Under the Hood of Energy Star and NABERS: Comparison of Commercial Buildings Benchmarking Programs and the Implications for Policy Makers

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Abstract

The Energy Star and NABERS building energy performance rating systems were developed in parallel in the US and Australia and share many common elements, including the use of statistical benchmarking based on real buildings to form the underlying basis of the systems. As both systems have now been in operation for 15 years or more, it is useful to compare and contrast these systems to understand the differences and similarities in approach. In both cases, after years of refinement as a voluntary initiative, the two systems are now the basis for mandatory rating and disclosure schemes in each country. In this paper, the Energy Star performance ratings for offices are compared with the relevant NABERS ratings to determine the differences and similarities in the following key aspects of their operation: input data types (e.g. area, hours, climate) and measurement approach, underlying datasets used for benchmarks and comparison, weather and other normalization factors, fundamental performance metric (e.g. primary energy vs greenhouse gas), actual stringency of rating for climates common to both tools, rating scale approach and use, market impact, and administration. The purpose of this review is to suggest policy implications based on the distinctions between the programs and to document context for comparisons of efficiency benchmarks from one country to another.

Introduction

Building energy performance rating and benchmarking[1], meaning utilizing energy consumption data for the purposes of comparing a building to its peers, has expanded worldwide as a policy tool intended to encourage identification and reduction of energy waste. Rating systems, programs, and policies have evolved significantly in the past few years as a result of continuous feedback, first from voluntary precursor programs and then from data collected from participating buildings. Across the United States (US), Europe, and Australia, mandatory benchmarking requirements and disclosure laws are creating additional data beyond that of voluntary precursors. This paper discusses the policy implications of the benchmarking

[1] The terms “benchmarks,” “benchmarking” and “rating” are not always understood the same way in different regions. For the purpose of this paper, a “benchmark” refers to any data collected on any metric that is meant to enable a comparison. Energy Use Intensity (EUI, or energy use per floor area) is a benchmark, and regular collection of this benchmark is “benchmarking.” A “rating” is more specific, and simplifies things by attempting to clarify the conclusion drawn from the benchmarking comparison. The Energy Star score and NABERS stars are examples of ratings.

approaches in the US and Australia, where the schemes used began as voluntary initiatives and have evolved to mandatory policies covering parts of the market in both jurisdictions.

Building energy performance rating is the act of collecting building energy use information and comparing that information to the energy use of other, similar buildings (real, averaged, or estimated) for the purposes of drawing conclusions about a building's energy efficiency. There is a wide variety of types of building energy rating schemes currently in use around the world. The ratings may be based on actual usage data (operational ratings) or physical building characteristics and assumed operations (asset ratings), and may be focused on the whole building energy performance, or parts of the building where different stakeholders have decision-making and investment authority (IPEEC 2014). This paper focuses solely on the energy benchmarking and rating of the operational performance of large commercial office buildings in the US and Australia.

Building benchmarking and rating policies are often accompanied by requirements for the disclosure of the benchmark results at a point in time, either calendar-based (annually or less frequent) or event-based (lease or sale). The requirements are to provide the benchmark results to enable the interested parties to make some comparison to other buildings and understand the larger context of the energy use of the building and associated costs and environmental impacts. The requirement may specify an energy intensity metric (energy per unit space) or a building energy rating.

Evolution of Rating Systems in the two countries

United States

Launched by the US Environmental Protection Agency (EPA) in 1999 as a key tool of the voluntary Energy Star Buildings initiative, Portfolio Manager is a free, online energy benchmarking software tool. It calculates a whole building energy efficiency rating of "1" to "100" for common commercial building types and multifamily buildings based on 12 months of energy usage data and basic information about building occupancy and operations. As of the end of 2014, it has been used to benchmark more than 400,000 buildings totaling more than 35 billion square feet (approximately 3.3 billion square meters) of space (US EPA 2015). Portfolio Manager is by far the most widely used benchmarking software tool in America, with the buildings benchmarked to date representing just under half of all U.S commercial building floor area. US policymakers have consistently chosen to leverage Portfolio Manager in benchmarking laws in part because of its widespread, voluntary usage in the real estate marketplace.

