

Written testimony to the U.S. House of Representatives
House Committee on Science, Space and Technology
Subcommittee on Investigations and Oversight

The Science Behind Green Building Rating Systems

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by

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Good morning. My name is John Scofield. I am a professor of Physics at *Oberlin College* and a member of the *American Physical Society* (APS). For the last 20 years I have conducted research and published peer-reviewed articles on solar cells, photovoltaic arrays, wind energy, energy efficiency, and green buildings. In 2007-8 I served as one of two staff for the *APS Energy Efficiency Study Committee* and was a contributing author to its final report, *Energy Future, Think Efficiency*. I have written two peer-reviewed articles which address energy consumption by commercial buildings certified under LEED NCv2 (new construction version 2), and it is on this topic that I am here to speak to you today. Subsequent references to LEED refer to this specific certification program. The comments I offer the Committee are mine alone and do not necessarily reflect the views of *Oberlin College* or the *American Physical Society*.

In 2000 the *US Green Building Council* (USGBC) introduced the *Leadership in Energy and Environmental Design* building rating system known as LEED. While this is just one of several systems for rating “green buildings” it has rapidly emerged as the most popular. It is commonly assumed that a LEED building is an energy-efficient building – though until 2007 there were relatively little data to back this up. In 2007 the USGBC commissioned the *New Buildings Institute* (NBI) to gather energy consumption data from LEED-certified commercial buildings and determine if, indeed, LEED buildings were using less energy than other buildings. In March 2008 NBI released its final report in which it concluded:

“...on average, LEED buildings are delivering anticipated savings. Each of three views of building performance show average LEED energy use 25-30% better than the national average, a level similar to that anticipated by LEED modeling.” [Turner & Frankel]

The NBI study and its conclusions have been widely disseminated by the USGBC and serve as the scientific basis for its claims that LEED-certification results in lower energy consumption and lower green house gas emission [USGBC, Watson].

With its publication the NBI study immediately drew criticism. New York contractor Henry Gifford criticized the study on two counts. The first was that the LEED data were self-selected, volunteered by building owners willing to share their data, and therefore not representative of all LEED certified buildings. He likened this to a voluntary (alcohol) breathalyzer test set up alongside the highway. Second, Gifford criticized NBI for comparing the **median** energy intensity of LEED buildings with the **mean** for all commercial buildings. Gifford further asserted that the mean energy intensity for the LEED buildings in the NBI study was actually 29% higher than the corresponding mean for all U.S. commercial buildings. [Gifford]. The USGBC and others discounted Gifford’s criticisms because it was not vetted through the peer-review process.

In 2008 the APS *Energy Efficiency Study Committee* confirmed one of Gifford's assertions by writing, "Whatever their efficiency, these 121 LEED buildings consume more total energy per square foot (either site or primary) than the average for the entire commercial building stock." [Richter et al.].

Cathy Turner, the lead author of the NBI study, made a summary version of the NBI LEED data available for independent analysis.

I have analyzed these data and identified key flaws in NBI's methodology. After correcting for these flaws I found that LEED buildings consume about the same amount of primary energy as to comparable, non-LEED buildings. LEED buildings are statistically no better and no worse. The same can be said about green house gas emission, since primary energy correlates strongly with carbon emission. My study was published in a peer-reviewed paper at the 2009 *International Energy Program Evaluation Conference* (IEPEC). Cathy Turner, co-author of the NBI study, was one of the reviewers of my paper [Scofield-1]. The paper may be obtained on the web at http://www.oberlin.edu/physics/Scofield/pdf_files/Scofield%20IEPEC%20paper.pdf.

About the same time a Canadian group published their analysis of the NBI LEED data in the journal *Energy and Buildings*, supporting, but clarifying, the conclusion reached earlier by NBI [Newsham]. Upon reading that paper I immediately recognized the Canadian group had made mistakes similar to those made by NBI. I quickly wrote a follow up paper correcting their analysis, and again reached the conclusion that LEED-certification was not yielding any significant reduction in primary energy consumption. My rebuttal paper was submitted to *Energy and Buildings* and published in record time [Scofield-2].

To summarize this portion of my testimony, my analysis of the LEED building energy consumption data gathered by NBI shows that LEED-certified commercial buildings use about the same amount of primary energy as their conventional counterparts. And keep in mind Gifford's criticism, that the buildings included in the NBI study are probably more efficient than the 80% of the LEED-certified buildings for which NBI was not able to collect energy data. I am not aware of any other comprehensive study of energy consumption by LEED-certified commercial buildings, or buildings certified by any other green building rating system, for that matter.

Inasmuch as buildings are responsible for roughly 40% of US primary energy consumption and associated GHG emission this has important policy implications. All strategies for reducing our nation's GHG emission start with improving building efficiency. LEED certification has not been useful at reducing building primary energy consumption and, by inference, GHG emission associated with building operation. There may be many green benefits from LEED certification – but reduction of primary energy consumption for building operation is not one of them. Studies have shown that, over the lifetime of a building, energy used for operating the building dominates – far exceeding the embodied energy of construction [Dimoudi & Tompa]. **There then appears to be no scientific basis for institutions such as colleges, universities, or the Federal Government to require LEED certification as a GHG or energy reduction strategy for its buildings.**

This largely concludes the central message of my testimony. I would like to take this opportunity to further address two related questions: (1) why is it that LEED certification has not achieved significant reductions in primary energy consumption for buildings, and (2) what advice so I have for selecting a green building rating system for Federal buildings to move our nation towards its goal of 30% reduction in building energy consumption?

