



ABGR/ NABERS
Northern Territory
Benchmark Report
2007

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EXECUTIVE SUMMARY

The Australian Building Greenhouse Rating (ABGR) is a scheme by which owners and occupiers of office buildings can rate their greenhouse gas emissions and energy performance, using a simple five star scale.

This report describes the 2nd revision of rating bands for the Northern Territory. Data has been sourced from the NT Department of Planning and Infrastructure, a market survey, and from Exergy's in-house records. This work follows an initial revision exercise in 2003/4 that was based on a smaller data set and led to revised benchmarks being incorporated into the ABGR rating scheme in 2006.

Based on the new data set, it is recommended that the rating bands are slightly relaxed, particularly at the lower performance end of the rating scale. This will have the effect of increasing the number of buildings that can be rated as well as increasing the average rating.

The revised whole building, tenancy and base building rating band equations are as follows:

$$R_{WholeBuilding} = 6.422206 - 0.03323 NGE_{WholeBuilding}$$

$$R_{Tenancy} = 6.413814 - 0.07242 NGE_{Tenancy}$$

$$R_{BaseBuilding} = 8.850637 - 0.09846 NGE_{BaseBuilding}$$

Furthermore, the application of the NABERS office water benchmark was tested via a small sample of buildings and it was concluded that although the average rating of the sample was higher than expected, there was insufficient data to propose any revision to the rating. However, the fact that the sample rated sensibly on the scale supports the extension of the NABERS office water benchmark to tropical regions.

1. INTRODUCTION

This report identifies suitable revised benchmarks for the operation of the Australian Building Greenhouse Rating scheme in the Northern Territory and potentially other tropical areas of Australia. The application of NABERS Office Water in the Northern Territory is also reviewed.

The benchmark data was gathered variously by Northern Territory Department of Planning and Infrastructure, a market survey and Exergy in a previous study.

1.1 The Benchmarking Data

The following data was used in the benchmarking exercise:

- Whole building energy use data: 48 sites (15 from Nth Qld)
- Base building energy use data: 20 sites (6 from Nth Qld)
- Tenancies: 55 Sites (7 from Nth Qld)

Most of the Northern Territory data were sourced from sites in Darwin, whilst most of the North Queensland data was from Cairns and Townsville. A more detailed breakdown of the NT sites follows:

- Whole Building:
 - Darwin: 26 sites,
 - Alice Springs: 6 sites,
 - Katherine: 1 site,
 - Nhulunbuy: 1 site.
- Tenancy:
 - Darwin: 34 sites,
 - Alice Springs: 6 sites,
 - Nhulunbuy: 1 site,
 - Katherine: 1 site.
- Base Building:
 - Darwin: 15 sites,

Inclusion of data from other tropical areas (all coastal tropical Queensland) was considered reasonable on the grounds that the climate and demographics of building type and use are comparable with the Northern Territory. The effect of the North Queensland data on the benchmark is examined later in the report.

Throughout this report, the greenhouse coefficients used have been the ABGR Northern Territory defaults of 0.69 kg/kWh for electricity and 0.2 kg/kWh for gas. This means that, should Queensland or Western Australia wish to use the “tropical” benchmark, further modifications will be required to adjust the benchmarks to reflect locally applicable greenhouse coefficients.

The distributions of the tenancy, whole building and base building data sets (including Nth Queensland data) are shown in Figure 1, Figure 2 and Figure 3 below. NGE refers to normalised emissions, which are the greenhouse emissions corrected for climate and hours of operation using the standard ABGR formulas.

