A Methodology to Evaluate the Effects of School Buildings' Occupancy and Usage on their Energy Consumption

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Outline

- Introduction
- Goal, Objectives and Scope
- Literature Review
- Methods
- Conclusion





Introduction

- Buildings account for 20-40% of energy use globally
- Green buildings offer potential for decreasing buildings' energy use by 25-30%
- Research on green buildings' energy performance (e.g. Menassa et al. 2012, Thiers and Peuportier 2012) shows mixed results
- Limited research on:
 - Schools (e.g. Issa et al. 2011, Robertson and Higgins 2012)
 - Schools' occupancy and usage (e.g. Ridley et al. 2014, Guerra-Santin et al. 2013)





Goal, Objectives and Scope

Construction Engineering and Management Group

- Goal and Objectives
- Evaluate schools' energy consumption in relation to their usage and occupancy
 - Develop and validate methodology to evaluate schools' energy consumption
 - Develop and validate methodology to evaluate schools' occupancy and usage
 - Investigate relationship between schools' energy consumption and their usage and occupancy

Scope:

- Manitoba schools
- Evaluation at building level and space level





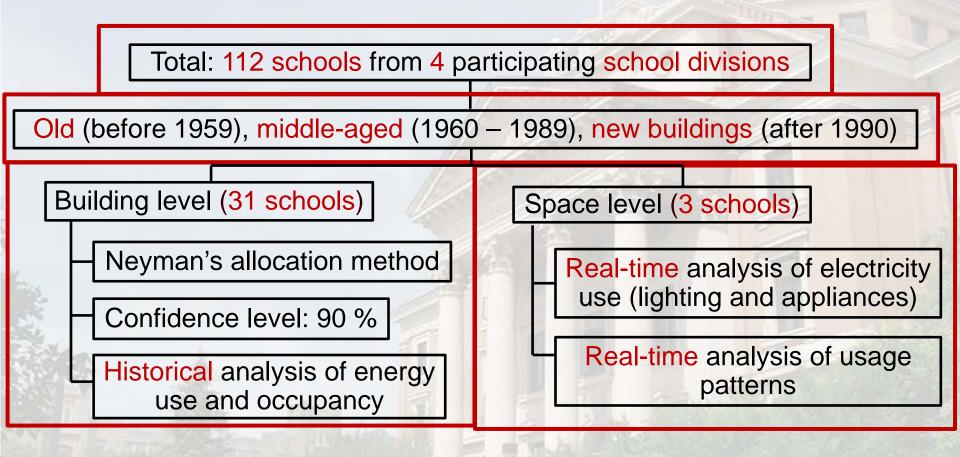
Literature Review

Method	Drawbacks		
Surveys and interviews (e.g. Chen et al. 2013, Ridley et al. 2014; Durand-Daubin 2013)	Subjective		
Visual observations/ monitoring of equipment use (Klein et al. 2012)	Labour-intensive		
Video monitoring of occupants (Zhou et al. 2008)	Privacy concerns		
Monitoring of WiFi connections (Zeiler et al. 2014)			
Use of radio-frequency identification technology (Spataru & Gillott 2011)	Only account for number of occupants		
Use of infra-red motion detectors (Yun and Lee 2014)			





Methods



One university. Many futures.

