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The Post-occupancy Performance of Green Office Buildings Evidence from the field

Guy Newsham, Ph.D. and colleagues



National Research
Council Canada

Conseil national
de recherches Canada

Proceedings of the 13th International Conference for Enhanced Building Operations, Montreal, Quebec, October 8-11, 2013

Canada

Introduction

- How do green buildings perform when occupied?
 - Indoor Environment Quality, Occupant Comfort and Well-being
 - Energy Use
- Fine-tuning of certification systems to ensure better performance
- A research consortium

<http://archive.nrc-cnrc.gc.ca/eng/projects/irc/post-occupancy.html>

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Field study

- Green vs. conventional office buildings (N=24)
 - Matched pairs
 - Across Canada and northern US, public and private sector
 - Size: 1300 to 38500 m²
 - Age: 1956 to 2009
 - Green: mostly LEED at some level



“Do ‘green’ buildings have better indoor environments? New evidence”,

Building Research & Information: <http://dx.doi.org/10.1080/09613218.2013.789951>

Proceedings of the 13th International Conference for Enhanced Building Operations, Montreal, Quebec, October 8-11, 2013

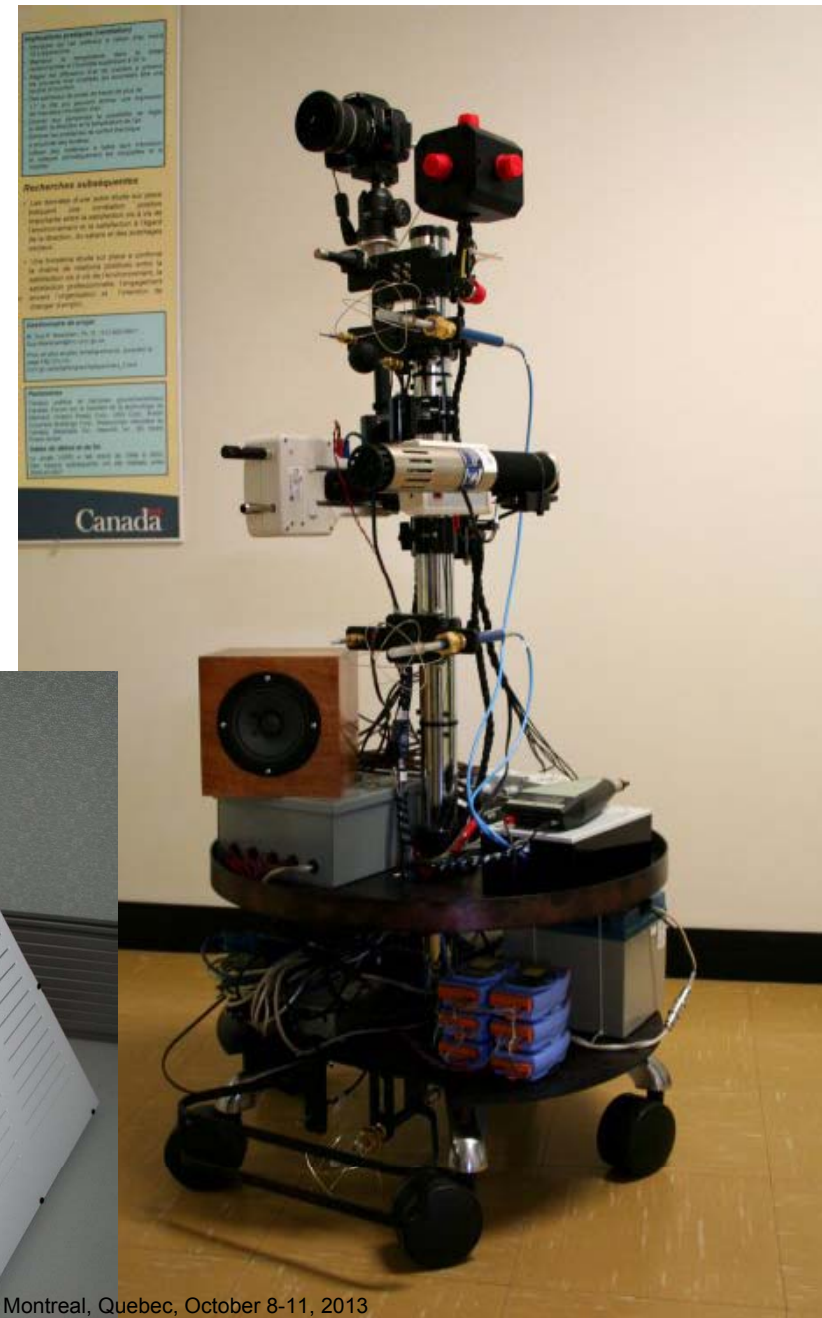
<http://nparc.cisti-icist.nrc-cnrc.gc.ca/npsi/ctrl?action=rtdoc&an=20857897&article=0&fd=pdf>

Field study

- Four sources of data from each building:
 - On-line questionnaire: environmental satisfaction, job satisfaction, health, absenteeism, environmental attitudes, commuting patterns (N=2545, response 39%)
 - On-site measurements of physical environment (N=974)
 - Interview with building manager: operational issues
 - Energy data: whole building utility bills (sub-systems & water, if available)