In the absence of any mandatory federal policy, benchmarking laws are being rapidly adopted across the United States at the sub-national level, particularly by large cities. Since 2007, 15 US cities, two states, and one county have created rules requiring energy benchmarking for privately owned commercial and/or multifamily residential property. Roughly half of these rules were adopted in the past four years, a bellwether for strong and sustained interest by policymakers. Details on the various requirements can be found at the regularly updated website: www.buildingrating.org

Adopted policies vary significantly in design, including policy scope (the types and sizes of buildings covered by the policy); compliance timeframes; benchmarking quality control measures; and information reporting and disclosure requirements. Yet they also share core design elements that provide strong continuity across jurisdictions. All of the adopted policies require use of the Energy Star Portfolio Manager tool, and most adopted policies require benchmarking to be conducted annually (the exceptions are the states of California and Washington, though these states may be modifying their requirements).

Australia

The NABERS (National Australian Built Environment Rating System) Energy rating for office buildings originated as the Australian Building Greenhouse Rating (ABGR) in 1999. Significant development effort on the system was expended when it was a voluntary program. The tool produces a rating from “1” to “6” stars in ½ star increments (initially five, and advanced levels of achievement have been added to distinguish the highest performers for office water and energy use). The rating is calculated from 12 months of performance data that is converted to greenhouse gas emissions, and accommodations are made for energy source, building size, type, and usage, and climate. The program is now managed by the NABERS National Administrator, in the NSW Office of Environment and Heritage. NABERS also operates in New Zealand, under license from the NABERS National Administrator. NABERS is distinct worldwide in offering building ratings for whole buildings and tenancies, and base building ratings for the areas controlled by the landlord. The base building covers the common areas and central building systems, whereas the tenancy rating covers tenant-occupied spaces. The most common type of NABERS rating is for the base building, and this is the basis for many policies in place in Australia, including the mandatory Commercial Building Disclosure (CBD) program.

The NABERS tool has expanded in scope beyond offices to include shopping centers, homes, hotels, and data-centers, and can also benchmark water usage (whole building only) for most of these building types. In offices the program can also assess waste and indoor environment quality.

Australia requires disclosure of the current energy rating of commercial office buildings in the event of the sale or lease of more than $2000m^2$ (approximately 21,700 ft^2). Enacted in 2010 and named the Building Energy Efficiency Disclosure Act, the law created the Commercial Building Disclosure (CBD) program which requires the use of the NABERS to produce a Building Energy Efficiency Certificate. The Certificate includes a NABERS rating, a tenancy lighting efficiency assessment, and general energy efficiency recommendations. CBD accredits assessors to produce the Certificates and submit them on behalf of building owners. The law requires the rating to cover the base building, unless it is impossible to distinguish the base building energy consumption from tenant-controlled consumption, in which case a whole-building rating is sufficient. The Certificates are valid for up to 12 months, or until the NABERS rating referenced expires.

Pre-mandate market penetration and effectiveness

Comparing voluntary implementation and results from the Energy Star program before New York City passed a mandatory requirement in 2009 and similar statistics from Australia before the enactment of the CBD program show similar market penetration and results. 60 percent of Australian office space was benchmarked before it became mandatory (Bannister, 2012). At the equivalent time before the NYC law became effective, the US benchmarked office space was somewhere between 40 to 50 percent (US EPA, 2010).

The mandatory benchmarking requirements in Australia and major US cities are increasing the use of the benchmarking programs. Additional research on the effect of benchmarking is being conducted based on the new datasets being created as result of these policies.

Initial Results of Mandatory Policies

The individual or collective impact of US benchmarking policies on energy efficiency, carbon reduction, real estate valuation, and other areas is beginning to be analyzed. A recent study by US researchers suggested that the benchmarking policies of four cities resulted in a statistically significant 2% reduction in utility expenditures per square foot (Palmer and Walls 2014). An evaluation by the US Department of Energy of the New York City benchmarking and transparency policy showed that for buildings covered by the policy, overall they reduced energy use by 5.7% between 2010 and 2013, while New York City's GDP grew and electricity prices fell (US DOE 2015). Previous analysis by the US EPA (2012) indicated that general use of Portfolio Manager is correlated with demonstrable energy savings in buildings over time.

