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2013
Better Buildings By Design

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An energy and economic modeling study of exhaust ventilation systems compared to balanced ventilation systems with energy recovery

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Efficiency Vermont
BBD 2013
BETTER BUILDINGS BY DESIGN

Efficiency Vermont

Learning Objectives

By the end of this program, participants will be able to:

- Understand the impacts typical Passive House ventilation systems have on annual heating and cooling loads in the Northeast climate compared to exhaust ventilation systems.
- Understand the impacts typical Passive House ventilation systems have on total site energy use in the Northeast climate compared to exhaust ventilation systems.
- Understand the cost-effectiveness of typical Passive House ventilation systems in the Northeast climate compared to exhaust ventilation systems.
- Understand an alternative ventilation strategy with the Lunos e2 and a decentralized approach.

Course Evaluations

In order to maintain high-quality learning experiences, please access the evaluation for this course by logging into CES Discovery and clicking on the Course Evaluation link on the left side of the page.

Learning Objectives:

1. Understand the impacts typical Passive House ventilation systems have on annual heating and cooling demand in various climates compared to exhaust ventilation systems.

2. Understand the impacts typical Passive House ventilation systems have on total site and source energy use in various climates compared to exhaust ventilation systems.

3. Understand the cost-effectiveness of typical Passive House ventilation systems in various climates compared to exhaust ventilation systems.

4. Understand the known issues and best practices for exhaust-only ventilation in residences.

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Starting points:

1. Heat recovery ventilation is a de-facto "requirement" for PHIUS+ projects in most North American climate zones

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4. Others (non-Passive House folks) have used high-performance exhaust ventilation systems in low-energy houses for many years

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Starting points, continued:

5. Could exhaust ventilation help reduce mechanical system upfront costs in my climate, while still providing good indoor air quality and very low energy use?

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6. With the steady drop in PV prices, could we build a net-zero (or beyond) house in our climate for less money using exhaust ventilation?

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6. With the steady drop in PV prices, could we build a net-zero (or beyond) house in our climate for less money using exhaust ventilation?

7. What about other climates?

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History:

HRV systems were an integral component in achieving peak load heating via ventilation air in "classic" Passive Houses, enabling "tunneling through the cost barrier" and reduced mechanical system costs compared to other low-energy buildings.

To date, peak-load space conditioning via ventilation air does not appear feasible in most North American climates - at least in detached single-family and small townhouse projects.

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The study:

Look at energy savings and cost-effectiveness for popular ERV/HRV systems compared to a high-efficiency exhaust-only ventilation system in various climates

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The house:

1,800ft^2, 3-bedrooms

The climates:

Charlottesville, VA - 4,000 HDD

Chicago, IL 6,700 HDD

Burlington, VT 7,300 HDD

Ottawa, ON 8,300 HDD

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Modeling assumptions:

1. Heat pump heating/cooling (COP varied with climate)
2. Set-points: 70F (winter), 75F, 50% RH (summer)*
3. Three systems: ERV - Ultimate Air 200DX, HRV - Zehnder Comfo 350, Exhaust - Panasonic)
4. Blower door test result: 0.60ACH_{50}*
5. Ventilation rate: 56cfm*
6. “Ideal” fan energy simulation*
7. Electric defrost, except for Charlottesville

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Energy Metrics Analyzed:

1. Annual heat demand
2. Latent cooling demand
3. Ventilation fan energy use
4. Defrost energy use
5. Space conditioning energy use

