LEED CERTIFICATION
intent, implementation, and results

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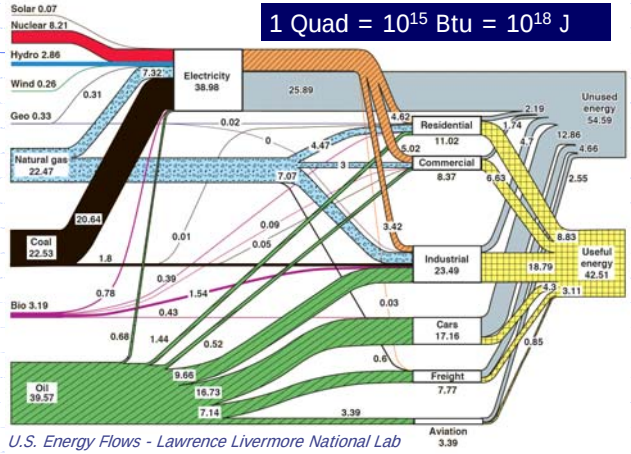
Outline

- Overview – US Energy flows and role of buildings

  Digression: define basic concepts
  gsf, EUI, site energy, source energy
- Energy efficiency potential for buildings
- LEED Certification – Intent and Implementation
- Do LEED buildings save energy – what evidence?
- Energy Benchmarking in major cities
- 2011 NYC benchmarking data for office buildings
  LEED shows no reduction in GHG emission or energy use
- Summariz

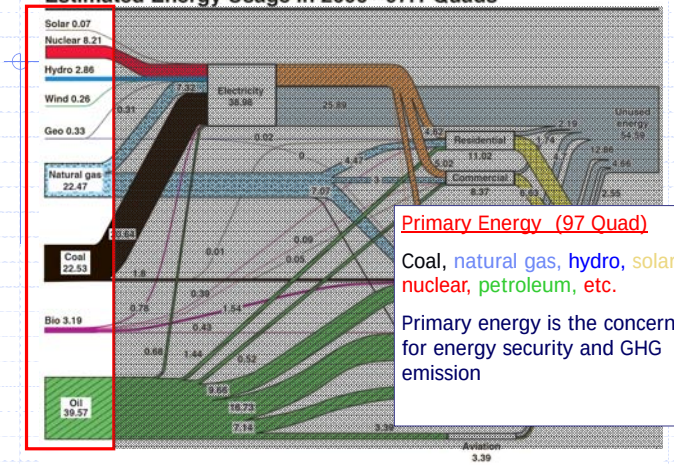
Estimated Energy Usage in 2006 ~97.1 Quads

1 Quad = 10^{15} Btu = 10^{18} J



U.S. Energy Flows - Lawrence Livermore National Lab

Estimated Energy Usage in 2006 ~97.1 Quads

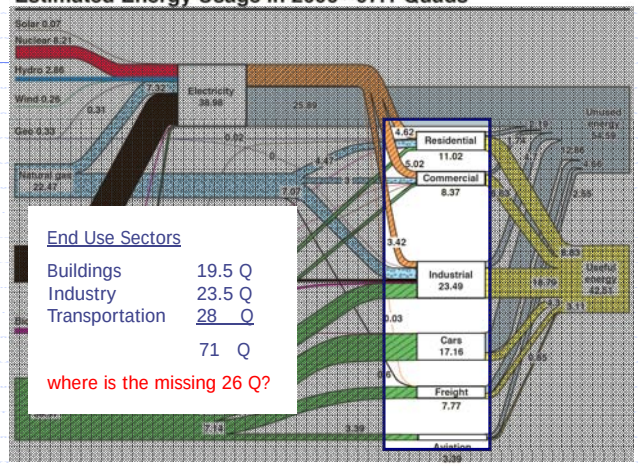


Primary Energy (97 Quad)

Coal, natural gas, hydro, solar, nuclear, petroleum, etc.

Primary energy is the concern for energy security and GHG emission

Estimated Energy Usage in 2006 ~97.1 Quads

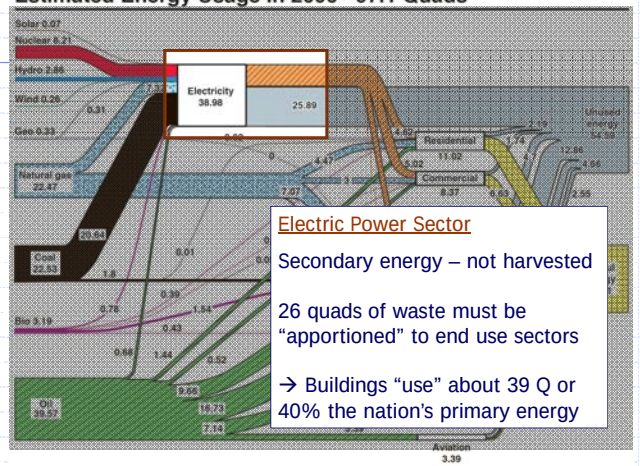


End Use Sectors

Buildings	19.5 Q
Industry	23.5 Q
Transportation	28 Q
	71 Q

where is the missing 26 Q?

Estimated Energy Usage in 2006 ~97.1 Quads



Electric Power Sector

Secondary energy – not harvested

26 quads of waste must be "apportioned" to end use sectors

→ Buildings "use" about 39 Q or 40% the nation's primary energy

Where does the energy go?

Figure 18
Residential energy end usage
In 2006 the residential sector consumed 21.8 quads[4] of primary energy.
This chart shows the relative amounts going to various residential end uses.[5]

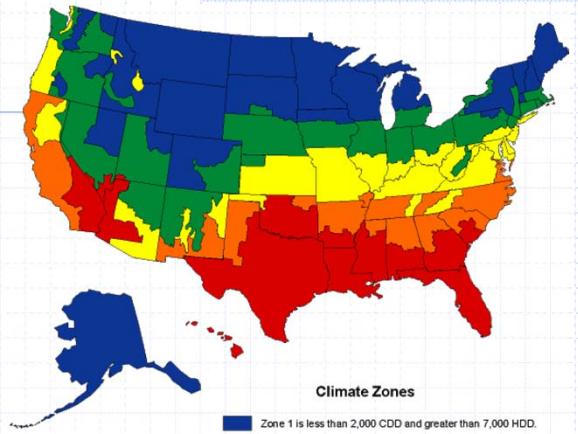
Space heating[6]	Space cooling	Water heating	Lighting	Refrigeration	Electronics	Wet cleaning	Cooking	Computers	Other
32%	13%	13%	12%	8%	8%	5%	5%	1%	3%

Source: Energy Data Book (2007); EERE, U.S. Department of Energy

Figure 19
Commercial energy end usage
In 2006 the commercial sector consumed 17.9 quads of primary energy. This chart shows the relative amounts going to various end uses.[7]
The category "Other" includes non-building commercial use such as street lighting, lighting in garages, etc.