The first-year results for the CBD program were released in 2013 and covered the period from November 2011 to November 2012. Because the requirements are triggered by sale or lease, compliance rates are not directly comparable to policies requiring annual reporting as in some US jurisdictions, but many buildings do update their Certificates on a rolling basis (DoRET 2013). In the first year, 1250 Certificates were issued covering 850 buildings. Eighty-nine percent of the net-lettable-area of the buildings rated was covered by a base building rating, leaving only 11 percent covered by a whole building rating (DoRET 2013).

The second year of the program ending November 2013 resulted in 1,081 Certificates covering 862 buildings. Buildings rated in both the first and second years of CBD showed an average improvement of 0.77 Stars between the two ratings. In the second year, 91 percent of the net-lettable-area received base building ratings and the remainder received whole building ratings (DoI 2014). Data for buildings that have been rated annually for 8 years shows an average reduction in energy intensity of 34% over this time (NABERS 2014).

NABERS and Energy Star Compared

Basics. Both NABERS and Energy Star provide intensity metrics in terms of source (primary) energy use or greenhouse gas emissions per unit area for buildings over a one-year period. Both programs normalize for weather and occupancy, so that comparisons across locations and occupancy levels are possible. Both programs convert that normalized intensity metric into a building type specific rating so performance can be evaluated by an interested non-technical third party. Energy Star only looks at the amount of energy used in the building, while NABERS adjusts the rating for any green electricity purchased for use in the building, although the unadjusted rating is also shown for all buildings[2].

While both programs target commercial buildings, in reality they evaluate different things. Energy Star evaluates whole building energy performance, and as a result the benchmarks

[2] The CBD program only uses the NABERS rating that ignores any credit for green energy

and ratings produced by the program speak very effectively to the overall impact of a building. The downside of the whole building focus is that separating the owner and tenant contributions to that overall impact is impossible. An office building with inefficiently operated central mechanical systems that also happens to have tenants with relatively low energy demands may attain the same rating as highly efficient and optimized building with demanding tenants. Certainly the program normalizes for occupant density, computer density, and special space use cases to counteract this possibility, but because it depends on assumptions made for the whole building, less extreme cases of these variations could easily impact ratings.

NABERS structurally addresses this potential by having separate ratings for base building, tenants, and whole buildings; though in reality the vast majority of rated buildings are base building ratings. The base building rating is based on energy use in common areas, lifts, and air-conditioning to tenancies. This flexibility afforded to NABERS by separately rating base buildings and tenancies has enabled the development of policies targeting those segments and potentially contributed to market penetration and passage of the national benchmarking requirements. Owners and operators do not have to contend with tenant data access or quality issues when producing the required benchmarks because the data used is their own.

It is important to view these ratings within that context and to be wary of extrapolating base building performance to whole building performance.

Calculation. Energy Star utilizes source (primary) energy intensity, meaning it considers the energy used to generate, transmit and deliver the energy consumed on site, to compare to a range of source energy intensities of that same building type across the country. From that comparison, the program produces the 1 to 100 score that roughly represents the performance percentile that building attains. Energy Star certifications are awarded when a qualified third party verifies this rating and the rating is over 75, representing top quartile for the building type. Not all building types can attain an Energy Star score or certifications, but most building types can utilize the tool to generate weather-normalized source energy intensity.

The NABERS program undertakes a similar process to normalize a greenhouse gas intensity metric (which accounts for the fuel source similarly to source energy) for weather and occupancy, and compares that number to the average or median intensities for that building type according to the NABERS dataset. Intensity metrics are binned and the bins are assigned star ratings, from 1 to 6 stars, in half star increments. When originally established, average performance was 2.5 stars and market leading performance was 4 stars, while 5 stars was viewed as aspirational. In 2014, the efficiency of the building stock had improved to the point where the average performance was 4.2 stars and peak performance was 6 stars – an additional rating point added in 2011 at 50% of the emissions of 5 stars.