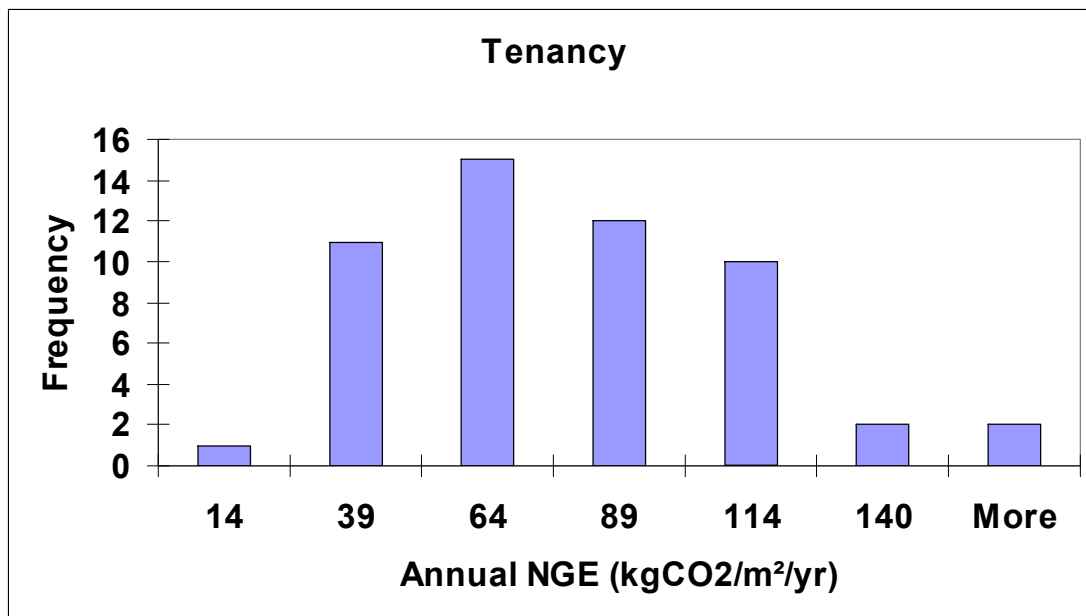


Figure 1: Tenancy normalised greenhouse emissions distribution

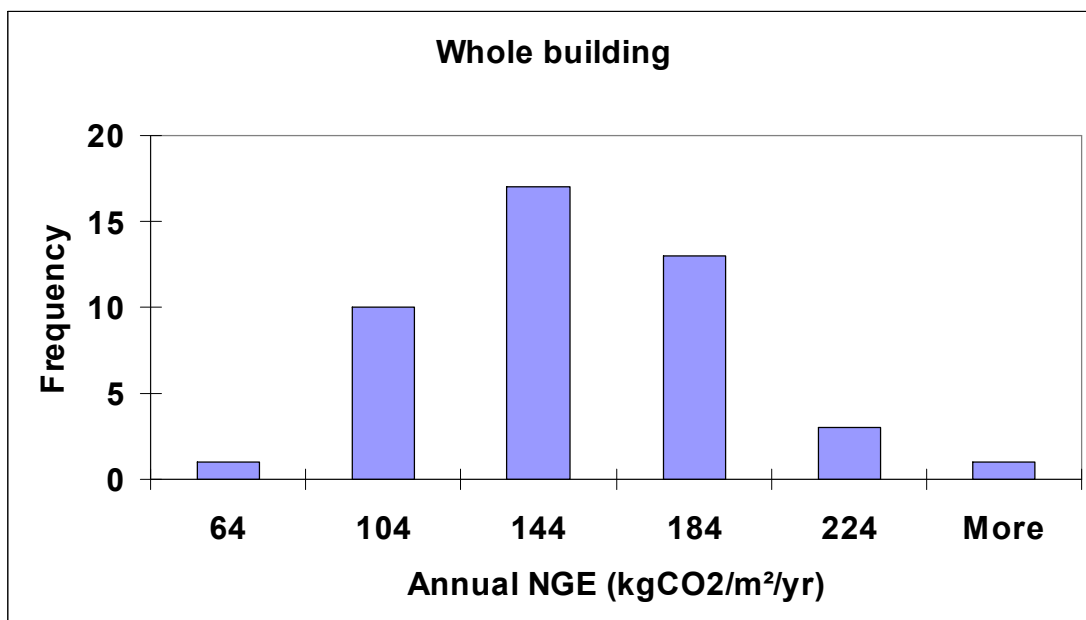


Figure 2: Whole building normalised greenhouse emissions distribution

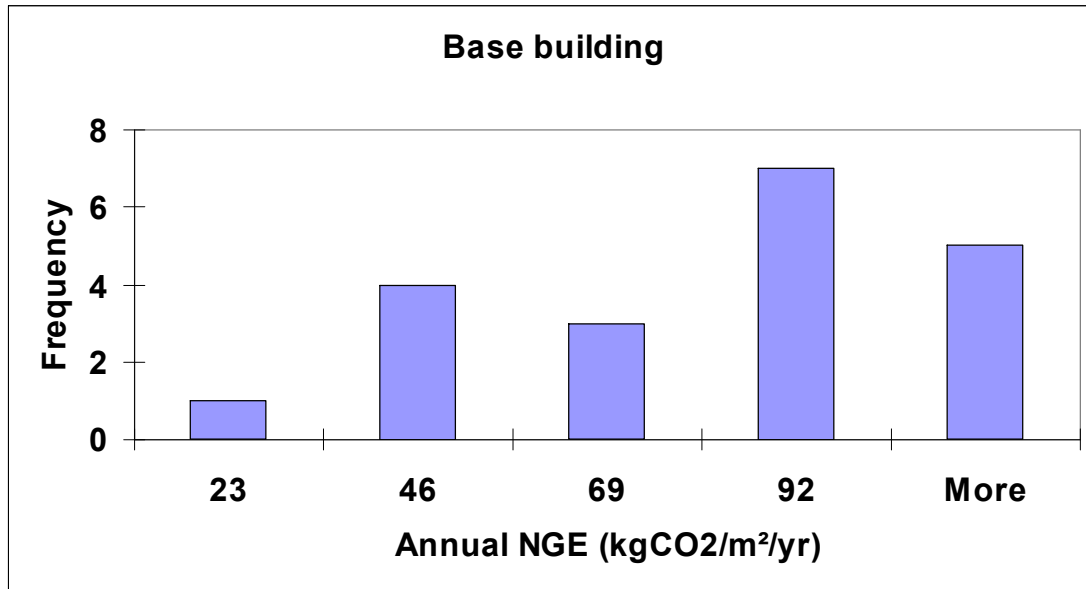


Figure 3: Base building normalised greenhouse emissions distribution

The tenant and whole building data display the expected Poissonian distribution. However, the base building data distribution is inconsistent. This is most likely to indicate inadequacy of data sample and data quality issues. As a result, the base building data is only of limited value in determining rating bands.

2. BENCHMARK DERIVATION PROCESS

2.1 Why Derive New Benchmarks?

2.1.1 A Short History of Northern Territory ABGR benchmarks

The original Northern Territory thresholds were based on an extrapolation of the ABGR national dataset to the Northern Territory after applying the theoretical ABGR climate correction to the rating bands. This process was effective only insofar as the climate correction is both correct and applicable to the nature of the building population in the Northern Territory.

Other states have used state specific benchmarking to ensure that ABGR rating bands correctly reflect the nature of the local market. This is a significant issue for the Northern Territory as the market is different to the broader national data set on the following grounds:

- The tropical climate is considerably different to that experienced in temperate climates;
- Buildings in Darwin tend to be smaller and simpler than those in the temperate climate data sets;
- Servicing of buildings in Darwin does not include heating, which eliminates a major source of complication and inefficiency in temperate region buildings;
- The style of occupancy and work habits of Territorians may also be different to other centres, with some evidence of less extended hours operation than in larger centres.

Overall these factors would tend to suggest that the original rating thresholds should have been expected to be a poor fit to the local building population. This was demonstrated in early ratings undertaken in the Northern Territory and other tropical areas that showed disproportionately high ratings for what were often fairly unremarkable buildings. As a result, the original rating bands were recognised as being inconsistent with the standards applicable to other states, where high ratings require a high level of technology and operational care to achieve.

To resolve these problems, it was essential to revise the benchmarks to be consistent with the application of ABGR in other states. This process was first attempted in 2003/4, when a first suggested set of new benchmarks were derived. However, the data set used for this exercise was very poor and it was agreed to repeat the exercise after more data had been collected. Nonetheless, these “first revision” benchmarks, as they will be referred to in

the balance of this report, were implemented into the rating system in 2006 as they were considerably more representative of the Territory building stock than the original benchmarks.

In recognition of the sparse nature of the data used to define the first revision benchmarks, an additional data collection exercise was conducted in early 2007 with a view to refining these benchmarks. This report documents the results of this new derivation of the benchmarks.

2.1.2 Threshold Derivation Process

Ratings thresholds provide a means of translating normalised greenhouse emissions to a star rating. The normalised greenhouse emissions represent the greenhouse performance of the building converted to a common basis of comparison through the use of a number of normalisation factors, being:

- Tenancy: Area, hours, equipment density
- Base building: Area, hours, climate
- Whole building: Area, hours, climate and equipment density

The common basis for comparison in all cases is:

- Area: All figures are assessed on a per m² basis
- Hours: All figures are normalised to (nominally) 50 hours per week
- Climate: The climate correction factor adjusts climate relative to Sydney as a base climate
- Equipment density: The equipment density is adjusted to 8W/m² based on 200W aggregate equipment consumption per computer

Throughout this report, the process for calculating normalised greenhouse emissions is constant for all the various rating thresholds – only the conversion of the normalised greenhouse emission to star rating is changed. This is consistent with the approach used under ABGR for the balance of the country.

To maintain consistency with other states, the threshold derivation process followed in this report uses the following guidelines:

1. The median of the building population should achieve approximately 2.5 stars. Given that 2.5 stars corresponds to a rating score between 2 and 2.5, the ideal median should be set at a rating score of 2.25.
2. The one star threshold should be set at a point such that around 20% of the population fails to achieve 1 star and thus cannot be rated.
3. Four stars should represent close to the top of the current market while 5 stars should in general not yet be achieved.
4. Rating bands should be linear, and for all rating thresholds, the sum of the base building and tenancy thresholds is equal to the whole building threshold.

5. For tenancies, an additional parameter is that it is desirable to set the 5 star limit to reflect that recommended to the ABGR National Administrator in a recent study of high performance tenancies. This limit is equivalent to 38kWh/m² or, for the Northern Territory, 26.4 kg/m² normalised emissions. This requirement has yet to be rolled out to other states but is a factor being considered under the current review of ABGR rating bands generally.

Clearly, not all of these guidelines can be satisfied simultaneously, so a degree of adjustment is required to achieve the best fit to all the competing requirements.

It is noted that although comparisons are made to the first revision benchmarks, the new process was conducted independently of that work based on an expanded data set.

2.1.3 Data Quality Assurance

It is inevitable in an exercise of this nature that not all of the data is reliable, representative or correct. As a result, some quality assurance is necessary. For this project the main quality assurance tests applied to data were:

- Buildings that appeared to show an occupant density of less than 1 person per 60m² were eliminated from the sample. These were considered to be unrepresentative and possibly spurious.
- Where it was possible to identify buildings that had multiple entries into the data set from multiple sources, these were reduced to a single entry;
- Where multi-floor tenancies of the same organisation within the same building were reported as single tenancies for each floor, these were reduced to a single entry based on the aggregate of the floors.

2.1.4 Approach to the Base Building Rating

Based on simple statistical tests, the calculated uncertainty in the mean of the whole building data set was, on a relative basis, 57% of that of the tenancy data set and 33% of that of the base building data set. This means that we can assign a higher level of statistical confidence to the whole building results than to the tenancy or base building results. As a result, it is most important that the whole building rating accurately reflects the statistics of the whole building data set.

The tenancy data set, while having a lesser level of certainty in the mean, is sufficiently large that it is possible to also have a good level of confidence in the results.