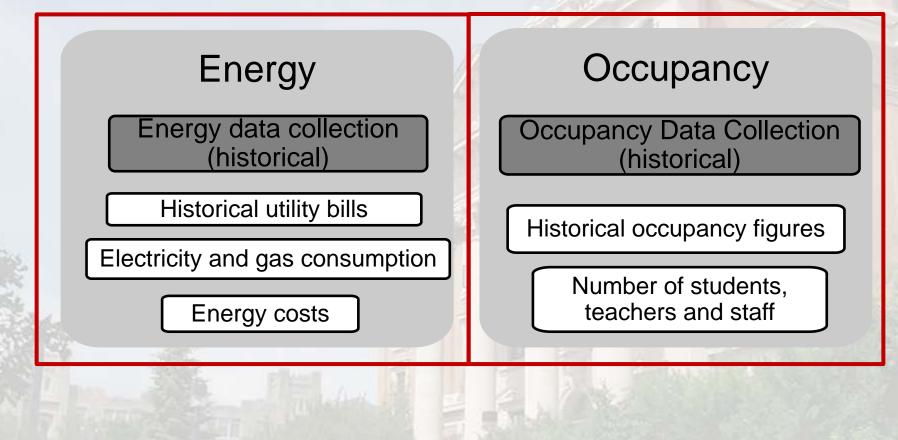


OF MANITOBA



Methods

Building-Level Analysis (31 schools)



One university. Many futures.



UNIVERSITY

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Methods

Occupancy Building-Level Analysis

School Name

School Address

Building Key Site manager Contact name and Information*

Building Type

Building climate zone

Number of Floors

ç		Circular
6		L-Shaped
1.31		U-Shaped
		I-Shaped
		V-Shaped
		Other (Specify)
	Surroundings (Check all that apply)	Attached to another building one side
		Attached to another building from two sides
		Attached to another building from three sides
		Attached to underground parking garage
		Attached to indoor above ground parking garage





Methods

Space-Level Analysis (3 schools) (1 classroom, 1 gym, 1 multi-purpose room) Electricity Usage **Usage Data Collection Electricity Data Collection** (real time) (real time) Occupancy sensors Power meters Document analysis (room schedules) Plug monitors Surveys (general and daily) **Observations**





Methods

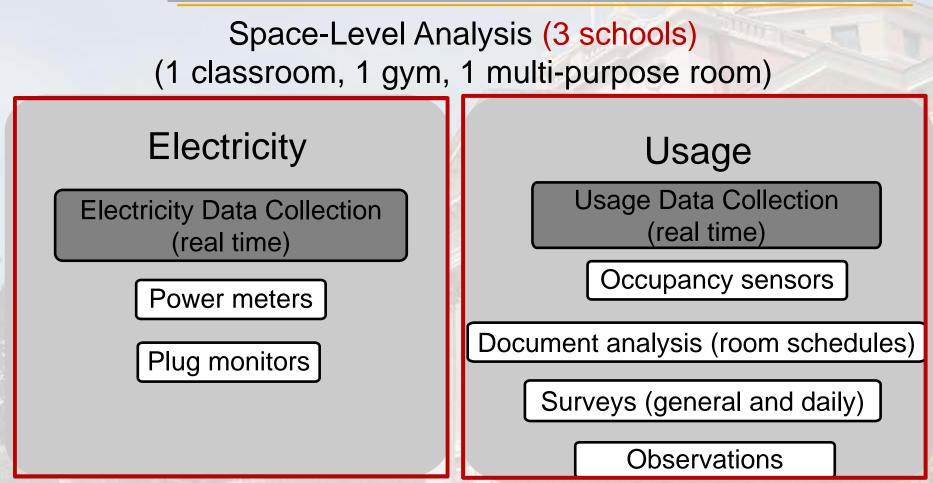
Electricity Space-Level Analysis (3 schools)







Methods







Methods

Schools Energy Consumption Survey

Personal strategies to increase energy efficiency

Please indicate the extent to which you agree or disagree with the following statements

17. I use less energy than other teachers/staff members at the school



Strongly Disagree

Disagree

18. In my primary work location (e.g. classroom, gym, music room), I know the potential reasons for energy waste

() Neutral

Personal strategies to increase energy efficiency

Please indicate the extent to which you agree or disagree with the following statements

17. I use less energy than other teachers/staff members at the school



Agree

Usage Space-Level Analysis

(General survey)

C



Disagree



18. In my primary work location (e.g. classroom, gym, music room), I know the potential reasons for energy waste







Methods

Usage Space-Level Analysis (Daily survey)

Please estimate the duration of active use for each of the following devices today

("active use" denotes times of direct interaction between a user and a device)

Your laptop/computer

Other laptops or computers (Leave blank if not applicable)

The projector

The stereo

Electric Sharpner

Device charging (e.g. cell phones or ipads or camera charger)

Other (Leave blank if not applicable) Please specify:

Other (Leave blank if not applicable) Please specify:

For how long were the lights switched off today?