Measurements

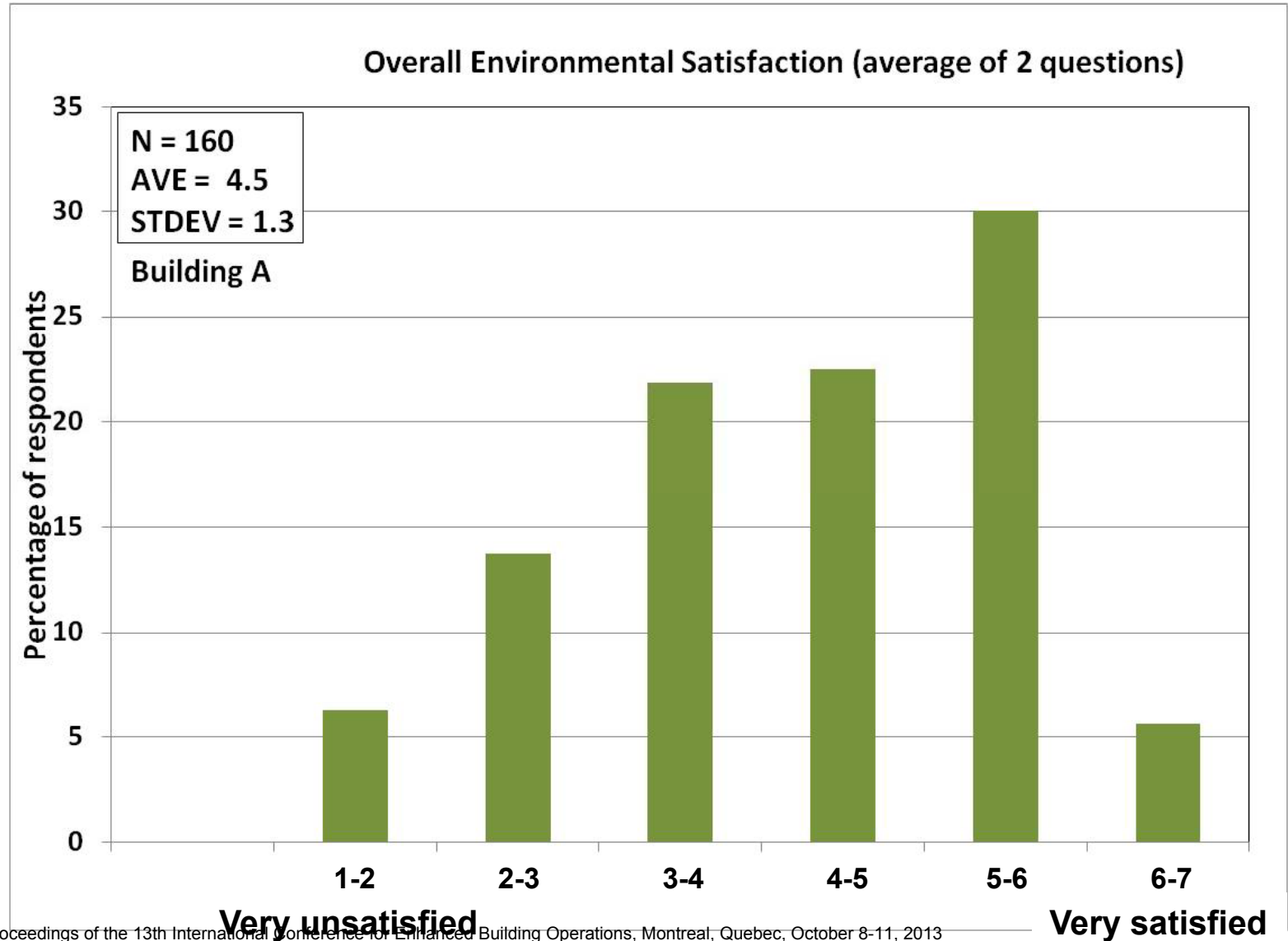
- Spot measurements
 - Temperature, humidity, air speed, formaldehyde, particulates, TVOC, CO₂, light level, noise, SII
- Longitudinal data
 - Temperature, humidity, air speed, CO₂, light level, noise



