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DfP Base Building Rating Tool

Recommendations Report

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List of abbreviations and acronyms

ABGR	Australian Building Greenhouse Rating
CO_2e	Carbon dioxide equivalent (accounting for the basket of six greenhouse gases)
DEC	Display Energy Certificate
EPBD	(European) Energy Performance of Buildings Directive
GIA	Gross Internal Area
GHG	Greenhouse Gas
kWhe	kWh of electricity equivalent
LER	Landlord Energy Rating
NABERS	National Australian Built Environment Rating System
NIA	Net Internal Area (as defined by RICS)
NLA	Net Lettable Area (common industry terminology for NIA)
REEB	Real Estate Environmental Benchmark
TUFA	Total Usable Floor Area = GIA less area of separable energy uses. Used for DECs

Summary

This report sets out discussions and recommendations for the main features of a NABERS base building energy rating for offices in the UK.

The following key recommendations are made in this report:

1. The rating should be set using the standard NABERS methodology (linear, 6 star scale with notional seventh star at zero) with the scale calibrated using empirical data from the population of air-conditioned commercial offices owned by BBP members.
2. The scale metric numerator (annual energy use) should be based on kWh of electricity equivalent (kWh_e) with the weighting factors for non-electrical energy carriers calculated by their primary energy equivalence to electricity. Thus 1 kWh of electricity is always counted as 1 kWh_e while, for instance, 1 kWh of natural gas is counted as 0.75 kWh_e, this being the ratio of the primary energy for natural gas to the primary energy for grid electricity, based on 2020 primary energy factors. This ratio will need periodic updating across the next decade, as by 2030 the ratio is currently projected to be 0.86.
3. The scale metric annual energy use should be normalised by net lettable floor area (NLA). Area measurement should be based on the RICS Net Internal Area figure, which is commonly used by the commercial building industry (albeit normally called NLA) and is broadly equivalent to the Australian NLA measurement.
4. A climate correction which allows for differences in both heating and cooling requirements in different parts of the UK has been proposed, based on simulation model estimates. This is projected to have a maximum impact of around 6% of the base building energy.
5. No year-on-year weather correction has been proposed, because it is calculated to be a relatively small driver in air-conditioned commercial offices and its application would create a significant extra administrative burden for the rating scheme.
6. An hours of use correction has been proposed based on simulation model estimates. The hours of use input data entered into the rating tool should be determined by using existing NABERS methodologies, but further work is required to ensure that these can be adequately translated into the UK context.
7. Base building/tenancy boundaries should be defined as per existing NABERS rules, but simplified estimation methods have been proposed to deal with common boundary transgressions such as fan coil motors. Most other boundary transgressions can be covered with variants of existing NABERS provisions.
8. Occupant density has been identified to have a larger, but still second order, potential impact on a base building rating, relative to Australia. This is probably because the fan coil unit HVAC design prevalent in the UK forces chiller operation to serve internal building loads all year round, whereas the VAV designs prevalent in Australia can meet these loads with

outside air for much of the year. Because it is a second order impact and occupant density is difficult to measure accurately, it is not proposed to provide an occupant density correction at this stage. However, it is proposed that relevant data should be gathered on this issue as part of the process to undertake ratings to allow for future analysis.

9. No benchmark adjustment has been proposed for the provision of car parks at this stage, as no data was available on the level of car park provision in buildings or the potential energy impact of these. However, it is proposed that relevant data should be gathered on this issue as a part of the process to undertake ratings to allow for future analysis.
10. District heating and cooling are proposed to be handled via default primary energy factors, as in many cases the district heating or cooling scheme is outside the control of the building owner or landlord. These coefficients are to be set as neutrally as possible. Buildings that are serviced by and can influence CHP or similar schemes are proposed to be handled as per existing NABERS cogeneration and trigeneration rules.
11. On-site renewable energy has been proposed, by default, to be allocated as per current draft NABERS rules, i.e. allocated to users based on relative consumption, unless there is explicit contractual documentation to the contrary.
12. Off-site renewable energy should not be recognised as differentiated from other forms of grid energy supply.

Overall, this report presents a framework for the adaptation of NABERS to the UK context and shows that the application of that framework produces plausible rating outcomes.

1. Introduction

1.1 Background

The National Australian Built Environment Rating Scheme (NABERS) rating for energy use in offices has been in operation in Australia effectively since 1999. The scheme has had major impacts, of the order of 40% on the average energy efficiency of medium to large office buildings over this period, as well as deep market penetration, reaching around 85% of commercial office floor area by 2018. This is the case particularly in relation to the “base building” energy rating which refers to all the energy used in common areas including for lifts and car parks and the energy used for HVAC in both common areas and tenancies.

The key features of NABERS that have contributed to this success are:

1. The use of a simple star rating that communicates the efficiency of a building to non-technical stakeholders
2. The separate assessment of base building energy use as the key indicator of the energy efficiency of an office building, enabling the building owner to assess and declare the efficiency of their building with first-order independence from the activities and efficiency of their tenants. This then creates competitive tension between building owners to show that their efficiency is better than others.
3. Well defined and detailed rules and quality assurance procedures to ensure that ratings are reliable and repeatable between different assessors,
4. Close cooperation with the construction and property industries and their multiple stakeholders, developing a high level of trust in the system and fostering significant reductions in energy use and carbon emissions.
5. Integration and enablement of other policy programmes, both in terms of upgrade programmes and most notably in terms of mandatory disclosure of NABERS ratings for office space sale or lease transactions greater than 1000 m^2.

The UK does not have a large-scale scheme equivalent to NABERS. The two most similar government programmes are:

1. Display Energy Certificates (DECs). These provide an energy efficiency rating for the total annual operational energy use of a building (a whole building rating in NABERS vocabulary). DECs are mandatory for buildings occupied by public sector organisations and visited by the public but are very rarely used voluntarily in the commercial sector. Being a whole building assessment, DECs do not provide the ability to separate building owner and tenant energy efficiency factors.
2. Energy Performance Certificates (EPCs). These provide an indication of the theoretical energy efficiency of buildings and are mandatory across most building types for new construction and to inform a sale or letting property transaction for an existing building.

> However, being theoretical rather than based on actual performance, they do not capture the myriad issues that cause buildings to underperform in practice relative to their theoretical potential (a problem commonly known as “the performance gap”).

The most direct comparator to NABERS in the UK is the Better Buildings Partnership’s Landlord Energy Rating (LER). This was developed by Verco for the BBP in 2012 and utilised the same key features as NABERS (base building rating, simple star scale, based on actual annual energy use). The rating however achieved limited uptake due significantly to technical (and therefore cost) issues with the measurement of base building energy in UK buildings, and the lower priority operational energy performance has been generally given by the industry until recently.

In response to this, the BBP has worked with the UK construction and property industries to develop the Design for Performance (DfP) initiative, which seeks to encourage issues of post-construction performance to be considered and monitored from design through to performance, including – notably – the provision of metering that enables the clear and consistent separation of base building and tenancy energy use. Central to the DfP approach is the concept of a Project Agreement, where a project owner commits to design, build, tune and operate a building to achieve a post-construction energy target which is verified by measurement after a year of occupancy. This approach follows and expands upon that used by NABERS in its Commitment Agreement, which has been applied to over 200 projects in Australia. As part of the development of DfP, the BBP has entered into a partnership with NABERS enabling it to access the 20 years of experience and intellectual property developed in Australia, with a view to adapting it to the UK.

The purpose of this report is to lay out the basis by which the key headline features of the NABERS Energy for offices base building rating are proposed to be adapted for the UK, with particular reference to the structure of the rating calculation and key input parameters. The intent is that this adapted rating will be used primarily in conjunction with the DfP Project Agreement for the assessment of new projects, recognising the challenges of metering faced by many existing buildings. However, the rating is also constructed to be accessible and relevant to existing buildings, and it is expected that there will be significant uptake from this sector over time.

In terms of general approach, the rating adaptation seeks to utilise as much as possible of existing NABERS methodologies and procedures except where these benefit from being adapted to suit the UK context. This maximises the benefit that the project can achieve from the mature intellectual property within NABERS.

1.2 Acknowledgements

The Design for Performance initiative would not have been possible without the financial support of the DfP Pioneers and the industry knowledge and substantial data provided by them, other BBP members and their advisers:

- Derwent London
- Grosvenor Britain & Ireland
- Great Portland Estates
- Landsec
- Legal & General Property
- Lendlease
- Nuveen Real Estate
- Stanhope
- The Crown Estate
- Aberdeen Standard Investments
- Carbon Credentials
- EP&T
- EVORA
- Hermes Investment Management
- MAPP
- M&G Real Estate
- Royal London Asset Management
- USS
- Verco
- Workspace

The exceptional support of these organisations and the many individuals within these organisations is gratefully acknowledged.

1.3 The Structure of the NABERS Rating

1.3.1 Input Data

The NABERS Energy for Office base building rating uses the following input data:

- **Area**: The building area is assessed as the Net Lettable Area (NLA), which is broadly the same as the RICS Net Internal Area measurement, being the internal measurements of the lettable spaces in the building. This is corrected for vacancies (voids), so that only the occupied NLA is used in the rating.

- **Hours of use**: The hours of use for the building are based on the hours that the building is required to be comfortable for occupants[a]. In Australia, leases generally define some form of operating hours figure, although the exact meaning of this (hours when the building is required to be comfortable versus hours when the HVAC plant must run, in particular) requires some interpretation for use in the rating. Where no satisfactory lease hours are available, a tenant occupancy survey is used, designed to determine the hours at which the occupancy is more than 20% of peak occupancy during a normal working day.
- **Climate**: Climate zone is determined by postcode. Each postcode is referenced to a meteorological forecasting zone, which is characterised by a single location (typically the largest city) in that zone via heating degree days and cooling degree days.
- **Energy**. Energy is measured based on energy bills for one year ("the rating period"). Most commonly the energy sources are electricity and gas, but they also include other fuels such as diesel, LPG and coal) covering the following base building end-uses as they apply to the office component of the building:
    - Centrally provided air-conditioning (chillers, boilers, pumps, fans and specifically including fan coil fans and other energy use of the air-conditioning system within office tenancies, but excluding specialist air-conditioning such as server rooms);
    - Lifts
    - Common area lighting and power
    - Car park lighting and ventilation
    - Centrally provided back-up generators

  Data from non-utility sub-meters is also used if necessary to ensure that the measured energy use matches the base building energy coverage requirements.

1.3.2 Rating Calculation

In Australia, the NABERS Energy for Offices rating uses greenhouse gas as its primary metric. This enables gas and electricity to be combined sensibly into a single unit that equates to environmental impact. The NABERS rating tool calculates a benchmark equivalent to the median greenhouse gas emissions for a building of the given size, hours and climate[b]. The ratio of the site's actual emissions to the benchmark emissions is calculated to determine the relative efficiency of the building. A ratio of 1 (i.e. the building performs at median) obtains a rating of 3

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[a] NABERS requires the weekly hours of use to be identified separately for each 'functional space' in the building (see section 5.2). Where the same space has different weekly hours of use at different times of year, it must be represented by different functional spaces to cover each circumstance.