However, the small size of the base building data set means that this can only be considered a notional sample. Not only is there a high level of statistical uncertainty in this sample, but also there is a greater probability of bias in the sample from incorrect data or non-random sampling patterns. Therefore, only a limited amount of confidence can be assigned to the base building data set.

On this basis, it was determined that the preferred approach is to derive statistically based whole building and tenancy thresholds, while using the subtraction of the tenancy thresholds from the whole building thresholds to determine the base building bands. The resultant base building thresholds were then compared against the base building data set to establish whether the fit to the sample was at least plausible.

2.2 ABGR Whole Building Rating

Applying the original rating bands to the whole building data set gives a mean value of 3.53 stars and a median of 3.63. The range is from 0.5 to 5 stars. The statistical uncertainty in the mean is ± 0.41 stars, which indicates that the initial equations are inappropriate for a target mean of 2.5 stars. This is in conflict with the intent of the rating scheme, the average of the population should be ≈ 2.25 stars. The distribution is shown in Figure 4, below.

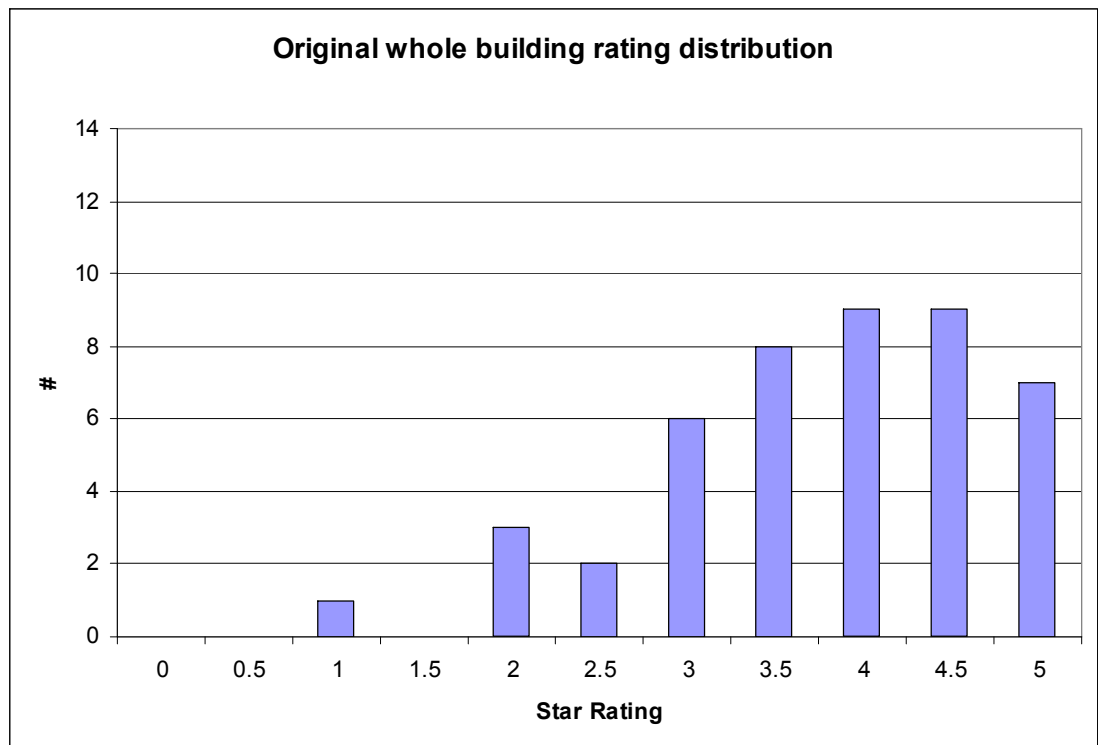


Figure 4: Original rating bands applied to the data set

The distribution confirms that the original bands were too easily achievable, the majority of buildings achieve 3.5 or 4 stars. Only 1 building scores less than 1.5. Based on the expected Poissonian distribution of the building population, more buildings should be below the 2.5 star rating than above it.

By contrast, the application of the first revision of the rating bands to the data set results in a mean rating of 1.77 stars and a median rating of 1.94. The range of ratings is -3.62 to 4.52. This suggests that the lower rating bands for whole building ratings are marginally too stringent as the intended mean rating should be 2.25. The distribution of ratings under the first revision bands is shown in Figure 5.

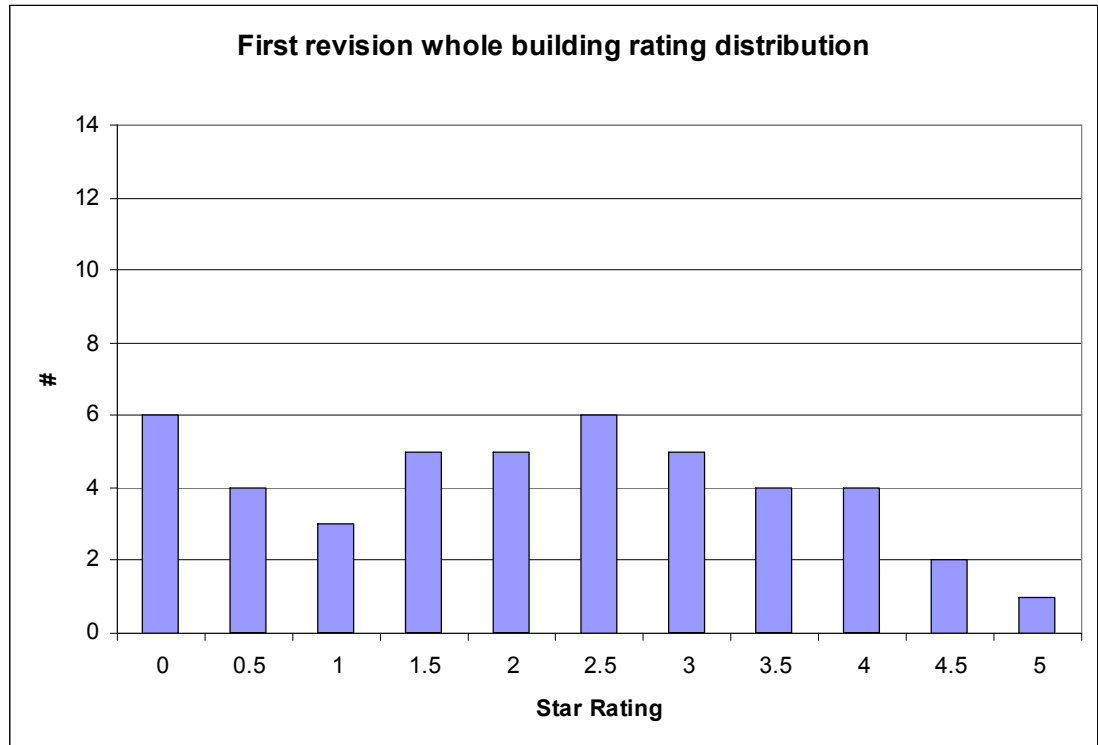


Figure 5: First revision rating bands applied to the data set

Applying the principles outlined in Section 2.1.2, new benchmarks were derived based on the new data set. The new distribution is shown in Figure 6, below.

The resultant rating thresholds give an average rating of 2.06 stars with a median of 2.20. The range of ratings is -2.35 to 4.31. This is a more desirable outcome as it places the mid point of the rating scale within the 95% confidence interval of the population mean, which is ± 0.41 stars. Furthermore, the distribution of buildings at the high end of the rating scale is realistic and comparable to that in other parts of the country.