Lighting[8]	Space heating	Space cooling[8]	Water heating	Electronics	Ventilation	Refrigeration	Computers	Cooking	Other
27%	15%	14%	7%	7%	6%	4%	3%	2%	15%

Source: Energy Data Book (2007); EERE, U.S. Department of Energy



Sidebar – gsf, EUI, source energy

gross square footage (gsf)
total building floor area

For most houses, climate dominates
→energy use (surface effect)

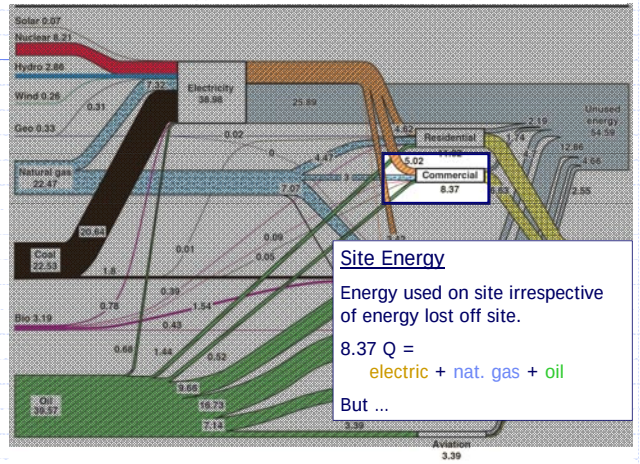
For commercial buildings E dominated by
→internal loads (E scales with volume)

Energy Use Intensity $EUI = \frac{(\text{annual energy used})}{(\text{total gsf})}$

energy flows:

electric, natural gas, district steam
district hot water, home heating oil
chilled water, etc.

How much energy do commercial buildings use?



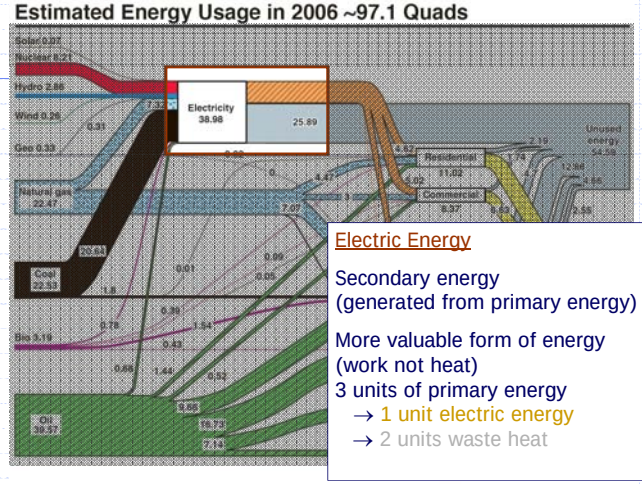
Site Energy

Energy used on site irrespective of energy lost off site.

8.37 Q =
electric + nat. gas + oil

But ...

Estimated Energy Usage in 2006 ~97.1 Quads

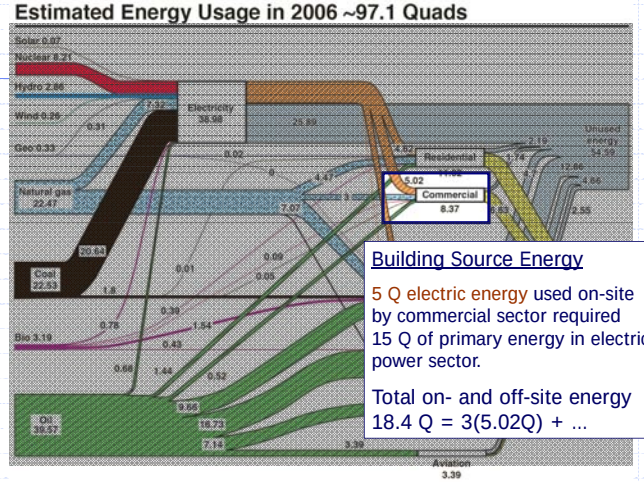


Electric Energy

Secondary energy
(generated from primary energy)

More valuable form of energy
(work not heat)
3 units of primary energy
→ 1 unit electric energy
→ 2 units waste heat

Estimated Energy Usage in 2006 ~97.1 Quads



Building Source Energy

5 Q electric energy used on-site by commercial sector required 15 Q of primary energy in electric power sector.

Total on- and off-site energy
18.4 Q = 3(5.02Q) + ...

Source Energy

Source Energy = 3 (Electric Energy) + (non-Electric Energy)

- Building source energy correlates with primary energy use, energy cost ($), and GHG emission
- EPA uses source energy for Building *ENERGY STAR* scores
- Commercial buildings use 8.4Q site energy, 18.4 source energy

To adjust for building size we look at energy intensity. For all U.S. commercial buildings:

Site energy intensity = 91 kBtu/sf

Source energy intensity = 190 kBtu/sf

Example: site vs source energy

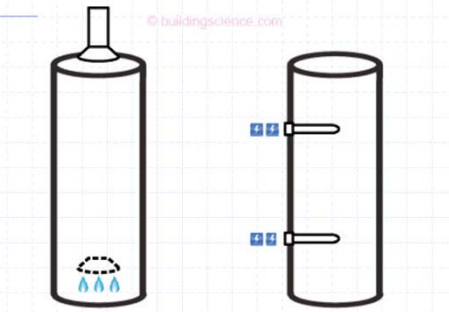


Figure 2: Site-Source Comparison for Domestic Water Heating

Energy Efficiency potential for buildings

- R&D in energy efficiency goes back to 1973 *Arab Oil Embargo*
- Numerous studies going back to the 70's demonstrate building energy can be reduced 30-50% using existing, cost-effective EE technologies
- Bottom fell out of oil market in mid-80's
- From 1970 – 2000 little success in lowering US building energy use
- In 2008 the *American Physical Society* (APS) published a study affirming the role of efficiency in buildings (Scofield coauthor of report)

US Green Building Council LEED rating

- **L**eadership in **E**nergy & **E**nvironmental **D**esign
- Green building rating introduced in 1998 by USGBC
- Goal is to promote sustainable building practices
- The Natural Resources Defense Council writes:

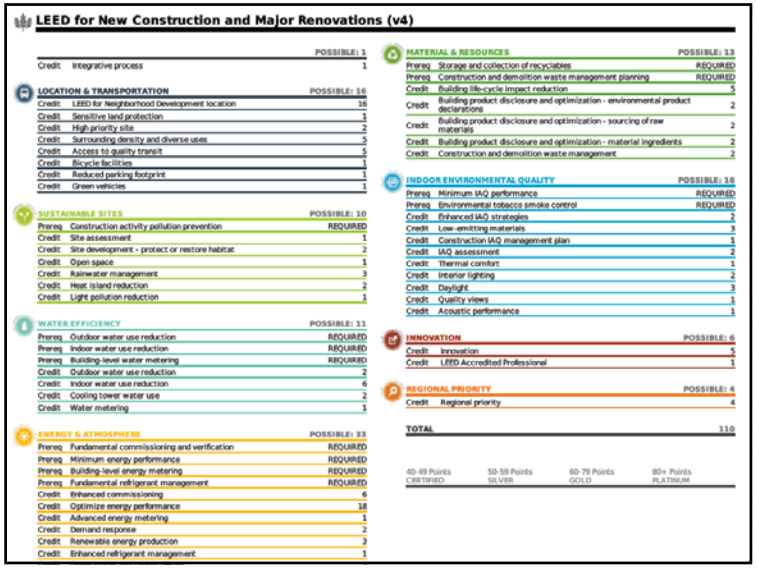
The LEED green-building rating system ... is designed to promote design and construction practices that increase profitability while reducing the negative environmental impacts of buildings and improving occupant health and well-being.