[b] This "custom benchmark" approach is actually used for all NABERS Energy and Water ratings except for NABERS Energy for Offices. NABERS Energy for Offices, being the first rating developed, uses a slightly different method whereby the site energy use is normalised to match a universal benchmark. While quite workable, this approach has a number of issues that are resolved by the use of the custom benchmark methodology. As a result, this project uses the custom benchmark approach, in line with the majority of NABERS Energy and Water tools.

stars while a ratio of zero (i.e. a zero emissions building would obtain a rating of 7 stars[c]. All other ratings are determined via a linear fit between these two points and its extrapolation[d]. The lowest rating that can be certified is 1 star; below that no rating can be certified. Approximately 80% of today's market typically can be rated on this scale, with the balance having a rating poorer than 1 star.

1.4 Key Adaptations Required for the UK

The following items are the main adaptations required for the UK. Each of these is discussed in more detail in the balance of the report.

1. Building population: The target population of office buildings for the UK scheme needs to be clearly identified.
2. Rating scale metric: A means by which different energy sources can be sensibly combined into a single metric is required.
3. Area: A suitable area metric, based on common UK practice, is required.
4. Hours of use: The methodology by which the benchmark is adjusted to compensate for different hours of use needs to be derived for the UK context.
5. Climate and weather: A climate correction suitable for the UK is required. The need for year-on-year weather correction must also be considered.
6. Rating scale: A median performance level based on the data for the target population is required to calibrate the scale.
7. Boundary adaptations: Means by which the common issues with measurement of base building energy in the UK can be addressed to enable existing buildings to be rated must be derived.

It is noted that this report does not cover all adaptations to NABERS Rules required for the UK, as these are potentially many and frequently minor. However, it is the intent of this report to present and discuss all the major rule variations needed. Generation of a UK set of Rules will follow the feedback on the recommendations of this report.

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[c] In practice, the highest rating awarded under the current NABERS scheme is 6 stars

[d] Again, for historical reasons, NABERS Energy for Offices has a bilinear rather than pure linear rating curve. However, more recent NABERS Energy and Water ratings have adopted a single linear approach.

2. Base Building Energy Data

2.1 Introduction

In order to ensure that the rating is relevant to the UK market, a significant data collection exercise was undertaken by BBP, with input from numerous BBP members. As with the previous LER data collection exercise, it is noted that the data being requested – as close an approximation to “base building” as possible – is not routinely collected and monitored in the UK, and as a result is both relatively difficult to obtain and of variable quality. In particular, the data requested consisted of whole building data and tenant data – the latter being the entirety of sub-metered energy on-charged to tenants – with the base building data being derived as the difference between these figures.

While the whole building data is reasonably reliable, the coverage of the excluded tenant data is not consistent and is known to have some systematic issues relative to the base building energy coverage (specifically, fan coil unit motors, but potentially other items as well) as well as a broad range of building-by-building issues. Furthermore, as data collection proceeded, it became obvious that there are also issues with floor area assessments, particularly in separation of retail and office areas, and possibly in the consistency of the method of measurement. As a result, any assessment of the data has to be cast in the light of the significant uncertainties about data accuracy.

2.2 The Data Set

A total of 186 building data points were identified within the UK[e] with sufficient data for use in this project (being location, base building energy use separately for gas and electricity and office NLA). The base building energy intensity of these buildings versus floor area is presented in Figure 1.

The data covers a wide range of floor areas and energy intensities. In order to reduce the impact of extreme outliers, data points outside the 5th and 95th percentiles were removed from the data set. These percentile levels corresponded to 12.7% and 222% of the sample average. The distribution of the original and reduced data sets by climate zone is shown in Table 1 and Table 2.

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[e] A number of otherwise useful data points were rejected because they were for buildings in Dublin

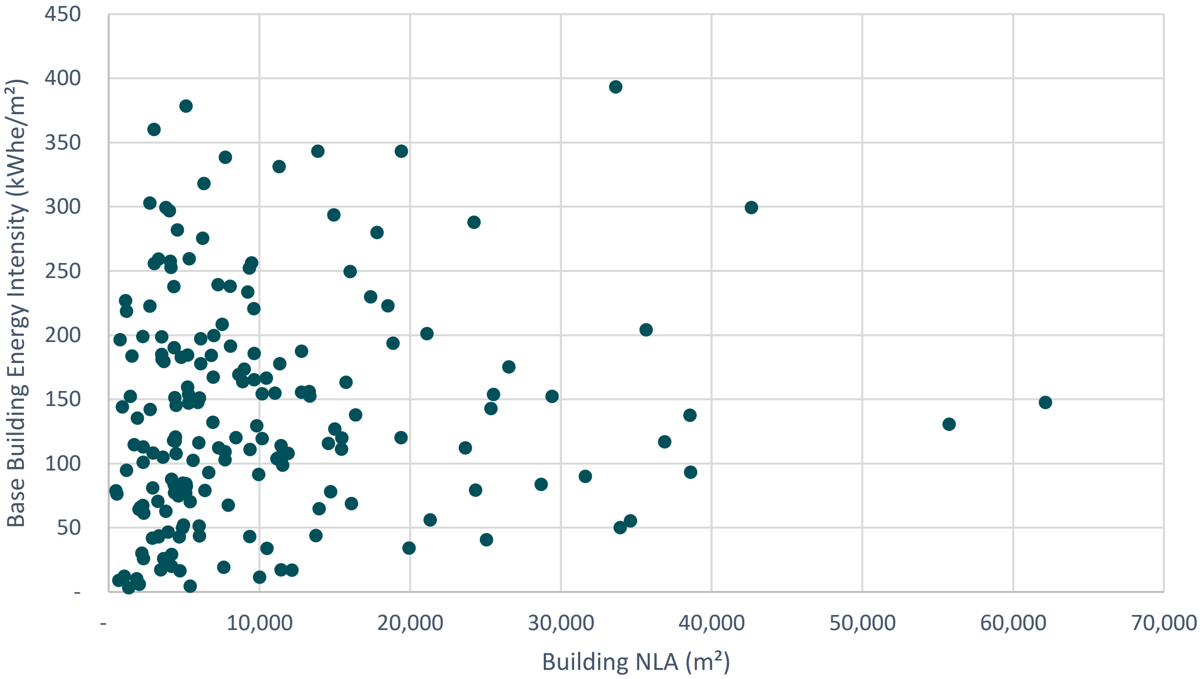

Figure 1. Base Building Energy Intensity vs. Floor Area

Climate Zone	Location	Points in Original Data Set	Points in Reduced Data Set
1	London	156	140
2	South Eastern	2	2
3	Southern	1	1
4	South Western	0	0
5	Severn Valley	5	5
6	Midlands	2	2
7	West Pennines	8	7
8	North Western	0	0
9	Borders	2	2
10	North Eastern	0	0
11	East Pennines	4	3
12	East Anglia	3	2
13	West Scotland	1	1
14	East Scotland	1	1
15	North East Scotland	1	0
16	Wales	0	0
17	Northern Ireland	0	0
18	North West Scotland	0	0
	Total	**186**	**166**

Table 1. Number of Data Points by Climate Zone

Data Source	Points in Original Data Set	Points in Reduced Data Set
1	32	26
2	31	29
3	19	18
4	18	14
5	18	17
6	12	12
7	11	9
8	13	10
9	10	10
10	10	10
11	7	7
12	5	4
Total	**186**	**166**

Table 2. Number of Data Points by Data Source (i.e. Portfolio).

As shown in Table 1, the data has a heavy bias towards London, with very limited data being available from other climate zones. In Table 2 it is shown that the data was well distributed amongst the different data sources, with no single portfolio dominating. Both tables show that the distribution of excluded outliers is also reasonably uniform.

No hours data was available with the base building data; based on the broader REEB dataset, it has been assumed that the standard hours are 60 hours per week for all the data points, as this was the dominant run time nominated in that dataset.

2.3 Basic Statistics

The sample data shows an average of 143kWh_e/m^2 and a median of 129kWh_e/m^2. As expected, the average is higher than the median, as the former is affected by essentially unconstrained higher energy intensities on the high side, while outliers on the low side are constrained by zero. The statistical error (95% confidence) for the average is approximately 11, indicating that the average of the population is 95% likely to fall within the range 132-154kWh_e/m^2, ignoring systematic data errors.

2.4 How This Data is Used

The primary function of the collected data is to inform the midpoint of the rating scale, based on the average or median. This is discussed in Section 8 in the context of the combination of this mid-point with adjustments for operating hours and climate, in order to produce the rating.

3. Building Population

3.1 Introduction

Prior to any discussion of the mechanics of the rating method, it is necessary to define clearly the building population which the rating is intended to target. This is particularly important for the UK, where the office building sector is not homogeneous in its scale, quality or environmental conditioning services.

3.2 NABERS Approach

In Australia, the commercial office market is remarkably homogeneous, as essentially all reasonable quality office buildings – commercial, governmental or institutional – are provided with both heating and cooling and are generally serviced similarly. This has made the definition of the target population for the NABERS rating trivial.

3.3 Discussion

Preliminary analysis has indicated that the UK office market is not homogenous, with the most obvious point of difference being between buildings that are centrally air-conditioned versus those that do not have significant mechanical ventilation and cooling; indeed the median whole building energy intensity of the former was estimated to be 67% higher than the latter. This difference represents both the difference in energy use for HVAC and the difference in tenant energy, and as such also reflects differences in the demographics of the building populations as well as their efficiency. This is confirmed by the fact that 85% of the buildings in the REEB data, representing commercial office buildings predominantly in London, are self-reported as air-conditioned, while only 20% of the buildings in the DEC data set (representing offices with public sector occupiers and a far greater regional spread) are categorised by their DEC assessor as being air-conditioned.

This non-homogeneity has the result that:

1. Any single rating scale will only be a good “fit” to one of these groups of offices in the market, while the other group will have a significantly different rating distribution. The current DEC scale – which is applied predominantly to buildings which do not have full air-conditioning[f] - is known to produce poor results when commercial office buildings – which

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[f] When the DEC scale was introduced in 2008, both the ECON 19 Type 2 Typical and ECON 19 Type 3 Good Practice benchmark levels were slightly better than the DEC mid-point rating of D100, respectively rating at D96 and D97.

are predominantly air-conditioned – are rated. The expectation of an unflattering DEC grade has contributed to negligible voluntary uptake of DECs in the commercial office sector since they were introduced in 2008, despite a significant reduction in commercial office sector energy intensity[g].

2. A good fit to both groups of offices, by using separate air-conditioned and non-air-conditioned scales, would undermine the incentive for well targeted use of natural ventilation in buildings by denying any rating value benefit. Furthermore, as many buildings are - in reality - partially air-conditioned, the creation of definitions to assign buildings into one or other rating scale – or a combination of the two – would add significant complexity to the rating assessment and quality assurance, for questionable benefit.

