

Occupant-centric Building Design and Operation in a Post-pandemic World (EBC Annex 79)

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Does teleworking save energy?



Energy and Buildings
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IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS, VOL. SMC-6, NO. 2, FEBRUARY 1976

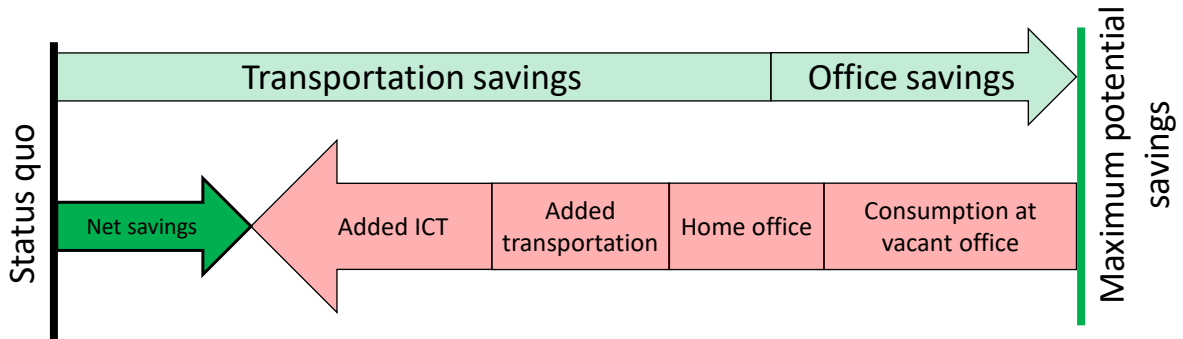
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Telecommuting—An Alternative to Urban Transportation Congestion

JACK M. NILLES, FREDERIC R. CARLSON, MEMBER, IEEE, PAUL GRAY, AND GERHARD HANNEMAN

Does telecommuting save energy? A critical review of quantitative studies and their research methods

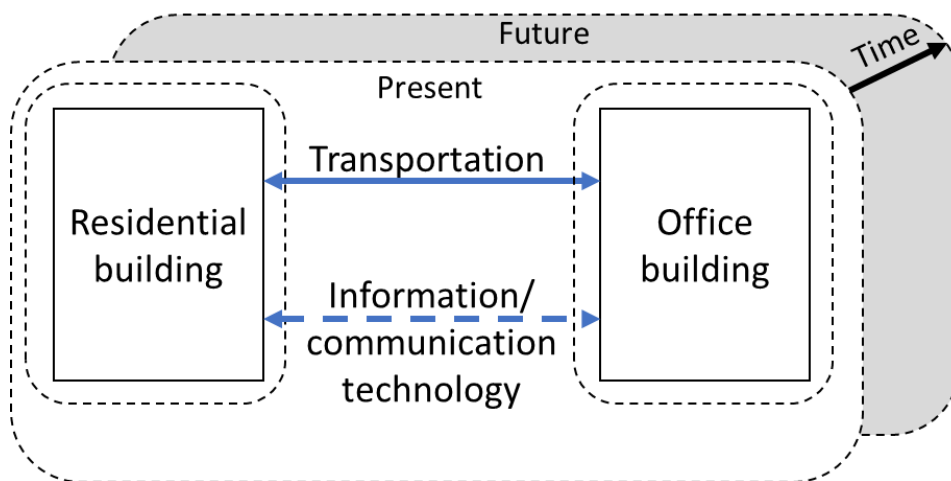
William O'Brien ^{*, A, #}, Fereshteh Yazdani Allabadi [#]



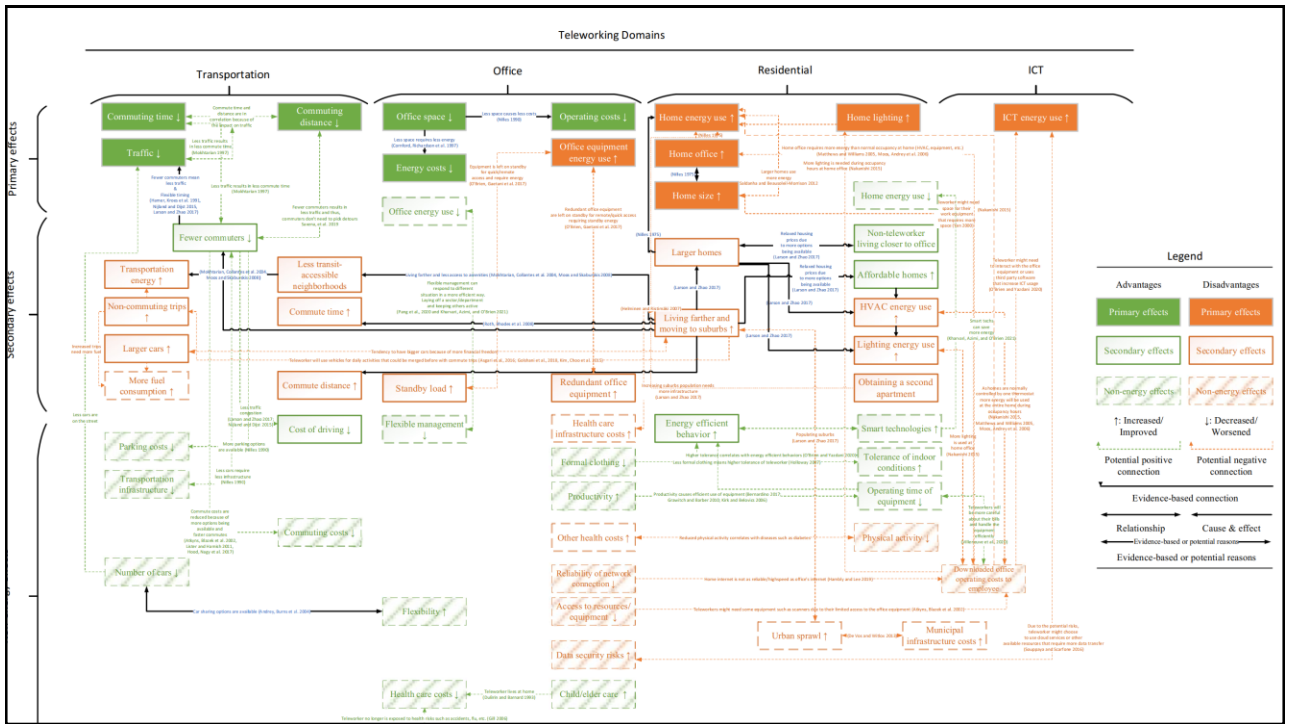
24 studies have looked at one or more domains; none have captured all.

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Spatial and temporal boundaries

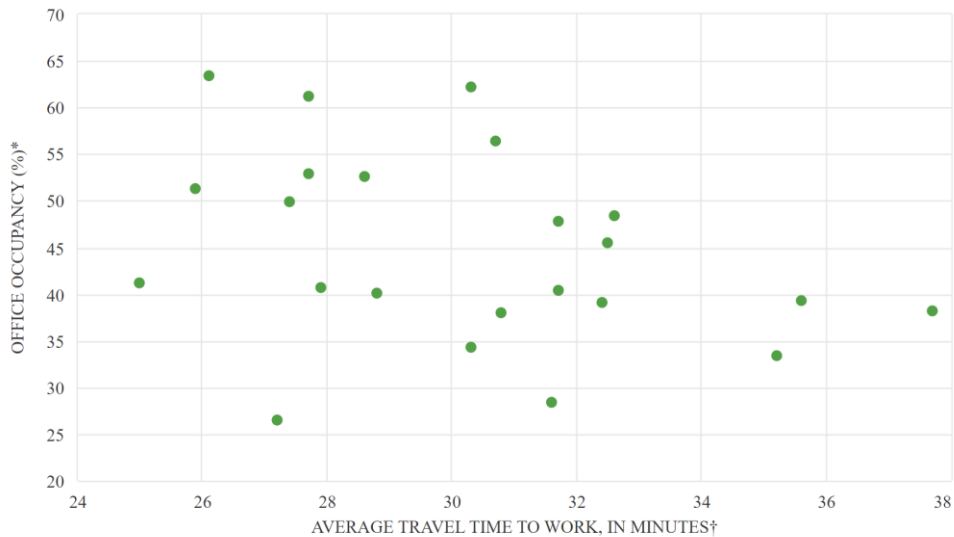


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Office occupancy vs. commute time for US cities