Intent of LEED – to save energy, reduce GHG emission, and lower environmental impact

LEED brought "sex-appeal" to energy efficiency

LEED Certification Process

- constantly being updated – now on version 4
- many different systems:
  new construction (NC), core & shell (CS), schools (schools), existing buildings, operation and maintenance (EB:OM), etc.
- level of certification depends on points earned
  certified (40), silver (50), gold (60), platinum (70) of 110
- Point categories:
  location/transportation, sustainable sites, water eff., energy & atmosphere, material & resources, indoor env. quality, innovation, regional priority



LEED for New Construction and Major Renovations (v4)

		POSSIBLE: 1
Credit	Integrative process	1
LOCATION & TRANSPORTATION		**POSSIBLE: 16**
Credit	LEED for Neighborhood Development location	16
Credit	Sensitive land protection	1
Credit	High priority site	2
Credit	Surrounding density and diverse uses	5
Credit	Access to quality transit	5
Credit	Bicycle facilities	1
Credit	Reduced parking footprint	1
Credit	Green vehicles	1
SUSTAINABLE SITES		**POSSIBLE: 10**
Prereq	Construction activity pollution prevention	REQUIRED
Credit	Site assessment	1
Credit	Site development - protect or restore habitat	2
Credit	Open space	1
Credit	Rainwater management	3
Credit	Heat island reduction	2
Credit	Light pollution reduction	1
WATER EFFICIENCY		**POSSIBLE: 11**
Prereq	Outdoor water use reduction	REQUIRED
Prereq	Indoor water use reduction	REQUIRED
Prereq	Building-level water metering	REQUIRED
Credit	Outdoor water use reduction	2
Credit	Indoor water use reduction	6
Credit	Cooling tower water use	2
Credit	Water metering	1
ENERGY & ATMOSPHERE		**POSSIBLE: 33**
Prereq	Fundamental commissioning and verification	REQUIRED
Prereq	Minimum energy performance	REQUIRED
Prereq	Building-level energy metering	REQUIRED
Prereq	Fundamental refrigerant management	REQUIRED
Credit	Enhanced commissioning	6
Credit	Optimize energy performance	18
Credit	Advanced energy metering	1
Credit	Demand response	2
Credit	Renewable energy production	3
Credit	Enhanced refrigerant management	1
MATERIAL & RESOURCES		**POSSIBLE: 13**
Prereq	Storage and collection of recyclables	REQUIRED
Prereq	Construction and demolition waste management planning	REQUIRED
Credit	Building life-cycle impact reduction	5
Credit	Building product disclosure and optimization - environmental product declarations	2
Credit	Building product disclosure and optimization - sourcing of raw materials	2
Credit	Building product disclosure and optimization - material ingredients	2
Credit	Construction and demolition waste management	2
INDOOR ENVIRONMENTAL QUALITY		**POSSIBLE: 16**
Prereq	Minimum IAQ performance	REQUIRED
Prereq	Environmental tobacco smoke control	REQUIRED
Credit	Enhanced IAQ strategies	2
Credit	Low-emitting materials	3
Credit	Construction IAQ management plan	1
Credit	IAQ assessment	2
Credit	Thermal comfort	1
Credit	Interior lighting	2
Credit	Daylight	3
Credit	Quality views	1
Credit	Acoustic performance	1
INNOVATION		**POSSIBLE: 6**
Credit	Innovation	5
Credit	LEED Accredited Professional	1
REGIONAL PRIORITY		**POSSIBLE: 4**
Credit	Regional priority	4
TOTAL		110

40-49 Points CERTIFIED | 50-59 Points SILVER | 60-79 Points GOLD | 80+ Points PLATINUM

Energy Efficiency in LEED

- largest category – 33 pts possible
- no performance requirement (except EB:OM)
- For NC points determined by energy "projections"

$$EER = \frac{\text{simulated design energy}}{\text{simulated baseline model energy}}$$

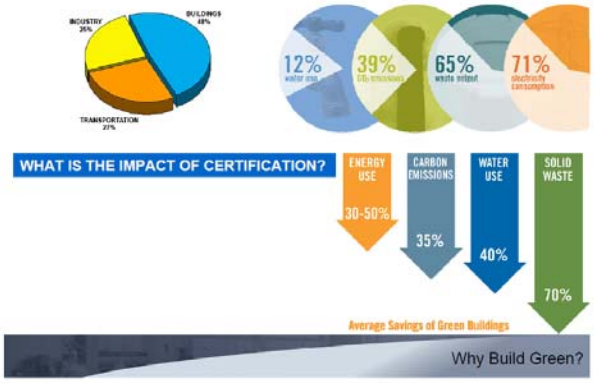
  more points awarded for lower EER
- For EB:OM points determined by ENERGY STAR score
  higher the score the more points awarded for EE
- For v.3 (v2009) added requirement to monitor annual energy use and report to USGBC for five years

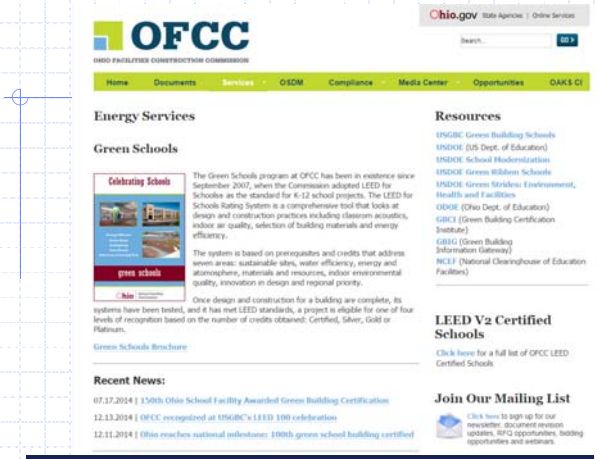
Energy and GHG savings only part of LEED – but it is the first part – w/o it no one would care

LEED proponents claim significant savings in energy and lowering of green house gas emission

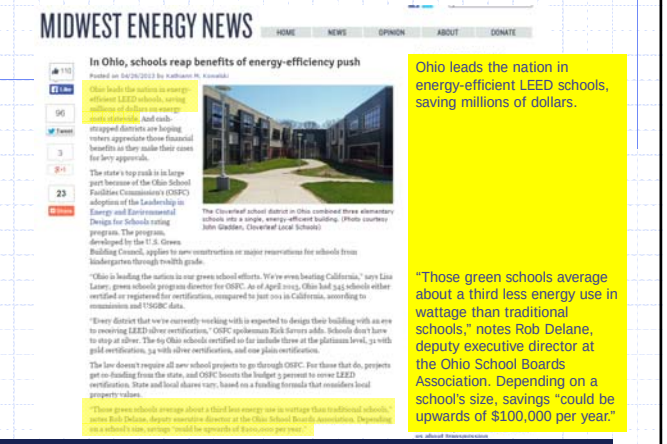
PLANET

from LEED BASICS, City of Blue Springs, MO





http://ofcc.ohio.gov/Services/EnergyServices/GreenSchools.aspx



Ohio leads the nation in energy-efficient LEED schools, saving millions of dollars.

"Those green schools average about a third less energy use in wattage than traditional schools," notes Rob Delane, deputy executive director at the Ohio School Boards Association. Depending on a school's size, savings "could be upwards of $100,000 per year."

http://www.midwestenergynews.com/2013/04/26/in-ohio-schools-reap-benefits-of-energy-efficiency-push/

Oberlin College Kahn Dormitory
LEED Silver NC 2,2

Energy savings claims are based on design simulations – not on measured energy performance

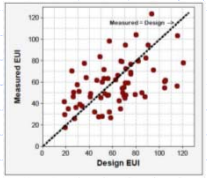
Documented gap between energy simulations and measured performance

Johnson, J. 2002, "Is What They Want What They Get? Examining Field Evidence for Links between Design Intent and As-Built Energy Performance of Commercial Buildings." In Pro*ceedings of the 2002 ACEEE Summer Study on Energy Efficiency in Buildings*, 4:161-170. Washington, D.C. American Council for an Energy-Efficient Economy.