3.4 Proposed Approach

It is considered more compelling to maximise the chances of commercial sector engagement with the rating tool, and thereby achieve greater transparency in the market about energy performance outcomes, than to prioritise alignment with the DEC rating scale. It is therefore proposed that the rating tool is most applicable to air-conditioned office space, as this represents the market for which the rating scale can most effectively create change via market demand for better rated buildings. This market segment consists primarily of air-conditioned commercial office buildings in larger cities and is the market segment generally represented by the REEB data and material to BBP stakeholders.

The data set presented in Section 2 is used to determine and test the values of parameters needed by the rating tool. This data set consists solely of buildings provided by BBP members.

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[g] The 2017 REEB data set median rates at F144 on the DEC A to G scale, whilst good practice (top quartile) is at E106. The 2010 REEB data set median rated at G195.

4. Rating Scale Metric

4.1 Introduction

The purpose of the scale metric is to provide a means by which the consumption of different forms of energy (most frequently grid electricity and gas, but also delivered liquid and solid fuels and piped heating and cooling water provided via a district scheme) can be combined into a single figure that can be converted into a rating.

The metric chosen needs to achieve a balance between competing policy and stakeholder objectives such as greenhouse gas emissions, energy efficiency and energy cost, all of which effectively carry different perspectives on the relative cost/benefit of different energy sources. At a pragmatic level, the key result to be sought from a rating scale is that it should encourage (or at least not penalise) the “right” decisions where a choice of fuel source and/or technology is available to meet a given need.

In 2012, the LER adopted the concept of kWh of electricity equivalent (kWhe) as a way to combine the amounts (kWh) of different energy carriers. This entailed two principles:

1. Electricity has a unity weighting factor (it is not weighted). This is significant because a unit of electricity retains the same value independent of the timing of the period for which the analysis is being undertaken[h] and even the building’s location around the globe. Because electricity is often / usually the dominant energy carrier for commercial offices, this approach greatly simplifies energy efficiency comparisons of buildings.
2. kWh of electricity are added to kWh of any other energy carrier multiplied by its given weighting factor. The challenge is then to decide these electricity equivalent weighting factors.

The LER adopted a factor of 0.4 as the weighting factor for fossil fuels relative to electricity (i.e. one unit of gas is equivalent to 0.4 units of electricity) because in 2012 this ratio was roughly correct for both CO_2 and primary energy (a surrogate for energy efficiency) and not too adrift on

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[h] It is noted that the UK market is already anticipating a future situation, facilitated by the universal roll-out of smart meters, when time of day carbon intensity weighting factors might be applied to grid electricity to reflect the marked diurnal variability in the sources of electricity generation when the grid is dominated by renewables. The intention will be to incentivise load shifting and prioritise demand management during peak periods. Until such arrangements start to be defined, it is considered premature to consider taking them into account for the UK’s base building rating tool, but a reality when every kWh of electricity is not counted equally is a matter the future administrators of the scheme will likely need to consider in due course.

relative cost. That situation had been relatively stable for the previous decade and it was felt that such a figure might be tenable going forwards, but this position no longer holds.

4.2 NABERS Approach

NABERS uses greenhouse gas as its primary metric in Australia. This position aligns well with Australia's high carbon intensity grid electricity, which averages 900 gCO_{2e} (scope 1+2+3) per kWh[i]; by contrast gas has a carbon intensity of 200-230 gCO_{2e} per kWh.

It is noted that NABERS is currently considering options for how it might handle decarbonisation of parts of the Australian grid; one of the options being considered is the use of primary energy, similarly to what is proposed in this report.

4.3 Discussion

The UK currently lacks a consistent approach to the relative weighting of gas to electricity in its building energy efficiency policies. Since the EPBD came into force in 2008, Part L and DECs have used greenhouse gas emissions as the unifying metric, but in both cases the carbon intensity figures for electricity have not been updated in line with the UK grid's rapid decarbonisation over the past decade. The UK's grid electricity direct emissions in 2018 averaged 180 gCO_2 per kWh[j] (they were around 500 gCO_2 per kWh in 2008) while gas is much the same as in Australia. During 2018-19, the carbon intensity of a kWh of electricity has likely dipped below that of gas and with the grid expected to continue to be decarbonised through to 2030. It is projected to fall to less than half that of gas by 2030 (from a position in 2008 when it was more than double), as shown in Figure 2.

This creates challenges for the use of carbon as a unifying metric in the UK. This is partly due to the rapidly moving ratio of gas to electricity emissions intensity, and partly due to the imbalance that a very high gas coefficient would produce in the interpretation of building efficiency; by 2030 a leading emissions-related question for buildings will be "do you use gas" which, while a fair question, is a rather one-dimensional test for any initiative that is seeking to improve both efficiency and emissions. Meanwhile, the price of a kWh of electricity is currently around five times that of gas, which means that a rating scheme based on carbon alone would underrepresent stakeholder interest in energy running costs.

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[i] National Greenhouse Accounts Factors July 2018, Australian Government Department of Environment and Energy

[j] 2018 UK Greenhouse Gas Emissions, Provisional Figures, p12, Statistical Release: National Statistics, BEIS, March 2019. The scope 1+2+3 value for CO_{2e} for 2018 (taking account of all GHGs and transmission and distribution losses) has not been published at the time of writing but can be expected to be around 200 gCO_{2e} per kWh.

This issue is being recognised by the planned 2020 update of Part L, which may propose compliance calculations are based on primary energy, as this is less disrupted by grid decarbonisation than greenhouse gas emissions. Furthermore, primary energy is mandated for building energy certificates (EPCs and DECs) by the revised EPBD (2018).

Primary energy represents the number of units of energy input into the production of a unit of energy delivered to a site. In the UK, the primary energy factor for electricity has dropped from 3.07 in 2012 to a projected 1.738 in 2020, reflecting the change in generation mix as the grid has decarbonised. In the next 10 years, the primary energy factor for electricity is expected to drop below 1.3, but cannot ever drop below 1[k]. By contrast, the primary energy factor for gas is relatively stable at around 1.1 to 1.2. This means that the relative weighting of gas to electricity on a primary energy basis is comparatively stable: between 2020 and 2030, it is expected to rise from 0.75 to 0.86 (whilst the carbon intensity of grid electricity more than halves).

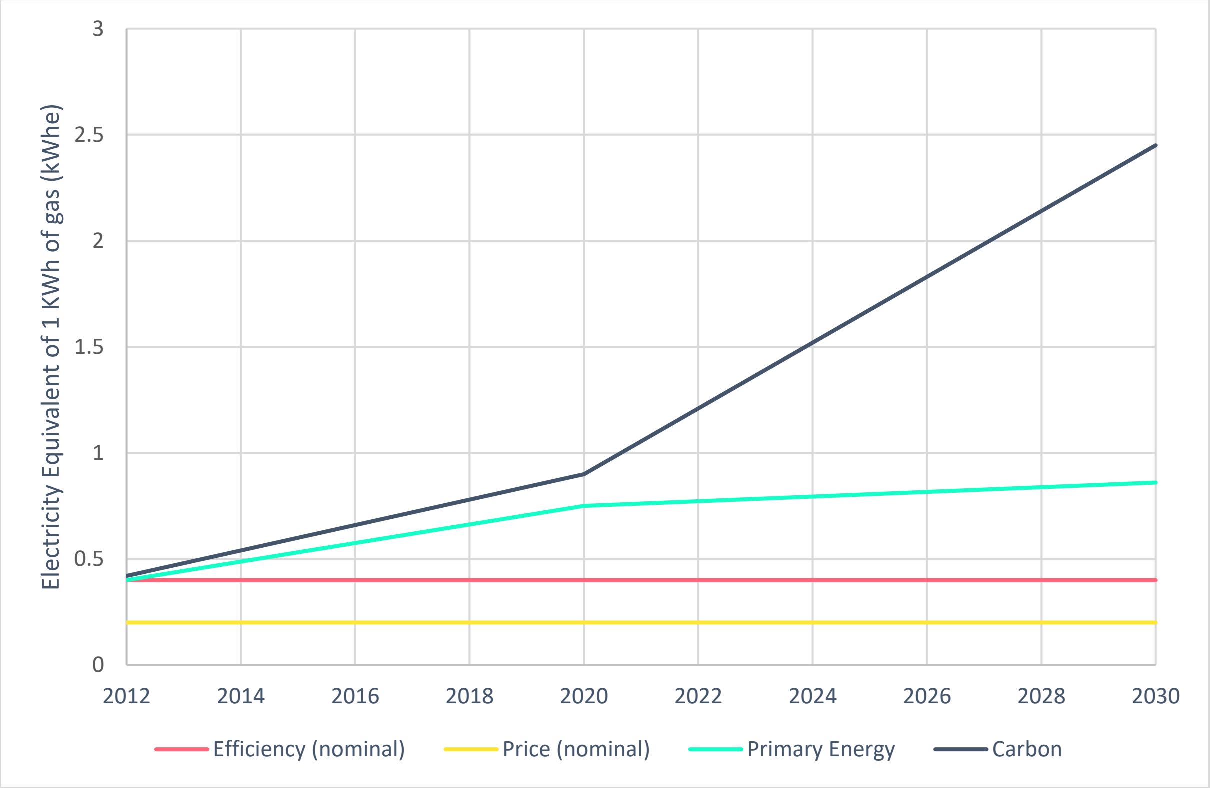

Figure 2 Past and projected future values for the electricity equivalent of natural gas

Ultimately, it is important to recognise that the weighting of gas relative to electricity is only important insofar as it promotes desirable decisions where choices can be made between fuels

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[k] Primary energy factors have been developed with the support of BRE and based on method used to derive the primary energy factors published in SAP set out in *Briefing Note – Derivation and use of Primary Energy factors in SAP Version 1.3 – 01/10/2019*.

and heating and cooling supply technologies. Appendix A reviews the key decisions of this type for commercial offices and concludes that for all values of gas weighting factor above 0.53, heat pumps are preferred to gas boilers and grid electricity with local heating is preferred to CHP. This means that any value of gas coefficient above 0.53 produces the same fuel selection decisions as the use of the current greenhouse gas weighting factors. With reference to Figure 2, primary energy is the only (non-carbon) metric that is projected to have a gas coefficient relative to electricity of more than 0.53.

Adopting primary energy as the weighting factor determinant, and using values for 2020[l], would imply updating the gas weighting factor used in the LER from 0.4 to 0.75 kWh_e per kWh of energy supply.

Appendix A also examines the extent to which the projected change in gas weighting factor from 0.75 to 0.86 by 2030 will cause ratings to change over time. It concludes this would generate a relatively small shift that could be readily absorbed over the time period, and thus does not create an unacceptable instability in a rating. The analysis also shows the amplitude of emissions reduction benefit increase with a fuel change from gas to electricity. Progressive/periodic updates of the gas coefficient will therefore up the ante for fuel change over time.

