. The consultation version of this tool was released in March 2021 by CSIRO. AccuRate Home is used to assess and rate thermal performance, home appliances and energy generation, as aligned with the requirements of NCC 2022 energy efficiency requirements. It supports computation of the annual energy use of a home, solar PV generation, battery storage, and electricity imports and exports. It includes the energy from key appliances such as heating and cooling appliances, hot water systems, swimming pool and spa pumps, lighting, onsite photovoltaic (PV) and battery systems as well as non-regulated plug-in appliances and cooking loads. AccuRate Home provides the rating based on the energy value of the home and can be used to generate NatHERS certificates. AccuRate Home provides the benchmark for accrediting other NatHERS software to meet the requirements under the NCC. Other software packages must provide results consistent with AccuRate Home.

BERS Pro

BERS (Building Energy Rating Scheme) Pro was developed by Solar Logic and is a thermal rating tool similar to AccuRate Home and FirstRate5. This tool uses the same calculation engine as AccuRate Home. In addition to regulatory building code compliance, BERS Pro can be used to optimise the thermal performance of dwellings. When used for energy audits, BERS can provide outcomes in terms of carbon emissions. The software can be used to demonstrate compliance with the NCC. BERS' graphical user interface makes it possible to input floor plans by tracing building geometry, making the process of assessment much quicker. BERS Pro models predicted heating and cooling energy performance based on standard assumptions of occupant use. Refer Appendix B for a project renovation case study highlighting how thermal improvement opportunities were optimised using BERS Pro 4.3.

FirstRate5

FirstRate5 was developed by Sustainability Victoria (Sustainability Victoria 2017) and is Victoria's leading residential building fabric thermal performance simulation tool. FirstRate5 models the energy efficiency of new and existing dwellings. A key difference between AccuRate Home and FirstRate5 is the latter's graphical user interface, which allows the building floor plan to be traced. This makes the building geometry data input process significantly quicker. The software uses the Chenath calculation engine, developed by CSIRO, to generate ratings. All assessments must be undertaken by a NatHERS assessor for a building application. NSW and ACT require an accredited assessor while other jurisdictions highly recommend it. The software is designed to provide tips, making the process of rating easier. As with AccuRate Home, FirstRate5 models predicted heating and cooling energy use based on standard assumptions of occupant use.

HERO

HERO (Home Energy Rating & Optimisation) is a recently developed NatHERS accredited software. It was developed by an ESD engineer and aims to be a next-generation modelling tool that can be used both to demonstrate NCC compliance and optimise dwelling design. The software can be used for single residential buildings (Class 1a) and apartments (Class 2). The software was built to improve input time and automation of outputs. Future versions aim to include cost-benefit analysis and integration with other design software (eg CAD). The HERO development team argues this software addresses limitations in the aforementioned thermal rating tools.

ESD rating tools

Building Sustainability Index (BASIX)

BASIX is a sustainable planning measure developed by NSW's Department of Infrastructure, Planning and Natural Resources and launched in 2004. This tool requires up to a 40% reduction in potable water consumption and between 10 to 50% operational energy savings benchmarked against average per capita data from NSW households. Following previous updates, an increase to the BASIX standards takes effect on 1 October 2023. This will include increased stringency to BASIX thermal performance and energy standards to align with the NCC 2022 7 star provisions, except in the north coast climate zone and apartment buildings up to five storeys. The NatHERS whole-of-home calculation will also be incorporated to align with the NCC 2022 (NSW Government nd). In NSW, all new residential dwellings and alterations or additions to dwellings of $50,000 or more must use this tool as part of the development application process.

BASIX uses the NatHERS simulation tools to assess building fabric thermal performance. BASIX is a free, accessible internet-based tool. As with the NatHERS tool, the user enters data relating to the house or unit design including location, size and building materials. BASIX analyses this data and determines how it scores against the energy and water targets. The design must pass specific targets, which vary according to location and building type, before the user can achieve a BASIX certificate. A BASIX rating is required to meet planning and building permit approvals in NSW. From 1 October 2023, the BASIX Materials Index will be used to report embodied emissions for residential buildings where the State Environmental Planning Policy (Sustainable Buildings) SEPP 2022 is required (NSW Government 2023).

BESS

BESS (Built Environment Sustainability Scorecard) is an assessment tool created by local governments in Victoria (BESS 2022). It can be used as part of the planning permit application process and to improve design and performance outcomes of housing. The tool was launched in 2015 and is currently used in 29 Victorian councils. The tool is free to use for planning permit applicants and includes the following criteria: management, water, energy, stormwater, IEQ, transport, waste, urban ecology and innovation.