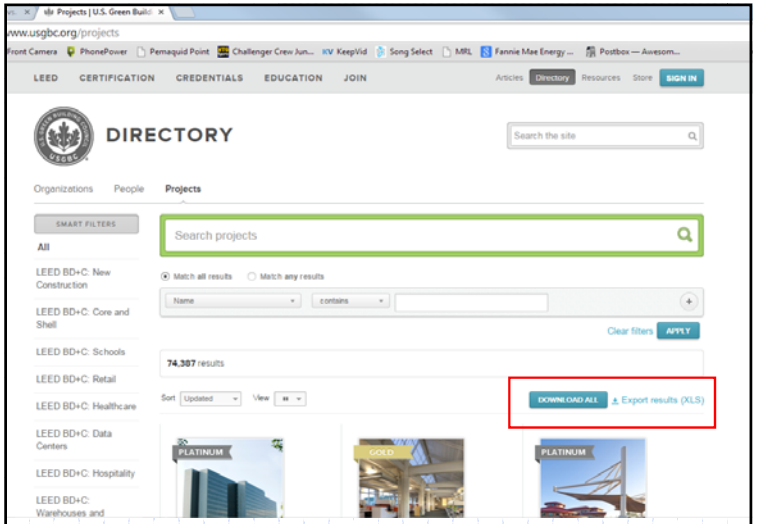
J. L. Barrientos Sacari, U. Bhattacharjee, T. Martinez and J. J. Duffy, "Green Buildings in Massachusetts: Comparison Between Actual and Predicted Energy Performance," *Proceedings of the American Solar Energy Society*, Cleveland, OH, July 9-13, 2007.

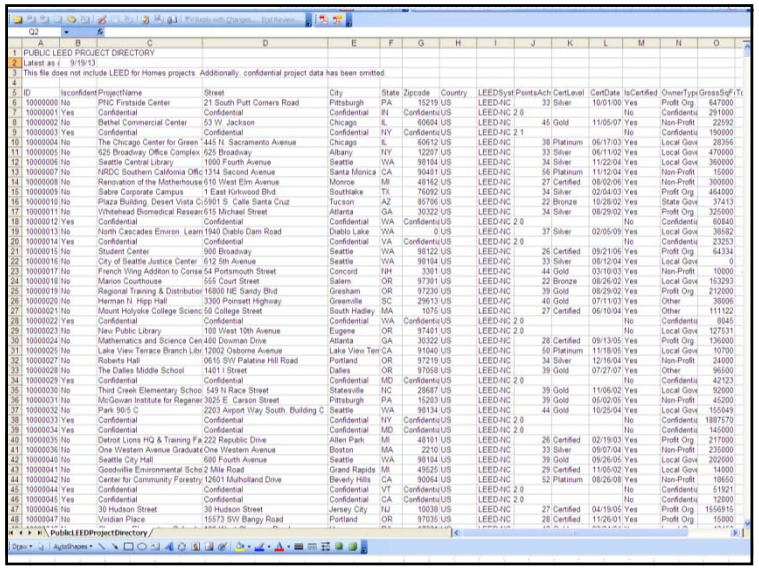
Cathy Turner Mark Frankel, "Energy Performance of LEED for New Construction Buildings—Final Report," *New Buildings Institute*, White Salmon, WA, 2008.

- Sacari et al. found measured EUI, on average, to be 40% higher than predicted EUI for green buildings.
- NBI found limited correlation between predicted EUI and measured EUI for LEED buildings.



How many LEED certified commercial buildings are there in the U.S. for which we would expect energy savings data to exist?





PUBLIC LEED PROJECT DIRECTORY

Latest as of (9/19/13

This file does not include LEED for Homes projects. Additionally, confidential project data has been omitted.

ID	IsConfidentProjectName	Street	City	State	Zipcode	Country	LEEDSyst	PointsAch	CertLevel	CertDate	IsCertified	OwnerType	GrossSqFt
10000000	No PNC Firstside Center	21 South Putt Corners Road	Pittsburgh	PA	15219	US	LEED-NC	33	Silver	10/01/00	Yes	Profit Org	647000
10000001	Yes Confidential	Confidential	Confidential	IN	Confidentia	US	LEED-NC 2.0				No	Confidentia	291000
10000002	No Bethel Commercial Center	53 W. Jackson	Chicago	IL	60604	US	LEED-NC	45	Gold	11/05/07	Yes	Non-Profit	22592
10000003	Yes Confidential	Confidential	Confidential	NY	Confidentia	US	LEED-NC 2.1				No	Confidentia	190000
10000004	No The Chicago Center for Green	445 N. Sacramento Avenue	Chicago	IL	60612	US	LEED-NC	39	Platinum	06/17/03	Yes	Local Gov	28356
10000005	No 625 Broadway Office Complex	625 Broadway	Albany	NY	12207	US	LEED-NC	33	Silver	06/11/02	Yes	Local Gov	470000
10000006	No Seattle Central Library	1000 Fourth Avenue	Seattle	WA	98104	US	LEED-NC	34	Silver	11/22/04	Yes	Local Gov	360000
10000007	No NRDC Southern California Offic	1314 Second Avenue	Santa Monica	CA	90401	US	LEED-NC	56	Platinum	11/12/04	Yes	Non-Profit	15000
10000008	No Renovation of the Motherhouse	610 West Elm Avenue	Monroe	MI	48162	US	LEED-NC	27	Certified	08/02/06	Yes	Non-Profit	300000
10000009	No Sabre Corporate Campus	1 East Kirkwood Blvd	Southlake	TX	76092	US	LEED-NC	34	Silver	02/04/03	Yes	Profit Org	464000
10000010	No Plaza Building, Desert Vista C	5901 S. Calle Santa Cruz	Tucson	AZ	85706	US	LEED-NC	22	Bronze	10/28/02	Yes	State Gov	37413
10000011	No Whitehead Biomedical Resear	615 Michael Street	Atlanta	GA	30322	US	LEED-NC	34	Silver	08/29/02	Yes	Profit Org	325000
10000012	Yes Confidential	Confidential	Confidential	WA	Confidentia	US	LEED-NC 2.0				No	Confidentia	60840
10000013	No North Cascades Environ. Learn	1940 Diablo Dam Road	Diablo Lake	WA	0	US	LEED-NC	37	Silver	02/05/09	Yes	Local Gov	38582
10000014	Yes Confidential	Confidential	Confidential	VA	Confidentia	US	LEED-NC 2.0				No	Confidentia	23253
10000015	No Student Center	900 Broadway	Seattle	WA	98122	US	LEED-NC	26	Certified	09/21/06	Yes	Profit Org	64334
10000016	No City of Seattle Justice Center	610 5th Avenue	Seattle	WA	98104	US	LEED-NC	33	Silver	08/12/04	Yes	Local Gov	0
10000017	No French Wing Addition to Conse	54 Portsmouth Street	Concord	NH	3301	US	LEED-NC	44	Gold	03/10/03	Yes	Non-Profit	10000
10000018	No Marion Courthouse	555 Court Street	Salem	OR	97301	US	LEED-NC	22	Bronze	08/26/02	Yes	Local Gov	153293
10000019	No Regional Training & Distributor	16800 NE Sandy Blvd	Gresham	OR	97230	US	LEED-NC	39	Gold	08/29/02	Yes	Profit Org	212000
10000020	No Herman N. Hipp Hall	3300 Poinsett Highway	Greenville	SC	29613	US	LEED-NC	40	Gold	07/11/03	Yes	Other	38006
10000021	No Mount Holyoke College Scienc	50 College Street	South Hadley	MA	1075	US	LEED-NC	27	Certified	06/10/04	Yes	Other	111122
10000022	Yes Confidential	Confidential	Confidential	WA	Confidentia	US	LEED-NC 2.0				No	Confidentia	8145
10000023	No New Public Library	100 West 10th Avenue	Eugene	OR	97401	US	LEED-NC 2.0				No	Local Gov	127531
10000024	No Mathematics and Science Cen	400 Dowman Drive	Atlanta	GA	30322	US	LEED-NC	28	Certified	09/13/05	Yes	Profit Org	136000
10000025	No Lake View Terrace Branch Libr	12002 Osborne Avenue	Lake View Ter	CA	91040	US	LEED-NC	50	Platinum	11/18/05	Yes	Local Gov	10700
10000027	No Roberts Hall	0615 SW Palatine Hill Road	Portland	OR	97219	US	LEED-NC	34	Silver	12/16/04	Yes	Non-Profit	24000
10000028	No The Dalles Middle School	1401 I Street	Dalles	OR	97058	US	LEED-NC	39	Gold	07/27/07	Yes	Other	96500
10000029	Yes Confidential	Confidential	Confidential	MD	Confidentia	US	LEED-NC 2.0				No	Confidentia	42123
10000030	No Third Creek Elementary Schoo	549 N Race Street	Statesville	NC	28677	US	LEED-NC	39	Gold	11/06/02	Yes	Local Gov	92000
10000031	No McGovan Institute for Regener	3025 E. Carson Street	Pittsburgh	PA	15203	US	LEED-NC	39	Gold	05/02/06	Yes	Non-Profit	45200
10000032	No Park 90/5 C	2203 Airport Way South, Building C	Seattle	WA	98134	US	LEED-NC	44	Gold	10/25/04	Yes	Local Gov	155049
10000033	Yes Confidential	Confidential	Confidential	NY	Confidentia	US	LEED-NC 2.0				No	Confidentia	1887570
10000034	Yes Confidential	Confidential	Confidential	MD	Confidentia	US	LEED-NC 2.0				No	Confidentia	145000
10000035	No Detroit Lions HQ & Training Fa	222 Republic Drive	Allen Park	MI	48101	US	LEED-NC	26	Certified	02/19/03	Yes	Profit Org	217000
10000036	No One Western Avenue Graduate	One Western Avenue	Boston	MA	2210	US	LEED-NC	33	Silver	09/07/04	Yes	Non-Profit	235000
10000040	No Seattle City Hall	600 Fourth Avenue	Seattle	WA	98104	US	LEED-NC	39	Gold	09/26/06	Yes	Local Gov	202000
10000041	No Goodwille Environmental Scho	2 Mile Road	Grand Rapids	MI	49525	US	LEED-NC	29	Certified	11/05/02	Yes	Local Gov	14000
10000042	No Center for Community Forestry	12601 Mulholland Drive	Beverly Hills	CA	90064	US	LEED-NC	52	Platinum	08/26/08	Yes	Non-Profit	18650
10000044	Yes Confidential	Confidential	Confidential	VT	Confidentia	US	LEED-NC 2.0				No	Confidentia	51921
10000045	Yes Confidential	Confidential	Confidential	CA	Confidentia	US	LEED-NC 2.0				No	Confidentia	12000
10000046	No 30 Hudson Street	30 Hudson Street	Jersey City	NJ	10038	US	LEED-NC	27	Certified	04/19/05	Yes	Profit Org	1556915
10000047	No Viridian Place	15573 SW Bangy Road	Portland	OR	97035	US	LEED-NC	28	Certified	11/26/01	Yes	Profit Org	15000

