**Exploring the application of the Carbon Risk Real Estate Monitor tool for Australian office buildings**

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# Abstract

Urgent transitions to mitigate effects of climate change are needed. Policies and reduction targets for greenhouse gas emissions associated with the built environment are emerging. Meeting these targets will be essential to ensure built assets are not stranded. Asset ‘stranding’ occurs when a building no longer meets emissions targets and, as a result, may not be allowed to be occupied or rented, resulting in implications for asset income and occupancy. The Carbon Risk Real Estate Monitor (CRREM) tool was developed in Europe to enable emissions analysis of assets and portfolios to reduce the risk of stranding. CRREM is regarded as one of the most valuable tools for asset management and valuations in Europe and UK, however, in Australia it has only recently been adapted for local conditions. This research provides key insights into the effective use of CRREM for Australian built assets.

Keywords: GHG emissions, office buildings, asset management, valuation, CRREM, Australia

# Introduction

The building sector has been identified as a substantial contributor to global warming, with some 37% of greenhouse gas (GHG) emissions attributable to buildings globally (UNEP, 2022). It has been suggested that the global building sector carbon intensity will have to decline from the current 52 kgCO2e/m2/pa to below 10 kgCO2e/m2/pa by 2050 in order to be in line with the 2ºC global carbon budget (Urban, 2020). As such, buildings have been identified as a key asset class for decarbonisation (IPCC, 2023), and consequently the need to set global and national carbon targets. Already, in certain locations around the world, in particular Europe and the UK, buildings are subject to increasing regulation and legislation relating to GHG emissions. Australia, one of the highest GHG emitters per capita in the world, has set a goal of reaching net zero emissions by 2050 (Climate Change Authority, 2019). The International Energy Agency (IEA) has suggested that Australia improve its National Construction Code and place greater emphasis on the building and transport sector’s environmental performance to help meet these carbon targets (IEA, 2023). The IEA review estimates that a 60% productivity improvement would be needed for a net zero aligned trajectory. Potential penalties for failing to meet emission targets could be detrimental to property asset incomes and values, resulting in broader financial implications for Australia.

The Carbon Risk Real Estate Monitor (CRREM) tool was developed as part of a Horizon 2020 funded project to assist building owners to better understand the emissions profiles of their assets and to enable financial investment decisions that reduce carbon footprints (CRREM, 2023a). The idea behind this tool is to enable investment decisions to be made that minimise adverse impacts on building value due to its carbon footprint. While this development is focused on the EU and UK specifically, it has since been expanded to include Asia Pacific and the Americas. Despite its demonstrable benefits and widespread international use (BRE, 2022, Stein, 2023), CRREM only recently entered the Australian market, and it has not yet been tested in the Australian context.

The CRREM tool enables the monitoring of energy performance of a single property, or portfolio. Utilising key inputs, the tool provides a visual graphic of the performance of the asset or portfolio, and identifies at which point the asset may be subject to ‘stranding risk’ as a result of regulatory requirements, and voluntary requirements like alignment with Science Based Targets Initiative (SBTIs) to minimize global warming to 1.5o or 2oC (CRREM, 2023b). The objective of the tool, is not to just provide a graphical representation, but focuses on the decarbonization requirements of the asset in comparison to overall sector targets and Intended Nationally Determined Contributions (INDCs). The decarbonization pathways created by CRREM are in the context of meeting emissions targets from the Paris agreement, and the associated emission pathways and budgets which then are contributed from building sector pathways, which have been converted for various property types (CRREM, 2020b). CRREM provides these decarbonization pathways as a way in which to benchmark where the current asset or portfolio sits (the pathway is effectively a form of carbon budget), as a result a user can then see clearly (as shown in Figure 1) the timing of when their asset may be stranded based on this pathway, and generates the realization of the need for retrofits to improve the energy efficiency and carbon profile of the asset or portfolio.

Figure 1. Example of CRREM decarbonization pathway and asset stranding

Source: CRREM (2022) v2.03 utilising Melbourne Case study building

This study aims to apply CRREM to a series of Australian commercial property case studies to evaluate the pathways, assumptions and data inputs for the Australian context. The objective is to explore the potential of CRREM as an innovative tool for industry and understand the nuances for its’ application in the Australian context.