A project receives a score for each criterion depending on how well it compares to best practice. The BESS overall score is determined by the category scores, factoring in the weighting of each category. 'Best practice' is defined within BESS as an overall score of 50% or higher while 'Excellence' is defined within BESS as an overall score of 70% or higher. There are four mandatory categories where minimum scores must be achieved: water (50%), energy (50%), stormwater (100%) and IEQ (50%).

eTool

Developed by two engineers in 2010, eTool uses a scientifically rigorous methodology of life cycle assessment (LCA), the international standard for measuring sustainability in buildings (Infrastructure Sustainability Council 2022). Rather than operating as a rating system, eTool aims to be a more holistic design tool than those previously discussed by providing an assessment over the full life cycle of a building (that is, construction, operation and end-of-life phases). To assess operational energy, it accepts input data from thermal energy modelling, ie from NatHERS tools. eTool outputs summarise the building's environmental and cost performance in absolute and comparative terms against an applicable benchmark. The software is aligned with international standards for assessing the environmental performance of the built form (EN15978 and ISO14044) and the tool is now integrated with other rating tools, including Green Star. It facilitates the implementation of a more holistic approach because it provides a wider range of 'useful' metrics (such as life cycle impacts from materials) and attempts to reduce environmental impacts across the whole building for the whole of its life. eTool includes four ratings of Bronze, Silver, Gold and Platinum.

Green Star

Green Star was developed by the Green Building Council of Australia (GBCA) and launched in 2003 (GBCA 2022). Green Star is a voluntary set of tools that evaluates the design, construction and operation of buildings and communities. More than 3600 projects have been certified to date, most of which are non-residential buildings. There are three tools that are relevant for residential development: Green Star Buildings, Green Star Communities and Green Star Homes. Green Star Buildings can be applied for all building types seeking to address key issues of climate action, resource efficiency and health and wellbeing.

Green Star Communities features five environmental impact categories: governance, liveability, economic prosperity, environment and innovation. Green Star Homes is designed for volume home builders and includes three categories: positive, health and resilient. Within each category are several credits. Points are awarded based on how a credit is addressed, and a total score is calculated. This score is then adjusted based on building type and climate zone. Table 1 shows the three certification outcomes possible for Green Star.

Rating	Point Score	Rating description
4 Star	45 – 59	Best Practice
5 Star	60 – 74	Australian Excellence
6 Star	75+	World Leadership

Table 1. Certification outcomes for Green Star Communities

NABERS Apartment Buildings

NABERS (National Australian Built Environment Rating System) was first launched in NSW in 1998. It was adopted in 2006 as the national approach to achieving minimum energy efficiency performance standards in the commercial sector. It is developed and managed by the NSW Office of Environment and Heritage. For residential projects, NABERS apartment buildings quantify the building's energy and water performance. The building is rated from one to six stars based on the energy use of shared services such as car parks, lobbies and gymnasiums. The water rating can include shared water use only or all water use, depending on the performance and metering. The outcome is a star rating based on a comparison with other buildings, not a percentage of points achieved. The scale of star ratings is provided in Table 2.

Rating	Rating description
1 Star	Making a start
2 Star	Below average performance
3 Star	Average performance
4 Star	Good Performance
5 Star	Excellent performance
6 Star	Market leading performance

Table 2. Certification outcomes for NABERS

Residential Efficiency Scorecard

The Residential Efficiency Scorecard was launched by the Victorian Government in 2017 and is now nationally available. The Scorecard aims to provide an in-depth understanding of energy performance and tailored recommendations to improve performance outcomes of existing housing (Victorian Government 2022). The rating is assessed based on the design and technology characteristics of the dwelling, the average energy cost to run a house per year, rating a house for performance and comfort (in both cold and hot weather). The Scorecard uses a rating scale from 1 (worst) to 10 (best) stars. Several factors are assessed including 'room sizes, window types, construction materials, insulation, hot water system, heating, cooling, lighting and other significant energy users in the house' (Certified Energy 2022). Recommendations for energy efficiency and cost savings are developed based on the comparison of energy use with similar homes.

International tools

International tools have influenced Australian rating tools and are examined here in the context of their influence in the Australian residential sector. The following international tools are discussed:

- BREEAM
- LEED
- Living Building Challenge (LBC)
- Passivhaus

BREEAM

BREEAM (Building Research Establishment Environmental Assessment Method), developed by the Building Research Establishment (BRE) in the UK, was the first tool launched in 1990. Since then, more than 550,000 buildings across more than 50 countries have been certified by accredited assessors, making it the most used sustainable building rating tool in the world (BRE 2022a). BREEAM allows owners, occupiers, property agents, building managers and designers of buildings to review and improve environmental performance throughout the design, construction and life of a building. BREEAM currently has a suite of six tools, three of which can be used for residential projects (see Table 3).

BREEAM Rating Tool	Project development phase	Assessment type
BREEAM UK New Construction V6 (2022)	Design and post-construction	New non-domestic buildings
BREEAM In-Use	Building occupation and management	Existing buildings in operation
BREEAM Refurbishment and Fit-out	Design and post-construction	Refurbishment and fit-out for domestic and non-domestic building fit-outs and refurbishments

Table 3. BREEAM rating tools by project development phase as assessment type (Source: BRE 2022b)

This rating system consists of an overall score derived from environmental ratings. The environmental ratings are in turn derived from the percentage of credits achieved under specified categories. For example, the BREEAM UK New Construction rating tool contains ten assessment categories: management, health and wellbeing, energy, transport, water, materials, waste, land use and ecology, pollution and innovation. The tools provide a rating across six possible outcomes, from Unclassified to Outstanding (Figure 2).