*As of 5/18/2022 †As of 2019

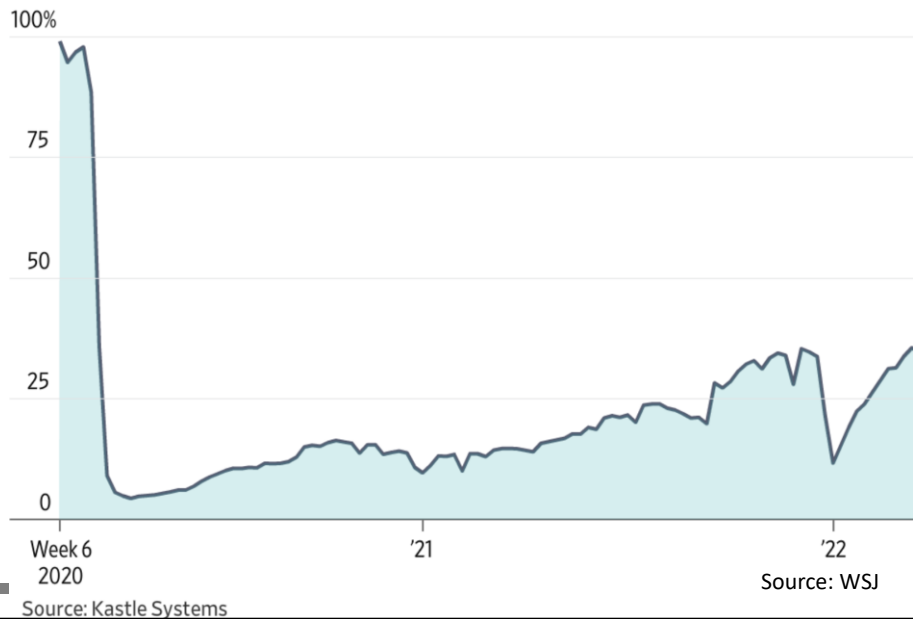
Source: U.S. Census Bureau 2019 American Community Survey, Kastle Systems

Source: WSJ

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Midtown (Manhattan) office occupancy



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Office buildings

- Minor positive energy benefit
- Highly dependent on adaptability:
 - Hotelling/hot-desking
 - Demand-controlled ventilation (DCV)
 - Occupancy-based setpoint and lighting control
 - Sleep mode on electronics

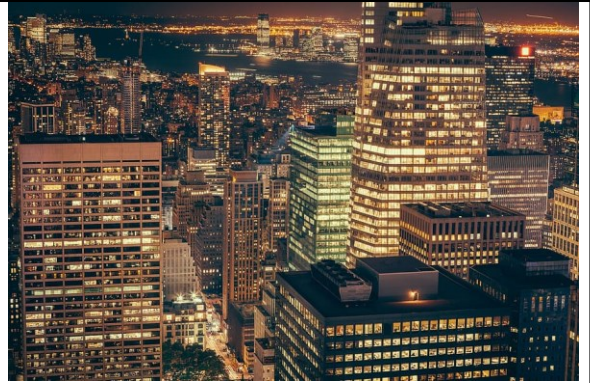


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Office buildings

Why Empty Office Buildings Still Consume Lots of Power During a Global Pandemic



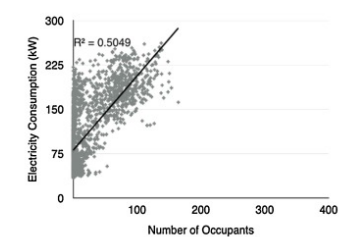
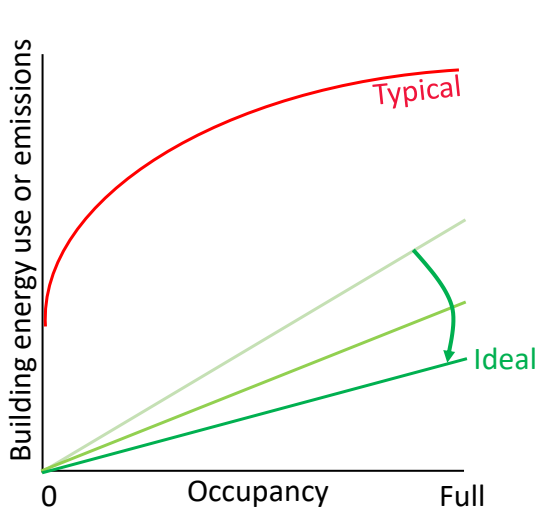
Commercial Building Electricity Reduction As Compared to Week of March 1st

	March 8 - March 14	March 15 - March 21	March 22 - March 28	March 29 - April 4	April 5 - April 11
US Total	5%	12%	18%	22%	25%
Northeast	7%	16%	21%	23%	26%
Midwest	4%	3%	11%	19%	25%
South	5%	10%	16%	22%	24%
West	4%	14%	21%	22%	27%

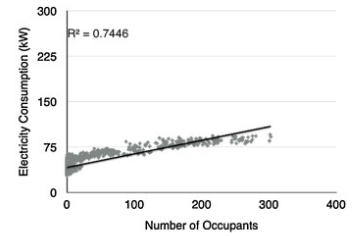
hatchdata

Source: www.hatchdata.com

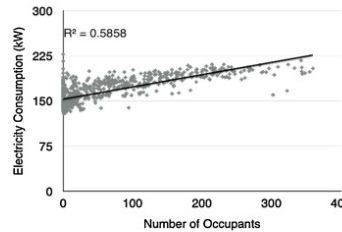
Office buildings



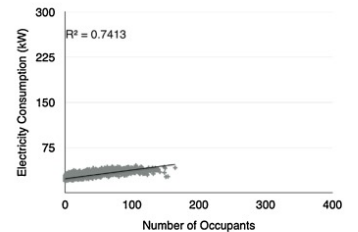
(a)



(b)



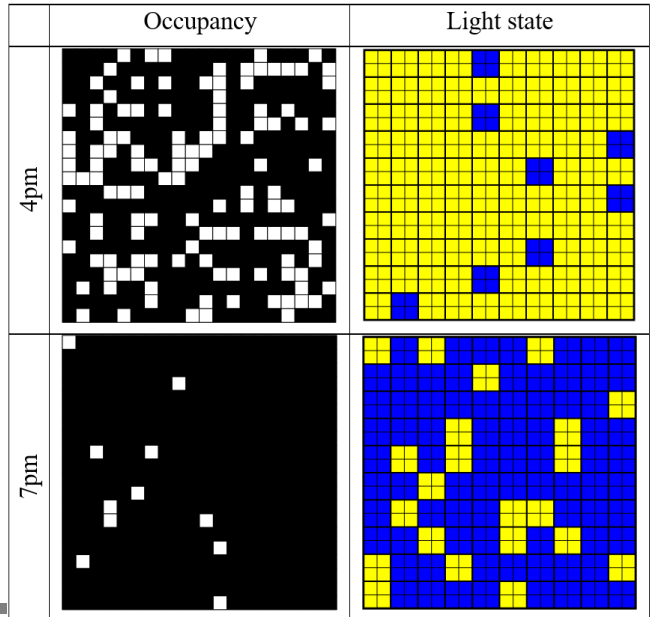
(c)



(d)