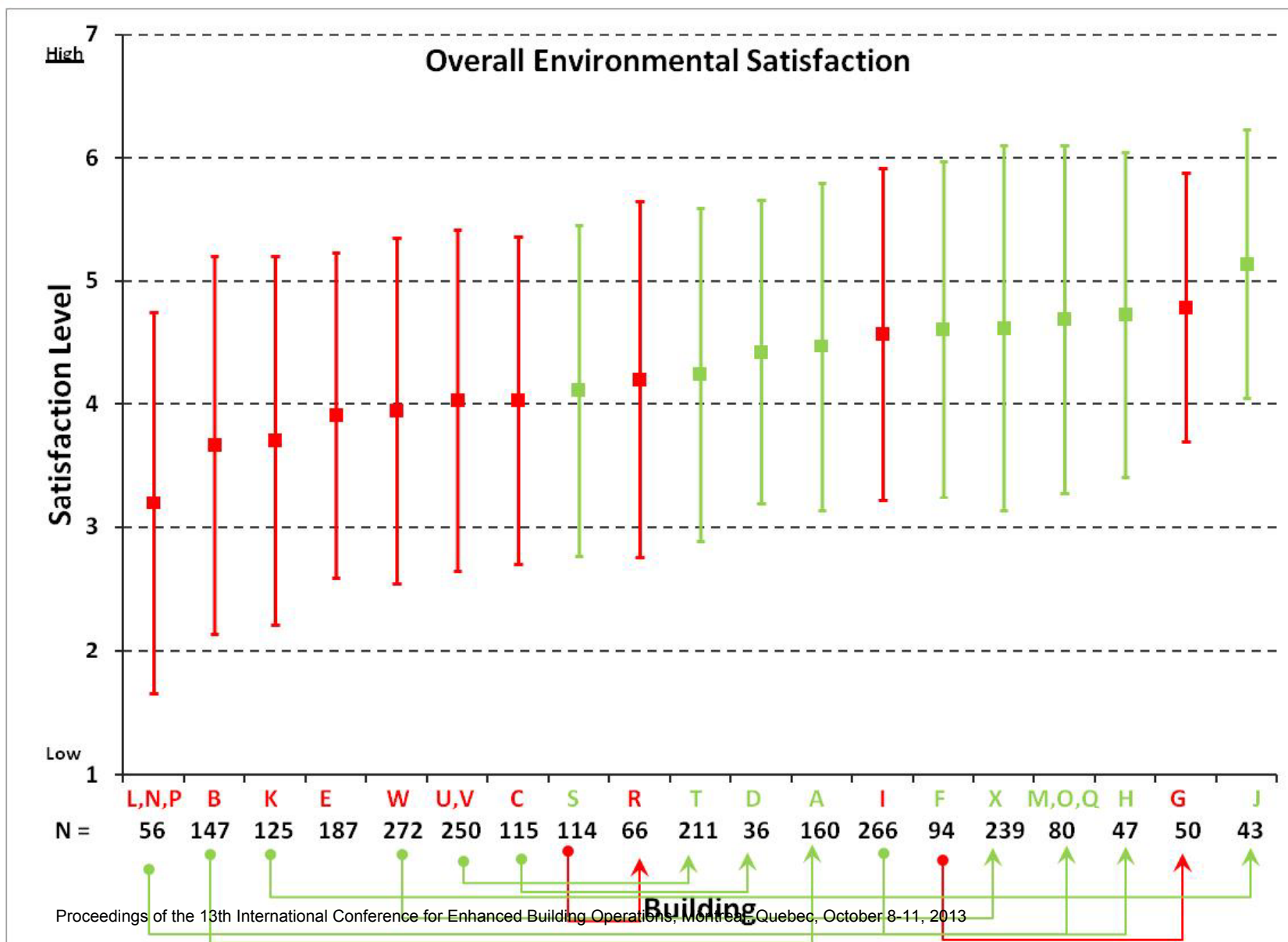
Indoor Environment Findings across Buildings

- 19 building “sites”
- Uses data at the site-average level
- Wilcoxon signed ranks tests (N=18)
(9 matched pairs of green vs. conventional sites)

Wilcoxon Tests



Wilcoxon Tests



Green vs. Conventional (Questionnaire)

- Green buildings score more highly on:
 - Overall Environmental Satisfaction
 - Satisfaction with Aesthetic Appearance, View to the Outside, Size of Personal Workspace
 - Satisfaction with Ventilation & Temperature
 - Preferred Change in Thermal Conditions
 - Frequency of Thermal Adaptive Behaviours
 - Noise from HVAC systems
 - Workplace Image
 - Positive Mood
 - Visual and Physical Discomfort Frequency
 - Sleep Quality at Night

Green vs. Conventional (Physical Measurements)

- Green buildings perform better:
 - Lower air speed
 - Fewer airborne particulates
- Green buildings perform worse:
 - Speech Privacy Index in Private Offices



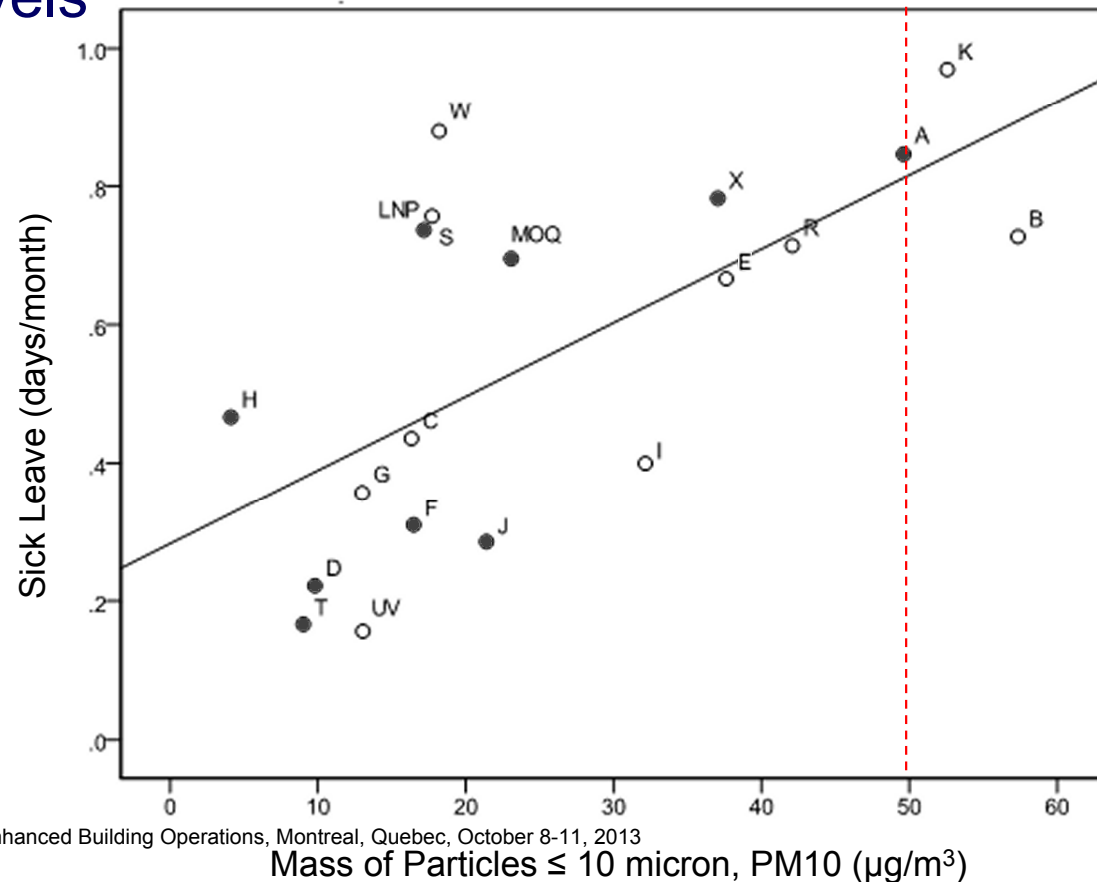
Green vs. Conventional (Physical Measurements)

- Acoustics solution!



