Rapid Review No.3 - Summary

Do green-rated office buildings save operational energy?

LOW CARBON LIVING CRC

Objectives of this rapid review

Around the world over the last three decades, the ambition for better environmental design in buildings has spurred the creation of a number of green building rating and certification systems. These include the Leadership in Energy and Environmental Design (LEED) in the USA, Building Research Establishment Environmental Assessment Method (BREEAM) in the U.K., and Green Star in Australia.

For office buildings, it has been generally assumed that among the potential benefits of achieving green rating certification is the cost savings from lower energy consumption. However, the evidence used to support such claims has often not been based on post-occupancy building energy performance but rather on energy consumption estimates at the design stage, where baseline comparisons may be easily biased by optimistic designer forecasts.

The aim of this rapid review is to identify and collect research that has adopted rigorous standards in assessing the energy efficiency from green rated office buildings. These are studies that use actual operational energy performance data that allows for the comparison of rating certified buildings with sets of matched non-certified buildings. Furthermore, we attempt to quantify the overall magnitude of any energy efficiency improvement using meta-analytic techniques.

The scope of the systematic review of academic literature was studies on office buildings located in developed countries, such as Australia, New Zealand, U.S.A., Canada and countries from the European Union. The rating schemes considered were LEED, Green Star, BREEAM, CASBEE and NABERS.

Key findings of this rapid review

Overall, the evidence was inconclusive as to whether green rated office buildings save operational energy.

The review found only six studies, published between 2009 and 2014, that fulfilled our criteria to be included in the analysis. All the studies were performed in the USA and concerned the LEED-certification system.

The included studies used two methods of calculating the mean energy usage intensity (EUI) of groups of buildings: building-weighted mean EUI and area-weighted mean EUI. For aggregating the effects across the studies, we used two main statistical models; each model was run for the two types of the mean EUI measures, resulting in four estimates of the overall effect (i.e. the average magnitude of energy savings, with confidence intervals).

The conclusions of the six included studies ranged from the certified buildings performing worse, similarly or much better than the non-certified buildings in terms of energy usage intensity. Two papers noted the high variation in performance among the included certified buildings, and weak or no relationship with the certification level or number of energy credits [1, 2]. One study [5] found 20% better performance in a subset of gold-certified buildings.

The number of certified office buildings used in the analyses was small and ranged from two (in two studies) to 35. Five of the studies provided data on building-weighted mean EUI and four studies on area-weighted mean EUI.

The average EUI improvement of LEED rated buildings ranged from to -0.1% to 21%, but with only one estimate out of the four being statistically significant (a 10% improvement for building-weighted mean EUI). Area-weighted mean EUI clearly showed no difference.

When aggregating the results in a meta-analysis for each EUI calculation method, we found similarly mixed results. Two meta-analytical means for the building-weighted EUI, based on effect sizes from 5 studies, indicated 11% and 23% (the latter statistically non-significant) less energy consumption per unit of area in the certified buildings relatively to the non-certified buildings. However, two meta-analytical means for the area-weighted EUI, based on effect sizes from 4 studies, showed no difference in energy consumption.

Limitations and future research

The limited number of studies, and the small number of buildings considered in at least some of the studies, clearly constrained the statistical power of the analysis and thus reliability of the results.

Limited data in the studies also prevented an analysis of variations in EUI on the basis of the specific certification level (i.e. Certified, Silver, Gold or Platinum).

None of the included studies reported on variables such as building occupancy, usage patterns, selection bias, etc., which could help explain variation observed in the data set. Other information, particularly related to risk of bias, was often missing, e.g., statements on study funding or potential conflicts of interests.

As the review ended up only examining buildings using the LEED rating scheme, care should be taken not to generalize the results to other green rating systems. LEED, Green Star, BREEAM, CASBEE and NABERS all vary in the precise design requirements and differ in the weighting given to energy in the overall credit allocation for achieving a rating certification level.

The results, therefore, highlight the need for further research in this space. Improving the selection of matching buildings, collecting data on potential explanatory variables (occupation, usage patterns, etc.), data sharing and more detailed method reporting should be part of the ongoing research agenda.

Further review of existing data using systematic review approach could also consider the value of including data sets potentially available from the grey literature (reports, theses), as well as non-English literature. Such an approach, although more time consuming, would likely result in a larger and more balanced data set for analyses, providing stronger evidence base for drawing conclusions on the performance of green-rated office buildings.

Studies reviewed

[1] Menassa, C., Mangasarian, S., El Asmar, M., & Kirar, C. (2012). Energy consumption evaluation of U.S. Navy LEED-certified buildings. Journal of Performance of Constructed Facilities, 26(1), 46–53.