4.4 Proposed Approach

It is proposed to use primary energy as the underlying scale metric, on the grounds that it strikes the right balance between efficiency, energy cost and environmental impact, is comparatively stable and aligns with appropriate decisions for fuel choice.

From the perspective of presentation, it is proposed to continue to use a kWh of electricity equivalent (kWh_e) approach as the primary means of expressing energy intensity, with electricity being 1 kWh_e per kWh and gas 0.75 kWh_e per kWh. It is recommended that this figure is updated in line with the changing dynamics of the electricity grid every 3-5 years. As identified above, the impact on ratings of the expected increase in the gas weighting factor is sufficiently small that this will not be disruptive.

For all further analysis in this report, the gas weighting factor is taken to be 0.75.

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[l] Ministry of Housing, Communities and Local Government, The Future Home Standard 2019 Consultation on Changes to Part L and Part F of the Building Regulations for New Dwellings: Impact Assessment.

5. Area

5.1 Introduction

As the rating is assessing energy use per m^2 of floor area, the determination of a reliable and accurate area figure is essential.

5.2 NABERS Approach

NABERS uses the Net Lettable Area as its primary area metric. Net Lettable Area in Australia is defined in the Property Council of Australia Method of Measurement document and consists of the internal area of the lettable spaces. Lift shafts, fire stairs, plant rooms, car parks, common areas, toilets and foyers are excluded from the NLA measurement.

The rationale for using this figure is twofold:

1. The NLA represents the effective production variable of the building, being the area that is let to tenants. Other areas, such as foyers, may contribute to the value and amenity of the building but are essentially non-productive spaces in terms of accommodating tenants and earning rent. As such they are an overhead to the productive capacity of the building rather than part of that capacity.
2. The NLA figure is the key variable used in most lease transactions in Australia and thus is well known and documented in most buildings.

To convert the NLA to the actual area used in the rating, the following areas are deducted:

1. Spaces without any heating or cooling
2. Spaces that do not form part of an office tenancy (e.g. shops)
3. Vacant tenancies (voids). Where a tenancy is vacant for part of the rated period, the area of the tenancy is reduced in proportion to the fraction of the rated year of the vacancy.

5.3 Discussion

Rentable area in the UK commercial office market is most often assessed using the Net Internal Area (NIA) measurement defined in RICS *Code of Measuring Practice* (2015), and often referred to as NLA by the industry. The NIA is very similar to the NLA methodology used in Australia as the basis of area measurement for NABERS.

This contrasts with the EPC and DEC methodologies, which use respectively Gross Internal Area (GIA), equal to the RICS Gross Internal Area as defined in the Code of Measuring Practice, and Total Useable Floor Area (TUFA), defined as GIA minus the area of separable energy uses. GIA is typically 25% larger than the NIA, and includes common areas and landlord areas such as reception areas, stairs, lift shafts and foyers, toilets, loading bays, garages and plant rooms.

The RICS Code specifically identifies the NIA as the appropriate measurement for office buildings.

5.4 Proposed Approach for UK

It is proposed to use the RICS Code of Measuring practice 2015 Net Internal Area as the basis of area measurements for NABERS UK. Given current conventions in the UK, it is expected the area will normally be referred to as the NLA.

No significant changes from the NABERS approach are proposed to the treatment of voids, non-office spaces or spaces without HVAC.

6. Hours of Use

6.1 Introduction

Office buildings typically operate between 50 and 70 hours a week, but in some cases may operate at the maximum 168 hours per week, with longer hours of servicing necessarily leading to increased base building energy use. Assuming that this operation reflects productive use of the building (as opposed to heating/cooling an empty space), it is necessary for the rating to adjust for actual hours of use so that a genuine long-hours occupancy is not penalised relative to a shorter hours occupancy.

6.2 NABERS Approach

NABERS Office Energy base building rating provides a correction for hours based on the hours that spaces are intended to be comfortable for occupancy. In order to accommodate the potentially complex occupancy patterns of large buildings, NABERS breaks the building into "functional spaces" for the evaluation of hours. A functional space is typically a floor or a tenancy (whichever is smaller); as a result, small buildings consist of 5-10 functional spaces while large buildings can have in excess of 50. For each functional space, the hours are evaluated individually using one of the following methods:

1. Core hours plus after hours: Core operating hours are taken from lease requirements for hours, interpreted to ensure that these represent the hours that the building is intended to be suitable for occupancy as opposed to merely hours when the HVAC is in operation. Documented requests by tenants for servicing outside these hours can be added to these core hours.
2. Tenant occupancy survey: Where lease specification of hours is inadequate, the tenant in each functional space is surveyed (this is based on a single survey of a senior manager in each space, as opposed to any statistical survey of occupants) to determine the hours in which the space has more than 20% of peak occupancy.

Spaces that show more than 60 hours per week have to be cross checked for the validity of those hours, either based on function (e.g. a multi-shift call centre) or via a tenant occupancy survey. The rated hours for the building are the area-weighted average of the hours for the individual functional spaces.

Note that the functional space methodology operates such that a building which, for instance, has to operate all floors in order to service a long-hours tenant on one floor will only get credit for the long hours on that specific tenant's floor. Other floors will have their hours determined based on the hours of use of the tenants on those floors.

6.3 Discussion

The scale of the adjustment for hours is potentially significant. Analysis based on empirical data for whole building energy use gathered by BBP for the Real Estate Environmental Benchmark (REEB) initiative suggests offices operating to 168 hours a week (24/7 occupancy) having 2-2.7 times the energy intensity of those operating to 50 hours a week. These figures can be contrasted with the DEC hours correction formula, which uses a multiplier of 1.47 between these different hours of operation. It is noted however that the DEC multiplier was selected to be conservative to reduce the impact of assessors exaggerating actual occupancy hours in order to improve a rating[m].

The hours correction used in NABERS was derived by the use of computer simulation, as there was inadequate data at the time the rating was formulated to derive an empirical correlation. Under the NABERS hours correction for base buildings, a building operating 168 hours a week is expected to use approximately twice as much energy than a building operating 50 hours a week.

Due to the lack of data available via REEB, a simulation-based approach has been used to derive the hours correction for the UK.

A series of simulations were run using a model of a standard Part L compliant building operating in London, Manchester and Glasgow (the same model as used for the climate modelling reported in Section 7.3). Three different building operating scenarios were used:

1. Higher efficiency building, 1 person per 9m^2 occupancy, 11.77W/m^2 equipment load, zero overnight equipment loads.
2. Higher efficiency building, 1 person per 9m^2 occupancy, 11.77W/m^2 equipment load, 50% overnight equipment loads.
3. Lower efficiency building, 1 person per 15m^2 occupancy, 7W/m^2 equipment load, 50% overnight loads

These scenarios were selected to provide some diversity in building operation rather than as a means of fully representing the potential range of scenarios.

The set of simulations demonstrated a linear and largely climate independent nature of the impact of hours, with the degree of occupancy having a moderate impact. 168 hours per week scenarios were shown to use typically 200-230% of the energy of the equivalent 50 hour scenario. This reconciles plausibly with the empirical data and is similar to the NABERS correction.

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[m] WT Bordass, private communication.

6.4 Proposed Approach

The proposed approach for the treatment of hours is that a linear benchmark adjustment based on the simulation results will be applied. It is proposed to use an hours correction equivalent to a 215% increase in energy intensity from 50 to 168 hours.

In terms of NABERS Rules relating to hours, it is proposed that the NABERS approach is adopted largely unchanged for the UK, subject to further work on the question of how or indeed whether operating hours are specified in UK leases.

7. Climate and Weather

7.1 Introduction

The impact of climate on the energy use of buildings is a sensitive issue to stakeholders, as they can see the changes in building running costs and plant operation between the seasons and witness the struggles of their buildings in extreme heating and cooling events. However, most commercial building types have a fairly muted response to climate because of their high volume relative to surface area and high internal loads, both of which operate to make the buildings less sensitive to climate. Furthermore, many building energy uses are climate independent. While summer and winter building operation may be different, the integrated energy use of the whole year is a balance of heating and cooling that to some extent self-compensates (more cooling, less heating and vice versa).

In the context of rating tools and the subject of making allowances for climate and weather, the difference between the two is as follows:

- Adjustment for climate aims to ensure that buildings located in different climate zones across the UK are rated on a level playing field. Benchmarks are therefore adjusted to account for the differences in average climate between different regions (typically using 20-year averages)
- Adjustment for weather attempts to vary benchmarks according to the difference between the “climate” experienced during the year of the measurement of a rating in a specific region and the 20-year average for that region. In principle, using this approach, a building’s rating would remain the same year-on-year, if the weather were the only change to which it was subjected.

7.2 NABERS Approach

NABERS for offices analysis has failed to find any strong empirical evidence for a climate impact on office buildings within the temperate areas of Australia, and as such uses a simulation-derived correction factor. The impact of this is fairly minor across the temperate areas of Australia but is moderately significant when comparing tropical to temperate locations.

7.3 Discussion

The REEB data set provides a comparatively weak basis for assessment of the impact of climate, as 85% of buildings in the data set are in climate zone 1 (London). The average whole building energy intensity in London in the data set is higher than that of other climate zones by a small but statistically significant margin, although being whole building data it is not clear that this relates to climate rather than use factors[n]. By contrast, the DEC data set (also whole building) provides a much broader geographical distribution, and the air-conditioned buildings in this data set show a weak trend to higher energy intensity in cooler climates (i.e. a trend in the opposite direction to the REEB data set). However, the significance or otherwise of this has to be viewed in the context that the standard statistical error associated with each of the data points outside London is greater than the identified trend.

The base building data set gathered for this report (see Section 2) lacks sufficient climate zone diversity to be of use in determining a climate correction (approximately 84% is London based). Thus, a simulation based approach, akin to that used for the NABERS climate correction, was required.

In order to replicate the simulation based approach used to derive the NABERS climate correction, a simulation study was undertaken to investigate the impact of climate on performance of a representative office building.

The study found that the net impact of the combined heating and cooling adjustments across climate regions is small (~6%). The impact of weather, year-on-year, is also relatively small: for London and Manchester respectively the maximum deviation from the average is around (~4%); it is interesting to note that the peak years are not the “hotter” or “cooler” years overall but the years in which both summer and winter are more extreme than normal (hotter summer AND colder winter). It is also noted that the heating correction stays within similar bounds, which indicates that heating-only buildings do not require any different treatment relative to air-conditioned buildings.

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[n] For example, higher rents on average in London may encourage higher occupant densities and hence higher tenant energy intensities.

8. Rating Scale

8.1 Introduction

The rating scale translates the technical performance into a simplified indictor that can be understood and engaged with by non-technical stakeholders; this is a critical step, as of course, it is generally the non-technical stakeholders that make decisions in relation to investments that may affect the efficiency. For such stakeholders, “5 stars” immediately communicates a higher level of quality while “50 kWh_e/m^2” is meaningless.