LEED

LEED (Leadership in Energy and Environmental Design) is a program developed by the US Green Building Council that provides third-party verification of green buildings (LEED 2022a). The first tool was launched in 1998. Since then more than 100,000 buildings have been certified across the suite of LEED tools. A significant number of certified buildings are outside the US, with certified buildings now in more than 120 countries. This reflects the tool's broad appeal and adaptability. Currently, LEED has a suite of eight tools, four of which can be used for residential projects as shown in Table 4 (LEED 2022b).

Figure 2. Certification outcomes for BREEAM (Source: Ove Arup & Partners Ltd 2014)

LEED rating system	Project development phase	Applicable building types
Building Design & Construction (BD+C)	Building design & construction	- New Construction & Major Renovation - Core & Shell - Data Centers - Healthcare - Hospitality - Retail - Schools - Warehouse & Distribution Centers
Homes	Design & construction	- Single family homes & multi-family low-rise (1 to 3 levels) - Multi-family Mid-rise (4 or more)
LEED recertification	Operations & maintenance	- Maintain and improve buildings that achieved the previous LEED certification
LEED Zero	Building design & Construction, Operations & Maintenance	- Projects to achieve net zero goals in carbon and/or resources

Table 4. LEED rating tools by project development phase and applicable building type

Figure 3. Certification outcomes for LEED (Source: Ove Arup & Partners Ltd 2014)

LEED provides a holistic evaluation by considering multiple critical elements that create the best building rather than focusing on only one factor such as energy or water. LEED evaluates eight primary criteria including location and transport, sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality, regional priority and innovation. The LEED ratings and associated points achievable (out of a possible 100, with ten bonus points) are shown in Figure 3.

Living Building Challenge (LBC)

LBC focuses on the creation of building projects to operate as cleanly, 'beautifully' and effectively as nature's architecture. It is operated by the International Living Future Institute (ILFI). LBC is organised into seven performance areas called Petals: place, water, energy, health and happiness, materials, equity and beauty. LBC has two main principles: that LBC compliance is based on actual, rather than modelled and anticipated, performance; and that all LBC projects must be holistic and address seven Petals through the core imperative.

This standard can be applied to a new building, existing structure, interior and landscape or infrastructure as well as various building projects including single-family residential, multi-family residential, commercial, institutional, medical and laboratory. Projects can achieve many certifications such as Zero Carbon certification, Zero Energy certification, CORE green building certification, Living Building Challenge Petal certification and Living Building Challenge Living certification. LBC case studies in Australia are provided in Further reading.

Passivhaus

Passivhaus or Passive House is a voluntary low-energy building standard that was developed in Germany in the late 1980s (Passive House Institute 2022a). The first house built applying the Passive House standards was constructed in Germany in 1990. Since then, more than 25,000 dwellings have been certified to this standard (Passive House Institute 2022a). The majority of these buildings are in Central Europe; however, there are increasing numbers of buildings around the world that meet the Passive House standard, including in the US and Australia. The standard can be applied to residential and non-residential buildings and to new and refurbished buildings. This rating tool aims to deliver an energy efficient and thermally comfortable building, with a limited focus beyond these elements. The Passive House Institute states the standard can result in energy savings of up to 90% compared with existing Central European buildings, and up to 75% compared with new buildings (Passive House Institute 2022b). It does this by applying passive design principles.

Figure 4. The Hütt 01 Passivhaus by Melbourne Design Studios (MDS) (Image: Matt C Photography (Maitreya Chandorkar))

To be certified to the Passive House standard, a building must meet the following four criteria, adjusted based on the country and climate zone (Passive House Institute 2022b):

1. Space heating energy demand is not to exceed 15 kWh/ m^2 of net living space per year or 10 W/ m^2 peak demand.
2. Renewable Primary Energy Demand (PER) (all plug-in energy loads) must not exceed 60 kWh/ m^2 of treated floor area per year for Passive House Classic.
3. A maximum of 0.6 air changes per hour at 50 pascals pressure, as verified with an onsite pressure test.
4. Thermal comfort must be met for all living areas during winter and summer with not more than 10% of the hours in a given year over 25 ^{0}C.

The implication of this for designers and builders is that the building must meet specific performance targets. During construction, a photographic record is made of the installation of thermal performance features. After construction, the building is pressure tested to ensure it meets the airtightness requirements (Parry 2018). This places the onus on the designers and builders to ensure the building meets the standards, thereby driving improved building outcomes.

Discussion

Australian residential rating tools can be classified into two types: regulatory and voluntary. As per NCC requirements, a minimum threshold is required to be met for building permits (most councils) or planning permits (some councils), depending on the type of development undertaken. These tools can be used to hypothesise a design's actual performance when realistic inputs are used.