PublicLEEDProjectDirectory

of LEED-Certified Buildings (9/29/14)

U.S. LEED-Certified Buildings	Before 9/29/2014		Before 1/1/2013	
LEED System	Total GSF	Number	Total GSF	Number
LEED for Retail (NC)	4,400	1	4,400	1
LEED for Schools	48,198,581	548	30,462,222	366
LEED FOR SCHOOLS v2009	19,572,898	241	4,121,258	63
LEED v4 BD+C: NC	114,298	1	0	0
LEED v4 O+M: EB	783,005	3	0	0
LEED-CS 1.0 Pilot	26,770,285	103	26,770,285	103
LEED-CS 2.0	174,678,615	806	154,798,722	713
LEED-CS v2009	57,160,124	311	10,018,044	82
LEED-EB 1.0 Pilot	1,668,000	3	1,668,000	3
LEED-EB 1.0 Pilot (original)	8,899,042	22	8,899,042	22
LEED-EB 2.0	125,270,013	372	119,159,028	306
LEED-EB O&M	360,609,567	779	347,813,913	747
LEED-EB:OM v2009	624,184,507	1,721	314,102,075	871
LEED-NC 1.0 Pilot	1,589,895	10	1,589,895	10
LEED-NC 2.0	33,068,635	282	33,033,689	281
LEED-NC 2.1	172,476,156	1,493	169,107,537	1,459
LEED-NC 2.2	599,445,758	6,113	478,261,825	4,914
LEED-NC Retail v2009	5,615,722	238	1,399,453	70
LEED-NC v2009	193,841,971	2,611	49,958,986	845
Totals	2,453,951,472	15,658	1,751,168,375	10,856
				1,931

- Only U.S. buildings
- LEED systems that address whole-building energy (not CI)
- as of Sept. 29 more than 15,000
- as of 1/1/2013 nearly 11,000
- over 1900 report energy to USGBC

What energy consumption data have been disclosed for these 11,000 U.S. LEED-certified buildings?

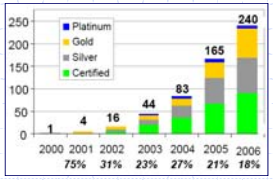
Published LEED energy performance data

1. Cathy Turner, Report prepared by NBI for the Cascadia Region Green Building Council. Jan. 30, 2006.
2. Rick Diamond et al., 2006 *ACEE Summer Study on Energy Efficiency in Buildings*, Aug. 13, 2006.
3. J. L. Barrientos Sacari et al, *America*
4. Cathy Turner and Mark Frankel, New
5. Kim M. Fowler and Emily M. Rauch,
6. David Baylon and Poppy Storm, *200*
7. John H Scofield, *International Energ*
8. Guy Newsham et al, *Energy & Build*
9. John H. Scofield, *Energy & Building*
10. Doug Widener et al, *U.S. Green Buil*
11. Kim Fowler et al, PNNL-19369, Sept
12. Kathryn Eggers and Doug Widener,
13. Dixon Oates, Kenneth T. Sullivan, J.
14. Carol Menassa et al, *Journal of Performance of Constructed Facilities*, **25** (1), pp. 46-53 (2012).
15. John H. Scofield, *Energy & Buildings*, **67**, pp. 517-524 (2013)

- 6 of these publications were produced by gov. or non-gov. orgs with vested interest in promoting green buildings w/o blind peer review
- 9 publications were peer-reviewed
- Many studies use same data
- Collectively data from 252 buildings (or fewer)

Energy Performance of LEED for New Construction

Turner & Frenkel, New Buildings Institute



"…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."

NBI LEED Study

- Long assumed that LEED buildings are energy-efficient
- Until 2007 little empirical data to support this
- USGBC engaged the *New Buildings Institute* to conduct a broad study of energy consumption by LEED commercial buildings
- NBI gathered energy consumption data volunteered by 121 of the 552 commercial buildings certified from 2000-6 under NCv2
- March 2008 NBI issued final report which concludes LEED buildings, on average, achieve 25-30% energy savings
- Study immediately drew criticism (e.g., Henry Gifford) for comparing **medians** with **means**
- Cathy Turner (NBI) made summary LEED data available for independent analysis

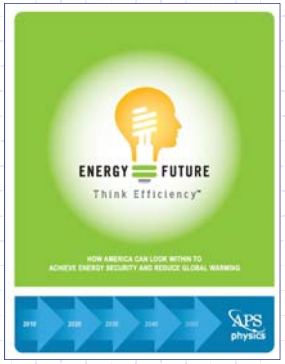
American Physical Society

Energy Efficiency Study

2007-8 study chaired by Burt Richter (Stanford) – Nobel laureate

Re: the NBI LEED building study

"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."