This paper begins by providing some background information about Australia and its carbon targets and the development of CRREM. This is followed by the Research Approach (with reference to the Data Collection and Data Analysis methods), the Results and then finally the Discussion and Conclusion.

# Background

## The Australian Context

Australia has recently committed to reducing its GHG emissions to 26-28% below 2005 levels by 2030 and net zero by 2050 (IEA, 2023). Several state governments and local councils have followed this up with setting their own carbon reduction targets, such as New South Wales (one of Australia’s most populous states) which have committed to reducing their emissions by 50% from 2005 levels by 2030 and net zero by 2050; while Victoria has committed to achieving net zero emissions by 2045 (NSW Government, 2020, Victoria State Government, 2023). In particular, the City of Melbourne has estimated to meet their ambitious emissions reduction targets for 2030 to achieve net zero emissions before 2050 and align their strategy to the C40 Climate Action Plan framework (C40 Cities, 2022). To meet these targets, there is a need to retrofit 77 buildings within the City of Melbourne every year until 2050. With every year of inaction, building owners and tenants increase their risk exposure to adverse effects on building occupancies, rents, and assets values. The IEA has welcomed Australia’s commitment to carbon mitigation, but has stated that stronger efforts are needed to improve energy efficiency and carbon target alignment and that there is room for improvement on the country’s transport and building sector’s energy efficiency performance (IEA, 2023).

Enacted in 2010, the Commercial Building Disclosure Program (CBDP) (CBD, 2020), mandates the declaration of energy efficiency for all commercial buildings, for sale or rent in Australia, as measured by certified energy ratings based on the National Australian Built Environment Rating System (NABERS). However, CBDP solely focuses on past emissions over a period of 12 months (referred to as base building) and does not require the future forecasting of emissions. Furthermore, as there is only a requirement to consider the base building energy considerations, the ratings are often underestimated due to the lack of whole building assessment. As such, Australia’s mandatory energy efficiency disclosure program neglects the need to consider and reduce future climate-risk factors and more holistically consider whole-of-building emissions. The CRREM tool provides a more forward-looking tool that has a broader consideration of the emissions profile of a building into the future, and exploring potential asset stranding considerations. Asset ‘stranding’ is where a building does not meet Paris aligned emission targets, which could comprise organizational, sector or government-based targets or requirements. For example, a building may not be allowed to be occupied or rented if it is performing beyond a specified target. (a penalty already occurring in the UK for buildings with poor energy efficiency) (Hirsch et al., 2019). The stranding of an asset leads to detrimental loss of income due to an inability for the space to be rented or occupied. Thus, property owners need a way in which to assess stranding potential and the ability to identify opportunities for retrofits and upgrades to ensure the property asset meets the emission target levels, and ensure continuity of income and occupancy (CRREM, 2020b).The next section provides more detail of the CRREM tool, its development and application within Australia.

## The CRREM Tool

Funded by the European Union (EU), the Carbon Risk Real Estate Monitor (CRREM) was developed to alleviate risks associated with asset ‘stranding’ and avoid obsolescence, accelerated depreciation and loss of income due to climate change, changing market expectations, and legal regulations. CRREM has been described as a tool that:

“*will accelerate the decarbonisation and climate change resilience of the EU commercial real estate state sector by clearly communicating the downside financial risks associated with poor energy performance and the quantification of financial implications of climate change on the building stock” (CRREM, 2020b).*