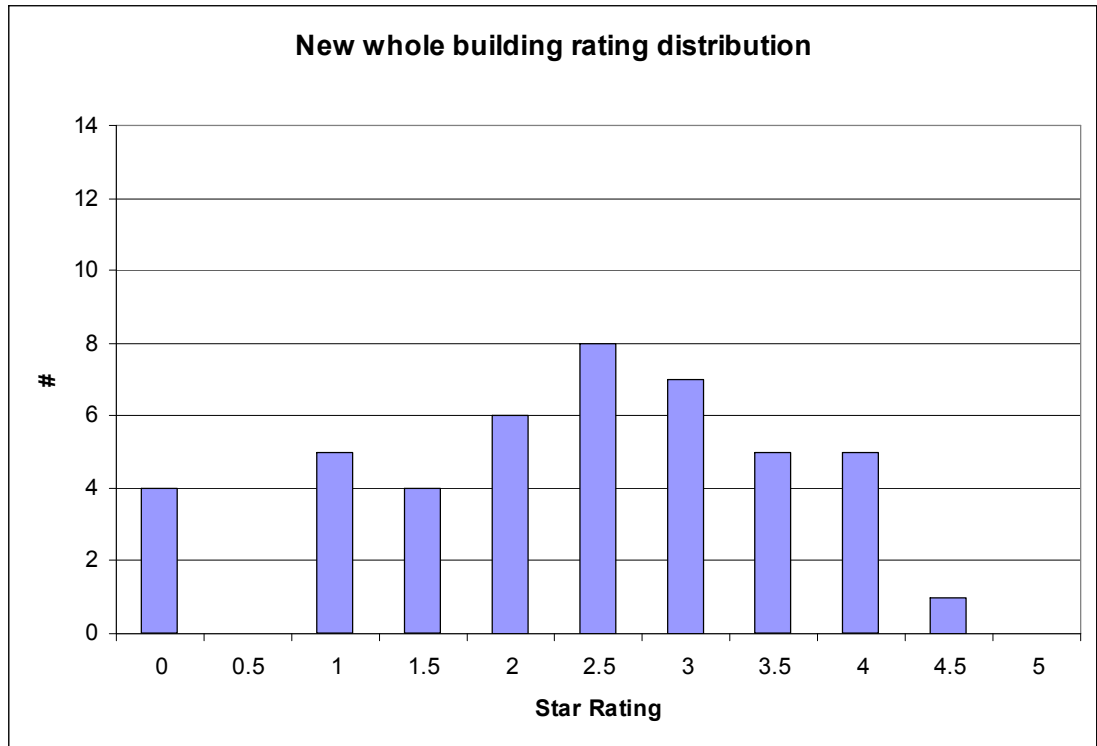


Figure 6: New star rating bands applied to the data set

Applying the new rating function to the tropical and inland sub-sets of the whole building data gave the following results:

	Tropical Sites	Inland Sites
No of points	30	16
Mean star rating	1.99	1.97
Median star rating	2.51	2.01

Table 1: Tropical vs inland whole building performance

The performance of each geographical location is fairly comparable. The smaller size of the inland sample means that it is of questionable significance. No definitive conclusion can be drawn about the half star difference in median ratings.

A summary of the old and new rating thresholds follow in Table 2:

Star Rating	Original thresholds (NGE)	First revision thresholds (NGE)	2007 revised thresholds (NGE)
Unratable	>264.30	>162.50	>178.23
1	264.30	162.50	178.23
2	220.44	137.87	148.13
midpoint	187.55	119.41	125.56
3	176.58	113.25	118.04
4	132.72	88.63	87.94
5	88.86	64.01	57.85

Table 2: Present and revised whole building star band thresholds

The formula for calculating the revised bands is shown below:

$$R_{WholeBuilding} = 6.422206 - 0.03323NGE_{WholeBuilding}$$

Where $R_{wholebuilding}$ is the “raw” rating and $NGE_{wholebuilding}$ is the normalised greenhouse emissions figure calculated in accordance with the ABGR methodology outlined in the document *Australian Building Greenhouse Rating Scheme: Methodology Description..* To calculate the number of stars, $R_{wholebuilding}$ is treated as follows: For star rating a , $a-0.5 < R_{wholebuilding} \leq a$ gives a rating of a stars while $a < R_{wholebuilding} \leq a+0.5$ gives a rating of a and a half stars.

2.3 ABGR Tenancy Rating

Using the original rating algorithm on the tenancy data set gives a mean of 3.18, a median of 3.42 and a range of -1.90 to 5.58 stars. The distribution of ratings is shown in Figure 7, below.

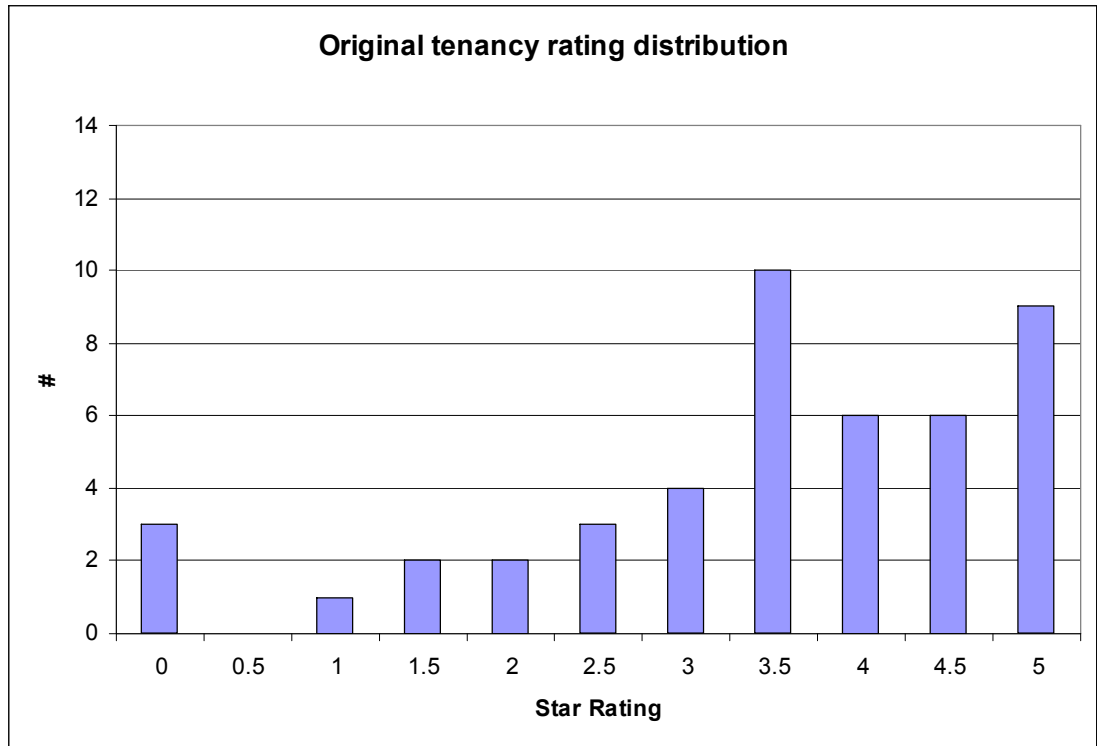


Figure 7: Original rating bands applied to tenancy data

This distribution of ratings is very top heavy, a larger proportion of the population rates above 2.5 stars than below it. The average performance of the population is well in excess of the target of the ABGR scheme. The uncertainty of the sample to a 95% confidence interval is ± 0.72 stars, the mean of this distribution lies outside this range.