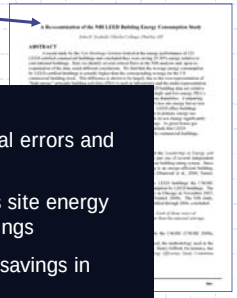


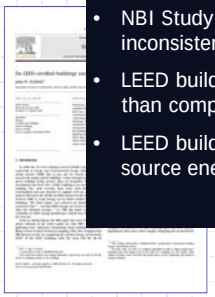
http://www.aps.org/energyefficiencyreport/

Scofield analysis of LEED building energy data

Re-evaluation of the NBI LEED Energy Consumption Study

Proceedings of the *International Energy Program Evalua* 12-15,





- NBI Study contained mathematical errors and inconsistencies
- LEED buildings used 10-15% less site energy than comparable non-LEED buildings
- LEED buildings demonstrated no savings in source energy

ergy?

Energy and Buildings, **41**, 1386-1390 (2009).

Published LEED energy performance data

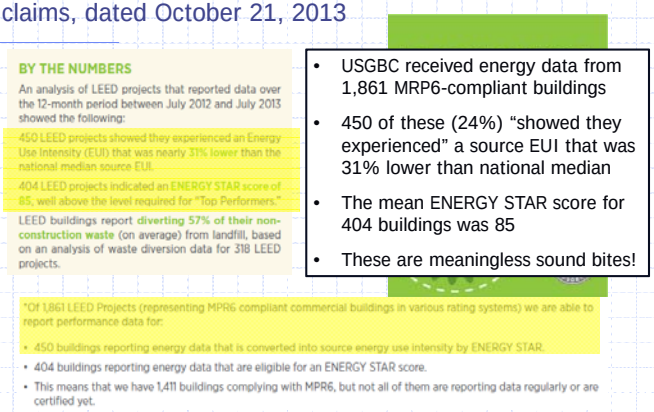
1. Cathy Turner, Report prepared by NBI for the Cascadia Region Green Building Council. Jan. 30, 2006.
2. Rick Diamond et al., 2006 *ACEE Summer Study on Energy Efficiency in Buildings*, Aug. 13, 2006.
3. J. L. Barrientos Sacari et al, *American Solar Energy Society Conference*, Cleveland, OH, 2007.
4. Cathy Turner and Mark Frankel, New Buildings Institute, White Salmon, WA, March 2008.
5. Kim M. Fowler and Emily M. Rauch, PNNL-17393, July 2008.
6. D. Baylon and P. Storm, *2008 ACEEE Summer Study on Energy Efficiency in Buildings*, Aug. 2008.
7. John H Scofield, *International Energy Program Evaluation Conference*, Portland, OR, Aug. 12-15, 2009.
8. Guy Newsham et al, *Energy & Buildings*, **41** (8), pp. 897-905 (2009).
9. John H. Scofield, *Energy & Buildings*, **41** (12), pp. 1386-1390 (2009).
10. Doug Widener et al, *U.S. Green Building Council* – Chicago Chapter, Fall 2009.
11. Kim Fowler et al, PNNL-19369, September 2011.
12. Kathryn Eggers and Doug Widener, *U.S. Green Building Council* – Chicago Chapter, Fall 2009.
13. Dixon Oates, Kenneth T. Sullivan, J. of Construction Eng. and Mgmt, **138** (6) , pp. 742-750 (2012).
14. Carol Menassa et al, *Journal of Performance of Constructed Facilities*, **25** (1), pp. 46-53 (2012).
15. John H. Scofield, *Energy & Buildings*, **67**, pp. 517-524 (2013)

- Subsequent peer-reviewed studies confirm my results
- All these studies rely on data volunteered by willing building owners – self-selected data that skews results (Gifford – voluntary breathalyzer tests)
- These 252 buildings represent just 2% of the 11,000 eligible LEED-certified buildings

What about the energy data collected since 2009 by the USGBC?

Should have data from nearly 2000 buildings, nearly 10X the number of buildings collectively contained in other studies.

USGBC puts out marketing literature with energy savings claims, dated October 21, 2013



BY THE NUMBERS

An analysis of LEED projects that reported data over the 12-month period between July 2012 and July 2013 showed the following:

450 LEED projects showed they experienced an Energy Use Intensity (EUI) that was nearly 31% lower than the national median source EUI.

404 LEED projects indicated an ENERGY STAR score of 85, well above the level required for "Top Performers."

LEED buildings report diverting 57% of their non-construction waste (on average) from landfill, based on an analysis of waste diversion data for 318 LEED projects.

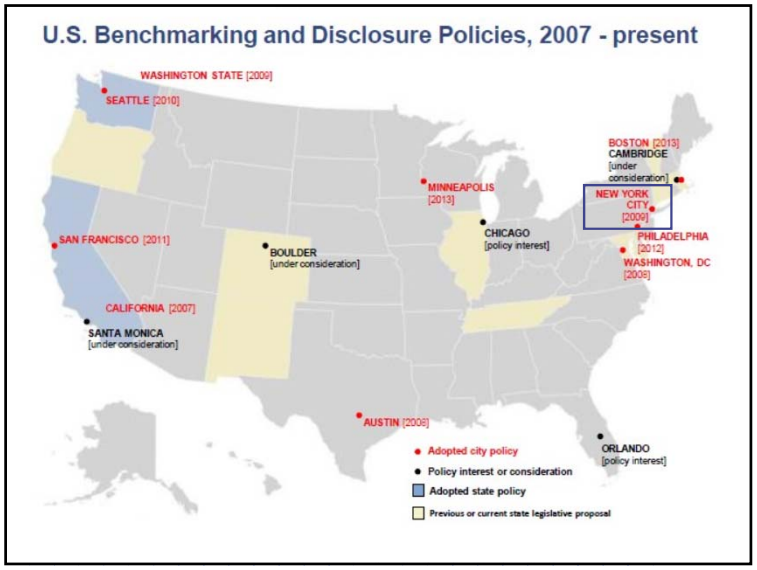
*Of 1,861 LEED Projects (representing MPR6 compliant commercial buildings in various rating systems) we are able to report performance data for:

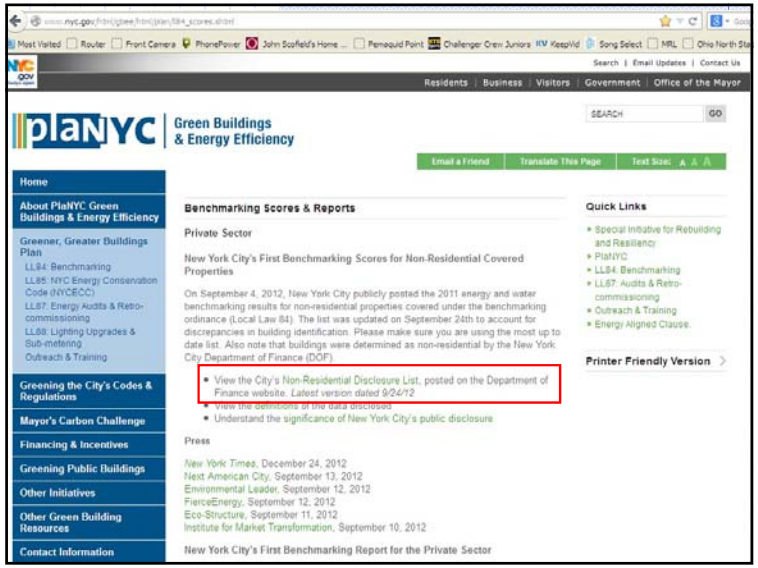
- 450 buildings reporting energy data that is converted into source energy use intensity by ENERGY STAR.
- 404 buildings reporting energy data that are eligible for an ENERGY STAR score.
- This means that we have 1,411 buildings complying with MPR6, but not all of them are reporting data regularly or are certified yet.