The CRREM project has created a free to use Excel based tool which has been funded by the H2020 program (European Commission, 2022). The tool provides country specific energy-reduction pathways that are aligned with the requirements of the Paris Agreement to limit global warming to 1.5°C. The tool allows its potential users to assess the carbon and energy performance of their buildings and portfolios, and then benchmark these assets against the CRREM pathways, thus supporting effective carbon risk management. The unique feature of the CRREM tool is its ability to enable building owners to evaluate their commercial properties’ capacity to meet targets while considering future retrofitting plans that are costed and planned within the assets’ life cycle strategies. It also allows a portfolio analysis and may assist in developing future investment strategies for management and ownership. Further, the tool could assist in the measurement and reporting of emissions and organisations’ action plans for built assets to achieve net zero. However, the application of CRREM within an Australian context has limited testing and application and further exploration of how the tool works on commercial building stock in Australia to understand the nuances is required to assist industry in their comprehension and utilization of the CRREM tool. Initially developed for the EU, the expansion of CRREM has meant that calculation of the pathways for each country are required. These are generated by calculating the carbon that could be emitted by the country (and sector) till 2050 and the trajectory of these pathways, start at the current energy intensity of each country’s building stock but converge to a comparable target (CRREM, 2023b). The CRREM tool has then utilized information and data from GRESB to develop individual pathways (per country) for the various property types which creates specific decarbonization trajectories to a target amount based on the property type. In Australia, due to our geographic variety, further extension of the nuance has been included to enable the consideration the climate zones to reflect the different heating and cooling requirements of different locations and how this subsequently affects the energy intensity of buildings (CRREM, 2023b).

While several versions have been released for Australia, the consistency and comparability when applied to Australian assets needs further investigation. CRREM may be utilised to assist asset owners in Australia to develop and refine their future retrofitting and upgrading plans that integrate asset life cycle planning towards net zero emissions. The testing of the CRREM tool and its different versions, and the implications and outcomes of the various optional inputs are explored in this study.

# Research Approach

This section describes the data collection and analysis approach used. The latest CRREM tool (Version V2.03) as well as previous releases (Version V1.22 and V2.02) were used to assess a portfolio of buildings from across Australia. The purpose of examining the different versions is to highlight how updates may affect the results, and in the context of decision making and asset planning, appropriate caution should be taken which version used in the assessment (especially seeing as this is a continuously evolving tool and constantly being updated).

There were 70 office buildings selected from three different Asset Owner’s portfolios, located in New South Wales, Victoria, Queensland, Northern Territory and Western Australia. Data collection is discussed first followed by analysis approach.

## Data collection

Data for the portfolio of buildings was attained through publicly available online information from three leading Australian property Asset Owners (referred to throughout this report as Asset Owner 1 to 3). Information on a total of 70 buildings was collected, with some data limitations, as described in Table 1.

Table 1 Case study data

|  |  |  |  |
| --- | --- | --- | --- |
| **Case Study Portfolio** | **Asset Owner 1** | **Asset Owner 2** | **Asset Owner 3** |
| **Assets** | 9 Offices2 Retail | 24 Offices12 Retail | 23 Offices |
| **Locations** | SydneyMelbourne Gold CoastPerthBrisbane | SydneyMelbourne Northern TerritoryBrisbane | SydneyMelbourne PerthBrisbane |
| **Collected data**  | Reporting periodTotal gross internal area (m2)Grid electricity usage (kWh)Natural gas usage (kWh)Renewable energy usage (kWh) | Reporting periodTotal gross internal area (m2)Grid electricity usage (kWh)Renewable energy usage (kWh) | Reporting periodTotal gross internal area (m2)Grid electricity usage (kWh)Natural gas usage (kWh) |
| **Missing data** | Average annual vacant area (m2) | Natural GasLimited Renewable EnergyAverage annual vacant area (m2) | Renewable EnergyAverage annual vacant area (m2) |

The study focused primarily on the mandatory data requirements in CRREM, as illustrated in Figure 1. As no ‘average annual vacant area (a mandatory input requirement for CRREM) was provided for any of the case studies a value of 0% was assumed. Additional data that was included, if available, were consumption of natural gas, renewable onsite and renewable offsite energy.

Figure 1 Mandatory data for the CRREM Tool

## Analysis

The analysis focused on three key phases.

1. Case study CRREM results, which included but not limited to, stranding year and cost of excess emissions. The outputs allow for individual buildings to be examined and compared, but also to be utilised at a portfolio level. The three portfolios were also compared against each other.
2. Comparison of results from the different versions of the tool for the different case studies. Asset Owner 1’s case study buildings were selected for this.
3. The sensitivity testing of the different options and implication of the non-mandatory data input requirements.

