Why Green Building Rating Systems are Almost Always Wrong About IAQ

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Are they really serious about it?

- Serious? Yes, of course they are serious.
- Are they doing a good job? No, **not even close**.
- "LEED" is supposed to mean "Leadership in Energy and Environmental Design"
- Is it leading or mis-LEADing? What is leadership? They aren't even seriously better energy-wise.
- Not "serious" about IAQ; just a few, weak, non-mandatory points. Not "serious" about energy either.
- It's a question about
  - 1) how high to set the bar: what is "high performance?"
  - 2) how detailed the bars are?

Summary: Green Building Rating systems

- Based on minimum number of points or credits – **no credits for IAQ are necessary to be "platinum!"**
- IAQ requirements are **overly general** without including best current and scientifically-justified practices or **confirmation in actual buildings**
- **Ignore interconnectivity** of building environmental concerns – separate, discrete point awards, encourages "point shopping"
- **Integrated design incentives or requirements lacking**, critical to overall resource efficiency – actually encourage balkanization of the design team and process ….including but not limited to energy and material use.
- Based on design, not actual performance.

Why are they almost always wrong about IAQ?

– Another 5 important reasons:

1. Designers (architects, engineers, interior designers, and other consultants)
2. Contractors – Builders, subs, suppliers…
3. Material suppliers (manufacturers, sales, distribution)
4. Occupants (residents e.g., workers, students, teachers, etc., and visitors)
5. Operators (facility managers, engineers, maintenance personnel, housekeeping)

Did I leave anybody out?

LEED 2009 for New Construction

"Designed to guide and distinguish high-performance commercial and institutional projects, including office buildings, high-rise residential buildings, government buildings, recreational facilities, manufacturing plants and laboratories" *

* http://www.usgbc.org/DisplayPage.aspx?CMSPageID=220

"LEED" 2009 for New Construction and Major Renovations

Certifications are awarded according to the following scale:

Certified 40–49 points

Silver 50–59 points

Gold 60–79 points

Platinum 80 points and above

i.e., no IAQ points are necessary to be Platinum!

Indoor Environmental Quality 15 possible points, 9 IAQ-related

prerequisite 1 Minimum indoor air Quality performance required
prerequisite 2 Environmental tobacco smoke (ETS) Control required
Credit 1 outdoor air Delivery Monitoring 1
Credit 2 increased ventilation 1
Credit 3.1 Construction indoor air Quality Management plan—During Construction 1
Credit 3.2 Construction indoor air Quality Management plan—Before occupancy 1
Credit 4.1 Low-Emitting Materials—adhesives and sealants 1
Credit 4.2 Low-Emitting Materials—paints and Coatings 1
Credit 4.3 Low-Emitting Materials—flooring systems 1
Credit 4.4 Low-Emitting Materials—Composite wood and agrifiber products 1
Credit 5 indoor Chemical and pollutant source Control 1
Credit 6.1 Controllability of systems—Lighting 1
Credit 6.2 Controllability of systems—thermal Comfort 1
Credit 7.1 thermal Comfort—Design 1
Credit 7.2 thermal Comfort—verification 1
Credit 8.1 Daylight and views—Daylight 1
Credit 8.2 Daylight and views—view

Total points available for IAQ = 9
-- "low emitting materials" = 4

Low-emitting materials certifications -- Limitations: current emissions testing programs

- Testing only extremely small sample of production; issues related to number of tests, representativeness, variability
- Infrequent testing
- Lack of evidence of repeatability of tests
- Testing not necessarily directly related to exposure:
  - Amount of product actually used - variations from test conditions
  - Ventilation rate in actual buildings can vary by factor of 2 to 10 (greater or lesser) compared with test conditions
  - Variations in humidity affect emissions and exposure (especially for formaldehyde and other water soluble species)
  - Variations in test atmosphere, e.g., ozone, other oxidants

Some Limitations: A.T. Hodgson's concerns -1

- Limitations of the overall product emission testing approach
  - Not well informed by toxicology
    - Toxicologists should be involved and inform process by developments in toxicology
    - Not sure what chemicals we should be looking for due to incomplete information on toxicology
    - Approach focuses on known chronic toxicants (systemic toxicants and carcinogens/teratogens/mutagens) at concentrations that can't be sensed; but, other potential health endpoints such as neurotoxic effects are not addressed

Some Limitations: Hodgson - 2

- Not all source parameters needed for modeling are characterized
  - To estimate impacts of diffusion sources over time, we need to know the bulk concentrations of chemicals of concern, their diffusion rates in the material(s) and their partitioning between the material(s) and air
  - Products may be reactive with ozone
  - Products may act as sinks and impact exposures to other chemicals