Predicting energy performance helps us understand how building design impacts energy use.

Appendix A lists a summary of the key tools used across Australia and beyond. In Australia, the main tools are the NatHERS tools but where required, BASIX and BESS play a significant role in building design and performance outcomes. More recent developments such as Green Star Homes will likely see greater uptake over the coming years.

In terms of international tools, LEED and BREEAM are leading tools in their own right, but they are not commonly used in the Australian residential building sector. However, there is an increasing use of other international tools such as Passivhaus and LBC. These international tools might be used for their focus on different elements compared to the Australian tools, going significantly beyond calculating heating and cooling energy demand. The focus on occupant health and wellbeing is a key outcome of these international tools and is increasingly something that consumers are seeking.

Although it is beyond the scope of this note, the only way to fully determine the comparative strengths and weaknesses of a tool is to apply multiple tools to a single building and compare the results. This is an impractical task for time-poor practitioners who need rules of thumb or checklists to deal with issues that consistently arise from project to project.

Identifying appropriate tools

With a range of rating tools available, how can a designer identify the right tool? In Australia, most designers will use one of the Australian tools to meet building code compliance and/or to optimise design and exceed minimum performance requirements. Tools such as LEED, BREEAM and Passivhaus are increasingly being applied in Australia, and may be considered when seeking international recognition of the rating outcome in addition to other regulatory requirements.

Other considerations relate to costs, underlying assumptions, time and resources required for the assessment and project requirements to demonstrate that a building's performance and characteristics are as claimed.

The questions below have been developed to assist design practitioners to select the most appropriate tool/s for their projects.

1. What is the aim of the project? To meet or exceed compliance? (Note that the term 'compliance' means meeting a minimum standard.)
2. What are the local planning and building permit requirements? Do they require the use of a specific tool? For example, all new houses and extensions in Australia must use a NatHERS approved tool (eg AccuRate), one approved by the jurisdiction (ie BASIX in NSW), and/or Deemed-to-Satisfy criteria. Is an accredited assessor required for the certification of a given method?

3. Which tools are the project team members familiar with? Note that different jurisdictions favour different tools. For example, in Victoria, FirstRate5 knowledge is more widespread than AccuRate.
4. What outcomes are desired from the assessment? Along with the use of a code compliance tool, it is possible to add value by using a voluntary tool to compare the actual, measured performance against the modelled performance.
5. Do you want the tool to help inform the design process or only as a rating? Note that voluntary ratings can attract additional costs if they are certified by the relevant organisation. The involvement of an assessor can entail additional costs unless the design team is familiar with and can use the software.

Other key criteria to be considered include:

- project boundary (resource use, whole of building, community)
- whether the building is residential or a mixed-use development (residential and commercial require ratings for both elements)
- dwelling type/s and number of dwellings
- applicable phases of the building project (design, construction, operation, renovation, end of life)
- availability of utility bill data for measured performance-based ratings
- underlying data/assumptions
- air flow model/ air infiltration level based on the assumption of air changes per hour (ACH) for the dwelling
- sensitivity in local topographical and climatic conditions to meet energy efficiency
- the need for specialist expertise, such as a NatHERS Thermal Performance Assessor
- associated costs
- energy focus only or an overall wellbeing or environmental focus.

Conclusion

This note identifies and discusses several Australian and international residential rating tools that address various stages of the planning, design, construction and post-occupancy phases of a building. Not all the tools are appropriate for all situations. Some of the tools meet regulatory requirements; others are designed to reward innovation and identify industry and international best practices. Some tools are easy to use, while others require specialist expertise to use and interpret results.

In the residential building sector, there is increasing demand to go beyond code compliance and an increasing focus on wellbeing.

Many of the tools covered in this note can help designers go significantly beyond minimum requirements and assist in design optimisation to improve thermal performance and comfort and potentially reduce costs.

While the focus of compliance tools has typically been on modelling and assessing heating and cooling energy needs, some tools are evolving to include wider sustainability considerations such as transport and life cycle assessment. The focus is also shifting to understanding the actual – rather than predicted – impacts of energy, water, waste and the indoor environment quality of buildings. This enables the gaps between design intent and actual performance to be reduced. As the building industry moves from mitigation to adaptation measures for building regulations, the role of rating tools will become even more significant.

Such an approach represents a significant departure from the traditional design-led, predicted performance approach and will require the building industry, designers, consumers and others to be mindful of new methods. The current range of building rating tools is likely to continue to evolve as further advances are made in design and building practices, materials, technologies, and as monitoring and evaluation evidence is analysed. It is critical that practitioners keep up to date with rating tools and code requirements as they evolve.