# Results & Discussion

## Objective 1: Apply CRREM to case study buildings.

This section presents the results of the analysis of the building portfolio using the CRREM tool. This section includes reference to individual building results followed by a comparison of the three portfolios side by side.

Figure 2 provides an example of the CRREM tool results for an office building (Building 1, a 6 star NABERS energy rating) located in Brisbane (Queensland) that is 76,000 m2. The stranding year is 2036 (the third earliest when compared against other case studies). This graph clearly informs the user from what year the building will not meet emission targets and may start leading to potential loss of income due to inability for the space to be rented or occupied. This indication of a loss of income is clearly seen in Figure 3 too. Figure 3 of the CRREM analysis for office building 1 illustrates the carbon cost of excess emissions (in USD dollar per year). From the stranding year 2036, the annual costs increases (in red) to a value of over $155,689 per year. An important consideration to note is the role and prominence in the results of the decarbonization profile of the grid, which has a substantial impact on the building profile of building performance. For example, the quicker the grid decarbonizes, the further out the stranding year is, if the building performance is maintained.

Figure 2 CRREM analysis of case study office building 1 located in Brisbane.

Figure 3 Carbon cost of emissions of office building 1.

Table 2 provides a side-by-side comparison of the three Asset Owners portfolio results for the carbon cost of excess emissions using the CRREM tool (V2.03). When comparing the portfolios side by side, the results show that Asset Owner 3 has the poorer performing office portfolio. With an average stranding year of 2028 and a carbon cost of excess emissions above $6,000,000 per year. In comparison Asset Owner 1 who has the best performing portfolio with an average stranding year of 2036 and a cost of excess emissions of over $1,000,000 per year. One must bear in mind while interpreting the results that Asset Owner 1 had the most complete data set and that Asset Owner 2 and 3’s case studies had some missing data which can influence the results.

Table 2 Comparison of portfolios using CRREM V2.03

|  |  |
| --- | --- |
| **Australian Property Asset Owner** | **Portfolio Results** |
| **Asset Owner 1** |  |
| **Asset Owner 2** |  |
| **Asset Owner 3** |  |

The CRREM tool clearly communicated the stranding year and the carbon cost of excess emissions of the individual buildings and from a portfolio perspective. The results and graphs (Figure 3 and 4) clearly informed the user from which year the building will run at a financial loss due to an increase in the cost of excess emissions. The tool also allowed for different property portfolios to be compared (Table 2), to help determine which portfolio performs better. To date in Australia, there has been a lack of tools to help inform users about the future risk to their buildings due to climate change and valuable information such as this will help prepare building owners, especially in Australia, to systematically address this risk and create greater preparedness (Hurliman et al., 2019, Deloitte, 2022). The results provided by the CRREM tool for the case studies provide valuable insight into the possible future performance of these buildings and helps to highlight potential areas of risk (such as stranding year and cost of excess carbon emissions). This study has shown that there is not only a need for a tool such as CRREM in the Australian market but that it has the potential to help foster the creation of climate resilient built assets due to the type of results it produces.

## Objective 2: Analyse the different CRREM tool versions

Three different CRREM tool versions were used for the analysis, namely V1.22 and V2.02 and the latest available tool version V2.03. Due to the completeness of data from Asset Owner 1’s properties, their portfolio was utilised for this comparative analysis. Figure 5 provides a synopsis of the differences in performance of the CRREM tools for the 11 individual assets in Asset Owner 1’s portfolio. The newer versions (V2.03 and V2.03) brought the year of stranding forward for all case studies and in some cases as much as 5 years. For example, building 2 (located in Western Australia) has a stranding year of 2042 with V1.22 and 2037 for both V2.02 and V2.03.

The newer CRREM versions V2.02 and V2.03 produced very comparable results, with all buildings providing similar stranding years, with the exception of 3 out of the 11 case studies (buildings 4, 5 and 8), where the year of stranding increased. There are no obvious reasons why these 3 buildings have a later stranding year. All three of these buildings are in Victoria (a total of 5 of the 11 were located in Victoria). These 3 buildings do not have the highest electricity consumption (Building 1 and 2 in fact have the highest of the 11) or the lowest (building 3 has the lowest). And they don’t have the lowest natural gas consumption either (Building 1 and 11 have). Thus, it is inconclusive why these 3 buildings have later stranding years with the newer tool version (V2.03) when compared to the previous version (V2.02).