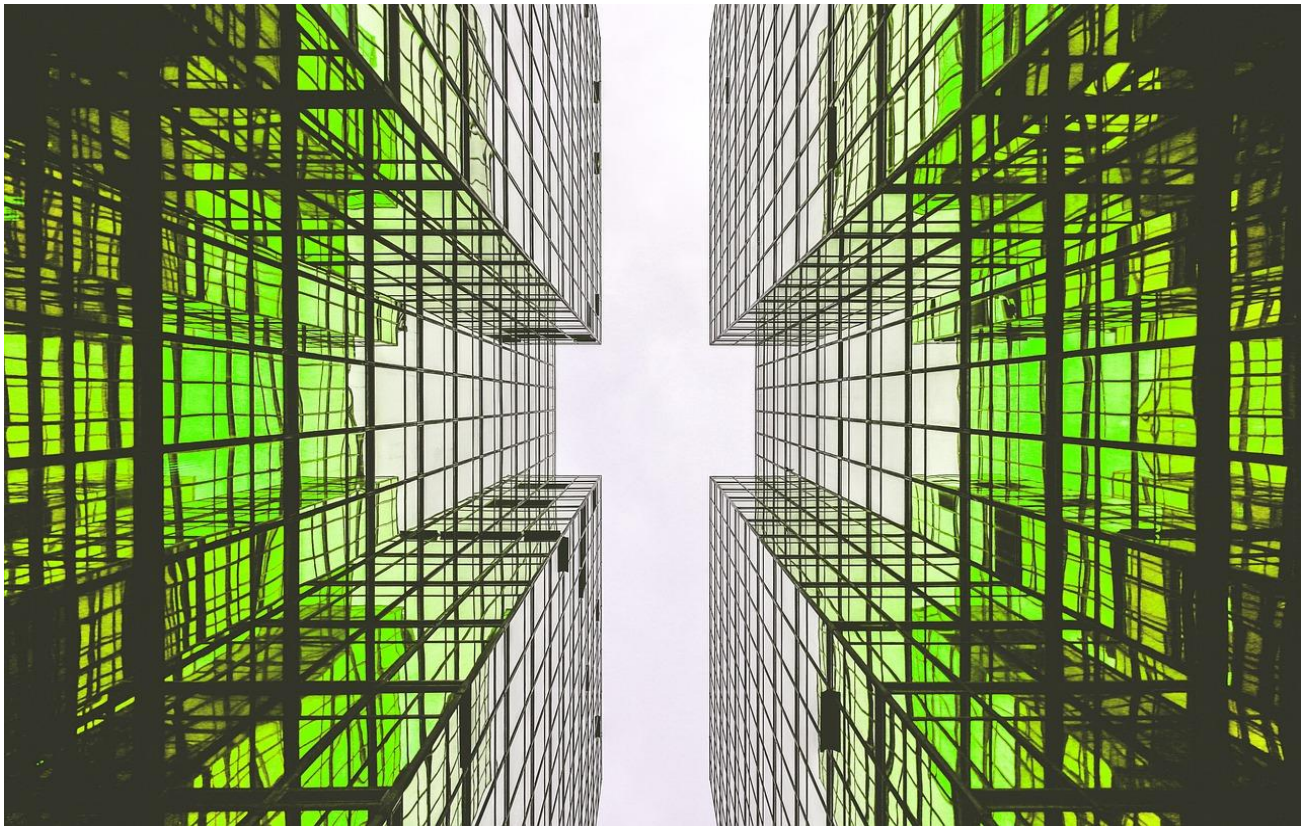
[2] Newsham, G. R., Mancini, S., & Birt, B. J. (2009). Do LEED-certified buildings save energy? Yes, but... Energy and Buildings, 41(8), 897–905.

[3] Oates, D., & Sullivan, K. T. (2012). Postoccupancy energy consumption survey of Arizona's Leed new construction population. Journal of Construction Engineering and Management, 138(6), 742–750.

[4] Scofield, J. H. (2009). Do LEED-certified buildings save energy? Not really... Energy and Buildings, 41(12), 1386–1390.

[5] Scofield, J. H. (2013). Efficacy of LEED-certification in reducing energy consumption and greenhouse gas emission for large New York City office buildings. Energy and Buildings, 67, 517–524.

[6] Tilton, C., & El Asmar, M. (2014). Assessing LEED versus Non-LEED energy consumption for a university campus in North America: A preliminary study. In ICSI 2014: Creating Infrastructure for a Sustainable World - Proceedings of the 2014 International Conference on Sustainable Infrastructure (pp. 1071–1076).



Disclaimer

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