NABERS ratings have to be undertaken by accredited third party assessors and are subject to an external audit process to ensure quality standards are maintained.

Data sources and impact on system structure. Energy Star utilizes data from the US Department of Energy's (DOE's) periodic Commercial Buildings Energy Consumption Survey (CBECS)[3] in most building types to create the benchmarks and scores. The most recent full version of this survey included performance information from 2003, but the 2012 version of the

[3] See http://www.eia.gov/consumption/commercial/

survey was released on March of 2016, and EPA has indicated it will update the scores to reflect the new results, which will likely effectively lower most scores. Where CBECS does not include information on a particular building type, the EPA has utilized industry surveys to provide performance comparison, often partnering with an industry association.

NABERS utilizes bespoke or ad-hoc industry surveys for all of its external data collection, as there is no CBECS-like building energy consumption survey conducted by the Australian government.

Energy Star covers at least 15 distinct building types, enabled by the CBECS data and the other surveys, while NABERS is available for offices, hotels, shopping centers and data centers. NABERS also covers water use for most building types as well as waste and indoor environment quality ratings for offices. Energy Star focuses on energy, as the name would suggest, but also can provide water intensity metrics for offices and several other building types.

Input data. Energy Star requires basic building info, covering gross floor area, location, and space usage, and also requires data on number of occupants, computers and occupancy hours, though defaults by space use type are available. Energy Star also confirms that the building is mostly heated and mostly cooled, by floor area. Finally, a year of energy data representing all the energy used on site is required to produce a rating. There are many additional inputs that can help better refine the rating for a building as well.

In comparison to Energy Star, NABERS requests and requires far fewer inputs of physical building characteristics to create a rating. These inputs are basically only the name, address, and net lettable area (a different metric than the gross floor area used by Energy Star), although there are extensive rules that cover many of the secondary factors and features to ensure a consistent basis of comparison[4]. The NABERS rules provide precise definitions of each of the input variables to ensure that these are calculated on a repeatable basis from building to building. The consistency of definition of these key variables avoids the need for the secondary factors that contribute to that variable to be explicitly declared. Compliance with the definitions is policed via the NABERS quality assurance and audit processes. It is certain that both the expansiveness of the Energy Star program and the simplicity of the NABERS program in these respects arise from the design decisions made by the program creators, and both lead to advantages and disadvantages for the program users. These differences in approach may also reflect differences in available industry data and thus are effectively customizations to the local market; however these distinctions do also hinder international comparability.

Summary of rating results for the same office building under both approaches

The authors of this paper published an earlier technical analysis of a sample office building to create ratings in each system, including more detailed information about the relevant inputs to the two rating schemes (Hinge et. al. 2016). A building of known NABERS performance in Sydney was selected and translated to the most similar climate for rating in the

[4] For example, while energy use is a simple input in NABERS, there are extensive rules defining the coverage of the energy use which may in turn require the use of submetering data to achieve compliance. Similarly, while area is a simple input, there are extensive rules ensuring that unconditioned spaces, for instance and excluded from the area used in the rating.

Energy Star system. San Diego was found to be the most comparable city in US in terms of climate to Sydney based on a comparison of Heating Degree Days (HDD), Cooling Degree Days (CDD), Dry Bulb (DB) temperature and Wet Bulb (WB) temperature. Los Angeles was the second best match[5].

Based on the same building information, the energy use required for the building to reach 2.5, 4.0, 5.0, 5.5 and 6.0 stars NABERS under the different fuel mix conditions (80%-20% electricity to gas ratio, 90%-10% and 100%-0%) were input into the Energy Star tool. The results are documented in Figure 1.

It can be seen that there is a linear relation between the scales, with a NABERS rating of 4 corresponding roughly to a qualifying Energy Star score of 75. This closely reflects the original position under NABERS whereby 4 stars was considered to be a good score. However, with movements in the market, scores of 4.5 stars and higher have become common, corresponding to scores of 85-90 under Energy Star. A similar dynamic is being seen in most US cities requiring benchmarking, where median scores are higher than national medians derived from CBECS, most extreme San Francisco in Minneapolis, where those cities' median Energy Star score for covered buildings is 87, dramatically above the expected median of 50.