Some Limitations: Hodgson - 3

- Specific limitations of chamber technology
  - Not suitable for measurement of compounds with low vapor pressures, e.g., SVOCs. Emissions of low vapor pressure compounds are controlled more by processes external to the product such as mass-transfer resistance at the surface and sorption onto chamber surfaces
  - Not suitable for measurement of chemicals that react quickly on chamber surfaces

Exposure Issues : Levin -1

- Concentrations ≠ Exposure (time spent, metabolic rate, route of entry)
- Emissions in Chamber can be < or > and/or ≠ Emissions in buildings (intentional “and/or”): importance of normalizing for source strength and variability of ventilation (OA, surface velocity) and T and RH effects
- Minimal knowledge of emissions of most SVOCs
- Acute effects ≠ Chronic effects: highest exposures, most important exposures
- Lack of concentration/exposure-based guidelines for most VOCs
- Odor testing not widely implemented

Reference rooms – Augustin, Eurofins

Reference rooms – Comparison

eurofins

	ISO 16000-9	New CEN standard	CA office	CA classroom
Floor m²	7	12	11.1	89.2
Height m	2.5	2.5	2.7	2.6
Volume m³	17.4	30	30.6	231
Loading m²/m³	depending on what product (wall, floor, …)			
Temperature °C	23	23	23	23
Relative Humidity %	50	50	50	50
Effective air change /h	0.5	0.5	0.675	0.81

Exposure Issues : Levin - 2

- Carcinogenicity not necessarily related to Acute or Chronic Effects
- Huge population variability, orders of magnitude differences in individual human responses
- Precision ≠ Accuracy
- Odor thresholds imperfect, Guidance values 10x too high (Japanese and American research)
- ∑ Single chemical effects ≠ Effects of mixtures

  (Kortenkamp et al, 2009, State of the Art Report on Mixture Toxicity, Study Contract Number 070307/2007/485103/ETU/D.1)*

  Treatment of mixtures: additive, synergistic, prophylactic; target organ; mode of action, and other potential combined or interactive
- Does not include cleaning and maintenance products or user/occupant behavior
- New products emerging, Old products are changing

* http://ec.europa.eu/environment/chemicals/pdf/report_Mixture%20toxicity.pdf

Emissions Testing, Certification and Labelling programs

- Numerous programs exist in Europe, North America, and Asia.
- There are significant differences among the programs.
- There is almost no published, peer-reviewed evidence of the efficacy of these programs in reducing exposure to indoor air pollutants.
- Many limitations exist that require further research as well as coordination and harmonization of protocols, acceptance of standard procedures and establishment of health-based guideline values for evaluating product performance, certification, and labelling.

Recommendations: Examples of problems that could be addressed by research

- Testing of wet products
- Accounting for Product or Specimen Variability
- Dealing with Cleaning Products and Air Fresheners
- Establishing Common Standardized Concentration Limits
- Develop guidelines based on existing models

Models for guideline development

- Chronic reference exposure levels (CRELs) adopted by the California Office of Environmental Health Hazard Assessment (OEHHA),.
- NIOSH criteria for pollutant exposure generally based on health,
- World Health Organization (WHO) Regional Office for Europe
  - Air Quality Guidelines for Europe,
  - recently released IAQ Guidelines, as well as guidelines for Dampness and Mold.
- European Community "Critical Appraisal of the Setting and Implementation of Indoor Exposure Limits in the EU, INDEX," completed in 2005, review and revision to establish guideline values.
- Hodgson and Levin (2003a, b) provided a process for establishing limit values that could be used as a model (Levin, 2006, 2010)

"Errors and Omissions" (no insurance)

- Green materials shown to not be much better or even as good as conventional materials (* #)
- Moisture problems are now recognized as related to major health (&)
- Moisture ignored as indoor environmental quality issue

* Alevantis et al, CA Dept of Public Health web site

Hoang et al, 2010, *Biodegradation and Biodeterioration*

& Mendell et al 2011, *Environmental Health Perspectives*

LEED NC 2009
Energy and Atmosphere 35 Possible Points

Prerequisite 1 Fundamental Commissioning of Building Energy Systems Required

Prerequisite 2 Minimum Energy Performance Required

Prerequisite 3 Fundamental Refrigerant Management Required

Credit 1 Optimize Energy Performance 1–19

Credit 2 On-site Renewable Energy 1–7

Credit 3 Enhanced Commissioning 2

Credit 4 Enhanced Refrigerant Management 2

Credit 5 Measurement and Verification 3

Credit 6 Green Power 2

28 total points available for low or green energy

OPTION 1. Whole Building Energy Simulation (1–19 points)