Kim and Srebric, 2017

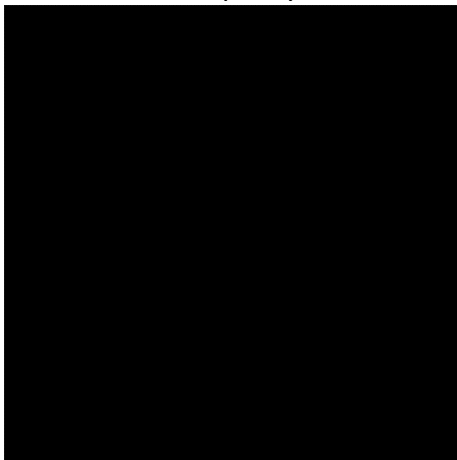
Occupancy and lighting controls



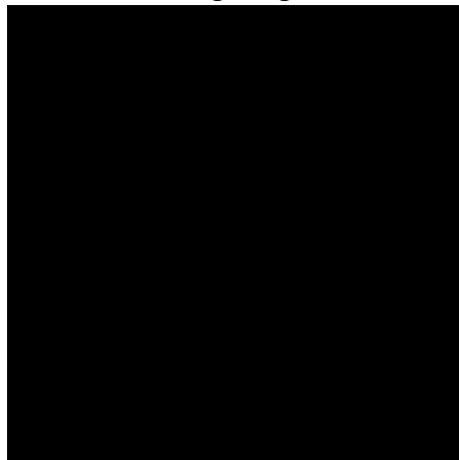
11

4 cubicles/lighting control zone

Occupancy



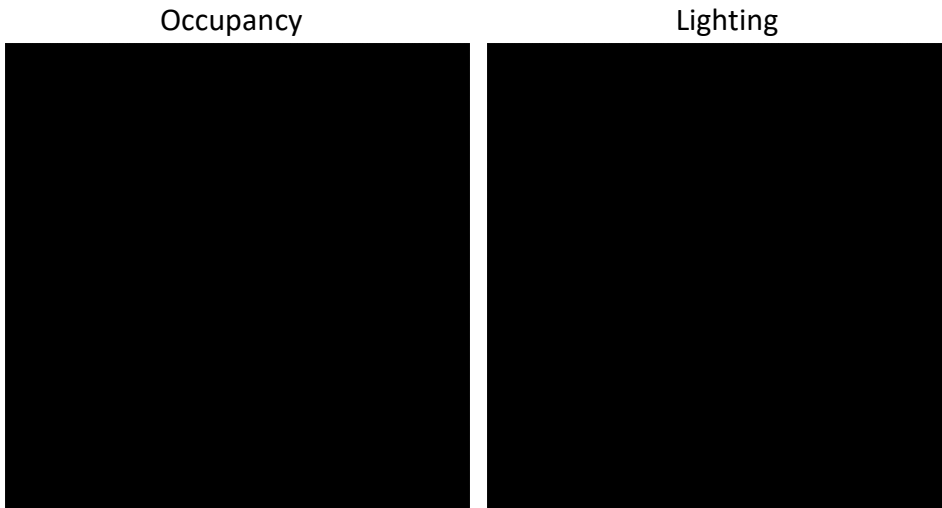
Lighting



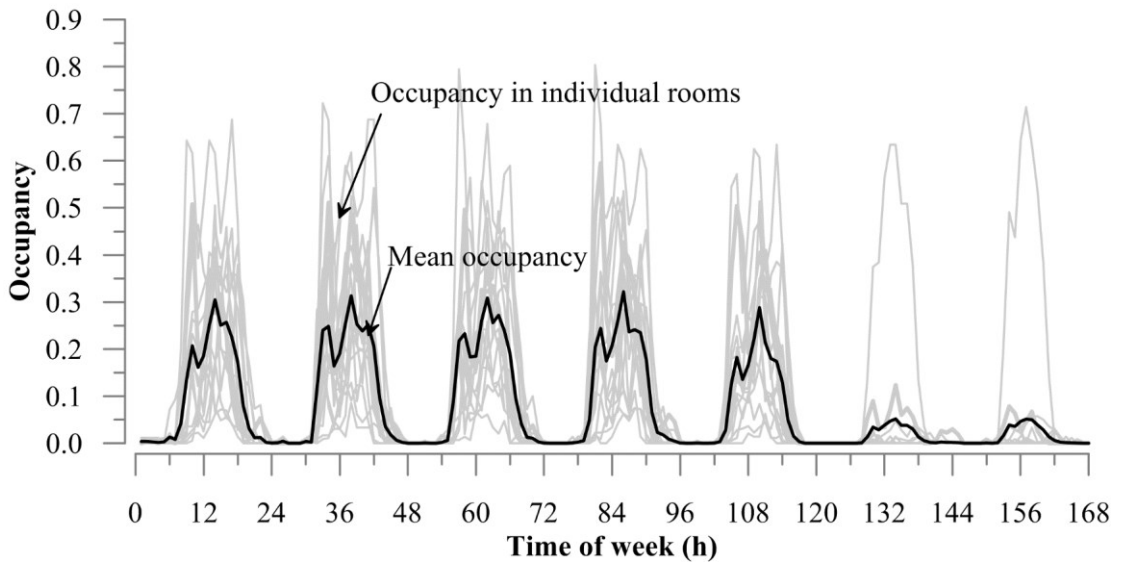
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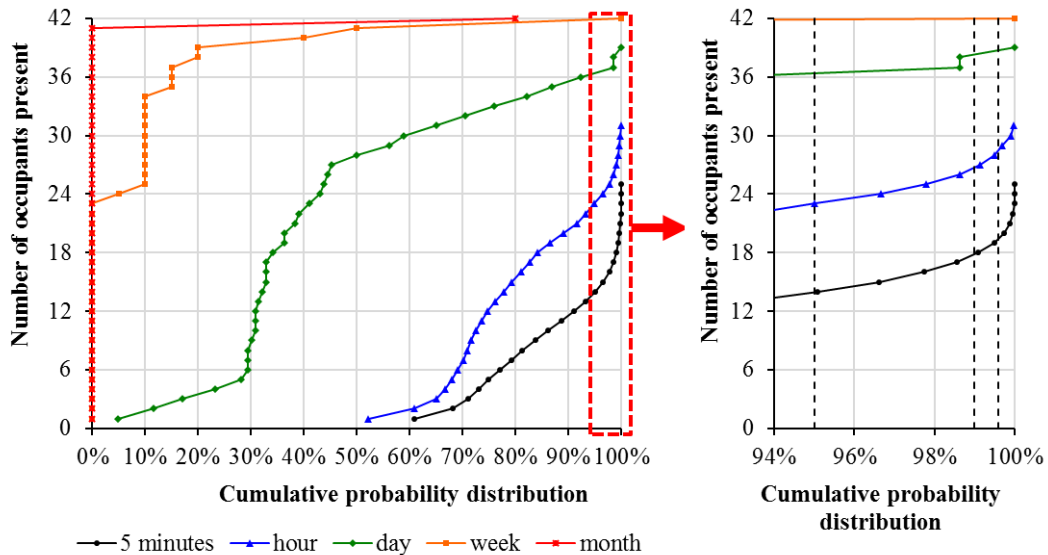
25 cubicles/lighting control zone



Office hotelling potential/probabilistic occupancy



Office hotelling potential/probabilistic occupancy



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Home

- Net negative effect
 - Previous estimates range from 0.1 to 20 kWh/teleworked day
- Highly dependent on operations
 - Zoned heating/cooling/lighting
 - Optimally-scheduled setpoints with vacancy setback
 - Laundry, baking, etc. shift peak loads
- Bigger home to accommodate office?
 - 4% larger (Nilles, 1990)