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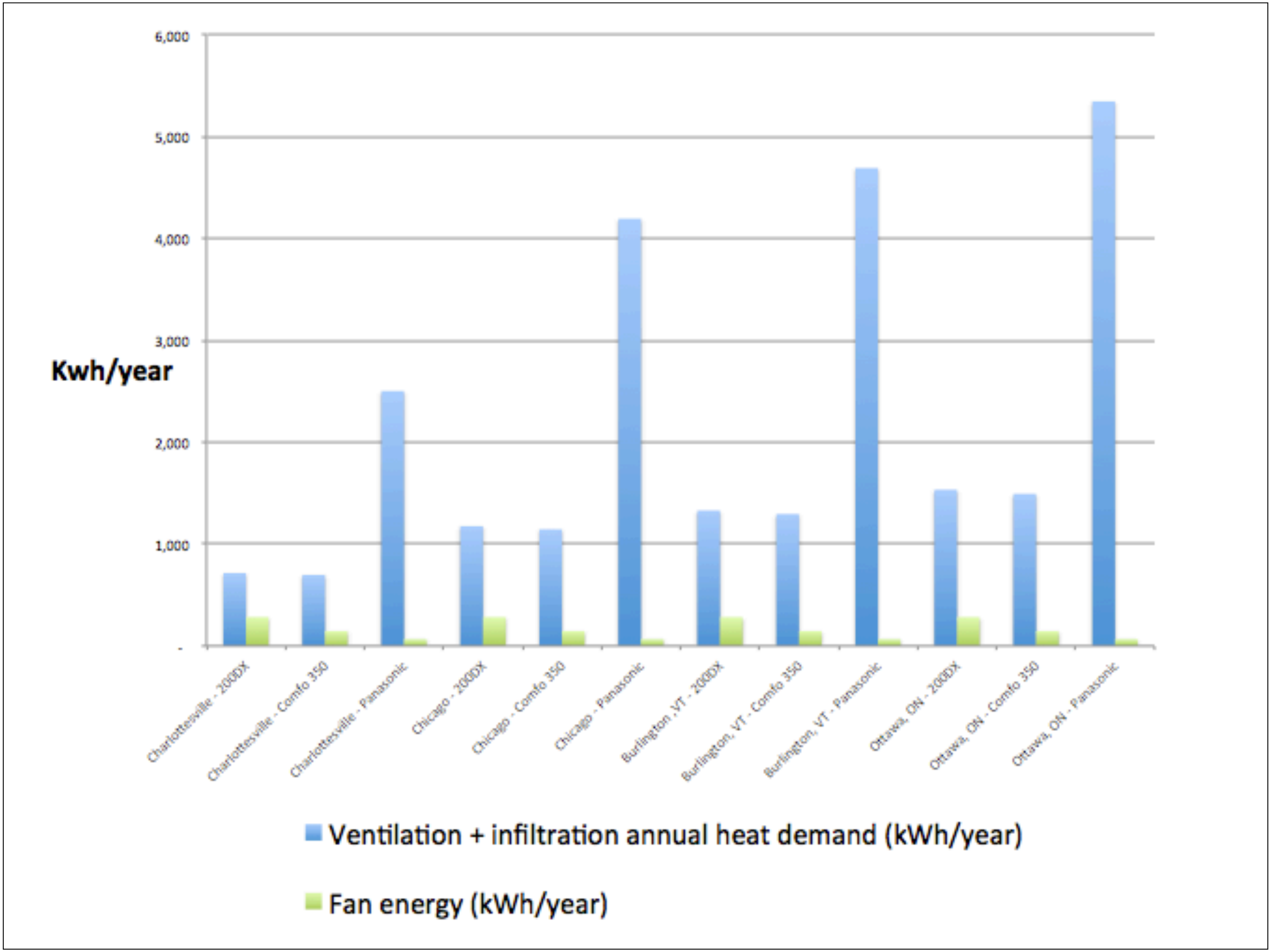
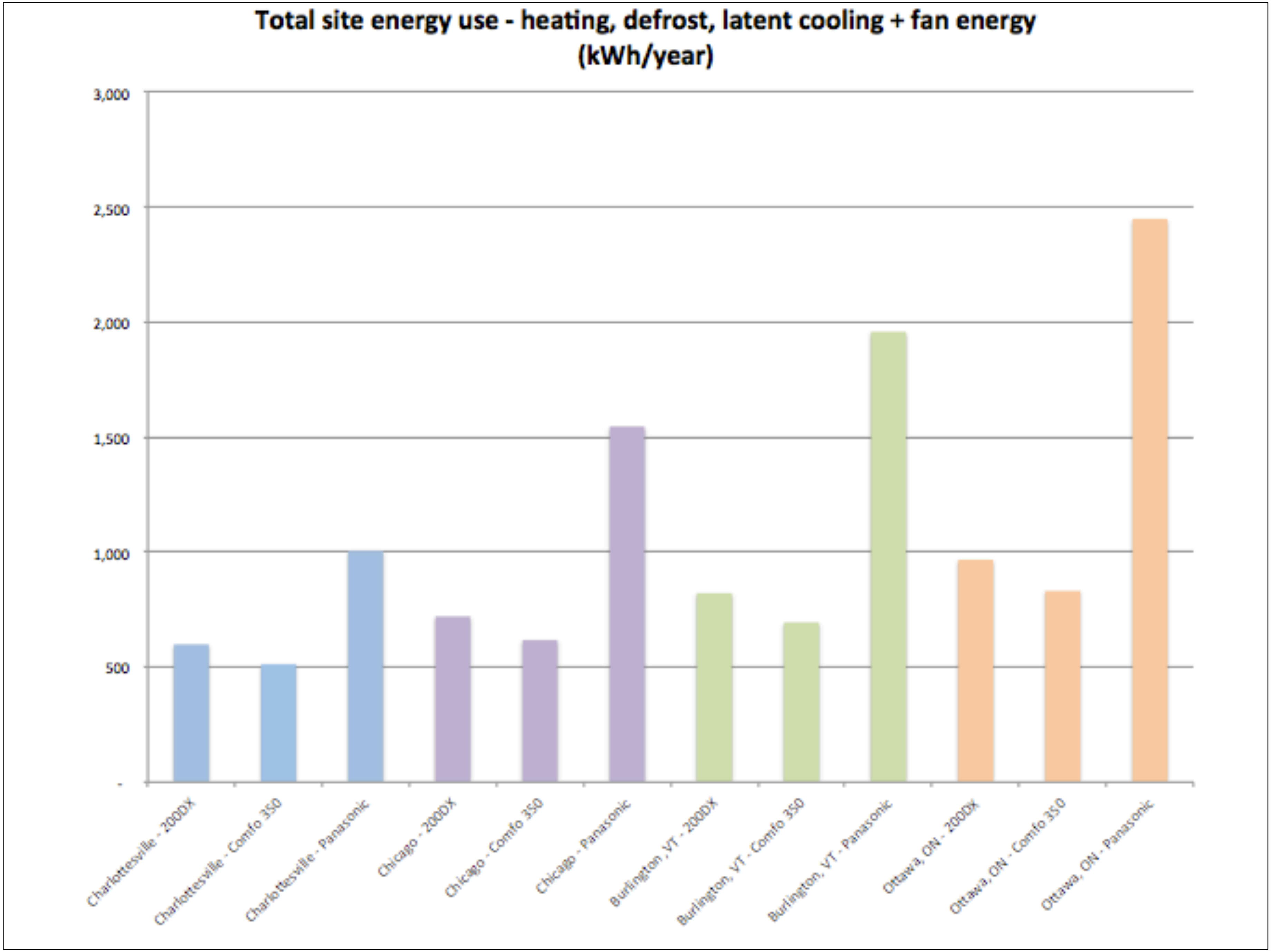