Methods

Usage Space-Level Analysis (Observations)

- Period and type
 - two weeks per school
 - Point-in-time (half-hour intervals)
- Data type
 - (States 1,2,3)
- Issues
 - Subject reactivity
 - Inter-observer reliability







Methods

Usage Space-Level Analysis (Observations)

	C	lass	room	Date:	Time:
	Observation		Definition (0 = Not visible in room OR around it) / blank = cannot be observed for any reason beyond observer co		
We	ather		1 Completely Clear = No clouds at all in- sight	2 Partial Clouds = One or more clouds in sight.	3 Completely Cloudy = clouds completely covering the sky, i.e. little-to-no sunlight
Teacher's laptop or computer in use	by students side		Off = Blind is completely up (window completely cleared)		
	r Blind by students side		Off = Blind is completely up (window completely cleared)	Partial = Blind is down but not covering the entire window.	Full = Blind is covering the entire window
(also check the charger alone)	by teacher side (closer to the {)		Off = Blind is completely up (window completely cleared)	Partial = Blind is down but not covering the entire window,	Full = Blind is covering the entire window
No = Lanton is not being used and/or	= Laptop is not being used and/or is lugged		Off = Blind is completely up (window completely cleared)	Partial = Blind is down but not covering the entire window,	Full = Blind is covering the entire window
			No = Projector is not being used and is unplugged	Idle = Projector is plugged in and on-stanby but not projecting any thing at the moment	Yes = Projector is being used to project somehting on the board
unplugged			No = speaker is unplugged	Idle = speaker is plugged in but not being us	Yes = Speaker is being actively used
			No = No chargers are plugged in	Idle = 1 or more devices chargers are plugged in but not connected to a device	Yes = 1 or more devices are being charged
Idle = Laptop is on standby or sleep n	node.		No = No other devices are plugged in (definition can be readjusted according to device)	Idle = 1 or more devices are plugged in but not being used (definition can be readjusted according to device)	Yes = 1 or more devices are actively being us (definition can be readjusted according to device)
screensaver or blank screen is on but laptop is plugged in Yes = Laptop is being actively used or projector			No = Laptop is not being used and/or is unplugged	Idle = Laptop is on standby or sleep mode, screensaver or blank screen is on but laptop is plugged in	Yes = Laptop is being actively used or proje screen is on
			No = Laptop is not being used and/or is unplugged	Idle = Laptop is on standby or sleep mode, screensaver or blank screen is on but laptop is plugged in	Yes = Laptop is being actively used or proje screen is on
			No = Stereo is unplugged	Idle = Stereo is plugged in but not being used	Yes = Stereo station is being actively used
			No = Electric sharpner is unplugged	Idle = Electric sharpner is plugged but not being used	Yes = Electric sharpner is plugged in and be used
screen is on			Off = All Classroom lights are off except emergency lights	Dimmed = Some classroom lights are on and some are off (as long as at least one light bulb is switched off not due to malfunction but using a specific light switch)	On = All classroom lights are on
			No = No one in present	Partial = 3 or less people are present	Yes = More than 3 people are present
			Gener	al Comments	





Conclusion

Research Contributions

- New methodology to quantify school occupancy and usage in relation to energy consumption
- Tool for use in schools in particular to:
 - Improve energy efficient occupancy and usage of existing schools
 - Design new schools that optimize energy-efficient occupancy and usage
- Recommendations/ best practices to improve energy-efficient occupancy and usage of new and existing schools





Questions