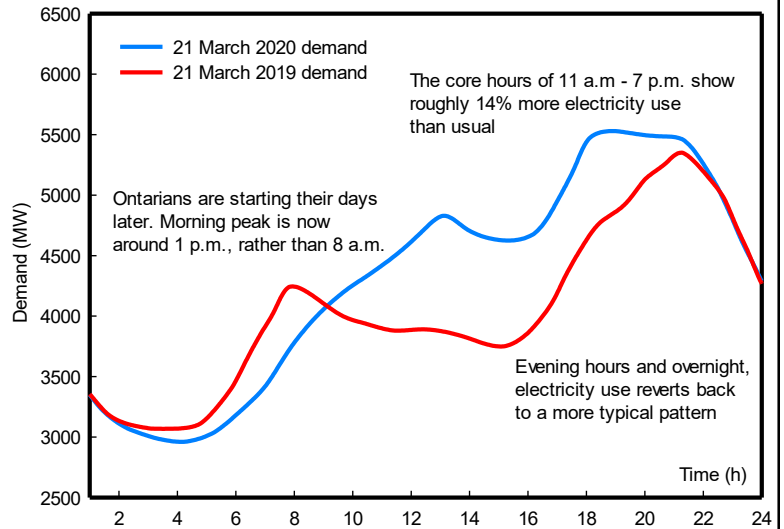


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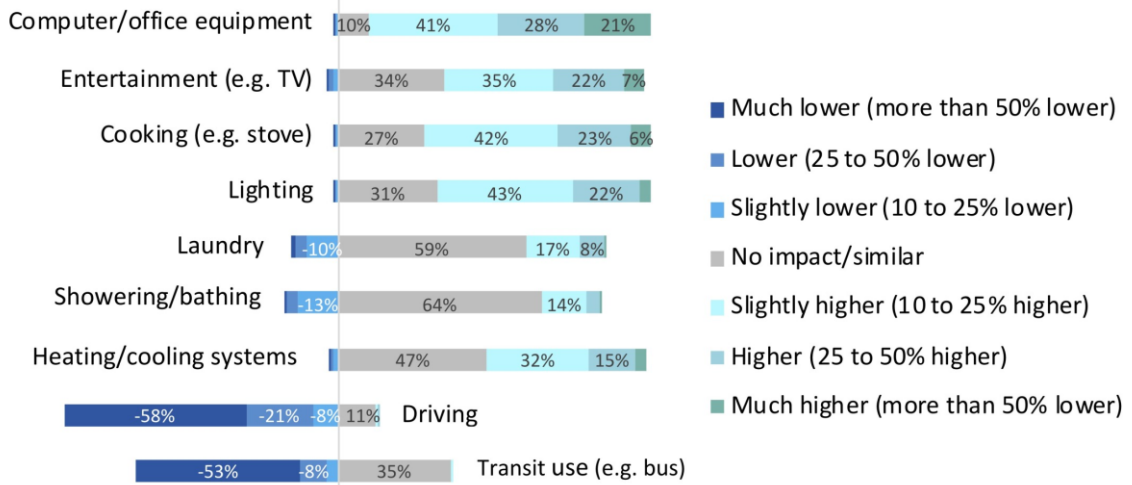
Ottawa residential electricity use

- Average daily home electricity use up from 19.7 kWh to 22.1 kWh (12.1% increase)
- Peak loads are up 15 to 20% over pre-COVID



Energy usage in the home (survey of 300 Canadians)

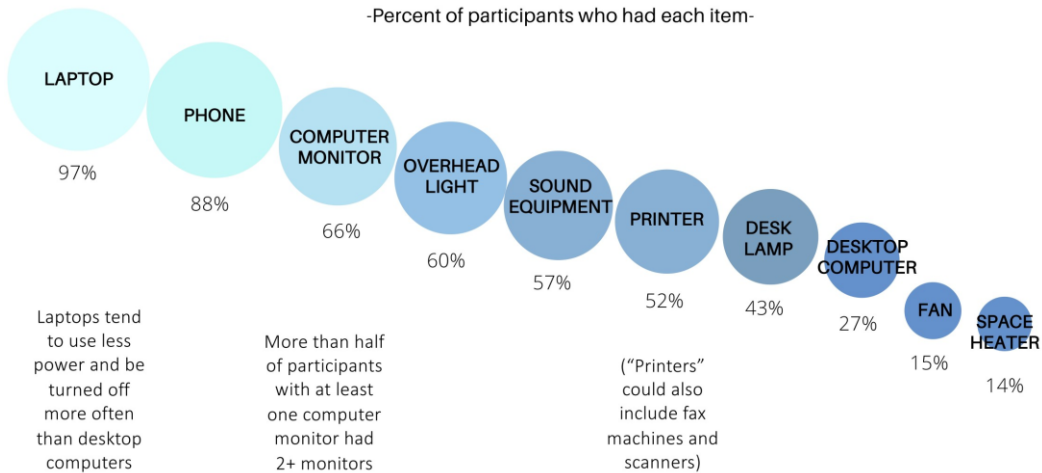
FOR EACH OF THE FOLLOWING ACTIVITES/SYSTEMS, HOW DO YOU EXPECT THEM TO AFFECT YOUR ENERGY USAGE NOW VS. A YEAR AGO?



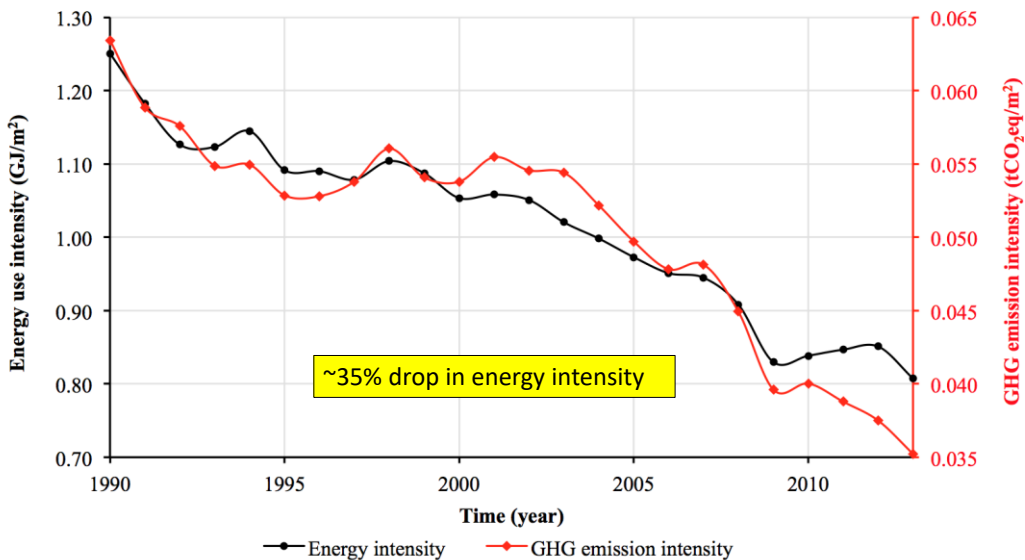
Energy usage in the home (survey of 300 Canadians)