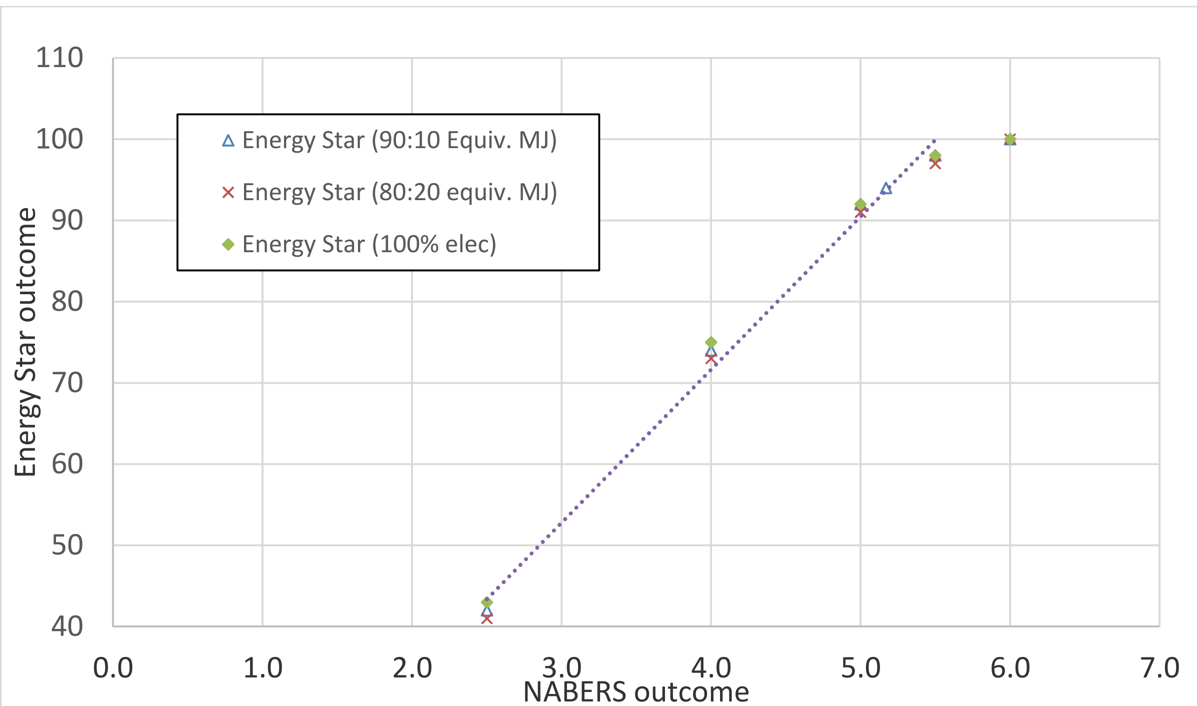

Figure 1. Comparison of NABERS and Energy Star ratings of a Sydney building translated to the San Diego climate. Results for the Los Angeles climate were essentially identical. *Source*: Hinge et al, 2016.

The small number of NABERS rated buildings that have achieved 6 stars, however, are "off the scale" for Energy Star, which has a maximum of 100. Note in this context that the

[5] The climate overlap between major Australian and US cities is relatively limited, making a more comprehensive multi-climate comparison difficult. However as climate has a limited impact on either benchmark the results provided are likely to be representative at least across temperate zones.

extrapolation of the NABERS scale is theoretically capable of rating zero emissions on its existing scale extrapolated to 7 stars; this does not appear possible with Energy Star because of the percentile scale.