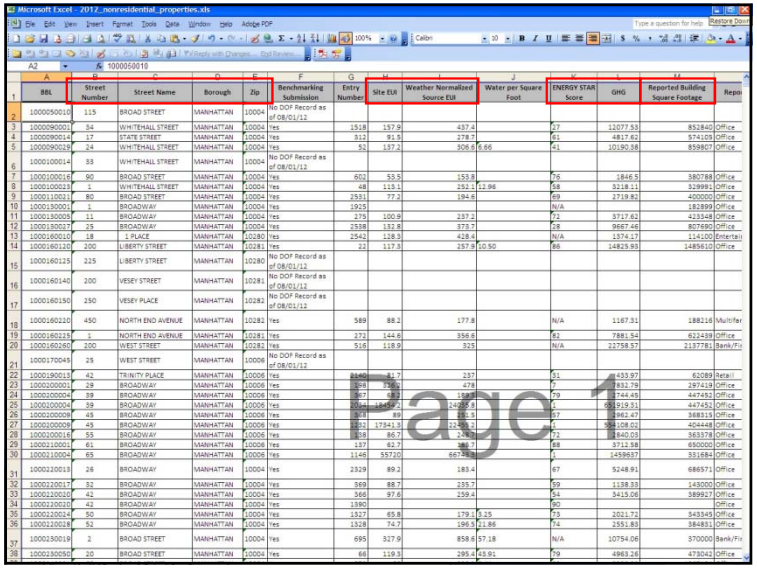
- USGBC received energy data from 1,861 MRP6-compliant buildings
- 450 of these (24%) "showed they experienced" a source EUI that was 31% lower than national median
- The mean ENERGY STAR score for 404 buildings was 85
- These are meaningless sound bites!

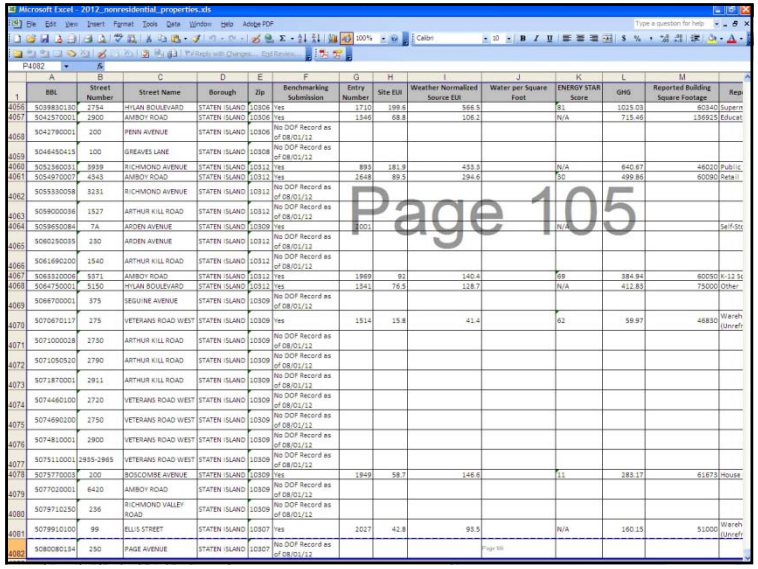
Energy Benchmarking Laws in major US cities are “lifting the veil.”

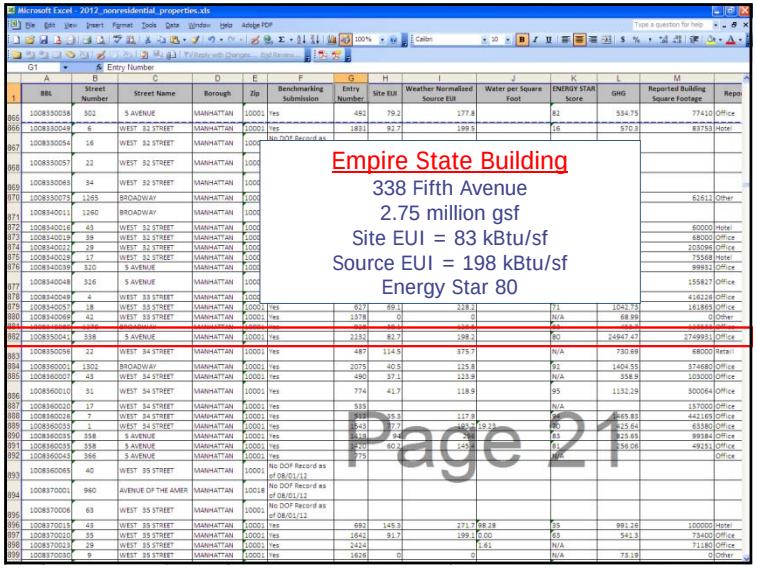
Soon building energy data will made public for hundreds – even thousands of LEED-certified buildings.