8.2 NABERS Approach

NABERS was originally defined as a 5 star scale with the market mid-point and best practice defining a linear scale between 2.5 stars and 5 stars[o]. In 2009, the NABERS scale was expanded to include a 6th star at half the emissions of a 5 star building, leading to a bilinear scale with the slope changing at 5 stars. Since 2009, however, new NABERS rating systems have adopted a single linear scale with the midpoint defined at the middle of the 3 star rating band (3.23 stars) and a theoretical 7 star rating (not awarded, the highest rating awarded remains at 6 stars) at zero. This approach simplifies scale setting and avoids the issues associated with separately determining a suitable benchmark for 5 stars.

The resultant scale can be characterised mathematically as:

$$R = 7 - 3.77358\frac{E}{B}$$

where R is the rating (as a decimal, rounded down to the nearest 0.5 to get the rating in stars, E is the energy intensity of the building and B is the benchmark energy use for the building.

In practice, NABERS have adopted a tabulated methodology for defining the rating bands, in order to clearly define rating bands and avoid issues with minor differences in rounding between different applications. The tabulated benchmark values are shown in Table 3.

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[o] It is noted that NABERS Energy for Offices applied corrections to site energy use to normalise to a standard benchmark, an approach it still uses today. However, this approach was superseded in all other NABERS Energy and Water ratings, for which the benchmark is adjusted to suit the features of the building. This latter approach, also used by DECs, has proven to be significantly superior and thus is the approach discussed in this report.

Star Rating	Benchmarking Factor (E/B*100)
6	0<BF≤26.5
5.5	26.5<BF≤39.75
5	39.75<BF≤53
4.5	53<BF≤66.25
4	66.25<BF≤79.5
3.5	79.5<BF≤92.75
3	92.75<BF≤106
2.5	106<BF≤119.25
2	119.25<BF≤132.5
1.5	132.5<BF≤145.75
1	145.75<BF≤159
0	159<BF

Table 3 Definition of the band boundary limits used by the NABERS 6-star scale

The general NABERS methodology for the calculation of the benchmark B follows a consistent pattern, whereby for a given building, the benchmark for a building with features x, y and z is calculated as an equation based on the mid-point of the population (As represented by the sample used for benchmarking), with modifiers for features x, y and z, i.e.

$$B_{x,y,z} = B(x, y, z)$$

Modifiers may be additive or multiplicative, depending on the behaviour of real building energy use in response to the feature.

The selected midpoint varies between the median and the average for different building types; the choice between these is generally based on non-technical factors.

8.3 Discussion

Based on a statistical analysis of the base building data supplied for the report, a value of 136kWh$_e$/m^2 is recommended as the midpoint.

8.3.1 Rating Distribution

Based on the rating formulation above[p], the rating distribution of the sample (excluding outliers) is as shown in Figure 3.

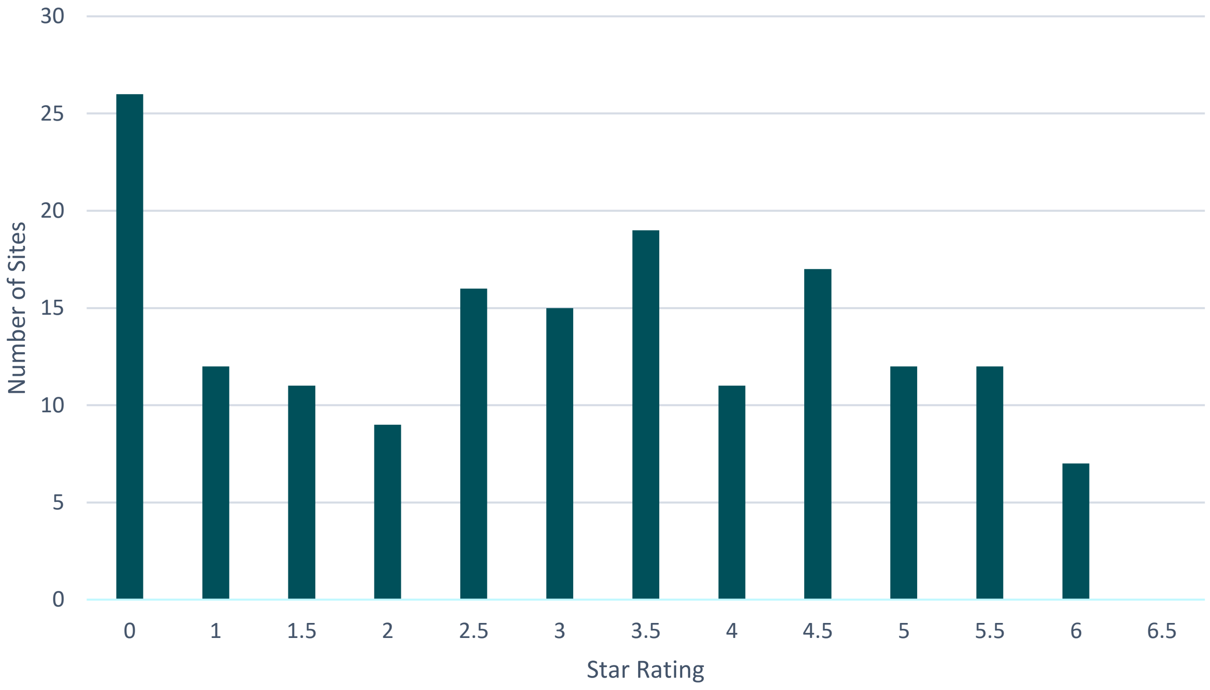

Figure 3. Star Rating Distribution of Data Set

The figure shows a distribution with a broad peak centred around 3-3.5 stars. The width of the distribution is wider than typical for NABERS ratings. This is likely because of two factors:

1. A higher than average error rate in the data, both in terms of accuracy of figures and in terms of energy coverage.
2. Non-homogeneity in the market, particularly with respect to the energy intensity of buildings without full (central) air-conditioning.

The lack of climate zone diversity in the dataset makes it difficult to test the degree to which the rating is uniform with respect to climate. Figure 4 shows the average rating achieved in each climate zone, along with the number of data points for each climate zone. The four climate zones with 3 or more data points have average ratings that lie fairly close to 3.25, which is the midpoint decimal rating for the scale.

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[p] For the purpose of expediency, the following graphs have been produced assuming that all buildings would have the fan coil motor addition applied to both the benchmark and the energy use. This has been represented by using M=136 in the above formulas.

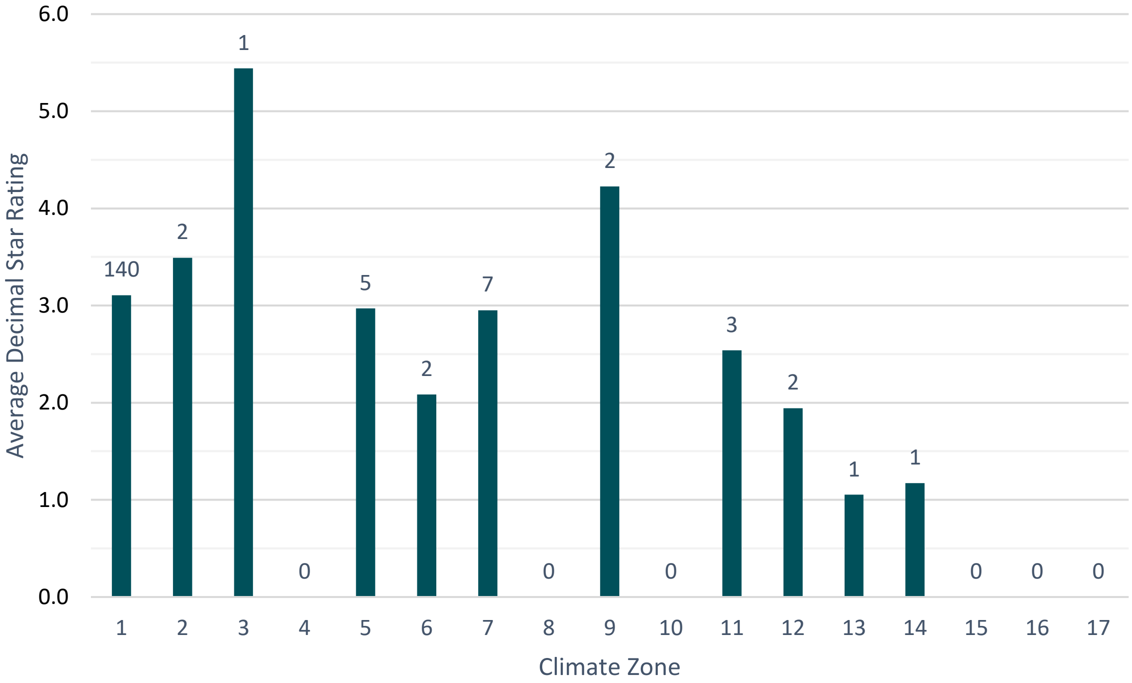

Figure 4. Average Decimal Rating by Climate Zone. Numbers at the top of columns indicate the number of data points.

The rating distribution has also been tested by data source (portfolio), as shown in Figure 5.

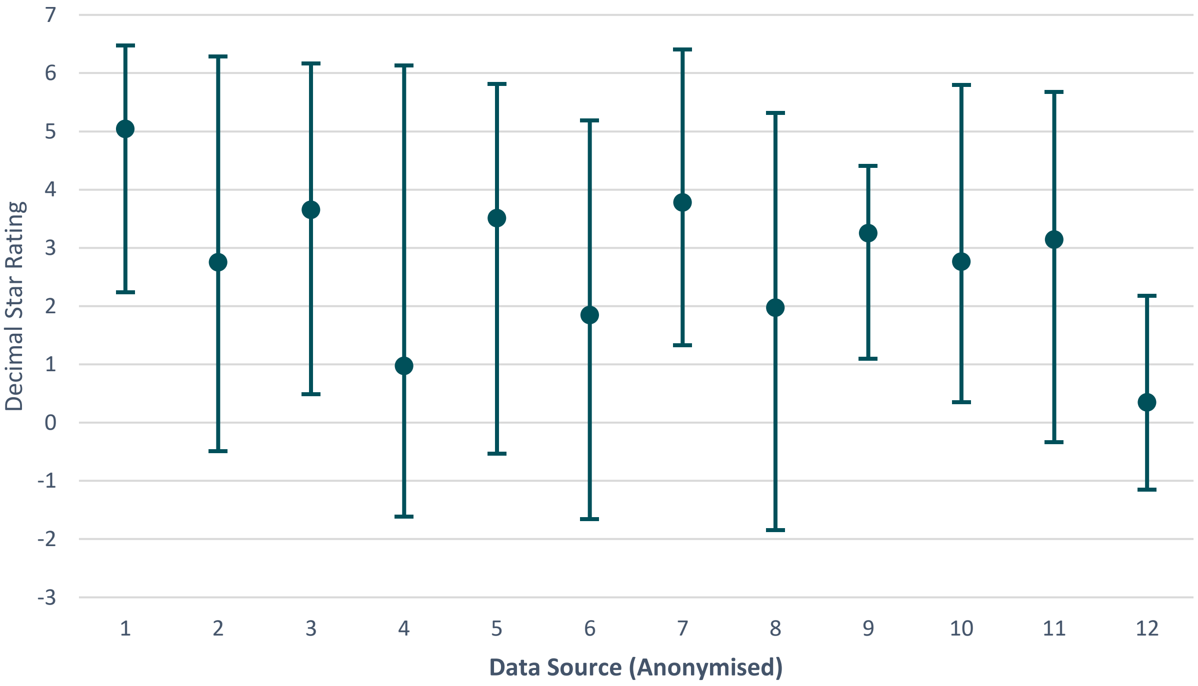

Figure 5. Average, Minimum and Maximum Decimal Rating by Data Source

The majority of portfolios show an average rating in the region of 2-4 stars and all bar one have a rating within the range of the sample average. These results appear plausible.