Discussion

International comparability

There is growing interest in international comparison of building energy performance, in part to understand trends toward energy and climate policy goals, as well as to understand policy effectiveness. A number of international efforts to compare simple, unadjusted building energy or carbon intensity have been underway: through ULI Greenprint, a 2015 IEA/IPEEC Building Energy Performance Metrics report, and work currently underway through the C40 Network of Megacities (ULI 2015, IPEEC 2015). There is an acknowledgement in many of these efforts of the need for some type of international normalization system to adjust for climate, differences in how buildings are used and how that use is characterized in terms of the assessment of hours and area. The US and Australian initiatives are often recognized as the most advanced toward this need for simple yet technically valid normalization.

Possibly the most striking aspect of the comparison of these two rating systems is that, in spite of many differences in detail, the underlying comparability of the ratings is actually very good, with an apparent congruence in the assessment of good practice between the two scales as demonstrated through the example. Further work will be needed to test whether the congruence in that example will be repeated for different buildings, and in more extreme climate regions. This indicates that establishment of a viable rating can take different paths and use significantly different levels of project resourcing and yet still achieve essentially the same assessment of building performance. Perhaps an eventual cross-borders understanding of building is more achievable than is commonly thought.

Similarities and Differences

Energy Star and NABERS have evolved similarly, and demonstrate remarkably similar market penetration and growth trajectories. Each started as voluntary tools for the commercial real estate industry to enable evaluation of energy performance in a national context, and for the responsible governments to recognize and reward high performance. Each tool has evolved from those origins to now become predominantly a reporting and compliance tool with which building owners provide the relevant authorities with a snapshot of annual energy use. As the predominant use changed from industry assessment to policy, the policy implications of the structural differences in each tool have grown.

The policy implications of the structural differences in the programs are significant. For example, it is noteworthy that the NABERS “Commitment Agreement” exists as a result of the base building focus. Nominally, the commitment agreement is nothing more than the owner or developer of a new building publicly committing to meet a certain NABERS star rating or higher. Supporting that basic premise is a well-developed package of materials that may ultimately result in the building design engineers effectively guaranteeing the actual base building rating. Certainly there are similar structures present in the US, beginning with Energy

Star's own Target Finder program and the "Designed to Earn Energy Star" certificate, but these tools are not intended to serve as performance predictions or guarantees. As a result, there are efforts to define "outcome based codes" that seek to provide more accountability in the design process, but the accuracy of even the best predictions of design energy use is not well documented. Evidence from Australia – where simulation is regularly used to predict base building performance for new buildings – is that base building performance can be predicted with acceptable accuracy; however for whole buildings the uncertainty associated with occupancy patterns and equipment loadings make accurate prediction far more problematic.

The difficulties associated with obtaining all the energy data required for a whole building assessment means that benchmarking requirements passed by US cities should be viewed as a substantial policy undertaking requiring significant effort on the part of both building owners and the cities themselves. This includes engaging tenants and utilities to get access to the data, with certain exceptions available for those unable to procure it that varies from city to city, and utility policies for providing the data vary as well. Energy Star has continued to add functionality for data collection and reporting to support city requirements.

While there are additional costs associated with such a broader benchmarking effort, there may also be additional benefits to the increase in tenant engagement and utility attention to commercial building data. Certainly the cities themselves and private service providers will benefit from this additional data to the extent it becomes public. It is not a leap to think that cities that know their building stock better will be able to more effectively craft additional policies targeting energy efficiency in commercial buildings.

It is also significant that while NABERS uses a base building rating and credits a much of its success to the matching of the base building rating to the domain of control of the landlord, Energy Star has been successful in rating the whole building as a combination of base buildings and tenants. It is not fully clear from available data, therefore, whether the base building rating approach carries significant benefits that merit the additional complexity that the assessment of energy use along this boundary entails[6]. This is also important as the ability of NABERS to expand to other countries has been significantly limited by the availability of base building energy data.

Dealing with changing building efficiency

Both systems have started with a scale determined from a historical dataset. Given the success of both systems in achieving population-level improvements, it is worthwhile to question whether the scales require updating. NABERS has adopted the position that it is not updating its scale but has extended the scale. As the scale works all the way to zero emissions, there is no risk of a building rating beyond the upper end of the scale; meantime, the average rating has risen significantly within the boundaries of the scale and market expectations of what constitutes an efficient building have increased.