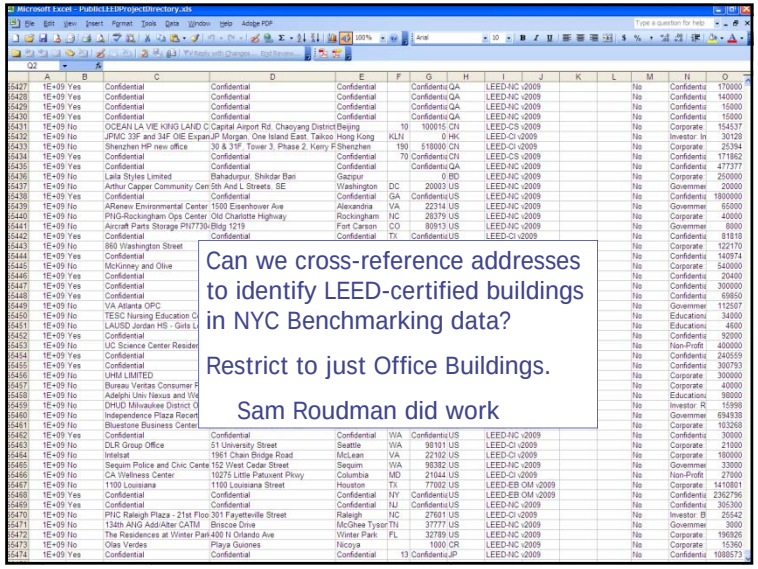












NYC LEED Office Buildings

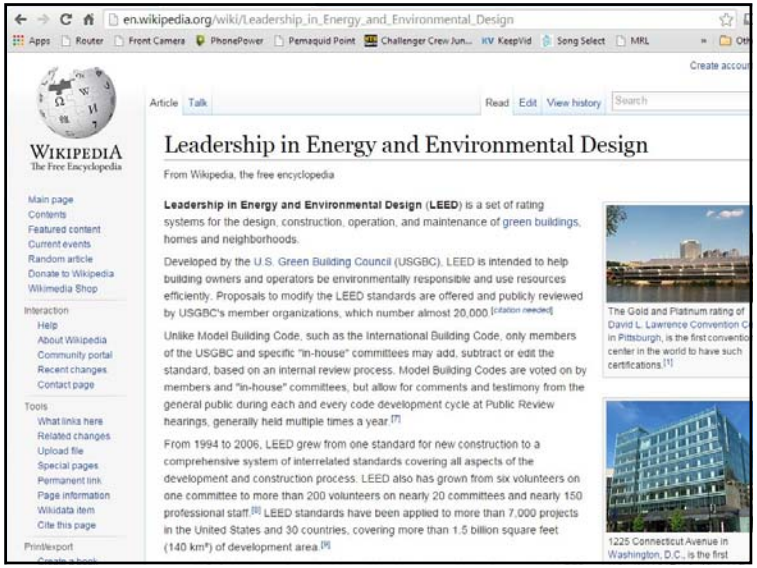
ID	gsf	EUI (kBtu/sf) Site	EUI (kBtu/sf) Source	GHG tonne CO2	EPR	LEED Certification System	Level	Date
1	719,481	81.3	167.2	5,009	92	EB:OM v2009	Gold	12/1/10
2	1,032,057	70.9	174.7	5,734		CS 2.0	Gold	10/19/10
3	1,093,934	60.2	180.2	6,015	93	EB:OM v2009	Gold	7/13/10
4	889,875	73.7	192.2	5,803	81	EB 2.0	Silver	6/14/09
5	142,554	71.3	193.7	838	83	CS 2.0	Gold	3/14/10
6	1,715,800	81.1	220.8	12,438	74	CS 1.0 Pilots Only	Gold	3/7/06
7	1,137,698	88.3	220.8	8,357	81	EB:O&M	Silver	1/5/10
8	573,338	99.5	221.0	4,907	79	EB:O&M	Certified	6/15/10
9	129,674	72.8	222.1	835	62	EB:OM v2009	Certified	2/15/10
10	125,836	84.4	223.0	946	61	CS 2.0	Gold	8/12/09
11	810,475	96.3	232.1	6,820	82	EB:O&M	Certified	2/1/10
12	1,273,197	103.4	241.8	11,402	86	EB:OM v2009	Gold	8/25/10
13	744,341	94.9	250.6	6,081	70	CS 2.0	Gold	8/30/10
14	356,686	83.6	257.7	2,744	75	EB:O&M	Certified	3/5/10
15	1,825,552	98.5	274.7	16,092		EB:O&M	Silver	6/12/09
16	1,047,808	96.9	281.5	9,169	87	EB:O&M	Silver	5/22/09
17	2,270,336	169.6	304.4	29,066	80	EB:O&M	Certified	7/29/10
18	2,552,494	116.2	313.5	26,514	71	EB 2.0	Certified	7/18/09
19	1,724,226	132.8	338.2	20,135	62	EB 2.0	Silver	6/8/09
20	622,439	144.6	356.6	7,882	82	EB 2.0	Certified	12/1/06
21	842,394	132.4	368.7	9,819	73	EB 2.0	Silver	5/19/09
22	721,979	88.3	251.6	5,778	73	LEED EB 2.0	Silver	4/10/09
23	2,212,676	213.4	362.6	30,782		LEED CS 1.0 Pilots	Platinum	5/7/10
sum	21,630,195			233,165		LEED-21 (bldgs 22 & 23 omitted)		
bld-wt mean		97.7	249.3		78			
gsf-wt mean		106.0	263.0		78			

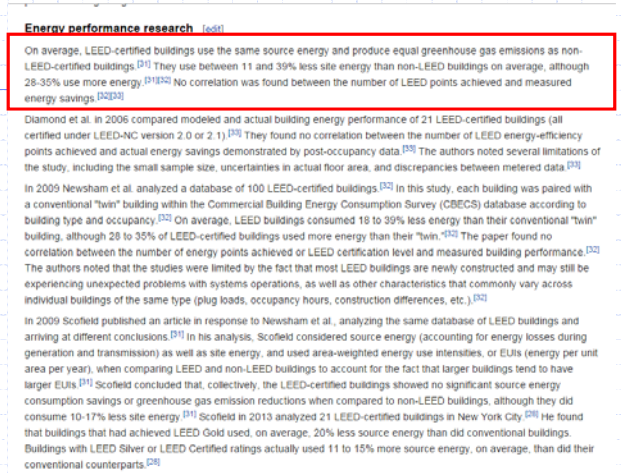
Scofield analysis of NYC LEED Office Buildings

Efficacy of LEED-certification in reducing energy consumption and greenhouse gas emission for large New York City office buildings

Energy and Buildings, **Vol. 67**, 517-524 (December 2013).

- Identifed 23 NYC LEED-certified office buildings
- Compared their energy performance to those of 953 NYC office buildings
- On average LEED offices showed no reduction in energy use or GHG emission
- LEED offices generally earned higher ENERGY STAR scores (by 10 pts)





Energy performance research [edit]

On average, LEED-certified buildings use the same source energy and produce equal greenhouse gas emissions as non-LEED-certified buildings.[31] They use between 11 and 39% less site energy than non-LEED buildings on average, although 28-35% use more energy.[31][32] No correlation was found between the number of LEED points achieved and measured energy savings.[32][33]

Diamond et al. in 2006 compared modeled and actual building energy performance of 21 LEED-certified buildings (all certified under LEED-NC version 2.0 or 2.1).[33] They found no correlation between the number of LEED energy-efficiency points achieved and actual energy savings demonstrated by post-occupancy data.[33] The authors noted several limitations of the study, including the small sample size, uncertainties in actual floor area, and discrepancies between metered data.[33]

In 2009 Newsham et al. analyzed a database of 100 LEED-certified buildings.[32] In this study, each building was paired with a conventional "twin" building within the Commercial Building Energy Consumption Survey (CBECS) database according to building type and occupancy.[32] On average, LEED buildings consumed 18 to 39% less energy than their conventional "twin" building, although 28 to 35% of LEED-certified buildings used more energy than their "twin."[32] The paper found no correlation between the number of energy points achieved or LEED certification level and measured building performance.[32] The authors noted that the studies were limited by the fact that most LEED buildings are newly constructed and may still be experiencing unexpected problems with systems operations, as well as other characteristics that commonly vary across individual buildings of the same type (plug loads, occupancy hours, construction differences, etc.).[32]

In 2009 Scofield published an article in response to Newsham et al., analyzing the same database of LEED buildings and arriving at different conclusions.[31] In his analysis, Scofield considered source energy (accounting for energy losses during generation and transmission) as well as site energy, and used area-weighted energy use intensities, or EUIs (energy per unit area per year), when comparing LEED and non-LEED buildings to account for the fact that larger buildings tend to have larger EUIs.[31] Scofield concluded that, collectively, the LEED-certified buildings showed no significant source energy consumption savings or greenhouse gas emission reductions when compared to non-LEED buildings, although they did consume 10-17% less site energy.[31] Scofield in 2013 analyzed 21 LEED-certified buildings in New York City.[28] He found that buildings that had achieved LEED Gold used, on average, 20% less source energy than did conventional buildings. Buildings with LEED Silver or LEED Certified ratings actually used 11 to 15% more source energy, on average, than did their conventional counterparts.[28]

Wrap Up

- LEED buildings have captured public's imagination
  - increased interest in sustainable practices
  - is leading to better buildings
- But there is little evidence that, on average, LEED-certification is actually saving primary energy or lowering greenhouse gas emission
- Claims of 30-50% energy savings are based on faith not science
- LEED certification adds real costs to building design & construction
- There is insufficient justification for governments to require that buildings be LEED certified
- LEED does deliver green publicity and green image
- Time to abandon green labels and seek green substance
- I look forward to the day when performance data show energy savings