HOME OFFICE EQUIPMENT

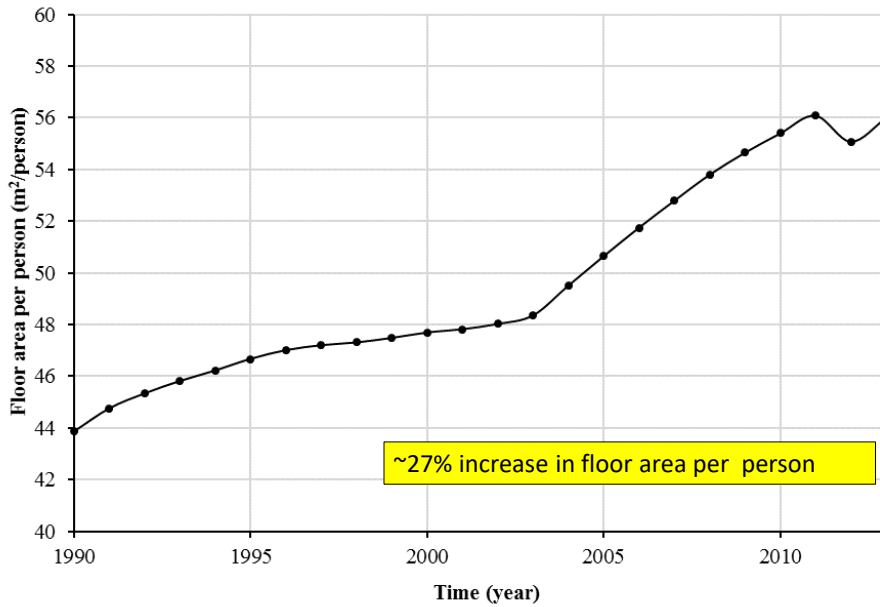
-Percent of participants who had each item-



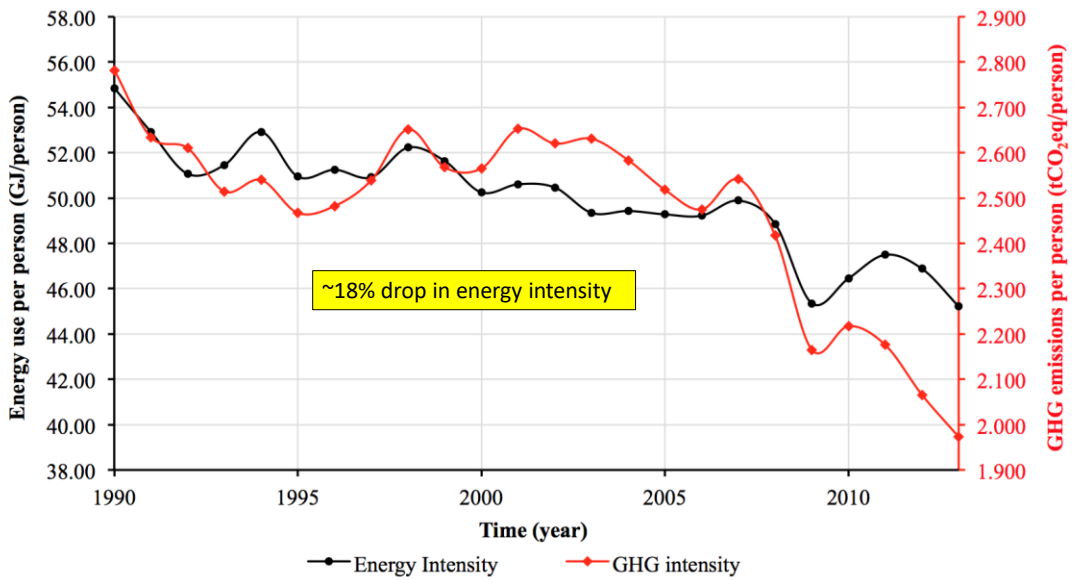
Floor area normalization: Canadian housing stock



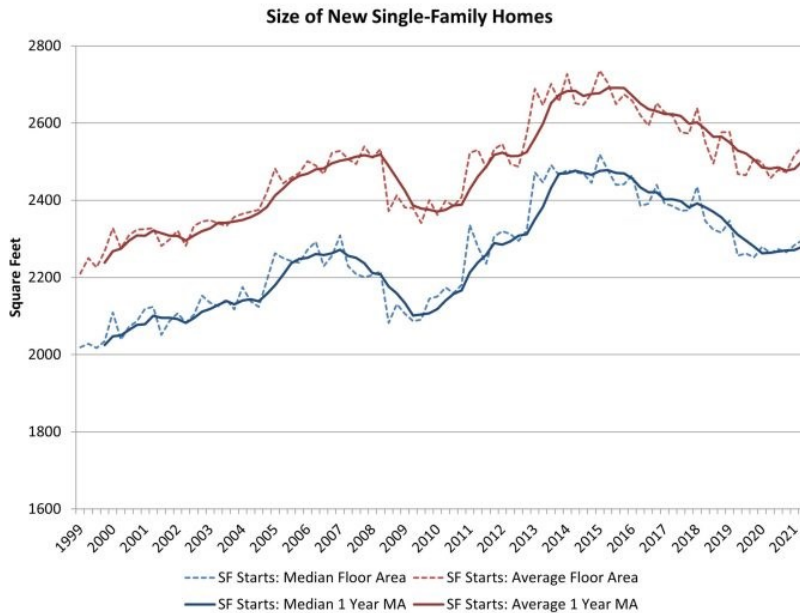
Canadian housing stock: Floor area



Floor area normalization



Midtown (Manhattan) office occupancy



Source: National Association of Home Builders (US)

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Attitudes towards teleworking

When you are forced to work from home, do you believe your employer should pay part or all of your ...

...energy bills?

17.2% of participants say "probably"



7.7% of participants say "absolutely"

...Internet and phone bill?

27.6% of participants say "probably"



19.2% of participants say "absolutely"

- 67% of participants wanted to work from home more than before based on this teleworking experience

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Energy usage in the home

- To improve the functionality of their home working environment...
 - 52.9% of participants had to **start using** more electronic devices/appliances
 - 32.3% of participants had to **buy** new electronic devices/appliances
- Teleworkers need equipment, which is associated with energy use

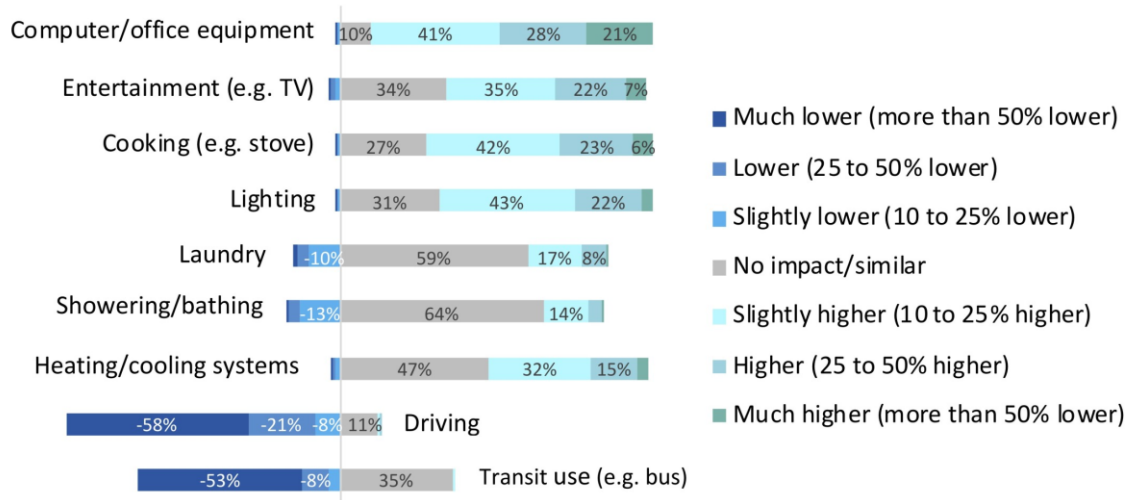
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Energy usage in the home