Appendix A: Summary of key residential rating tools

		Criteria										
		Applicable to building and/or planning approvals	Certified to meet building code	Models building fabric energy use	Models appliance energy use	Models CO2 emissions	Models water use	Account for energy generation	Uses measured energy data	Uses measured water data	Uses life cycle assessment / cost-benefit analysis	Requires qualified assessor for certification
Residential energy rating	AccuRate Home	Australia wide	✓	✓	✓			✓				✓ – requires qualified assessor in NSW
Residential energy rating	BERS Pro	Australia wide	✓	✓	✓	✓						✓ – requires qualified assessor in NSW
Residential energy rating	FirstRate5	NSW, VIC, TAS, ACT, QLD, WA & SA	✓	✓								✓ – requires qualified assessor in NSW
Residential energy rating	HERO	Australia wide	✓	Uses NatHERS outputs	✓						✓	✓
Australian ESD tools	BASIX	NSW		Uses NatHERS outputs			✓					
Australian ESD tools	BESS	VIC			✓		✓	✓				
Australian ESD tools	eTool	Voluntary		Uses NatHERS outputs or similar	✓	✓	✓	✓			✓	✓
Australian ESD tools	Green Star – Communities and Home	Varies with jurisdiction & development type				✓	✓	✓	✓ – used with Green Star Certificate	✓ – used with Green Star Certificate		✓
Australian ESD tools	NABERS Apartment Buildings	Australia wide							✓	✓		✓
Australian ESD tools	Residential Efficiency Scorecard	Australia wide		✓	✓			✓				✓
International ESD tools	BREEAM	UK: use on multi-occupancy residential buildings		✓		✓	✓	✓				✓
International ESD tools	LEED for Homes (US)	US: varies with jurisdiction & development type		Uses NatHERS output		✓	✓	✓				✓
International ESD tools	Living Building Challenge (LBC)	Worldwide			✓	✓	✓					✓
International ESD tools	Passivhaus Standard (EU)	EU: used in some jurisdictions		✓	✓	✓			✓			✓

Appendix B: Case study optimisation

Jacob & Jade's House Renovation, ACT

Case study by Sarah Lebner, Cooee Architecture.

Year of design completion: 2018
Year of project completion: 2022

Figure 5. Completed house (image: Ben King)

Figure 6. Exterior of house before renovation (Image: Cooee Architecture)

Figure 7. Interior of house before renovation (Image: Cooee Architecture)

Project background

Jacob and Jade's House was freezing cold, draughty and dysfunctional. Its original condition included a concrete slab on ground, single-skin uninsulated concrete block walls, a very thin roof structure with minimal straw insulation and single-glazed windows (with only two small north-facing windows) (Figure 6 and 7).

This house is located in Canberra, ACT, which has a harsh climate. This should be considered when comparing energy rating results.

Australian Institute of Architects

Project optimisation

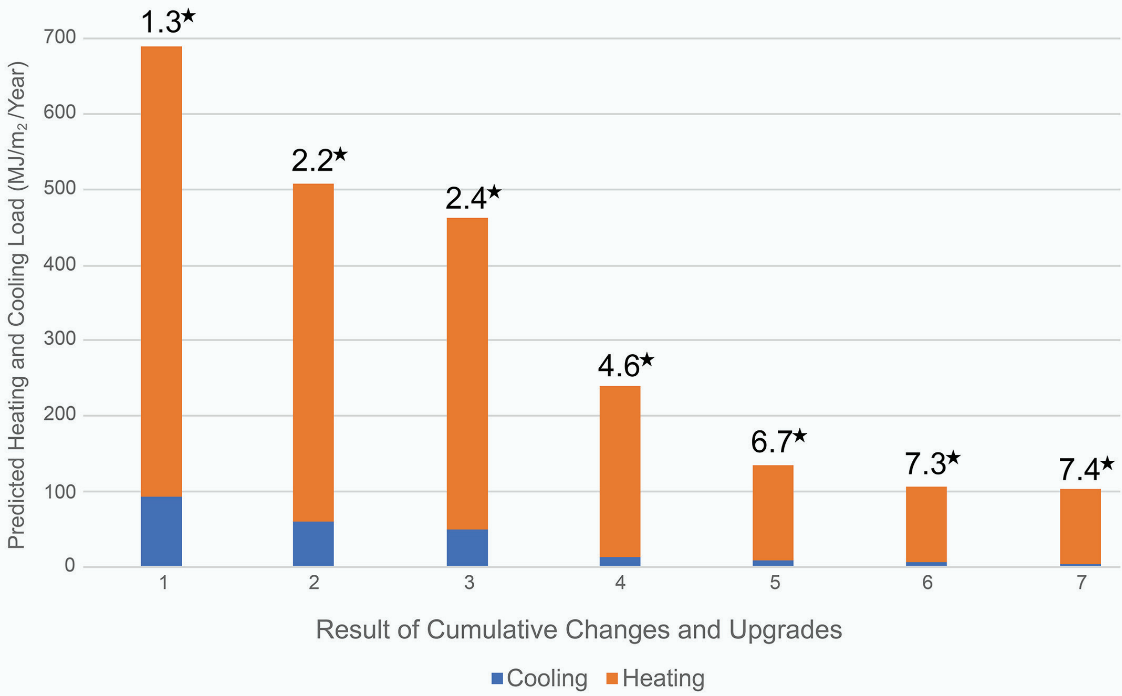

Figure 8. Thermal improvement opportunities modelled for the renovation using BERS Pro 4.3 (Source: Light House Architecture & Science). Key: Orange represents the predicted heating load, blue represents the predicted cooling load.