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[6] As base building energy excludes tenant light and power, it is necessary for the rating to use a precise definition of what must be included within the base building energy use used in the rating. This requires that the building metering is configured in a particular manner that while common in Australia appears uncommon elsewhere in the world.

Energy Star has updated its scale in the past, is currently updating it to utilize CBECS 2012, and will do so in the future as needed. However, unlike NABERS, a maximum energy Star rating of 100 does not equate to zero energy and thus there is a bracket of high performance buildings that cannot be differentiated from each other under this scale. Of course, updates to the underlying dataset may adequately reflect progress and recalibrate the scale. Alternatively, the scale may, like NABERS, need to be extended beyond its current upper rating.

Outstanding question: What is happening in tenant spaces?

In both countries and both programs, the role of the tenants in an office building is a subject of great interest. In the US, enabling national legislation has been passed to create the "Tenant Star" program. This program will be developed by the US EPA and DOE and implemented in conjunction with the whole building Energy Star program to recognize achievement of roughly top 25% energy efficiency in tenant spaces. Experience with NABERS tenancy ratings in Australia shows that creation of such a rating is feasible, provided that the intensity of IT usage can be successfully normalized. This is made more challenging by the dynamic and evolving nature of the use of IT in office environments.

Assuming successful development of the Tenant Star program, perhaps a base building benchmark could come from the Energy Star program and allow for the comparison of the tenant/base building split in energy use. It seems unlikely that a market facing rating or leadership distinction, like the Energy Star, should be created given the whole building program's success. Perhaps a base building benchmark would enable "commitment agreements" in the US that could aid the effectiveness of the US design industry.

It remains to be seen if either program is driving energy efficiency in tenant spaces. Potentially because Energy Star does not distinguish between tenant and base building energy use, owners in the US are incentivized to engage their tenants and help them reduce energy consumption in their space. It will be difficult to test this hypothesis without additional data. It is also possible that NABERS may be missing the opportunity to have the owner engage the tenants about energy use, but it will similarly be difficult to test that hypothesis.

Conclusions

Both the Energy Star and NABERS rating systems have evolved from government developed but real estate industry supported voluntary initiatives, to more recently become the basis for mandatory policies in each country. Both initiatives have shown major success, and have lessons that are relevant in the US and Australia, and beyond.

It is not yet possible to compare the programmatic success levels of the two initiatives because of the lack of comparable data on market impact, although both are evidently creating impacts. NABERS has strong buy-in from the building owner community and a powerful market transformation mechanism for the building owners through the base building rating, but the impact on tenants is not well documented. Energy Star inherently encourages a more holistic approach that may drive more balanced outcomes between owners and tenants, and avoids the issues of demarcation that complicate NABERS. However, it also does not enable some of the market transformation mechanisms that appear to be important drivers for NABERS, like commitment agreements.

Both systems have expanded outside of initial home country-boundaries. Energy Star has become a very widely used tool, now the basis for benchmarking and transparency policies throughout the US, and was recently adapted for use in Canada. NABERS also has been adapted for New Zealand and certainly interest exists outside Oceania.

Potentially, the ideal scenario is for both programs and both countries to continue to build upon their existing momentum by utilizing successful approaches from the other program. For example, Energy Star may well benefit from a better communication of tenant/owner responsibility in attaining a certain rating by clarifying the landlord/tenant split in energy use responsibility. NABERS may benefit from better utilizing whole building or tenant specific metrics to increase the awareness of the tenant role in determining office building energy consumption, from fit out to operations. Perhaps additional data collection or more frequent ratings may be shown to be beneficial in US cities and could become part the programs in Australia.

Finally, further comparison of both tools' existing output, in more extreme building use scenarios and climates, may highlight differences in how the systems operate. Distinctions in general space use, like in occupant density or computer requirements, may also shed additional light on rating distinctions, as may fundamental differences in space use mix within an individual building. At this moment from analysis of the systems and available data, we can only identify positive relative consistency in building energy efficiency for rated buildings, but cannot draw conclusions about the relative merits of either approach.

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