Finally, the rating distribution has been tested by area as shown in Figure 6. No clear trend in rating with building size can be seen.

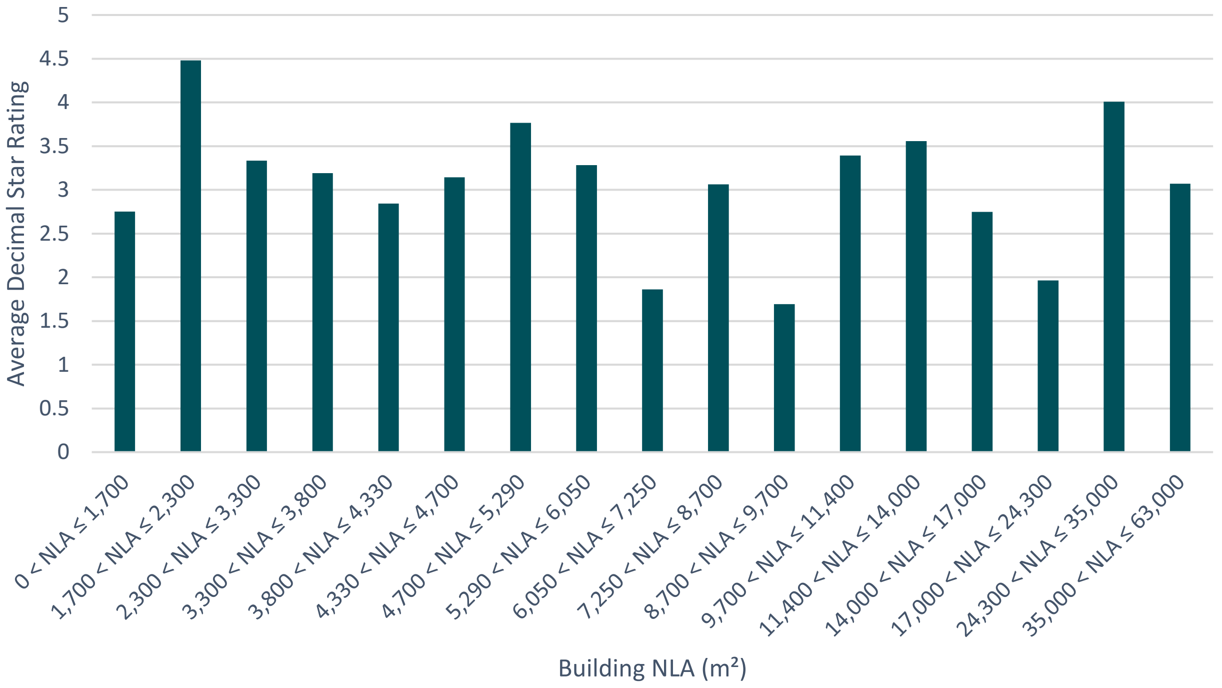

Figure 6. Rating distribution by building area
[Each column represents the average rating across groups of 10 buildings allocated in order of increasing area. T-tests show that only one of these groups (1700<NLA<2300) has a potential difference from the population average.]

8.3.2 New Buildings

It is expected that the key users of the rating in the short term will be new buildings, so it is important that the rating scale produces plausible results for this group. To test this, a number of examples have been drawn from the earlier DfP development work, as listed in Table 4. These results are within expectation for pre-construction estimates of new buildings. A comparison with how these projects rated on the LER scale also shows consistency and that the proposed new scale will not entail a major change in expectations for how a new building will rate under the new DfP rating tool (for those already using the LER).

Project	Rating inputs	Star rating (proposed scale)	Star rating (LER scale)
Climate simulations for this report	50 hours, 45-50kWh$_e$/m^2 London	5.5-5.7	5.4-5.6
Project 1, new building simulation	77 hours, 96kWh$_e$/m^2 London	4.8	4.8
Project 2, TM54 calc Medium	56 hours, 51kWh$_e$/m^2 London	5.6	5.8
Project 3, simulated NABERS profiles	55 hours, 77kWh$_e$/m^2 London	4.9	4.8
Project 4, simulated, DH/DC connected	50 hours, 74kWh$_e$/m^2 London	4.8	4.8

Table 4. New building estimated star rating results. All buildings other than project 4 have gas heating.

9. Boundary Issues

9.1 Introduction

One of the key challenges of applying the base building rating concept to UK buildings is that the metering and operation of the buildings is not necessarily sympathetic to the application of a sensible base building boundary. Most specifically, fan coil fan motors are essentially always on the tenant meters in UK buildings; other items such as on-floor chilled water and hot water pumps on-floor outside air fans and electric reheats are present in some buildings.

One of the core tenets of Design for Performance initiative is that the simplest resolution of these issues is for them to be addressed at design, and as a result the primary initial audience for the rating (and its Rules) is new buildings. For this sector, the key requirement is to clearly define the base building boundary, in a manner similar to that done in NABERS[q].

However, for the rating to be useful to the existing building market – and indeed for new buildings that are built with boundary issues not correctly resolved – it is also necessary to have methodologies to enable the maximum number of buildings to rate both fairly and at reasonable cost.

9.2 NABERS Approach

9.2.1 Base Building Boundaries

NABERS defines the primary base building energy use inclusion boundaries as follows:

- Common area lighting and power (for examples lift lobbies, foyers, plant rooms and common-area toilets)
- Lifts and escalators
- Air-conditioning and ventilation, including:
    - Base building services to meet normal requirements
    - Centralised supplementary services provided for tenants (such as supplementary tenant condenser water loop)
    - Supplementary services provided to ensure that premises are safe, lit and comfortable for office work, providing there is no special tenant requirement
- Exterior lighting
- Generator fuel where it serves central services

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[q] https://www.nabers.gov.au/publications/nabers-energy-and-water-offices-rules

- Car park ventilation and lighting where internal or external car parks within the legal boundaries of the building are provided for tenant use
- Exterior signage
    - Primarily for identifying or advertising the building owners
    - Displaying the building name or related to a tenant or building owner; or
    - Provided to a tenant as a condition of lease.

9.2.2 Tenant Supplementary Air-conditioning

NABERS defines supplementary air-conditioning as being air-conditioning provided in addition to the base building system that is used to serve special tenant needs, such as meeting rooms and server rooms. The NABERS rules in this area are relatively complex and cannot be summarised in short form, but in general supplementary tenant air-conditioning is only allocated to the base building if it supplants services that would normally be expected to be provided by the base building.

9.3 Discussion

9.3.1 Base building boundaries

The NABERS boundaries for base building remain desirable for UK buildings. This is because the boundaries reflect the complete energy use of the HVAC, and thus do not risk creating perverse incentives to maximise the benefits of landlord versus tenant[r]. This does mean however that simple and robust methodologies are needed to deal with the more common boundary issues.

9.3.2 Tenant supplementary air-conditioning

The standard arrangements for supplementary air-conditioning in Australian buildings are quite different to UK buildings: the most common arrangement in Australia is that the landlord provides a tenant condenser water loop (which is treated as a base building end-use) and tenants connect water-cooled packaged air-conditioning units to this for heat rejection. This approach is not used in the UK, where tenants generally will connect to the landlord chilled water and hot water system or use air-cooled split air-conditioning systems.

Under LER, all air-conditioning plant on the tenant boards, as well as any domestic hot water plant, was considered to be within the base building coverage, which is a wider coverage than used under NABERS, which essentially ignores local domestic hot water on the tenant meter, and

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[r] For instance, in a building where heating is on the tenant meters, the landlord is incentivised to minimise the use of any central heating at the expense of maximising the heating that occurs on the tenant meters.

permits some tenant supplementary air-conditioning to be considered as being outside the base building scope.

It is fairly clear from the above that this is an area which will benefit from some modification for both NABERS and LER approaches in order to get the best result.

9.4 Proposed Approach

9.4.1 Base Building Boundaries

It is proposed to adopt the primary NABERS Boundaries essentially without significant modification[s]. Note that some minor clarifications of wording are likely to suit the UK context.

9.4.2 Tenant Supplementary Services

It is proposed to resolve the tenant supplementary service boundaries as follows:

Item	Treatment
Local DHW within tenancies	Not included in base building rating[t]
Air-conditioning services to separable specialist areas (large meeting rooms (TBD) and server rooms)	Not included in base building rating; affected areas excluded from rated floor area.
Air-conditioning to general office (i.e. all office areas other than the separable specialist areas), including fans, chilled water and hot water use, pumps, local standalone air-conditioners, electric reheats.	Included in base building rating

This approach differs from the LER in that it permits some energy use other than tenant light and power to be considered to be tenant rather than base building energy. It differs from NABERS in that, outside specialist separable areas, all air-conditioning is considered to be base building, whereas NABERS considers air-conditioning to smaller meeting rooms and some situations of air-conditioning to general office (where there are exceptional loads) to be excluded from the base building. The difference arises because in the UK, it is expected that these situations would most often be resolved by adding loads to the base building chilled water and hot water systems (or to base building VRF systems), and so by default are already a base building inclusion; in Australia,

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[s] Consideration should be given to the treatment of energy use for bicycle storage and associated shower facilities, as inclusion of these with the base building coverage arguably disincentivises provision of such facilities, which in turn has wider repercussions on overall sustainability outcomes.

[t] This will incentivise point of use electric water heating within tenancies, supporting a direction of travel away from higher carbon and frequently very ‘lossy’ centralised gas-fired water heating.

these systems are normally resolved by use of local air-conditioners and thus by default not a base building inclusion.

9.4.3 Common Boundary Issue Resolutions

The general philosophy used in the resolution of boundary issues is to provide a simple methodology to calculate a “deemed” amount of energy to be added to the building’s metered energy use. It is proposed that a number of more common issues should be provided with a standard calculation that does not contribute to the error calculation, thereby enabling the building to be rated. However, in all cases, the deemed additional energy calculations are intended to be higher than actual use would be, thereby incentivising improvements to metering. Resolutions have been developed for fan coil motors, on-floor pumping, and on-floor fans.