The first revision of ABGR bands applied to the data set used in this study give an average rating of 1.97 and a median value of 2.29 stars. This result is somewhat low relative to the intent of ABGR, but well within the 95% confidence bounds. The distribution of the data is shown in Figure 8:

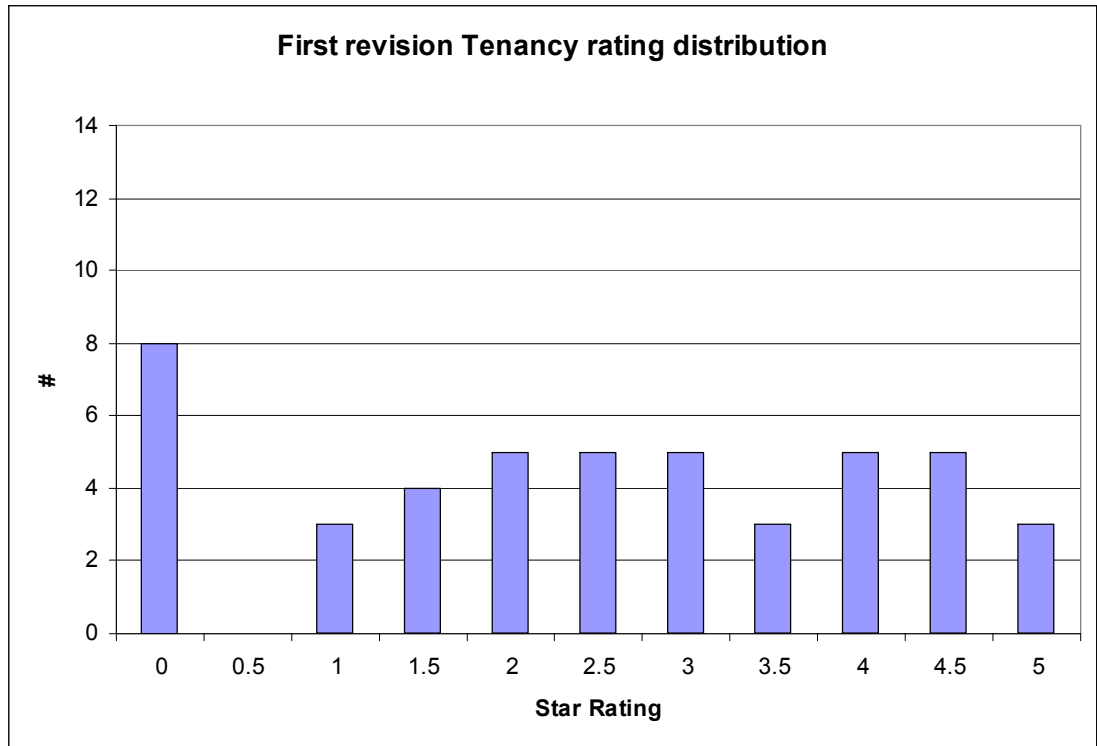


Figure 8: First revision tenancy bands applied to the data set

Applying the process outlined in Section 2.1.2 gives a new set of rating thresholds such that the sample achieves a mean rating score of 2.14 and a median rating score of 2.30, both of which translate to 2.5 stars. This is a very minor adjustment from the first revision bands only. The effect on the distribution is shown in Figure 9, below:

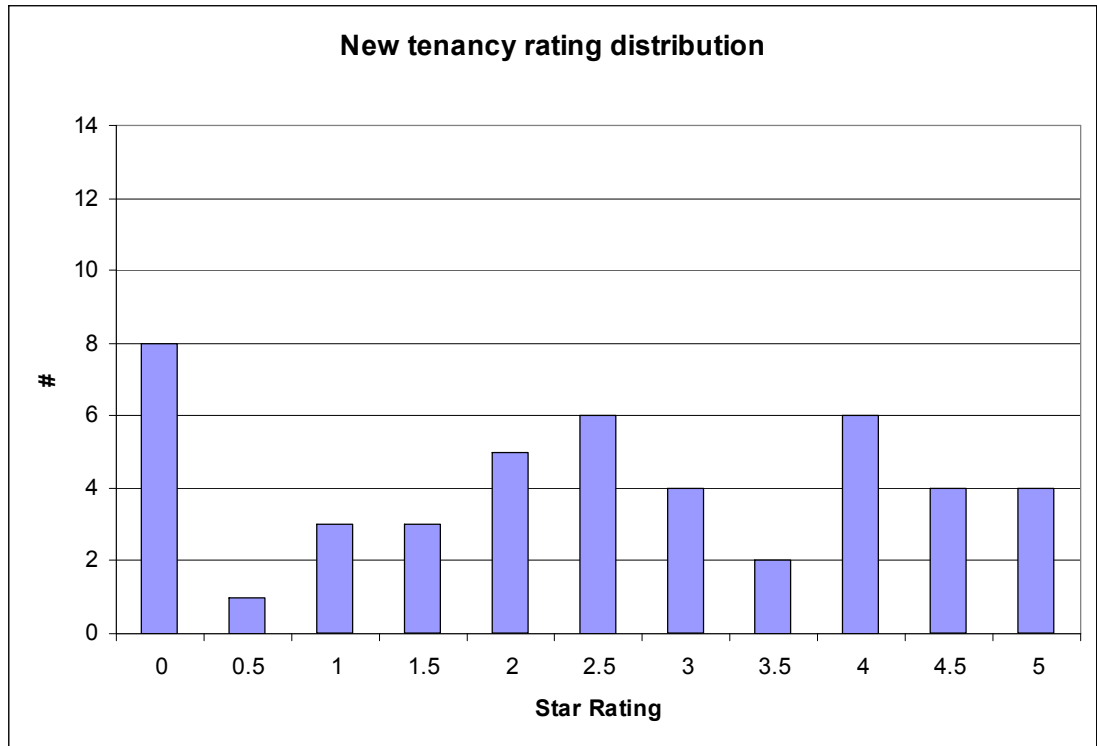


Figure 9: New tenancy bands applied to the data set

Revised tenancy band thresholds are shown in Table 3:

Star Rating	Original thresholds (NGE)	First revision thresholds (NGE)	2007 revised thresholds (NGE)
Unratable	>116.3	>83.13	>81.66
1	116.3	83.13	81.66
2	96.2	68.84	67.85
Midpoint	81.02	58.13	57.49
3	76.0	54.56	54.04
4	55.8	40.28	40.23
5	35.6	26.00	26.42

Table 3: Present and revised tenancy star band thresholds

The equation for the latest revised bands is:

$$R_{Tenancy} = 6.413814 - 0.07242 NGE_{Tenancy}$$

Where $R_{tenancy}$ is the “raw” rating and $NGE_{tenancy}$ is the normalised greenhouse emissions figure calculated in accordance with the ABGR methodology outlined in the document *Australian Building Greenhouse Rating Scheme: Methodology Description*.. To calculate the number of stars, $R_{tenancy}$ is treated

as follows: For star rating a , $a-0.5 < R_{tenancy} \leq a$ gives a rating of a stars while $a < R_{tenancy} \leq a+0.5$ gives a rating of a and a half stars.

2.4 ABGR Base Building Rating

As previously discussed, the base building rating thresholds have been derived from the subtraction of the tenancy thresholds from the whole building thresholds due to the inadequacies of the base building data set.

However, while the current data set of 20 base building samples is far from ideal, it is substantially (almost triple) the data available to the 2003/4 analyses. As a result, it is worthwhile to at least compare the data set to the existing and proposed rating bands.