First, let me address the shortcomings of LEED. To borrow a metaphor, building energy efficiency is a stool supported by three legs: (1) design, (2) construction, and (3) operation and maintenance. The “D” in LEED is for design – the acronym includes no letters for the other two legs, and they are not sufficiently addressed by LEED. Moreover, LEED certification is contingent upon accumulating a certain number of points awarded for a checklist of “green” measures that are included in the building design ranging from trivialities such as bike racks, employee showers, and parking spaces designated for efficient cars, to potentially more substantive points for demonstrating an energy-efficient design. Energy efficiency points, however, are based on how much lower projected energy consumption is as compared with projections for a baseline case – the baseline case being a conventional design selected by the architect that meets building codes (that is a building that if it were any worse, would be illegal). One might expect that baseline energy consumption for similar buildings is a well-defined number. That is not what NBI found in its study. NBI found that baseline energy consumption put forward by LEED designers of similar buildings varied by as much as 400%! In short, designers can “game” the system simply by constructing a very inefficient baseline case (one no one would actually build) to which their design is to be compared. The LEED rating is achieved before the building is ever occupied and is not contingent upon achieving any measured energy performance target.

In addition, studies have shown there to be little or no correlation between energy projections made by the design team and actual energy consumption once the building is constructed and occupied [Johnson]. For instance, in their study, NBI found no correlation between the number of energy efficiency points awarded by LEED and measured energy consumption. If your goal is to lower measured energy consumption then you should focus on that, not a hypothetical projection of energy consumption calculated before the building is even constructed based upon untested assumptions regarding building occupancy and usage.

It is my experience that what LEED designers deliver is what most LEED building owners want – namely, green publicity, not energy savings. Long before the building is occupied LEED building owners reap enormous green publicity from so-called news articles that are nothing more than press releases that list the many benefits of the intended building along with the architect’s optimistic energy projections. After the building is occupied the owner has little to gain – and much to lose – by measuring and publicly reporting the energy consumption. It is no accident that nearly 80% of the owners of LEED-certified commercial buildings eligible for the NBI study were unable or unwilling to provide metered energy data for their buildings. No doubt Henry Gifford is right when he supposes the LEED buildings studied by NBI are not representative of the larger LEED building population.

This lack of credible metered building energy data is bigger than just LEED – it applies generally to *High Performance Buildings*. The U.S. Department of Energy (DOE) website hosts a High Performance Buildings database that includes data for a mere 129 buildings. Compare this to the thousands of commercial buildings now certified by LEED. Data for these 129 buildings are submitted by building owners or their representatives without independent validation, and the vast majority of these do not include metered data, but rather, design projections. Similarly the DOE hosts a Zero Energy Buildings (ZEB) database which lists only nine commercial buildings – reporting metered data for only four of them. One of the four is my own institution’s *Adam Joseph Lewis Center*. Since its inception this building has been described by its architect as a ZEB, it has been listed as such on the DOE’s web site, and it is included in the recent ZEB study released by NBI [New Buildings Institute]. Yet utility meters show this building has been a net-energy importer for each of its 11 years of occupancy. There is a huge gap between green building mythology and scientifically demonstrated performance.

It seems that the high performance building community prefers to play “fantasy football” to the real game on the field. But physics trumps politics – our nation’s energy expenditures, green house gas emissions and primary energy consumption continue to rise.

Finally, what advice do I give the Subcommittee as it considers adopting some green rating standard for Federal Buildings?

Buildings last a long time – often more than 100 years, particularly in the case of Federal buildings. Studies have found that the energy used to operate a building over its lifetime is much greater than the energy used in its construction. There is no single characteristic more important for a green building than the lowering its annual energy consumption. Numerous studies, including the 2008 APS Energy Efficiency Study, have concluded that cost effective deployment of energy efficient technologies can significantly lower energy consumption both for new and existing buildings. Clearly all building owners, and in particular, the Federal Government, should seek maximal, cost-effective deployment of building energy efficient technologies. These will lower operating costs, save natural resources, and lower green house gas emissions.

But green building rating systems, in my opinion, are not moving this nation towards these important goals. They are, instead, a distraction, tapping our time and financial resources while yielding little documented reduction in the only metrics that matter. I am not aware of any comprehensive study that uses credible metered energy data for a large number of buildings to demonstrate the effectiveness of any green building rating system at reducing primary energy consumption. As I have already pointed out you can’t even get the metered data to compare the results of various green building designs. What frequently passes for building science are so-called “case studies” that are nothing more than marketing brochures written to put the best spin possible on a particular building design and its design team. Many lack metered data making it impossible to compare the results of different designs.

The Federal government would not require or fund wide-spread use of a drug without scientific research that demonstrates its efficacy. Data from a few, hand-selected cases would not suffice. The standards are clear. Similarly the Federal government should not require or spend my tax dollars on green building certification absent scientific proof that these measures have achieved significant reduction in primary energy consumption. Individuals who suffer from arthritis may choose to wear copper bracelets – but the government should not mandate or fund such unsupported remedies.

The closest thing to a scientifically-based green building rating system of which I am aware is the *Energy Star* building score. It isn’t very sexy, but it is based upon 1) metered energy data, 2) primary (or source) energy consumption, and 3) requires data validation by a third party. What I would like to see is a green building rating system that combines the sex appeal of LEED with the substance of Energy Star and, of course, has scientifically demonstrated success before any consideration of a mandate.

At night I occasionally scan through my cable-TV channels and run across an “infomercial” for the latest and greatest “weight-loss” program. Americans spend tremendous amounts of money on such programs chasing the promise of lean sexy bodies with little effort or time. And yet we remain a nation of obesity. The science of weight loss is pretty simple – a lower, long-term caloric intake combined with regular exercise. The recipe doesn’t yield rapid results – but it yields real, sustainable results. Similarly we know how to make our buildings more energy efficient. We need to stop chasing the energy infomercials.

Thank you for your attention. I look forward to answering any questions you may have to the best of my ability.

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