10. Allowance for Tenant Occupant Density

10.1 Introduction

While the base building rating does not directly include tenant loads, the HVAC energy use is affected by the loads generated by the tenancies. Thus, there is potential for the base building rating to be affected by the density of occupancy and equipment of the tenants.

10.2 NABERS Approach

In Australia this question has been raised several times over the life of NABERS, and it has been demonstrated that this interaction is of second order impact on a building's rating[u]. This is a convenient outcome, as it avoids the need to assess tenant occupant density which can be a significant and potentially intrusive exercise.

10.3 Discussion

The UK of course has a very different climate to Australia, so the question bears re-examination. To this end, two simulation models were run:

- Scenario 1: 1 person per 15m^2 with equipment loads of 7 W/m^2
- Scenario 2: 1 person per 9m^2 with equipment loads of 11.77W/m^2.

The difference in tenancy energy use between Scenario 1 and Scenario 2 was a 47% increase from Scenario 1 to Scenario 2. The maximum impact this has on the base building energy was 11%, occurring in London. The lowest impact was in Glasgow(5%).

To put the above in context, a deviation of 11% from median is equivalent to approximately half a star.

Overall the interpretation of the above results was that UK buildings will generally be affected more than Australian buildings by tenant load density due to the relative load sensitivity of the dominant HVAC design paradigm, particularly in the warmer areas of the country. The scale of the effect in London is likely to be around a quarter of a star for realistic variations in tenant load and half a star for major variations, down to approximately half of this level in cooler climates.

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[u] See for instance "Load Resilience in High Performance Buildings", P Bannister and H Zhang, Proceedings International High Performance Buildings Conference Sydney 2016.

10.4 Proposed Approach

It is proposed not to provide a correction for tenant load density at this stage of tool development. This is because:

1. The scale of the effect is second order and effort required for a landlord to determine the tenant load density is considered too high;
2. The accuracy with which tenant load density can be determined is relatively poor.
3. The absence of a correction may encourage innovation in design and operation to make use of some form of free cooling; by contrast, a correction for occupant density may entrench the design status quo.

It has been proposed by NABERS that further data should be collected on this issue, by the addition of a basic tenant density measurement to the rating[v]. This measurement would play no part in determining the rating but would gather data that could be used to develop a rating adjustment in the future.

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[v] The format of this is yet to be decided, but it is expected to be similar to the current NABERS computer counting methodology, but simplified and with provisions for dealing with agile workplaces.

11. Car Parks

11.1 Introduction

Lighting and ventilation services for car parks are included in the energy coverage for the NABERS Energy base building rating for office building. Larger car parks have the potential to become a significant overhead to building energy use, affecting the rating outcome.

11.2 NABERS Approach

The NABERS Energy for Offices base building rating includes the energy use of on-site car park services where these are provided for the exclusive use of tenants. This reflects normal metering arrangements in Australian buildings. However, the number of car park spaces plays no part in the benchmarking, and thus buildings with larger or more heavily serviced car parks are penalised relative to those with small, lightly serviced car parks. In this context it is noted that most Australian office buildings have reasonably sized car parks, although increasingly these may not be for the exclusive use of tenants.

By contrast NABERS Energy for Shopping centres provides a benchmark adjustment based on the numbers of internal and external car park spaces. This was justified on the basis that the data was available and the car park provision was not necessarily purely a function of the shopping centre (e.g. in some cases the car park space numbers were affected by the site being linked with a transport centre).

11.3 Discussion

The NABERS position on this issue dates from the scheme’s inception and was determined by two factors:

1. No data on car park space numbers or servicing was available
2. It was felt that the bias against buildings with highly serviced car parks would encourage buildings not to provide dedicated tenant car parks and thus potentially decrease tenant car dependency.

Discussions with UK stakeholders indicate that office car parks dedicated to tenants are generally small (and rare) in London, although bicycle storage areas are becoming common. Car park space provision is potentially larger and more common in regional centres. Car park space numbers and servicing are not known for the buildings in the data set. As a result, there is currently no empirical basis upon which to consider a benchmark correction. The potential that regional centres may have significantly different car park provisions than London is a potential risk to the perceived fairness of the scheme.

11.4 Proposed Approach

It is proposed at this stage to provide no benchmark adjustment for car park provision. However, it is proposed that the standard rating assessment should be expanded to include a count of indoor and outdoor car park spaces in order to gather information to permit this issue to be investigated in more detail in future.

12. District Heating, District Cooling and CHP

12.1 Introduction

District heating and cooling systems and CHP have the effect of creating a unique primary energy mix within supplied buildings which may differ significantly from that of buildings using grid electricity and local provision of heating and cooling.

12.2 NABERS Approach

In Australia, utility-scale district heating and cooling systems are rare[w]; where present, a cogeneration or trigeneration plant will primarily supply one or two relatively closely connected buildings. As a result, NABERS requires calculation of the specific efficiency of the district plant and assigns greenhouse intensity based on these calculations, which is a relatively complex and onerous process.

12.3 Discussion

Utility-scale district heating/cooling systems are arguably more common in the UK than in Australia and, within given precincts, buildings may not have a choice as to whether to connect to these systems, a situation which is very uncommon in Australia.

This difference means that the relationship between the building and the district heating/cooling provider may be far more arms-length than it is in Australia, and consequently it cannot be guaranteed that sufficient details of the operation (and consequent primary energy intensity) of supplied energy will be available. Furthermore, as the district heating/cooling supply is in effect a utility, it operates at a disconnect from the efficiency of the building, creating a potential bonus or millstone on the building’s performance that is outside the agency of the building operator to control.

As a result, there is a reasonably strong argument that, where the district heating/cooling supplies are provided by a third party, they should be assigned a generic supply coefficient rather than using the site-specific coefficients used under NABERS in Australia. Such coefficients would need to be set on as neutral a basis as possible, implying that they should reflect standard practice heating and cooling technologies, which in the UK would imply air cooled chillers (approximate COP 2.75) and condensing boilers (approximate seasonal efficiency 85%). The resultant weighting

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[w] Barangaroo is probably the most prominent example of this type, although the district heating and cooling plant operated in central Adelaide has operated for far longer.

factors would be 0.36 for chilled water supply and 0.88 for heating hot water[x] (possibly rounded to 0.4 and 0.9 respectively, to avoid suggesting a misleading level of precision) on a relative primary energy basis; electricity from a district source would be assessed as per grid electricity, i.e. at a weighting factor of 1.

As a comparison, using the NABERS formulation[y] for allocation of emissions for cogen and trigen, a CHP plant converting 100 units of gas into 30 units of electricity, 30 units of chilled water and 30 units of hot water would be deemed to be generating electricity at a weighting factor of 1.11, chilled water at 0.4 and hot water at 0.98.

12.4 Proposed Approach

It is proposed that supplies from third party district heating and cooling schemes are deemed by default to have fixed energy weighting factors based on the concept of maintaining a fairly neutral impact. Such coefficients would be approximately 0.4 for chilled water and 0.9 for heating hot water (on a primary energy basis with gas weighting of 0.75 kWh_e/kWh).

Where the building owner owns or operates the district heating or cooling system, the full NABERS methodology, based on the actual performance of the system on an annual basis, would be applied for the rating but the result using default factors would also be reported to enable comparisons on a like-for-like basis.

To provide some incentive for district heating and cooling operators to perform well, it is also proposed that where the district heating/cooling scheme is assessed for the rating period using the full NABERS methodology, the derived coefficients may be used by buildings within the serviced precinct, with the resultant modified rating being reported separately from the "standard" rating in a manner similar to the representation of buildings with Green Power in Australia.

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[x] Of course, if it is argued that the default assumption for space heating hot water is a heat pump rather than gas, then this coefficient would be lower, at typically 0.4.

[y] Modified to use a default boiler efficiency of 85% and chiller COP of 2.75, in line with the assumptions above.

13. Allocation of On-Site Renewables

13.1 Introduction

It is increasingly common for a commercial office building to have a PV installation installed, either on the façade/roof or in the immediate surroundings. Typically, the PV system would be owned by the building owner. The question arises whether the output from the installation should be credited preferentially to the base building energy use (so that only any surplus would accrue to the tenant's energy use) or to whole building energy use. The same discussion would apply to other forms of electricity generating on-site renewables e.g. wind turbines, although these are currently rare.

13.2 Discussion

Most UK buildings operate as an embedded network, i.e. the building owner owns and operates the submetering system by which tenants are on-charged for their metered energy use. Where a building has an on-site renewable energy supply such as wind or solar, there is generally no clear method by which the energy from the renewable supply can be allocated between the tenants and the building owner.

This situation is the subject of a current ruling discussion for NABERS in Australia. While not finalised, the general approach of this ruling is that by default, renewable energy generated within an embedded network is allocated between users in proportion to their use of energy[z]. This default can be overridden where there is an explicit contractual allocation of the renewable energy between parties.

13.3 Proposed Approach

It is proposed that the NABERS solution to this problem is adopted once finalised.

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[z] So if there are two users of the network, one drawing 40% of the energy and the other drawing 60%, then 40% and 60% respectively of the renewable energy generated on site and supplied to the common switchboard of these users would be allocated to the two users.

14. Off-Site Renewables

14.1 Introduction

One of the options for a building to reduce its environmental footprint is to directly contract electricity purchase from a renewable energy generator. For such generators, the primary energy coefficient is approximately 1.1 (versus a 2020 grid electricity primary energy coefficient of 1.738, giving a supply with a coefficient of approximately 0.63).

14.2 NABERS Approach

Under NABERS, sites that have purchased Green Power (which is certified to be 100% renewable energy from certified new renewable energy sources (i.e. not legacy hydroelectricity), based on balanced purchases and sales of renewable energy by the retailer) are permitted to use this as a discount from the energy used to calculate their headline rating, although the rating assuming normal grid supply must also be declared. The Federal mandatory disclosure scheme does not recognise the use of Green Power to boost ratings.

At this stage, NABERS has no mechanism for recognition of other forms of external renewable energy purchase, such as PPAs[aa]. It is noted that there are considerable complexities in this area, caused by the issuing of certificates for renewable energy and subsequent trade or destruction of those certificates. Many PPAs allow the generator to retain (and therefore on-sell) the certificates, with the result that the environmental benefit of the generated electricity has been traded away; any scheme to recognise PPAs in NABERS ratings would therefore need to deal with this issue to avoid double counting. Certificates of this nature are more broadly equivalent to carbon offsets, which NABERS has to date specifically not permitted to be considered in a rating.

14.3 Discussion

As far as can be determined, there is no equivalent to the Green Power scheme in the UK. The Renewable Energy Guarantee of Origin (REGO) scheme[bb] is the nearest equivalent, but it is a certificate-based scheme rather than a contract purchase based scheme. As a result, it functions more like an offset scheme, which would not currently be recognised under NABERS.