Figure 4 CRREM tool version analysis of Asset Owner 1’s portfolio of buildings.

Three different CRREM tool versions were used, namely V1.22, V2.02 and the latest available version V2.03 for assessing Asset Owner 1’s office buildings. The newer tools brought the stranding year forward for all case studies, by as much as 5 years in some cases. The newer tool versions (V2.03 and V2.03) provided very similar results in all case studies except 3. It is understood that substantial changes were made to various data inputs (in particular the decarbonization pathways) between the V1.22 and the later version, which has meant an update to the results understandably. Further refinement is demonstrated in the later version comparisons, although this appears to be limited. Figure 6 shows that the portfolio’s stranding year range does decrease significantly from the old tool version to the newer tool versions, but also reduces the variation in results. This is likely a result of the which can be due to updates to tool calculation methods, data updates and completeness. It is interesting to note the subtle difference in tool results from V2.02 and V2.03. Details on the variations were provided in a list of updates, but the user may not be privy to exactly how these changes may affect the results, as such users need to be more aware of the changes per tool version and statements and how results from older tool versions are still utilized in reporting or decision-making and how this may change going forward.

The CRREM tool is a useful approach to consider both individual buildings and portfolios, however, updates to data inputs, particularly, information pertaining to Australia’s decarbonization of the grid, will subsequently and understandably change outcomes and results. Users of the tool should be aware of version updates, which will be continued to be updated with more information as this becomes available.



Figure 6 Comparison of stranding year range for Asset Owner 1's portfolio based on three CRREM tool versions

## Objective 3: CRREM tool sensitivities

Using two buildings, one located in Sydney (Building A), and another located in Melbourne (Building B), an analysis was performed examining the role of how different data inputs and assumptions in the tool affected the stranding year of the assets. While not comprehensive across all the buildings, this snapshot provides an indicative analysis of how different data inputs affects the stranding year of different buildings. Table 3 provides a synopsis of the seven data input scenarios applied and the results for each asset. For both Building A and B, their years of stranding were 2037 and 2038, respectively, utilising mandatory data of electricity grid usage in kWh. However, stranding years were earlier by 2 years for Building 1, and 4 years for Building 2 when natural gas data was included, demonstrating a substantial effect on the stranding year because of natural gas consumption. Subsequently, additional data was included for the different scenarios: inclusion of on-site renewables, refrigerant data, change in the location base to market-based approach, inclusion of other on-site renewables like heat pumps and including or excluding air-conditioning. Apart from the inclusion of air conditioning for Building B, which shortened the stranding date by a year (from 2034 to 2033), the other analyses demonstrated no change to the actual stranding year. Interestingly, the carbon cost of excess emissions did not change either with Test 3 to 6.

Table 3 CRREM data input sensitivity analysis

|  |  |  |  |
| --- | --- | --- | --- |
| **Sensitivity Test** | **Building A, Sydney**  | **Building B, Melbourne** | **Notes and assumptions** |
| **Year of Stranding** |
| 1: With only mandatory data | 2037 | 2038 | Mandatory Data Electricity Grid usage kWh |
| 2: Inclusion of Natural Gas Data | 2035 | 2034 | All case studies did provide natural gas data |
| 3: Inclusion of onsite renewables | 2035 | 2034 | All case studies did provide onsite renewable data |
| 4: Inclusion of Refrigerant data | 2035 | 2034 | 12kg of R134a (HFC) assumed\* |
| 5: Change from location based to market-based approach | 2035 | 2034 | Location based approach used for all case studies |
| 6: Inclusion of other on-site renewable such as heat pump | 2035 | 2034 | Assumed 0 for all case studies as data not provided |
| 7: No Aircon selected | 2035 | 2033 | Aircon selected 'Yes' for all case studies |

A series of inputs (7 in total as detailed in Table 4) were tested for 2 case study buildings (Building A and B located in Sydney and Melbourne). Except for natural gas and air conditioning (which brought the stranding year forward), the other 5 sensitivity tests had limited impact on the CRREM tool stranding year results.