All Buildings

- Linear regression (N=19, individual sites)
- Physical features associated with improved occupant outcomes:
 - lower articulation index (better speech privacy)
 - lower background noise levels
 - higher light levels
 - greater access to windows
 - lower predicted mean vote (better thermal comfort)
 - lower number of airborne particulates



Energy

- Re-analysis of data from 100 LEED-certified buildings, matched with 100 conventional buildings:
 - On average, LEED buildings used 25% less energy than conventional counterparts
 - But, about one-third of buildings used more
 - And, little correlation between energy credits and actual energy savings

Energy and Buildings 41 (2009) 897–905



Contents lists available at ScienceDirect

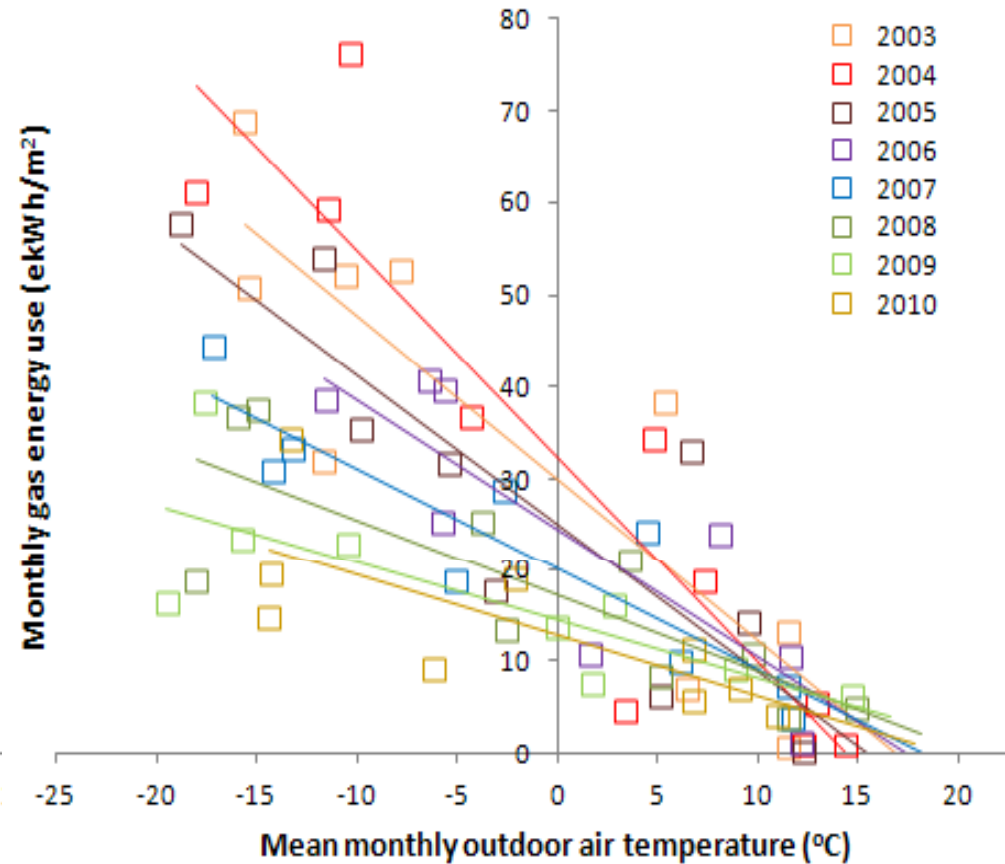
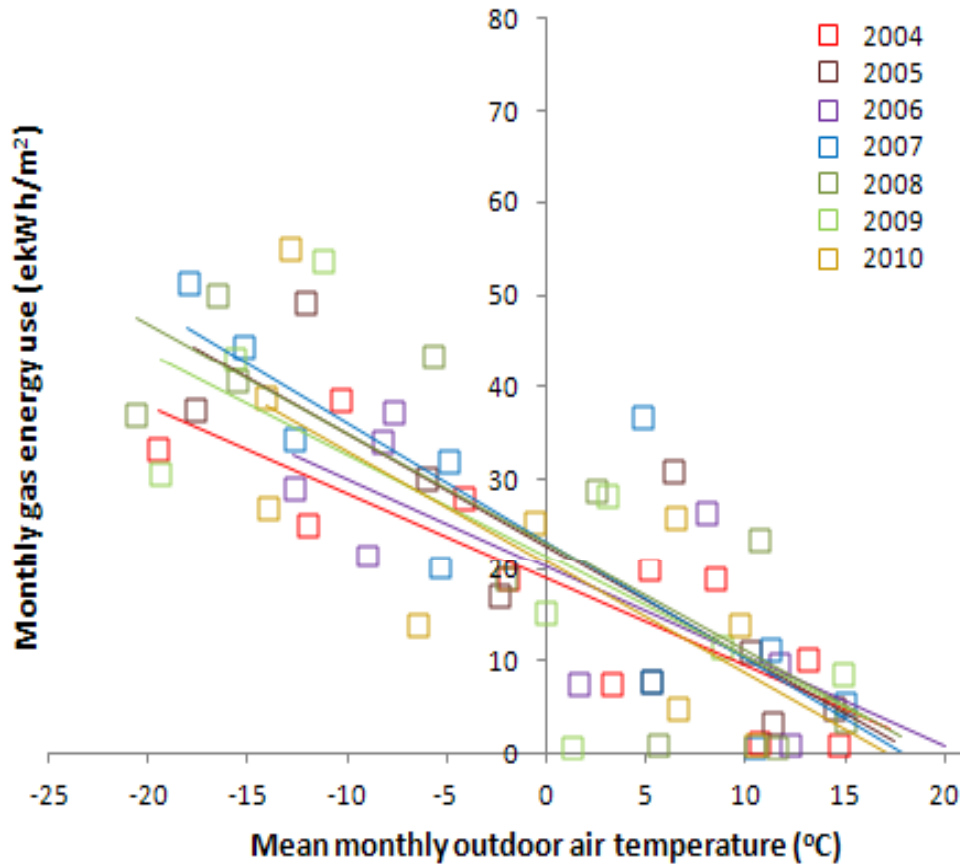
Energy and Buildings