Demonstrate a percentage improvement in the proposed building performance rating compared with the baseline building performance rating. Calculate the baseline building performance according to Appendix G of ANSI/ASHRAE/IESNA Standard 90.1-2007 (with errata but without addenda1) using a computer simulation model for the whole building project. The minimum energy cost savings percentage for each point threshold is as follows:

New Bldgs	Exist'g Bldgs, Retro	Points
12%	8%	1
14%	10%	2
16%	12%	3
18%	14%	4
20%	16%	5
22%	18%	6
24%	20%	7
26%	22%	8
28%	24%	9
30%	26%	10

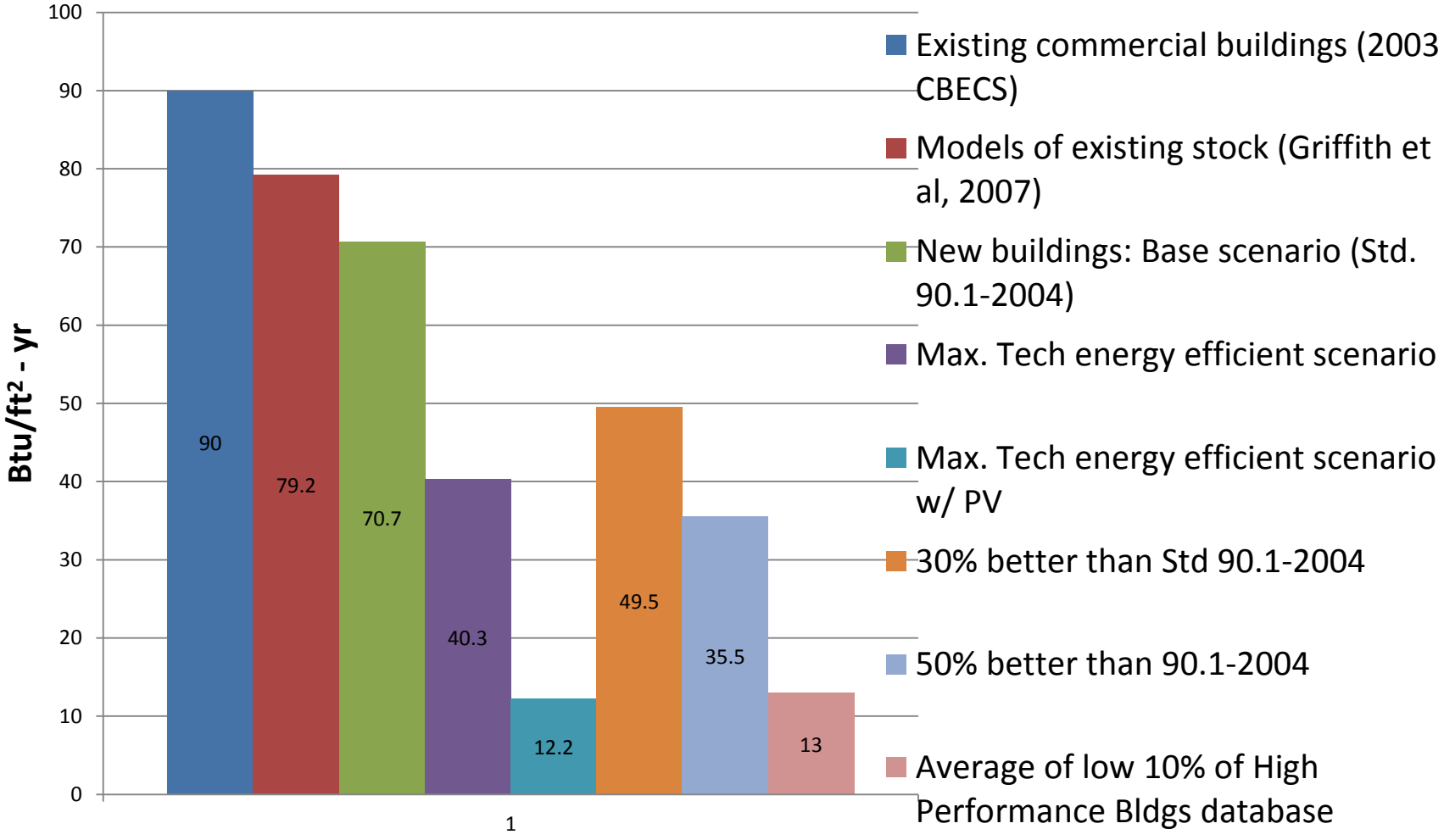
New Bldgs	Exist'g Bldgs, Retro	Points
32%	28%	11
34%	30%	12
36%	32%	13
38%	34%	14
40%	36%	15
42%	38%	16
44%	40%	17
46%	42%	18
48%	44%	19

What are the energy efficiency goals?