Cooee Architecture engaged Light House Architecture & Science as the Energy Efficiency Rating (EER) consultants to optimise the thermal improvement opportunities for the renovation using BERS Pro 4.3 (Figure 8). The steps considered to improve the energy rating were:

1. The existing EER rating was established as 1.3 NatHERS stars.
2. Small pop-out extensions would capture more northern solar gain (Figure 9). Building these alone, and leaving the rest of the house as is, would have achieved 2.2 stars EER.
3. Replacing windows (often considered as a 'magic pill') with thermally-broken double glazing would have improved the rating to just 2.4 stars EER.
4. Installing a new roof allowing R5 ceiling insulation increases the rating to 4.6 stars EER.
5. Insulating the external walls, except for the garage, takes the home to 6.7 stars EER. This was a combination of R2.5 batts in new standard 90mm framed walls and XPS board insulation lining applied to retained concrete block walls.
6. The external wall between the home and the garage is sometimes missed. Treating that wall as a thermally external wall results in a 7.3 star EER rating.
7. The final touch, adding ceiling fans to living rooms and bedrooms, results in a 7.4 star EER rating.

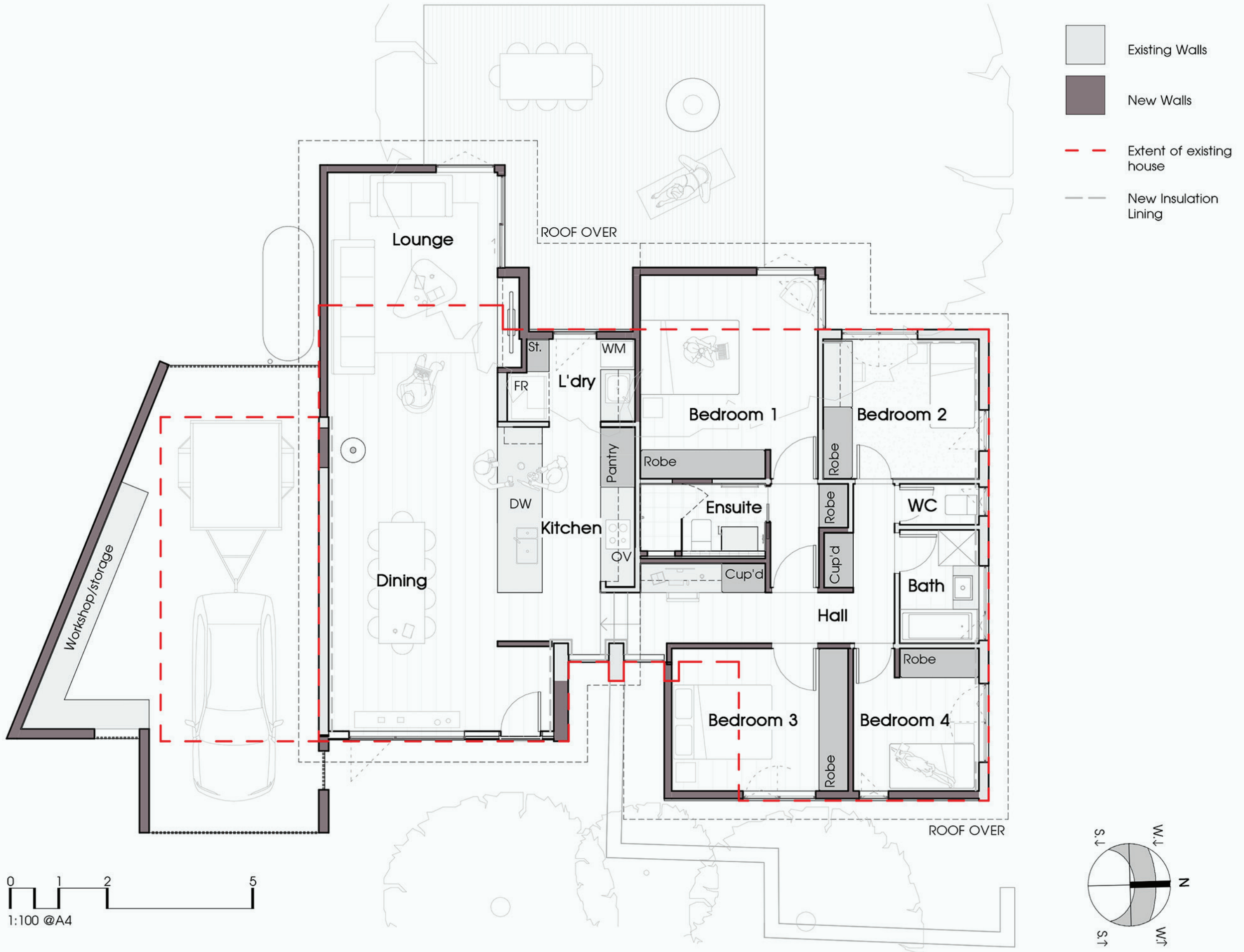

Figure 9. Proposed floor plan showing pop-out extensions to capture northern solar gain (Image: Cooee Architecture)