## Observed limitations and considerations

The results are heavily reliant on country-specific normalization pathways, useful for global investors, However, this may have concerning outcomes for local building owners who are ‘waiting for the grid’ to decarbonize rather than focus on retrofitting their buildings to improve energy efficiency and reduce their emissions. CRREM also places quite a lot of reliance on technological advances required to achieve 1.5°C target and that this technical change must be taken into account until 2050 (CRREM, 2020a). However, there is no certainty of these advances occurring in time. In addition, there is uncertainty associated with estimated future operational energy and carbon has been well documented and papers such as Prataviera et al. (2022) have highlighted that the range of errors in results can range between 18% to 48%, and that in some cases overestimation of daily peaks in energy demand can be as much as 80%. So this also may be a factor for consideration in strategy planning for individual assets and portfolios. What is clear, that for the built environment to make their contribution to reducing emission, engagement in energy efficiency programs and implementation of energy efficiency and net zero carbon retrofits are required.

The tool also has limitations when it comes to the use of emission factors. Studies such Molina-Castro (2022) have found that the uncertainty range associated with this factor can be between 2.5% and 97.5%, with most of the standard uncertainties estimated between 15% and 50%. Further in the Australian context, only the country emission factor is utilized, and at present no regional emission factor data for Australia currently being factored into the tool (which is used in NABERS based on state/territory grid generation). At present, only weather based data for normalizing heating and cooling considerations have been included. However, the CRREM tool does allow for user-defined inputs to be used, so one can insert and apply emission factors based on the state/territory locations. However, this requires additional inputs and considerations by the user. The tool also does not include normalization of hours of use, which may have some implications if comparing CRREM and NABERS particularly around energy intensity.

Further this study is limited by only utilizing a small portfolio of buildings, with limited access to energy data and information from some of these buildings, for example gas consumption and renewable energy generation, which may significantly affect the results and outcomes for individual buildings and the portfolio overviews presented.

# Conclusion

Climate change is negatively impacting businesses, cities and communities on a global scale. More specifically sea level rise and frequent natural disasters will have direct impact on the quality and maintenance of buildings and infrastructures causing increasing risk to real estate owners (Winters, 2021). One such risk is the risk of stranding, when a property will not meet regulatory efficiency standards or market expectations making them less marketable and more costly to refurbish (CRREM, 2023a). There has been a lack of tools available to property owners and professionals to assist them with addressing this risk. The EU funded CRREM tool helps to address this and enables its potential users from the real estate sector to assess the carbon and energy performance of buildings and portfolios and benchmark assets against the CRREM pathways, supporting effective carbon risk.  CRREM also provides information on the financial risks associated with poor energy performance and helps quantify the financial implications of climate change on portfolios (Winters, 2021). The tool has been widely supported and adopted by several European countries, as is evident with its alignment with the Netherlands based Global Real Estate Sustainability Benchmark (GRESB) organisation, a leading ESG benchmark for real estate and infrastructure investments across the world (GRESB, 2020).

The building sector needs to continue to work towards mitigating the effects of climate change. Tools such as CRREM combine current financial considerations of Asset Owners (property owners) with a practical way to provide a better understand the future environmental and financial risk of their assets. By providing information such as the stranding risk, building owners can see when their asset no longer meets emission targets and might become a financial liability as it may not be allowed to be occupied or rented. Even though CRREM has been widely adopted in several European countries, it has only recently been introduced in Australia and no research has been conducted to understand its usability within this context. This study helps to address this, applying the CRREM tool to 70 Australian office building case studies from three different leading Australian property Asset Owners. This study found that CRREM provided valuable insight into the future risk of these portfolios, however more detailed analysis is required to understand how inputs like state/territory emission factors might affect results for individual buildings and portfolios, and whether this may provide a more useful approach compared to a single emission factor for Australia for the purposes of asset strategy development, planning and reporting. Further, given the embedded nature of NABERS in the Australian commercial office market, it would be useful to understand the relationship between asset stranding and NABERS ratings. Further research into the relationship between CRREM and NABERS is needed and users of CRREM should continue to include a sensitivity analysis when interpreting the results.

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