journal homepage: www.elsevier.com/locate/enbuild



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

Energy Case Study



Building B - conventional

(2010) 371 kWh/m²

Building A – LEED renovation

(2010) 290 kWh/m²

Conclusions

- Best research to date
- On average, green buildings had superior indoor environments
- Gained knowledge about key physical features affecting occupant outcomes in all buildings
- On average, LEED buildings had lower energy use
- Green building rating systems could be improved:
 - consideration of a LEED credit related to acoustic performance
 - a greater focus on reducing airborne particulates
 - enhanced support for the interdisciplinary design process
 - development of post-occupancy evaluation protocols, and their integration into on-going certification systems
- Complements research on real estate and business outcomes

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Thank You

Questions?



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Literature Review

- Little post-occupancy data available
- Tentative observed trends for IEQ:
 - Indoor Air Quality improved
 - Lighting about the same
 - Acoustics worse

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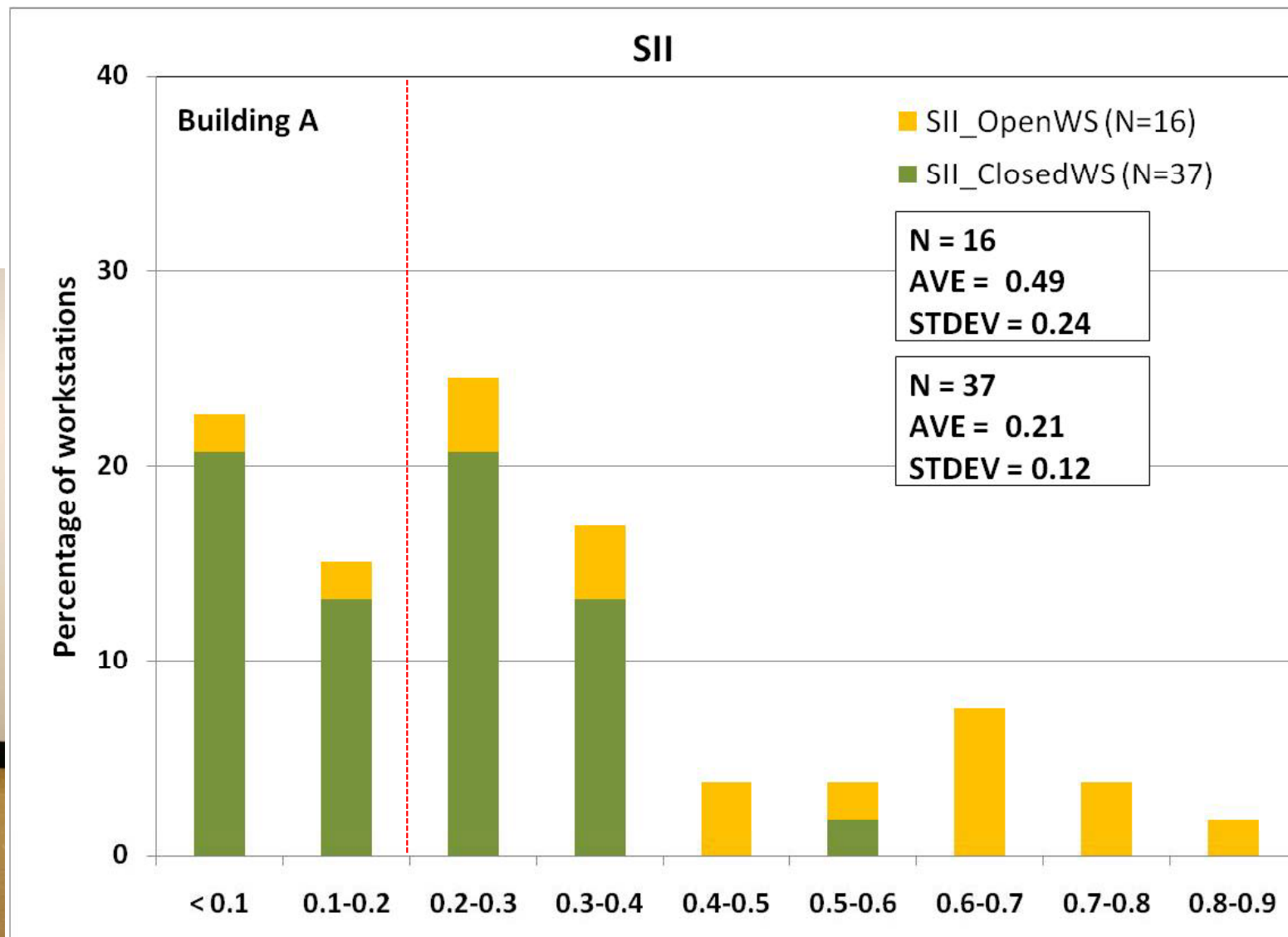