Not captured in the NatHERS ratings was the priority placed on draft sealing throughout this process, as well as good quality window furnishings. These important details mean the home is expected to perform better than the 7.4 star rating predicts.

Note: While changing the order of these priorities would produce different comparative improvements, on the whole they would tell the same story.

Once the improvement areas are decided, it's worth working with the EER consultant to assess where the best thermal return on investment lies. The graph below (Figure 10) demonstrates how the energy rating would have changed with the level of ceiling insulation as the variable. This breakdown supports the installation of cost-effective R5 roof batts, which fit perfectly in the new 240mm roof rafters.

It's also worth testing different glazing options. This will produce different results depending on many individual project factors. For this case study, double-glazed uPVC with a Low-E coating achieved the same energy rating as a more expensive triple-glazed unit would have (Figure 11).

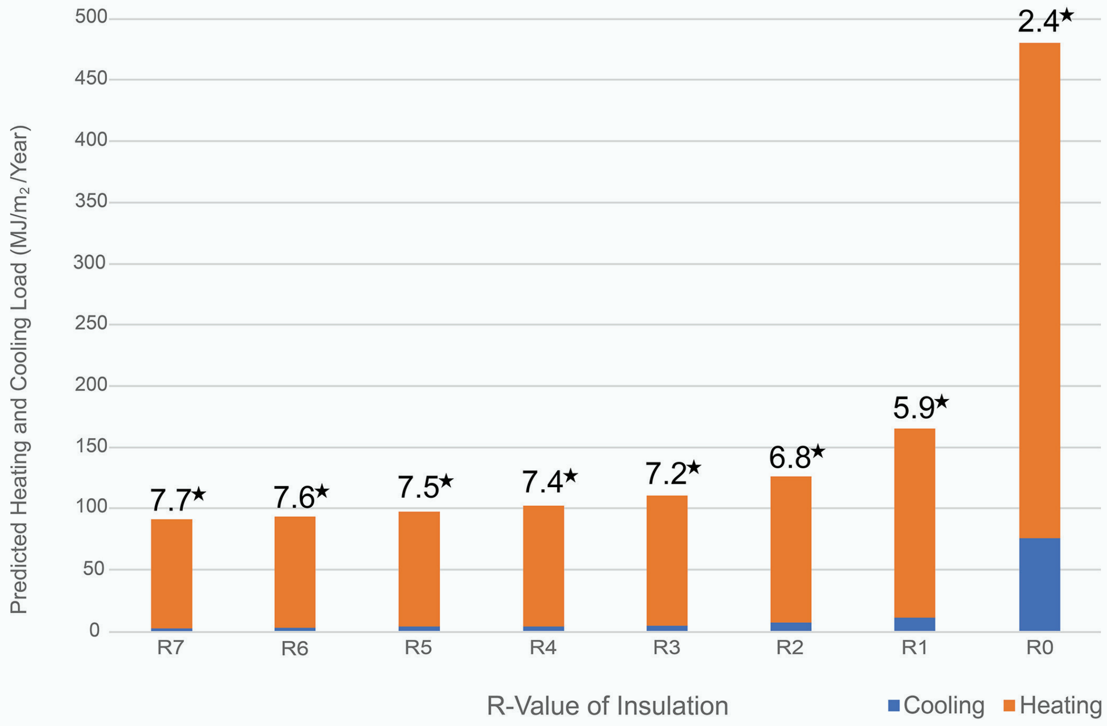

Figure 10. Ceiling insulation as the variable, diminishing returns modelled using BERS Pro 4.3 (Source: Light House Architecture & Science). Key: orange represents the predicted heating load, blue represents the predicted cooling load. The columns represent different levels of insulation (R value). The bold numbers above each column represent the resulting star rating.