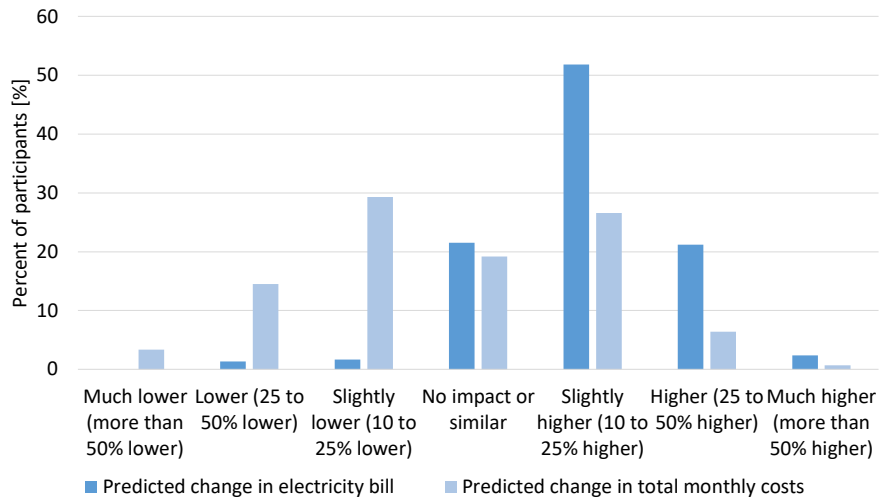
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Energy usage in the home

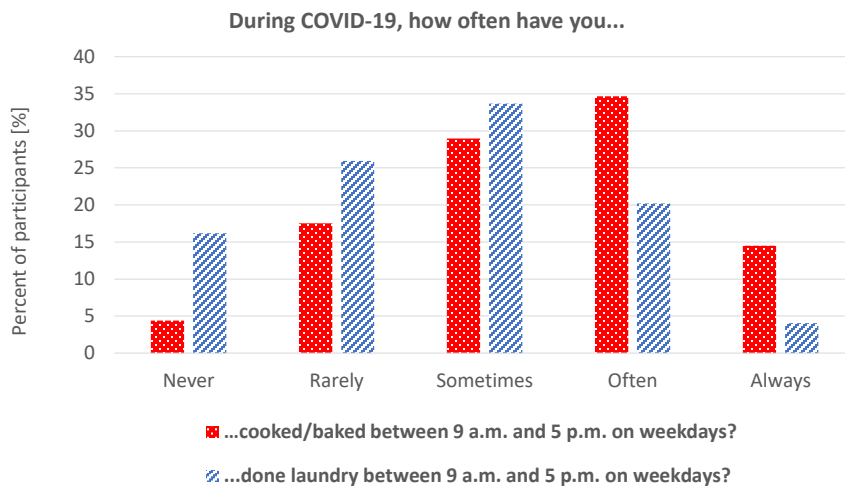


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Energy attitudes & behaviours



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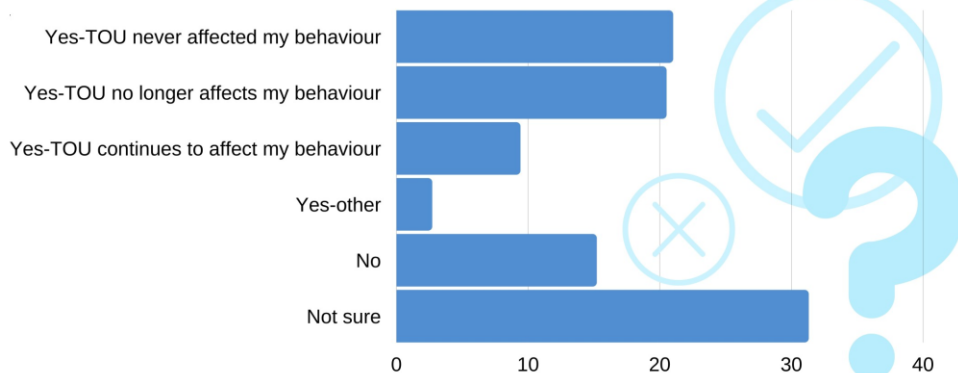
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Energy attitudes & behaviours

HAS YOUR ELECTRICITY PROVIDER STARTED CHARGING A FLAT/CONSTANT RATE DURING COVID-19, RATHER THAN TIME-OF-USE PRICING (TOU)?

Percent of Ontario participants [%]



31

31

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Attitudes towards teleworking

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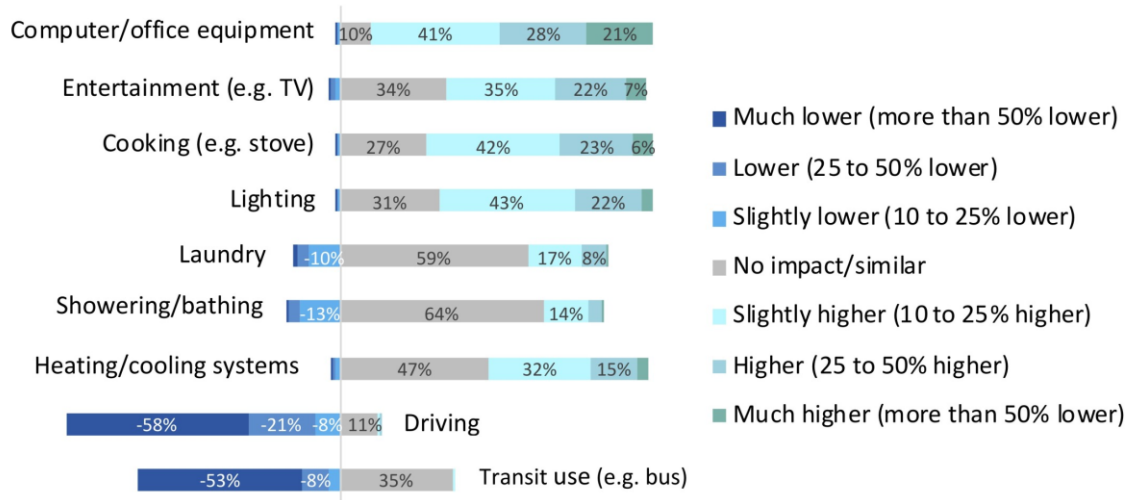
Follow-up survey results

- **“Does your current residence have air-conditioning?”**
 - 77% of the respondents have central A/C
 - 9% do not have any A/C
 - One person said they had both central A/C and a portable/window A/C unit
 - Only one person said they have multiple window/portable A/C units (1 in the room they work in, 1 in their bedroom)
- **“How often are you using air-conditioning compared to last summer?” Of the 51 respondents who had A/C:**
 - 47% of respondents say they are using their A/C more during the day
 - 43% of respondents say they are using their A/C the same amount as last summer

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Energy usage in the home

FOR EACH OF THE FOLLOWING ACTIVITIES/SYSTEMS, HOW DO YOU EXPECT THEM TO AFFECT YOUR ENERGY USAGE NOW VS. A YEAR AGO?



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Attitudes towards teleworking

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Transportation

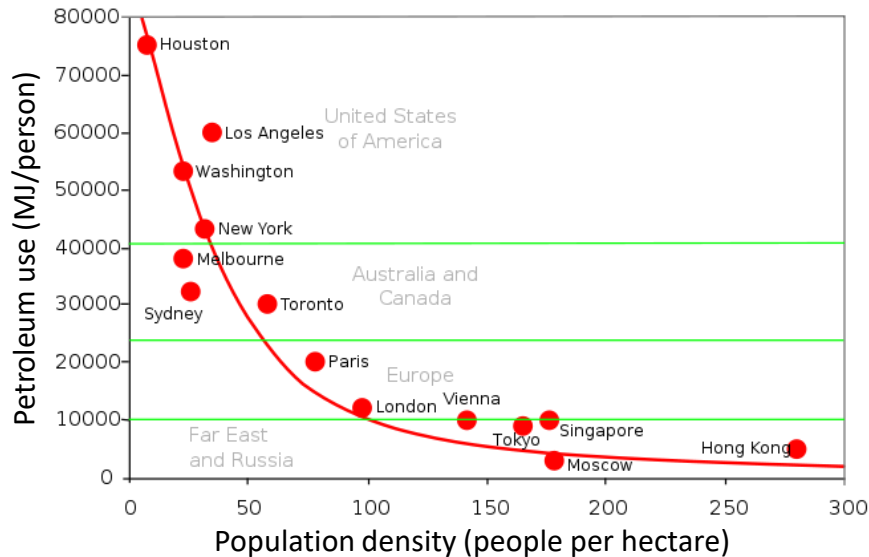
- Probably the biggest energy/emissions-saving opportunity
- BUT, 3 of 21 studies reported an increase in transportation use from telework
- Major rebound effects:
 - Poorer trip-chaining
 - Family now has car to use
 - Bigger/more cars
 - Suburban sprawl
 - Less traffic → more driving by others
- Unclear what comes first:
 - Teleworkers move farther
 - Suburbanites start teleworking more



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Transportation energy vs. density



Newman and Kenworthy (1989)

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The New York Times

America's Biggest Cities Were Already Losing Their Allure. What Happens Next?