POST-OCCUPANCY EVALUATION OF ENERGY AND INDOOR ENVIRONMENT QUALITY IN
GREEN BUILDINGS: A REVIEW

Questionnaire

Module	# Items	Description	N
Core	35	Environmental and job satisfaction, demographics, job demands	2545
1	16	Organizational commitment, workplace image, internal communications	843
2	11	Acoustics	880
3	14	Thermal comfort	865
4	34	Chronotype, sleep quality, positive/negative feelings (affect)	876
5	13	Health	828
6	25	Commuting, environmental attitudes	798

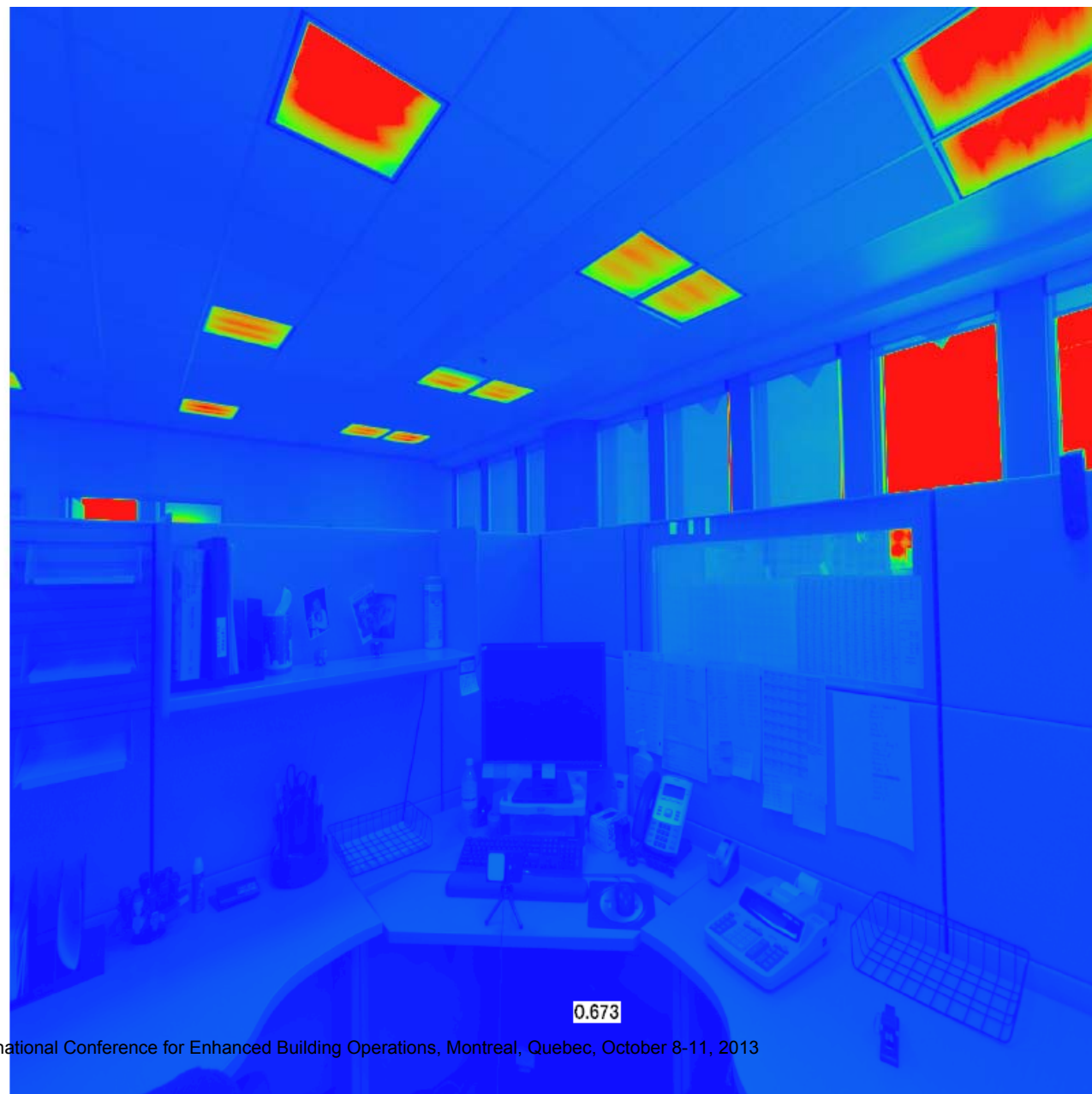
Example results



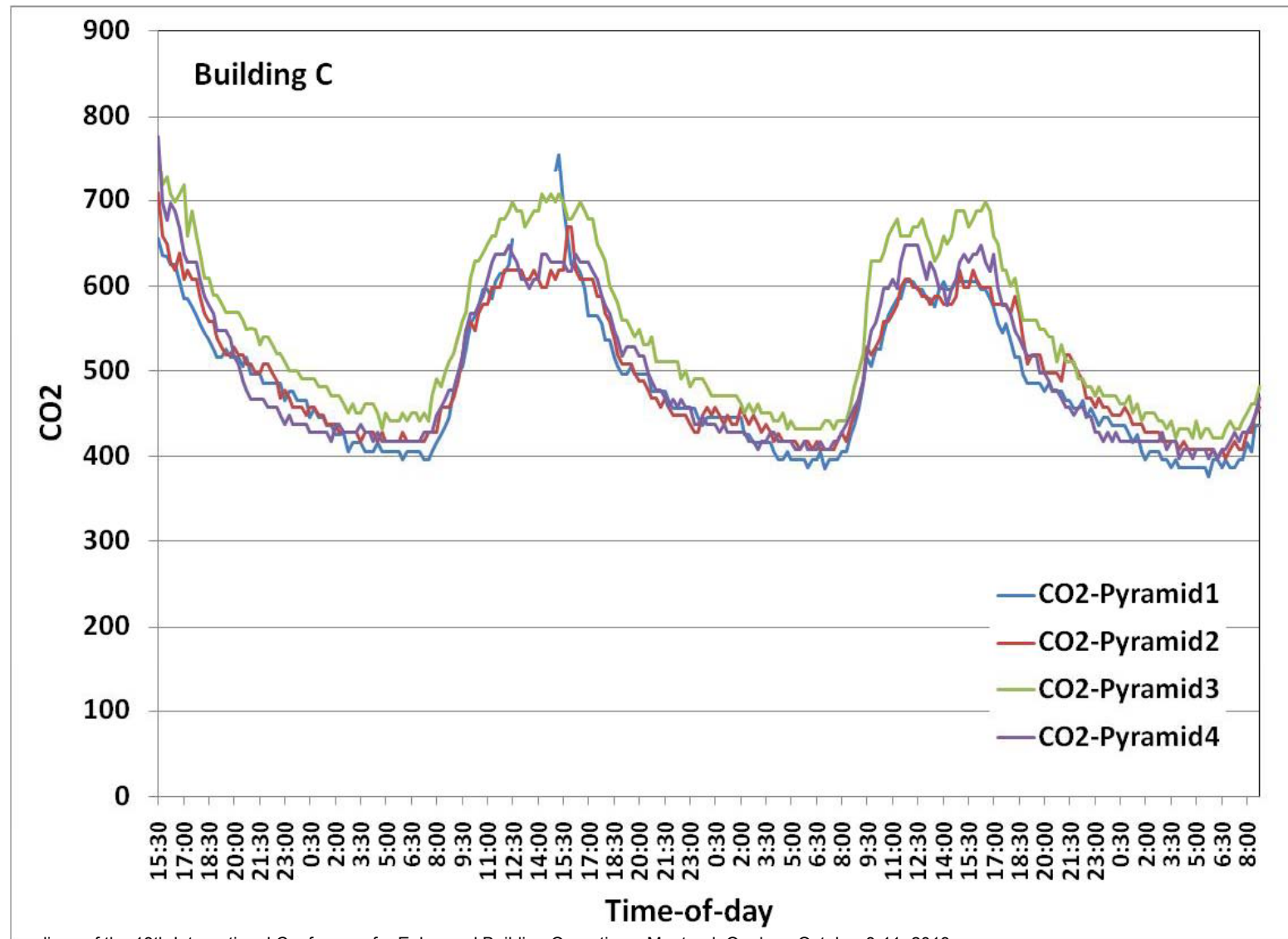
Example results



ed/m²
1900
1700