- What are the energy efficiency goals? Improvement over current performance
- Are they aggressive enough?
- Are they being achieved in buildings getting the points for achieving them?
- Are there measurements of actual performance to support the claims of LEED AP consultants?

EUI – site energy

(adapted from Griffiths, 2007)



How is LEED misleading about IAQ?

- Assumption that the points ensure good IAQ, no need to understand what makes for good IAQ
- Assume ASHRAE standards for ventilation (62.1, 62.2) and thermal conditions (55) ensure good IAQ;
  - doing "better" (i.e., more outdoor air) than the standards makes for even better IAQ.
- Outdoor air – more is not always better for IAQ -- outdoor air can be polluted.
- Compliance with 62.1, 62.2,and 55 is often claimed when not realized. Never confirmed.

Do design assumptions = performance?

- "LEED" is based largely on design assumptions
- Abundant evidence that buildings are not performing according to design assumptions or even meeting minimum code standards (Newsham, Scofield, Persily and Goran, others)
- Does this apply to LEED-rated buildings any less than to non-LEED-rated buildings? Maybe.
- Studies of LEED-rated buildings based on actual performance are scarce

"Do LEED-certified buildings save energy? Yes, but. . ."

Guy R. Newsham *, Sandra Mancini, Benjamin J. Birt

"On average, LEED buildings used 18-39% less energy per floor area than their conventional counterparts. However, 28-35% of LEED buildings used more energy than their conventional counterparts. Further, the measured energy performance of LEED buildings had little correlation with certification level of the building, or the number of energy credits achieved by the building at design time. Therefore, at a societal level, green buildings can contribute substantial energy savings, but further work needs to be done to define green building rating schemes to ensure more consistent success at the individual building level. Note, these findings should be considered as preliminary, and the analyses should be repeated when longer data histories from a larger sample of green buildings are available."

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"Do LEED-certified buildings save energy? Not really…"

Scofield, 2009, *Energy and Buildings*

ABSTRACT: Newsham et al. have recently published a re-analysis of energy-consumption data for LEED-certified commercial buildings supplied by the New Buildings Institute (NBI) and US Green Building Council. They find that, on average, LEED buildings use 18–39% less energy per floor area than their conventional counterparts, consistent with and adding clarity to conclusions originally reached by NBI. These conclusions, however, hang on a particular definition of the mean energy intensity of a collection of buildings that is not related to the total energy used by those buildings. Furthermore, site energy considered by Newsham et al. and NBI, unlike source energy used for the EPA's building Energy Star rating, does not account for the energy consumed off-site in generating and delivering electric energy to the building, whose inclusion is crucial for understanding greenhouse gas emission associated with building operation. Here I demonstrate that both the site energy and source energy used by the set of 35 LEED office buildings and Newsham et al.'s matching CBECS office buildings are statistically equivalent. Hence Newsham et al. offer no evidence that LEED-certification has collectively lowered either site or source energy for office buildings.

John H. Scofield, *Energy and Buildings*, 41 (12), (2009), 1386-1390

Scofield's Conclusions

- Further, the measured energy performance of LEED buildings has little correlation with certification level of the building, or the number of energy credits achieved by the building at design time.
- Here I demonstrate that both the site energy and source energy used by the set of 35 LEED office buildings and Newsham et al.'s matching CBECS office buildings are statistically equivalent.
- Hence Newsham et al. offer no evidence that LEED-certification has collectively lowered either site or source energy for office buildings.

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Commissioning ?

- Could vastly improve IAQ. Does it ever really happen?
- Cx - commissioned at part and full load – this would require most buildings to be commissioned over a period of at least 9 months in order to “see” all the seasons.
- Requires occupied buildings in use – most LEED commissioning is done before occupancy.

What's important?

- Level of discrimination (detail) *or* the level of aggregation or disaggregation of environmental impacts
- In "LEED," metrics for indoor environmental quality are at very high level of aggregation, i.e., details that matter are invisible or simply not considered sufficiently.
- IAQ is one of the categories of "green" that get neglected.

Thank you for your attention

Questions?

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