The urge among some residents to leave because of the coronavirus may be temporary. But it follows a deeper, more powerful demographic trend.

The Guardian

Escape to the country: how Covid is driving an exodus from Britain's cities

THE WALL STREET JOURNAL

Escape to the Country: Why City Living Is Losing Its Appeal During the Pandemic

POLITICO

The death of the city

Teleworking, not the coronavirus, is making urban living obsolete.

Reasons to Love (and Not Leave) Toronto

TORONTO LIFE

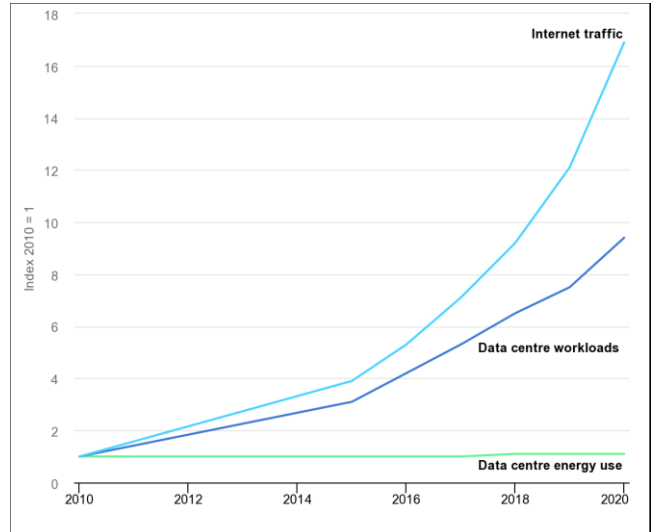
To people fleeing the city for more square footage and less density, we say pffft. Pandemic or not, Toronto is thriving. Let us count the ways

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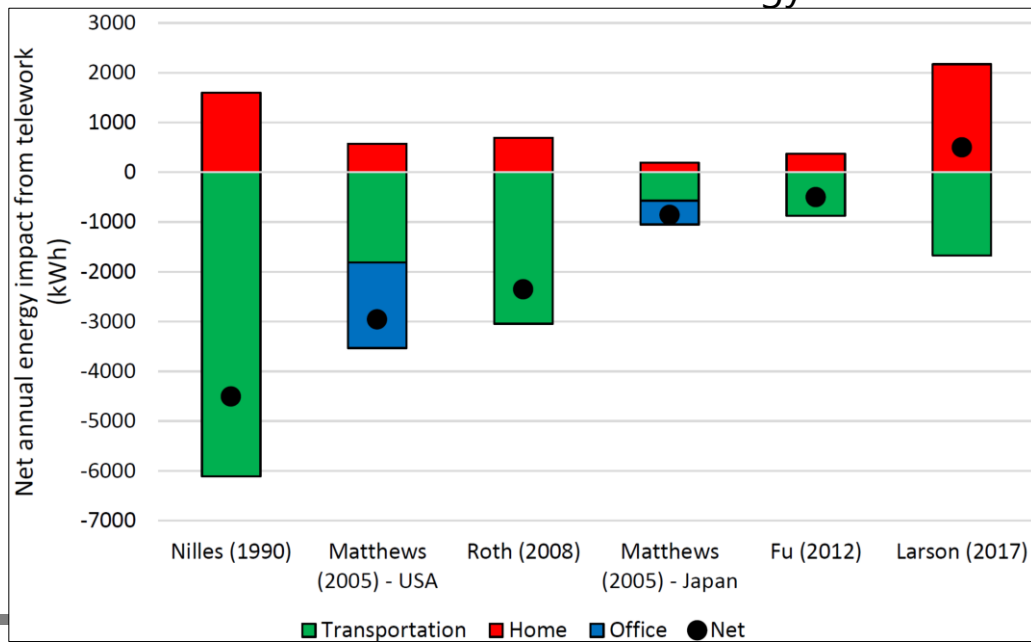
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Information and Communications Technology (ICT)

- Negative effect, but enabler of teleworking
- Global data transmission uses 1.1-1.4% of total electricity use – expected to double in a decade
- Major uncertainty about energy-intensity and data *actually* used for work
- 0.1-1.0 kWh \approx 1 GB (e.g., 0.5-1 hours of Zoom meetings)



The verdict on whether telework saves energy overall



Changing occupant expectations



THE WALL STREET JOURNAL.

A-HED

Brrr! Air-Conditioned Offices Give Chilly Reception to Returning Workers

Employers beware: People who once put up with thermostats set to deep freeze now want the kind of climate control they had working from home



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Energy in Buildings and
Communities Programme

IEA EBC Annex 79 Occupant-centric building design and operation

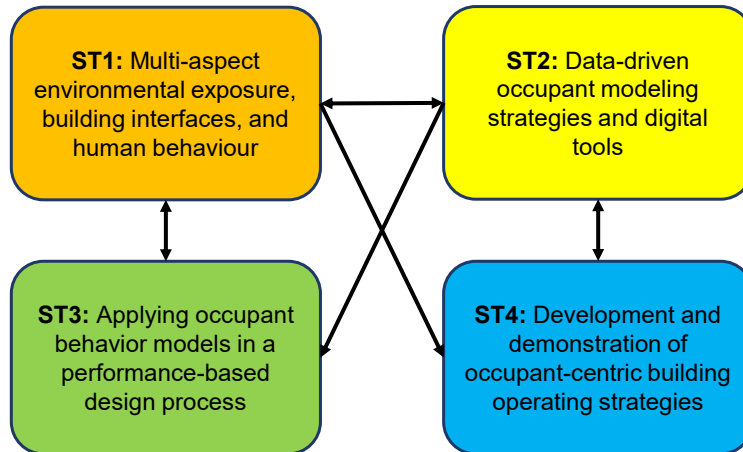
2018-2023

Prof. Andreas Wagner (Germany) and Liam O'Brien (Canada)



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Organization in four subtasks



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Countries involved

1	Australia
2	Austria
3	Belgium
4	Brazil
5	Canada
6	China
7	Denmark
8	France
9	Germany
10	Italy
11	Netherlands
12	Norway
13	Singapore
14	Sweden
15	Turkey
16	UK
17	USA
18	Switzerland
19	UAE
20	Hungary
21	Poland