1500
1300
1100
900
700
500
300
100



Example results

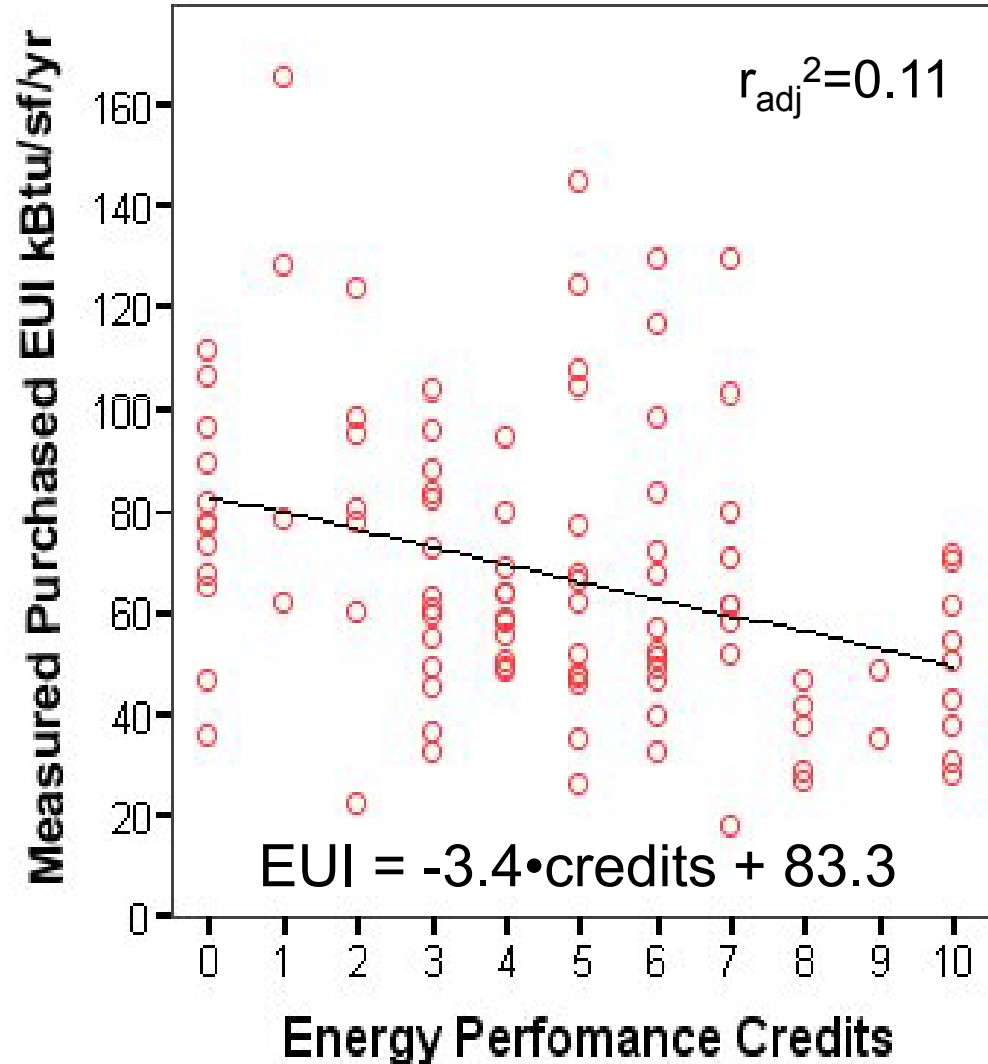


Green vs. Conventional (Questionnaire)

- No statistically-significant difference on:
 - Environmental attitudes
 - Job demands
 - View quality (for occupants that had a view to the outside)
 - Commuting distance
 - Chronotype
- No biases in demographic profiles
- Suggests occupants of green buildings were not biased and samples were appropriately matched

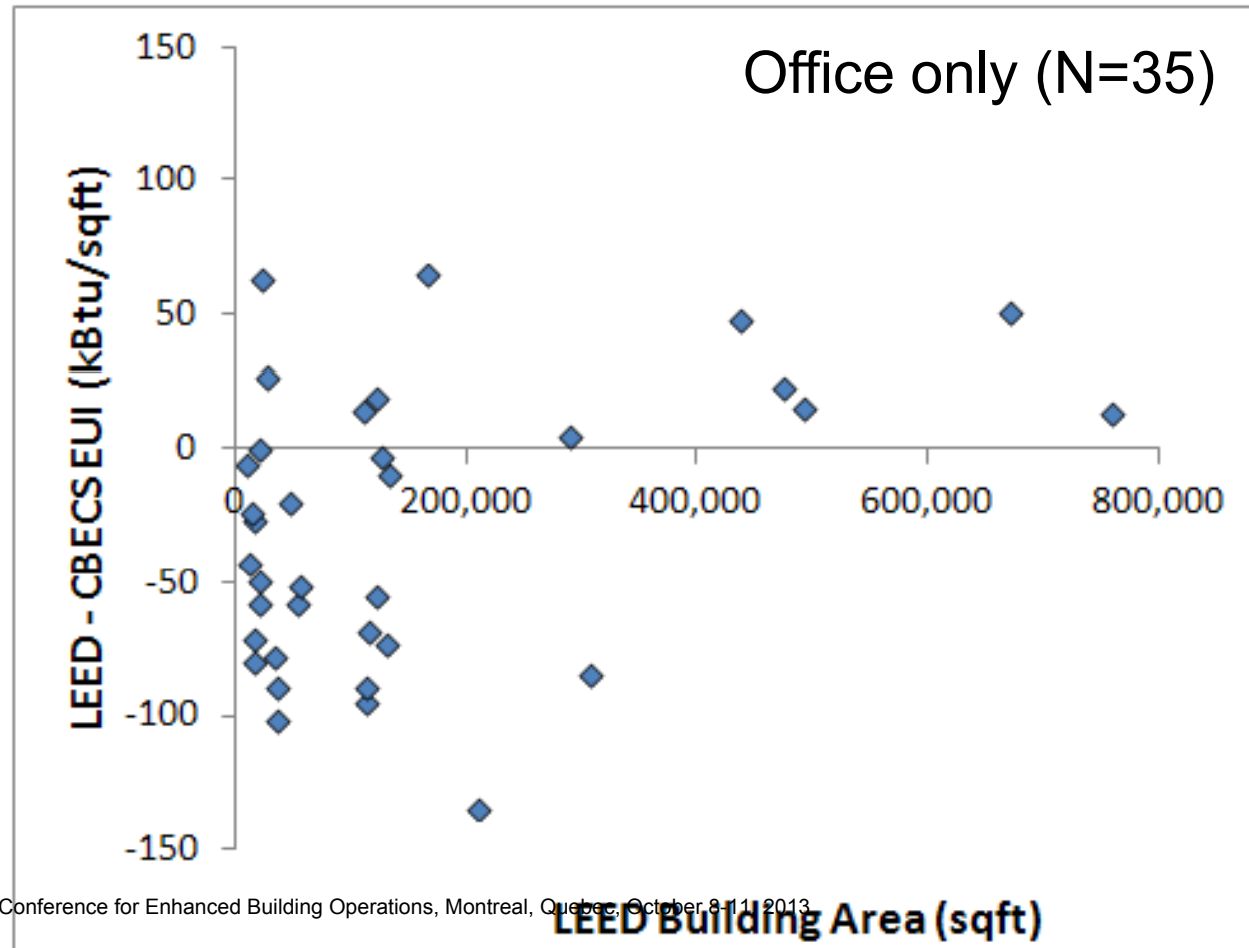
Energy

- No effect of certification level
- Regression n.s. for:
 - offices only, and
 - % savings vs. model baseline
- No effect of additional commissioning and M&V credits
- Small sample, first year of operation, self-selection



Introduction – Energy

- Scofield, JH. 2009. “Do LEED-certified buildings save energy? Not really...” *Energy and Buildings*, 41 (12), 2009, 1386-1390
- Source energy vs. site energy
- Weight results by building size



Construction Costs

Building Research & Information

Volume 41, Issue 2, 2013



Construction costs comparison between 'green' and conventional office buildings

DOI: 10.1080/09613218.2013.769145

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pages 198-208