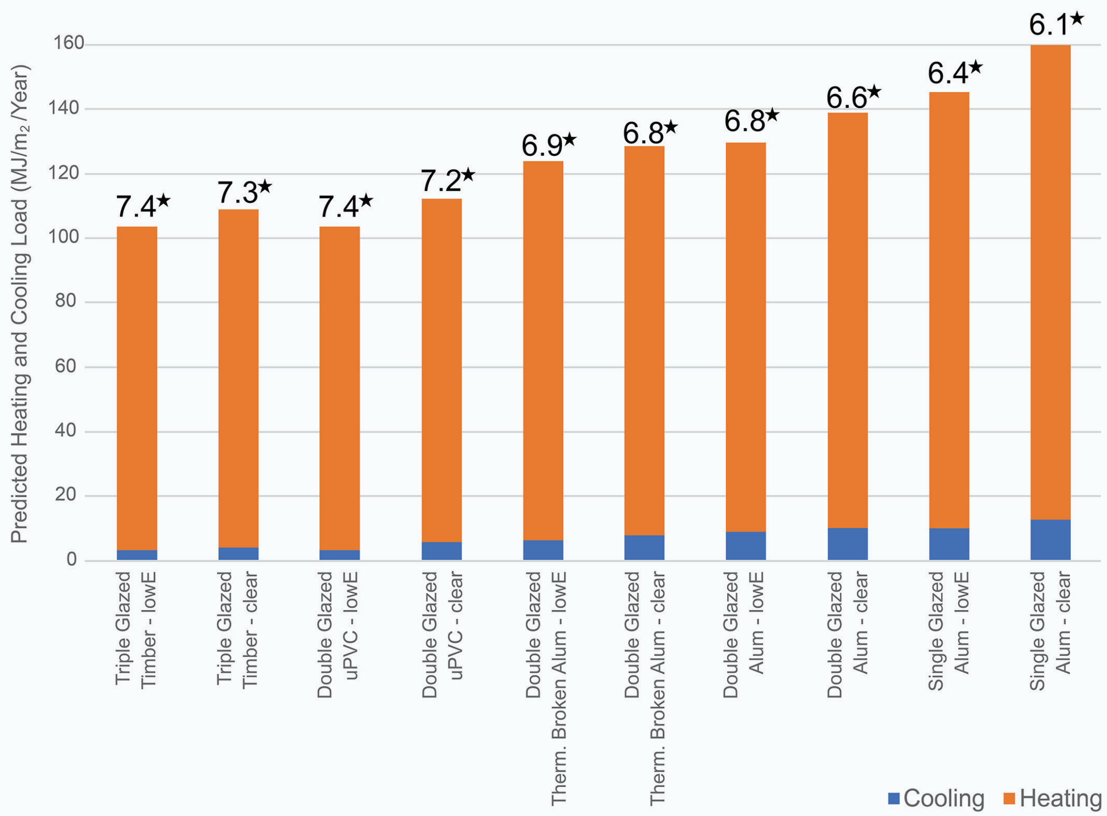

Figure 11. Windows as the variable, modelled using BERS Pro 4.3 (Source: Light House Architecture & Science). Key: orange represents the predicted heating load, blue represents the predicted cooling load. (Note: a timber frame is used to demonstrate the triple-glazed option because a triple-glazed uPVC frame was not available in the software at the time.)

Summary

In summary, a suggested process for using NatHERS tools during design collaboration would be:

1. For renovations, model the existing home as a starting point.
2. Establish a 'base case' design that includes the most likely construction materials and the most conservative version of the design (ie withhold from testing larger glazing at this point.)
3. Seek feedback from the assessor on any limiting design factors such as adding shading to a western window, or a northern eave that's too big. Optimise your 'base design'.
4. Execute different model runs that isolate the impact of each material option you are considering. This helps you understand where the best return on investment lies.
5. Collate the preferable material combination for your '90%' outcome.
6. At this point, with your optimised outcome, you may like to test the impact of thermally-negative design changes. For example, if you're pondering the impact of a bigger window to a significant view, testing this on your optimised design is the most informative stage to do so.

Further reading

Tools

AccuRate Home: https://www.energyinspection.com.au/products/accurate/

BASIX: https://www.basix.nsw.gov.au

BESS: https://bess.net.au

BERS Pro: https://www.nathers.gov.au/news/bers-pro-completes-accreditation-process

BREEAM: https://bregroup.com/products/breeam/

eTool: https://etool.app/

FirstRate5: https://www.fr5.com.au/

FirstRate5 is available for download: https://www.fr5.com.au/home/2022/05/25/release-of-fr5-v5.4.0-beta-version

Green Star: https://new.gbca.org.au

HERO: https://www.hero-software.com.au

LEED: https://www.usgbc.org/leed

Living Building Challenge: https://living-future.org/lbc/

NABERS Apartment Buildings: https://www.nabers.gov.au/ratings/spaces-we-rate/apartment-buildings

NatHERS: https://www.nathers.gov.au

Passivhaus: https://www.passivhausassociation.com.au

Residential Efficiency Scorecard: https://www.homescorecard.gov.au

Case study resources

LBC case studies: https://living-future.org.au/aus-projects/

NatHERS worked examples for AccuRate Sustainability, BERS Pro, FirstRate5, and HERO:
https://www.nathers.gov.au/worked-examples

Passivhaus case studies: https://www.passivhausassociation.com.au/project-register

Projected weather files for building energy modelling:
https://agdatashop.csiro.au/future-climate-predictive-weather

Your Home selection of best practice sustainable design and construction:
https://www.yourhome.gov.au/case-studies

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