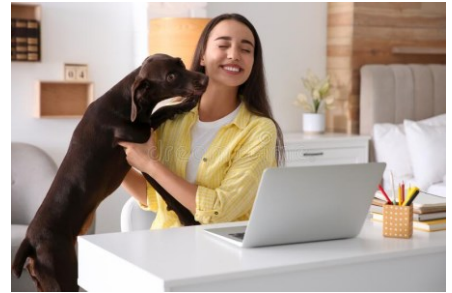
Non-member countries/observer status



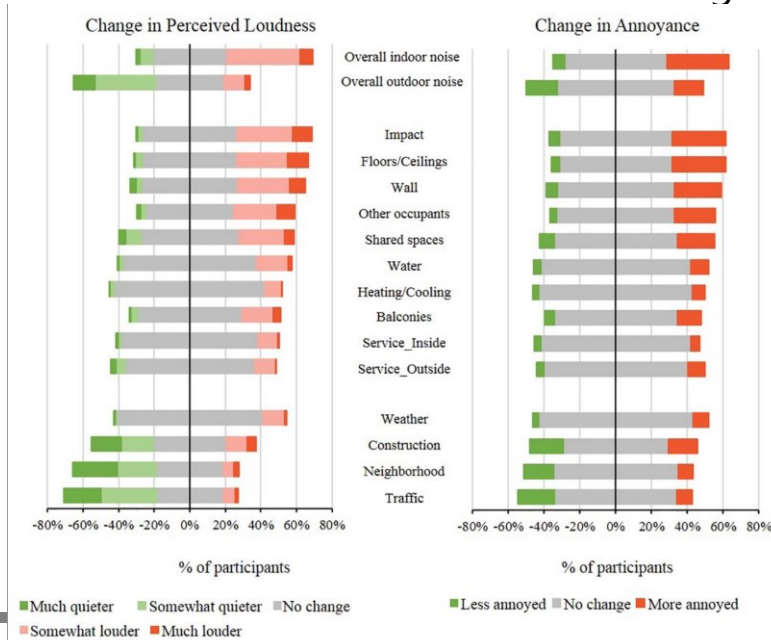
45

Comfort at home and in offices

- Office workers have come to expect a high degree of personalized control over their environment
 - We need to provide high IAQ without major energy penalties
- Homes are prone to discomfort with telework and other new uses
- Use of air-conditioning likely to increase at home

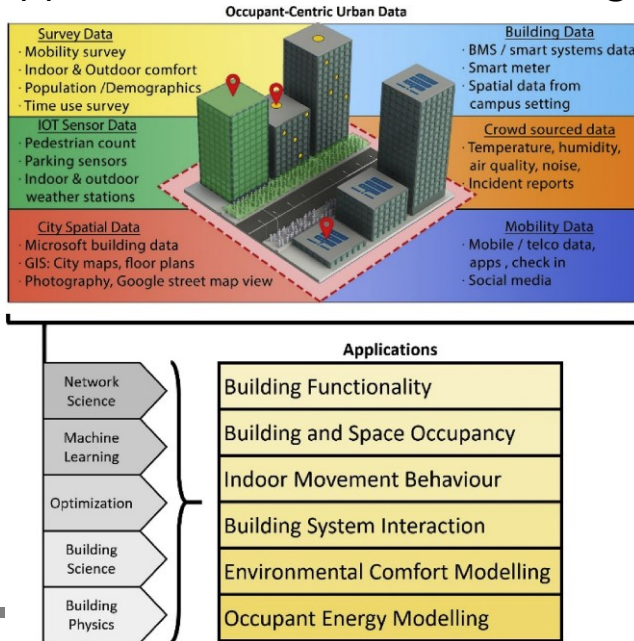


Impact of noise in multi-unit residential buildings

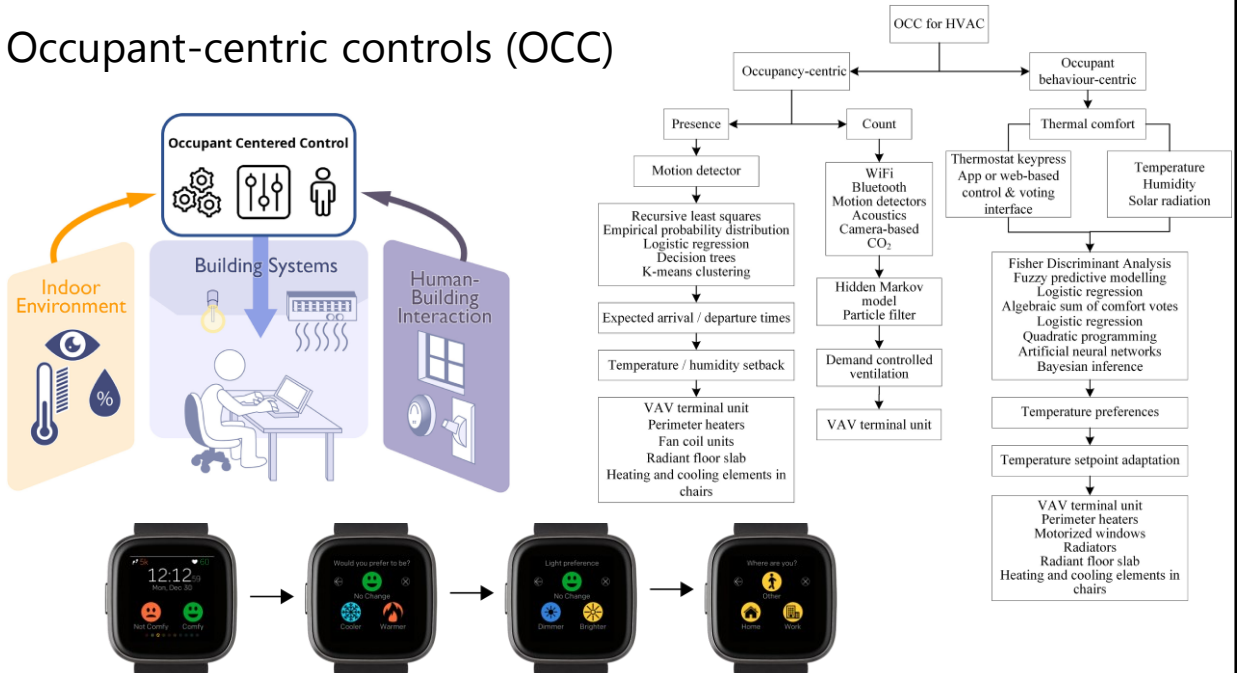


Andargie, Touchie, O'Brien (2021)

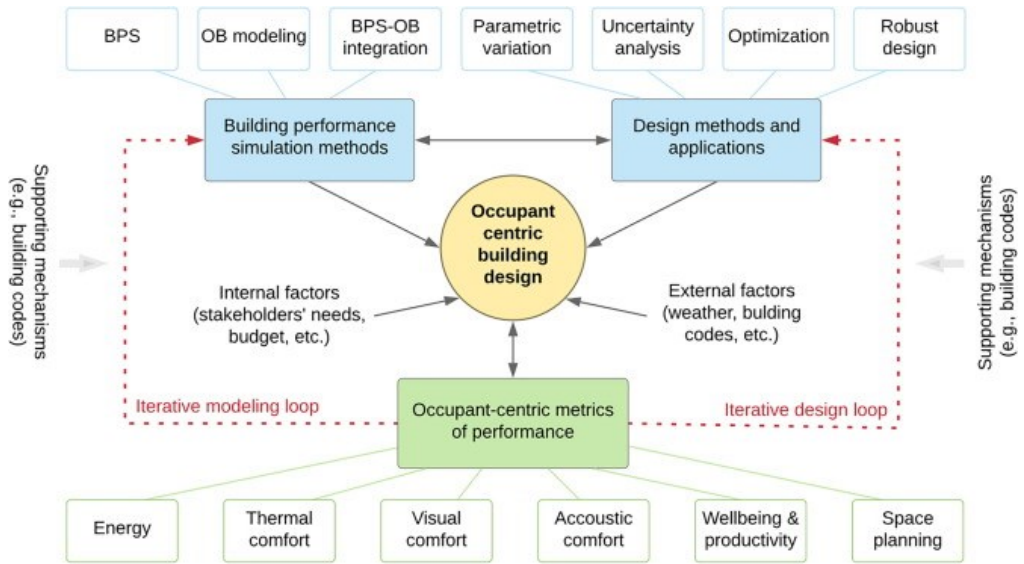
Data-centric approaches to research and design



Occupant-centric controls (OCC)



Occupant-centric design



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