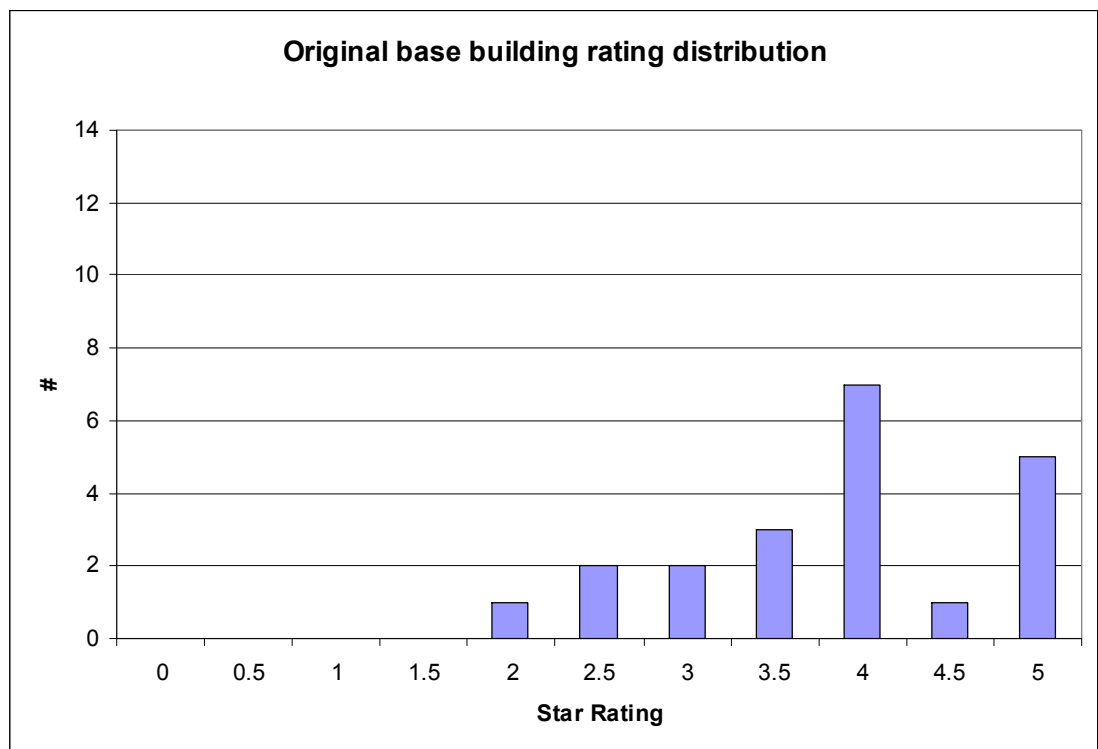


Figure 10: Original rating bands applied to base building data set

Using the original rating bands, the mean of the population is 3.76, the median is 3.78. The uncertainty in the mean at a 95% confidence interval is ± 1.24 stars. The; this puts both the mean and the median of the population outside of the target for ABGR. Thus, even with such a large uncertainty in the data, the original rating thresholds would appear to be a poor fit to the population as represented by the current sample. This can be seen in Figure 10, where the sample is clearly skewed to the upper end of the rating scale.

Applying the first revision bands to the data gives a mean of 1.43 and a median of 1.47. Although the high level of uncertainty in the mean means that this result should not be taken too seriously, there is a reasonable case that these bands should be relaxed.

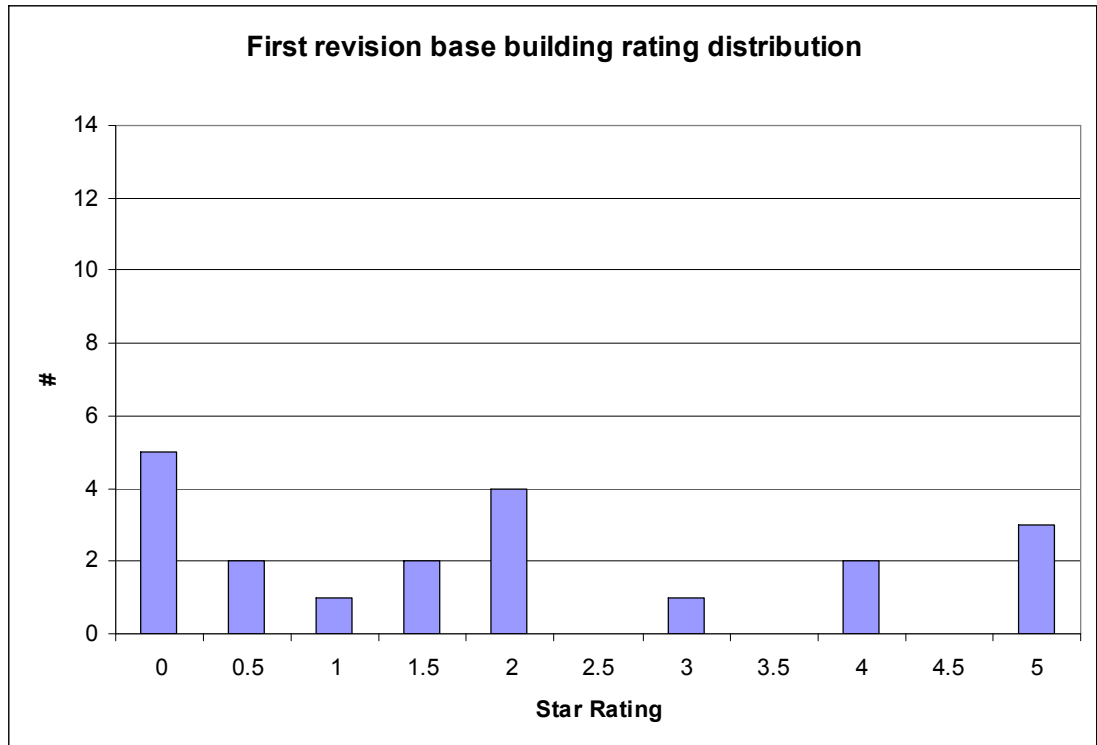


Figure 11: First revision rating bands applied to base building data set

Applying the newly derived rating thresholds to the current data set, the revised mean rating score is 1.89 and the median rating score is 1.94. These figures both correspond to a (high) 2 star rating. Given the high level of statistical uncertainty (± 1.24 stars), this is well within the uncertainty bounds for 2.5 stars. The distribution of the building sample performance is shown in Figure 12, below.

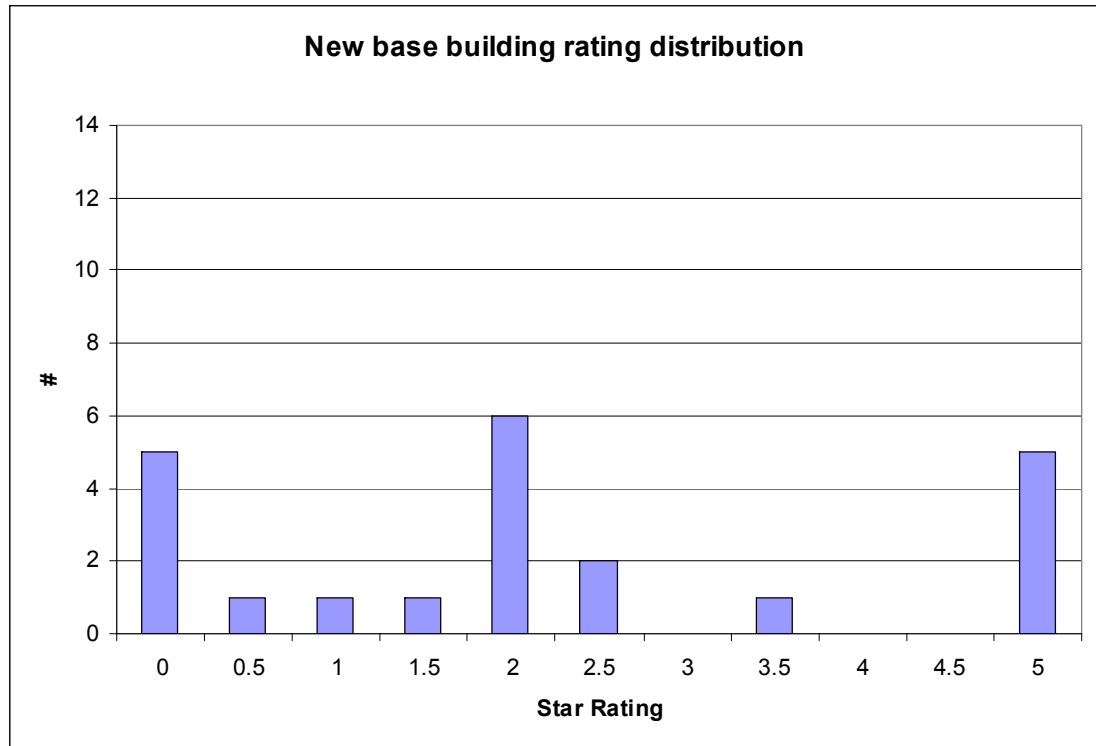


Figure 12: New rating bands applied to base building data set

Again, the sparseness of the data is evident in this distribution. The extreme values and the high uncertainty in the sample mean are both strong indicators of inconsistency and possible erroneous information in the base building data. The previous and revised thresholds are shown in Table 4:

Star Rating	Original thresholds (NGE)	First revision thresholds (NGE)	2007 revision thresholds (NGE)
Unratable	>147.93	>81.74	>96.57
1	147.93	81.74	96.57
2	124.26	69.82	80.29
Midpoint	106.51	60.87	68.07
3	100.59	57.89	64.00
4	76.92	45.96	47.71
5	53.25	34.04	31.42

Table 4: Present and revised base building star thresholds

The equation describing the most recent revision of the ratings is:

$$R_{BaseBuilding} = 8.850637 - 0.09846 NGE_{BaseBuilding}$$

Where $R_{basebuilding}$ is the “raw” rating and $NGE_{basebuilding}$ is the normalised greenhouse emissions figure calculated in accordance with the ABGR

methodology outlined in the document *Australian Building Greenhouse Rating Scheme: Methodology Description*. To calculate the number of stars, $R_{basebuilding}$ is treated as follows: For star rating a , $a-0.5 < R_{basebuilding} \leq a$ gives a rating of a stars while $a < R_{basebuilding} \leq a+0.5$ gives a rating of a and a half stars.

2.5 Inclusion/Exclusion of Northern Queensland data

During the previous benchmarking study, data was used that was collected from sites in Northern Queensland¹. As the primary purpose for this current study is to derive bands for the Northern Territory, it is important to establish a rational basis for the inclusion of these sites.

For the current data set, the breakdown of sites and their location is as follows:

- Whole building: 33 sites – NT; 15 sites – Nth Qld,
- Tenancies: 48 sites – NT; 7 sites – Nth Qld,
- Base building: 14 sites – NT; 6 sites – Nth Qld,

Logically, the only samples of interest for this analysis are the whole building and tenancy data sets. The current methodology provides no avenue for the base building data to influence the rating bands, furthermore, the base building sample is the smallest so results will have the least confidence level. Thus, no statistical analysis of this population was conducted.

The statistical analysis technique chosen was a t-test, the output of which is a confidence interval that the means of the two populations are the same. Two, two-tail t-tests were conducted, one assuming unequal population variances and another assuming equal variances. If there is a sufficient confident level (95%) in the results, then barring other subjective considerations a decision to exclude the populations can be made.

2.5.1 Whole Building Data

The results of the t-tests for the whole building data were:

- Unequal variances:
 - means – NT = 126.84, Qld = 140.02
 - P stat = 0.308
- Equal variances:
 - means – NT = 127.27, Qld = 137.3
 - P stat = 0.466

¹ To be consider “Northern” the sites had to be further North than the Tropic of Capricorn

The P stat for these tests shows that for unequal variances there is a $\approx 69\%$ confidence level that the populations have different means. Assuming equal variances gives only a $\approx 53\%$ confidence level that the populations have different means. These results do not provide a statistical basis for the exclusion of the Northern Queensland data. The similarities of the populations can be graphically represented in their distributions. Histograms of the populations are shown in Figure 13 and Figure 14, below:

Given that the mean NGE for the Queensland site is marginally higher than that of the Northern Territory sites, the impact of the inclusion of these site in the sample is a marginal relaxation of the whole and base building thresholds.

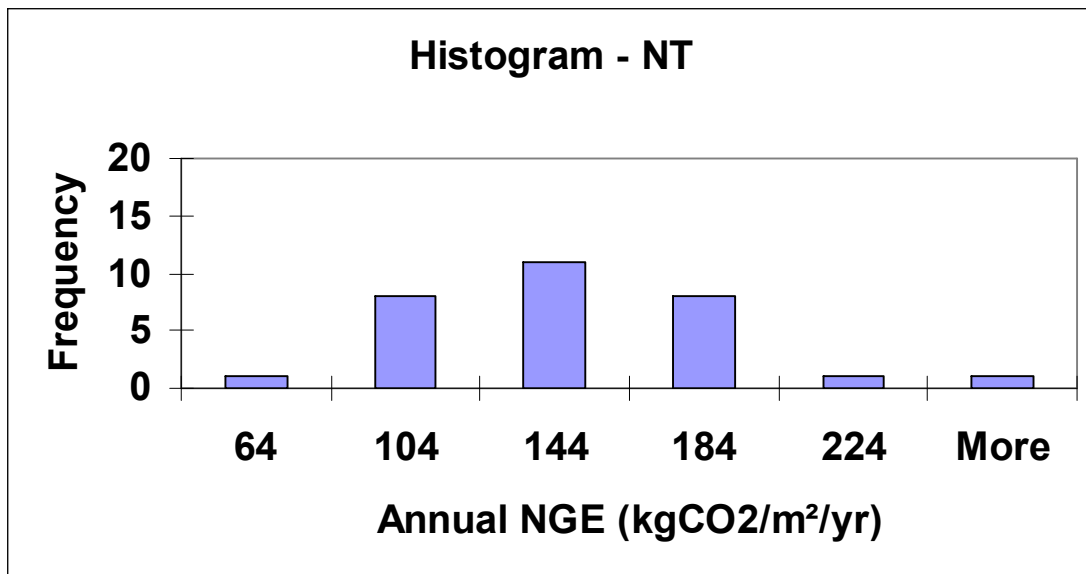


Figure 13: Whole building NGE histogram – NT

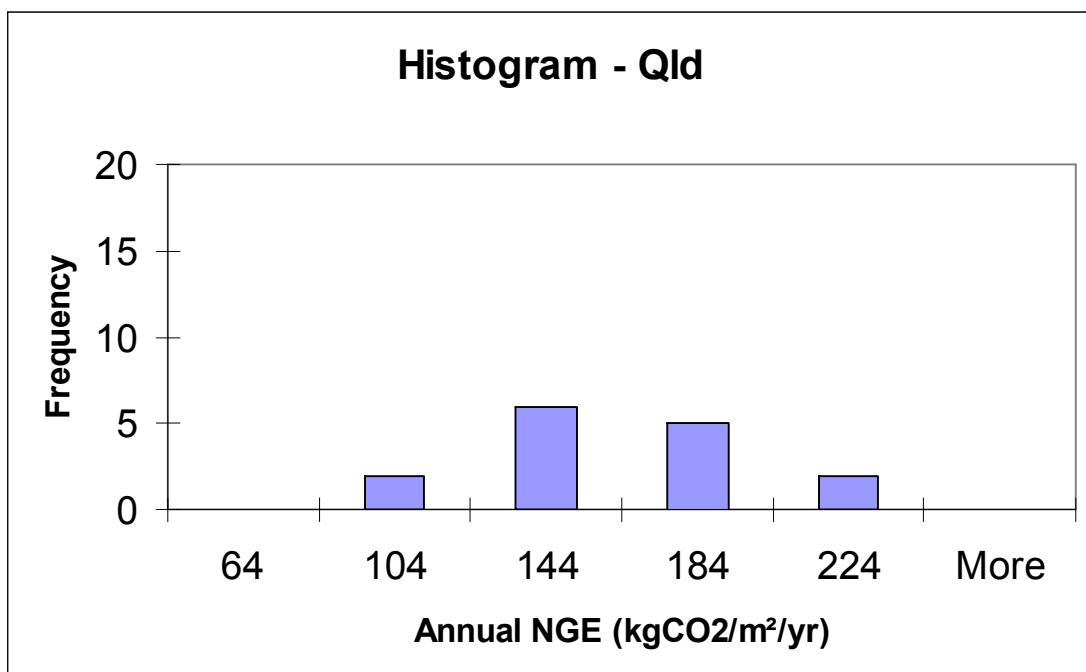


Figure 14: Whole building NGE histogram – Northern Queensland

2.5.2 Tenancy Data

The results for the t-tests for the tenancy samples were:

- Unequal variances:
 - means – NT = 62.20, Qld = 100.51
 - P stat = 0.000262
- Equal variances:
 - means – NT = 62.12, Qld = 105.89
 - P stat = 0.002028

The results of this test show that there is a \approx 98-99% confidence interval that the means for the two data sets are statistically different. This translates to a statistical basis for excluding the Queensland data. However, the caveats associated with this conclusion are:

- The Queensland data only has 7 points, thus it may not be a true representation of the whole population of tropical Queensland buildings.
- The data was all gathered from sites of one organisation thus is heavily dictated by the operational culture of that organisation. This means that the bias is more likely to be representative of this issue rather than any fundamental geographical issue.

It was decided to retain the North Queensland tenancy data within the sample for the following reasons:

- The national direction for ABGR is towards creating national tenancy rating bands. The North Queensland sites were consistent with the Northern territory sites that are not necessarily well represented in the national data set.
- From a technology based standpoint there is no reason why geography would play a part in the energy consumption of a tenancy.

It is noted that the effect of the inclusion of these sites is limited as the 5 star point was determined via an independent study rather than from the data sample. To the extent that the North Queensland buildings decrease the median NGE for the sample, the median base building rating NGE will be increased. The overall impact of these data point is therefore not considered to be particularly problematic.

2.6 NABERS Office Water

The existing NABERS Office water is based on data from Melbourne to Brisbane but no data for tropical regions. As a result, it has not been operated in these climates pending some degree of validation. This is particularly important given that the rating data set shows a very strong dependence on

climate, reflecting the increased heat rejection requirements (and thus cooling water requirements) of warmer climates.

The water data submitted for the study consisted was wholly submitted as part of the 2007 survey and includes only data from the Northern Territory. There were 11 sites for which water data was submitted, 5 with cooling towers, 3 without and 3 with a blank field. The performance of the different plant types is as follows in Table 5. Predictably, the sites with air-cooled HVAC perform considerably better.

	Air-cooled HVAC	Water-cooled HVAC
Mean star rating	4.17	2.9
Annual mean water consumption (kL/m ²)	0.47	1.82

Table 5: Water benchmark performance of sites with and without cooling towers

Overall, this is a fairly small data set from which any conclusions must be drawn with care. The analysis used the climate correction approach outlined in the original NABERS water methodology. The distribution of ratings is shown in Figure 15.

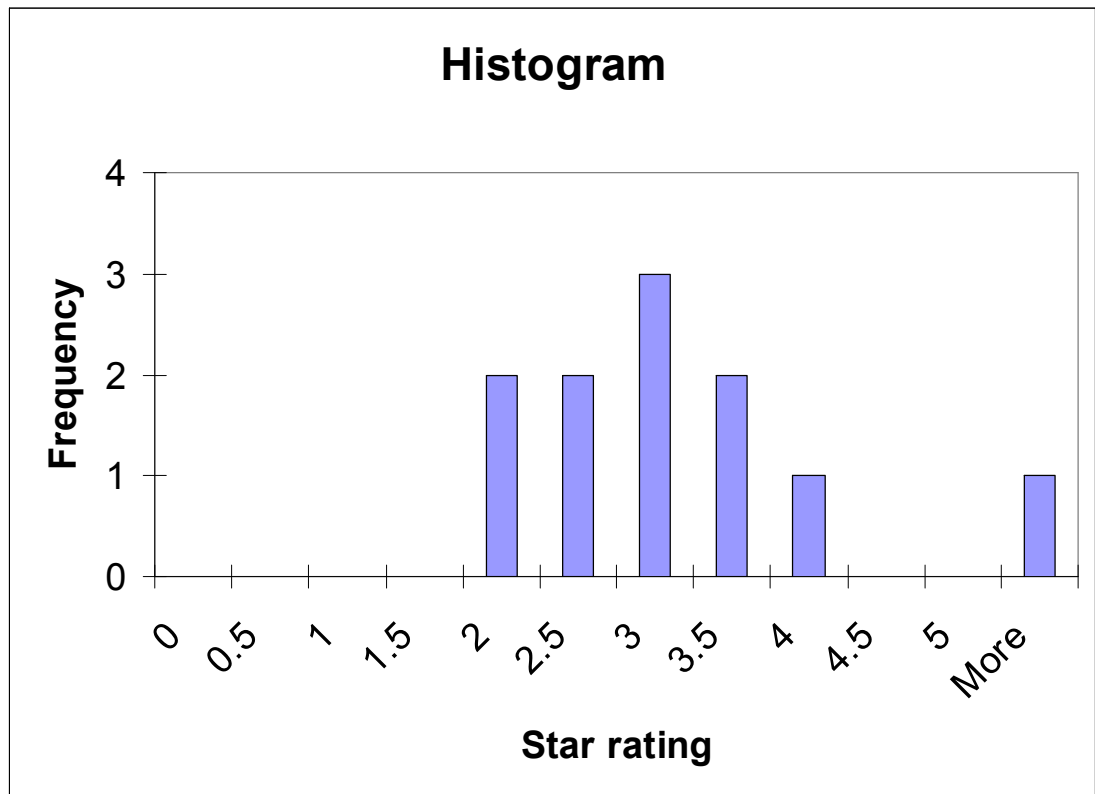


Figure 15: NABERS water benchmark of data set.

The mean of this sample is 3.41, the median is 3.18 and the range is 2.24 to 5.80. To put this in context, the 95% confidence interval is ± 0.69 stars, which places the ideal midpoint of 2.25 outside the confidence interval of the sample

mean. However, given such a small data set, it would be rash to draw a definitive conclusion on the basis of these results.

As a result, it is recommended that:

1. NABERS Office Water can be extended to tropical regions, given that the data set does not demonstrate any unreasonableness when evaluated against the rating;
2. The existing climate correction for NABERS Office Water should be retained unaltered in the extension to tropical regions until a more definitive tropical data set is available.

3. CONCLUSIONS

This report has described the process of revising the ABGR bands for Northern Territory buildings. The revision was necessary due to the identified issues of high performing base building systems in the original rating bands and the weakness of the data set used to formulate the first revision of the benchmarks that forms the basis of the current bands.

This revision presented in this report is based on data provided by Northern Territory Department of Planning and Infrastructure, data on record from Exergy's previous studies and from a market survey which was a joint effort between Exergy and NT DPI.

The data sample was much more substantial in this study than in previous attempts at resetting the thresholds. However, further tuning of the bands is recommended if and when more data becomes available. The benchmarks presented in this report are the most accurate developed so far, and will assist the ABGR model to be more effective in tropical regions.

The revised whole building, tenancy and base building rating band equations are as follows:

$$R_{WholeBuilding} = 6.422206 - 0.03323 NGE_{WholeBuilding}$$

$$R_{Tenancy} = 6.413814 - 0.07242 NGE_{Tenancy}$$

$$R_{BaseBuilding} = 8.850637 - 0.09846 NGE_{BaseBuilding}$$

Furthermore, the application of the NABERS water benchmarks to a small group of buildings indicated that the Northern Territory buildings were performing better than expected. However, as the sample was very small, no change to the benchmark is recommended at this stage. The fact that the sample rates sensibly on the scale is sufficient to support the extension of the NABERS office water benchmark to tropical climates at this stage.

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