[aa] A PPA (Power Purchase Agreement) is effectively a bilateral, off-market contract to buy electricity from a generator such as a solar or wind farm.

[bb] https://www.ofgem.gov.uk/environmental-programmes/rego/about-rego-scheme

Where approaches similar to Australian PPAs are used, there are problems similar to Australia in avoiding double counting of renewable energy benefits in the presence of tradeable certificates.

14.4 Proposed approach

Given that the purchase of off-site renewables is not a mainstream activity in the UK, and the grid is already heavily decarbonised, it is proposed that no recognition is given to the purchase of off-site renewable energy in the NABERS UK rating at this stage.

The question of recognition of PPAs in Australia may be addressed in the near to medium future; it is suggested that the application of any determination from that to the UK environment should be reconsidered at that point.

15. Appendix A: Analysis of Energy Weighting Factor Impacts

When determining a single factor rating such as NABERS, it is necessary to determine a means of combining the energy use associated with different energy sources (e.g. electricity and gas) into a single figure. This is typically done with the use of weighting factors, that recognise that there are differences in environmental and cost impact between different energy sources. The values of these weighting factors can have important ramifications for the energy source selection or change decisions made by industry in order to optimise the performance of their building. For the purpose of argument, the key decisions of this type can be characterised by the following two simple examples:

1. Heat pump versus gas boiler: Does the weighting give preference to a gas boiler operating at 90% efficiency versus a heat pump operating at a COP of 2.5?
2. CHP: Does the weighting preference CHP, notionally producing 1 unit of electricity and 1.5 units of useful heat from 3 units of gas, against the use of grid electricity and local heating, either by heat pump or gas boiler?

The results of the first example are characterised in Figure 7 below:

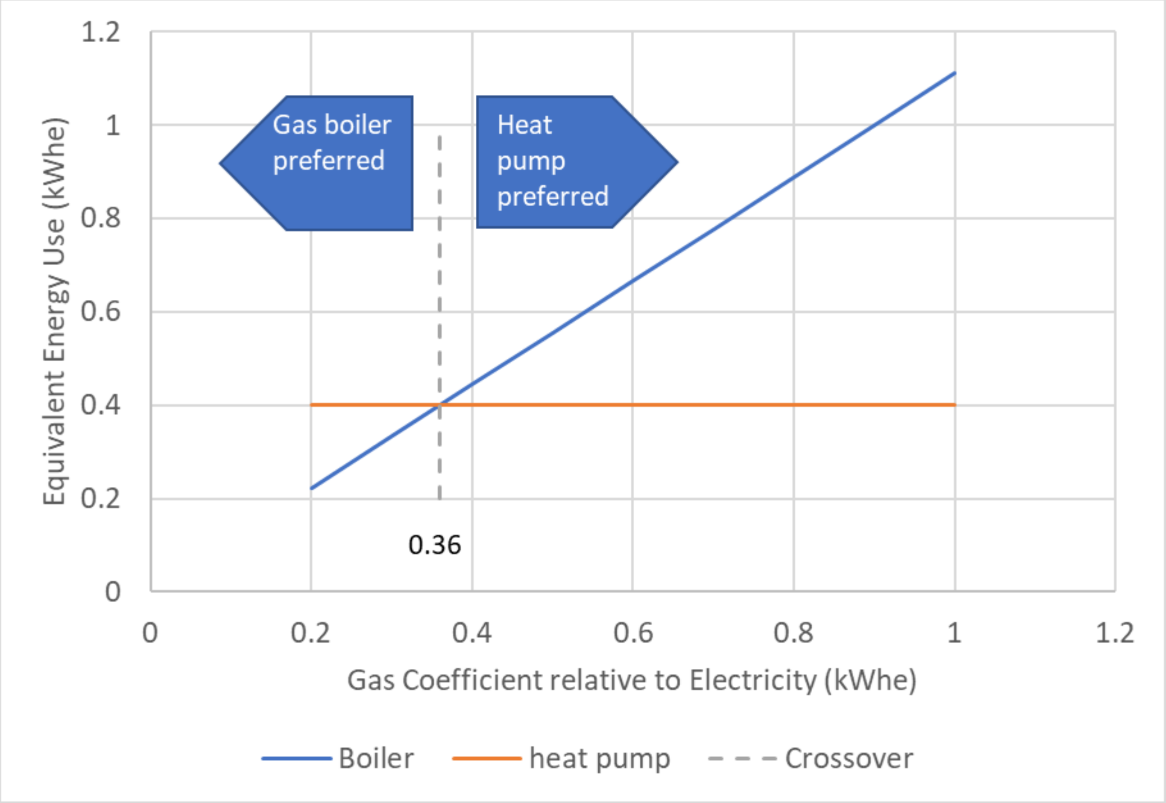

Figure 7. Effect of gas coefficient on heat pump versus boiler decision.

It can be seen in the figure that below a gas coefficient of 0.36 relative to electricity, the gas boiler solution uses less kWh$_e$ than the heat pump. However, above this figure, the heat pump is always the preferred solution.

For the second example, the situation is a little more complex, as the heating in the non-CHP situation could be provided by either a heat pump or a gas boiler. The results of this example are characterised in Figure 8.

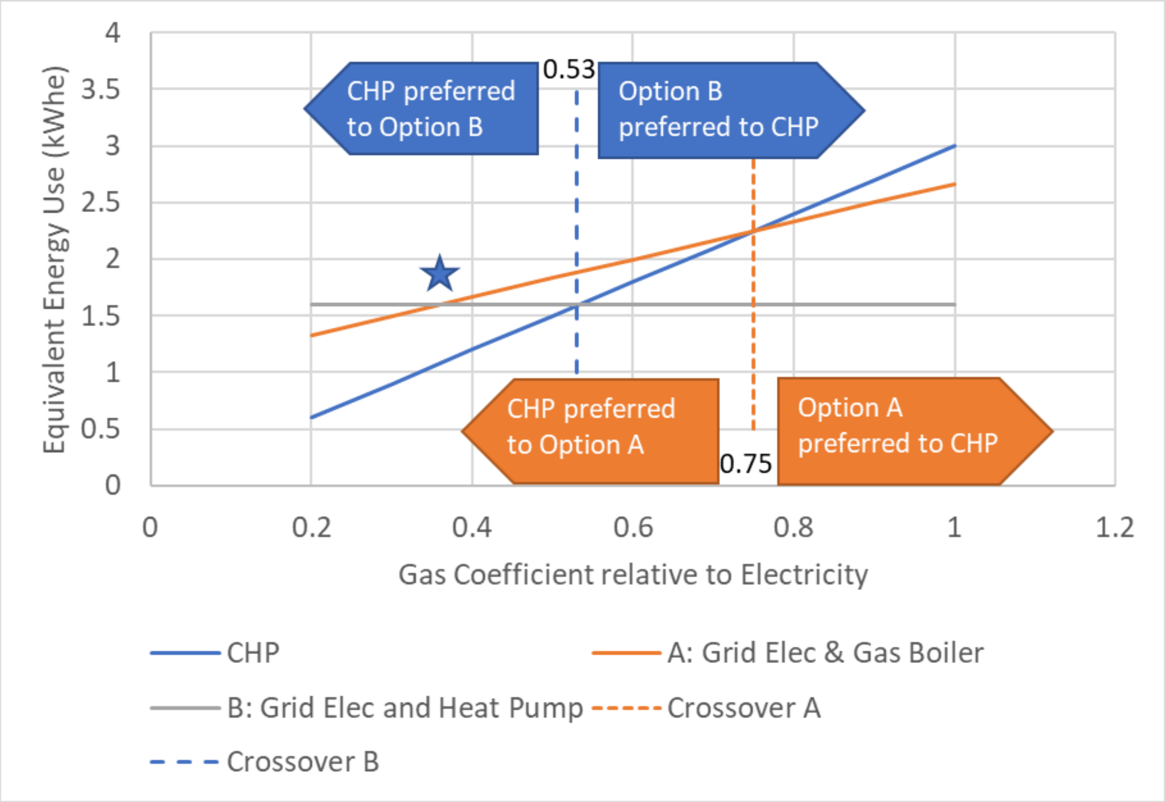

Figure 8. Effect of gas coefficient of CHP versus local solution

It can be seen in the figure that above a coefficient of 0.53, the grid electricity plus heat pump solution (B) is preferable to CHP, while the grid electricity plus boiler solution (A) is preferred to CHP above a gas coefficient of 0.75. However, this latter point is somewhat moot as the crossover of lines A and B (marked by the star in the Figure) occurs at 0.36, indicating that above a coefficient of 0.36, option B is preferred to option A.

Based on the above, therefore, it can be concluded that for all values of gas coefficient above 0.53, heat pumps are preferred to gas boilers and grid electricity with local heating is preferred to CHP. This means that any value of gas coefficient above 0.53 produces the same fuel selection decisions as the use of the current greenhouse gas weighting factors. With reference to Figure 2, primary energy is the only (non-carbon) metric that is projected to have a gas coefficient relative to electricity of more than 0.53.

A further question arises with regards to the extent the projected change in gas weighting factor from 0.75 to 0.86 will cause ratings to change over time. To test this, consider three buildings:

1. A median building using 48% gas and 52% electricity (which is approximately the median ratio of gas to electricity in available base building data assessed in this report)
2. A building using the same amount of energy, but 70% gas (approximately the highest gas to electricity ratio in the data set
3. A building also using the same amount of energy but all electric.

The results are shown in Table 5.

	Gas weighting 0.75		Gas weighting 0.86	
Building	KWh_e	Ratio to median	kWh_e	Ratio to median
1. Median	0.52+0.48*0.75=0.88	1.00	0.52+0.48*0.86=0.93	1.00
2. High gas	0.3+0.7*0.75=0.825	0.94	0.3+0.7*0.86=0.90	0.97
3. All electric	1+0*0.75=1	1.17	1+0*0.86=1	1.08

Table 5. Impact of changing gas weighting coefficient on different fuel mix buildings

As the gas weighting factor increases, the high gas building moves from 94% of median to 97% of median, a shift of 3%. Meantime, the all-electric building moves from 117% of median to 108% of median, a shift of 9%. On a standard NABERS scale, a star is 26.5% of median, so the change in rating for these two relatively extreme buildings is less than 0.35 of a star over 10 years. This is a relatively small shift that could be readily absorbed over the time period, and thus does not create an unacceptable instability in rating.

A further perspective would be to look at the change in benefit associated with a fuel change. For heat pumps, at a coefficient of 0.75, the emissions drop is 52% when switching from gas; this figure changes to 58% at a factor of 0.86. Equivalent figures for the reduction in emissions in switching from CHP to grid electricity plus heat pumps are 29% and 38%. In both cases, the same decision is promoted but the amplitude of benefit increases. Progressive update of the gas coefficient will therefore up the ante for fuel change over time.

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