6,000
5,000
4,000
3,000
2,000
1,000
-
Kwh/year
Charlottesville - 200DX
Charlottesville - Comfo 350
Charlottesville - Panasonic
Chicago - 200DX
Chicago - Comfo 350
Chicago - Panasonic
Burlington ,VT - 200DX
Burlington, VT - Comfo 350
Burlington, VT - Panasonic
Ottawa, ON - 200DX
Ottawa, ON - Comfo 350
Ottawa, ON - Panasonic
Ventilation + infiltration annual heat demand (kWh/year)
Fan energy (kWh/year)



Total site energy use - heating, defrost, latent cooling + fan energy (kWh/year)
3,000
2,500
2,000
1,500
1,000
500
-
Charlottesville - 200DX
Charlottesville - Comfo 350
Charlottesville - Panasonic
Chicago - 200DX
Chicago - Comfo 350
Chicago - Panasonic
Burlington, VT - 200DX
Burlington, VT - Comfo 350
Burlington, VT - Panasonic
Ottawa, ON - 200DX
Ottawa, ON - Comfo 350
Ottawa, ON - Panasonic

Economic Analysis - a simplified approach:

1. Use rough estimates for installed system costs (roughly $2,000, $4,000, $5,500)
2. Use exhaust system cost and energy use as baseline
3. For ERV + HRV, calculate incremental upfront system cost divided by lifetime incremental energy savings ($/kWh)
4. Assume 20-year lifetime

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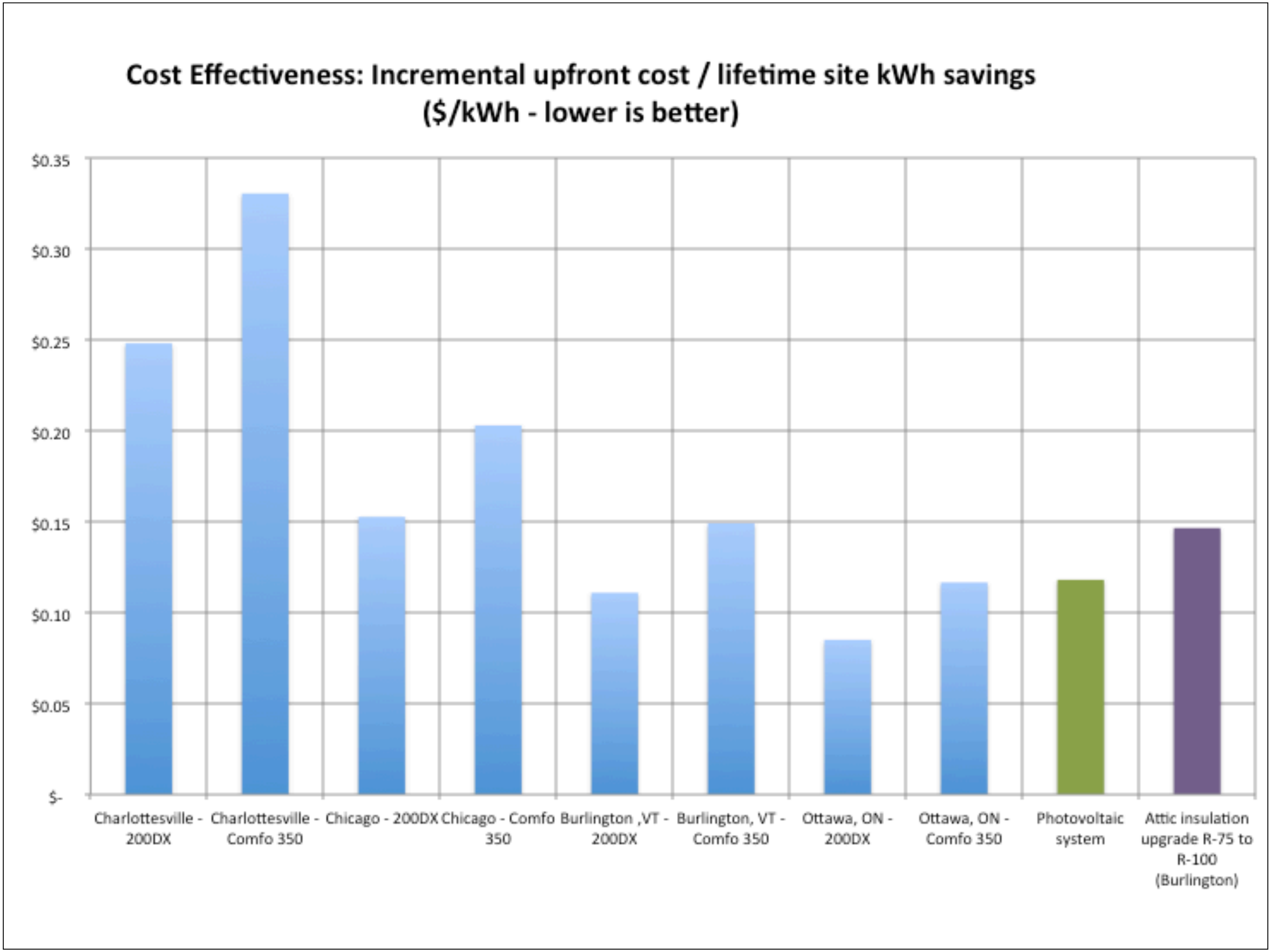
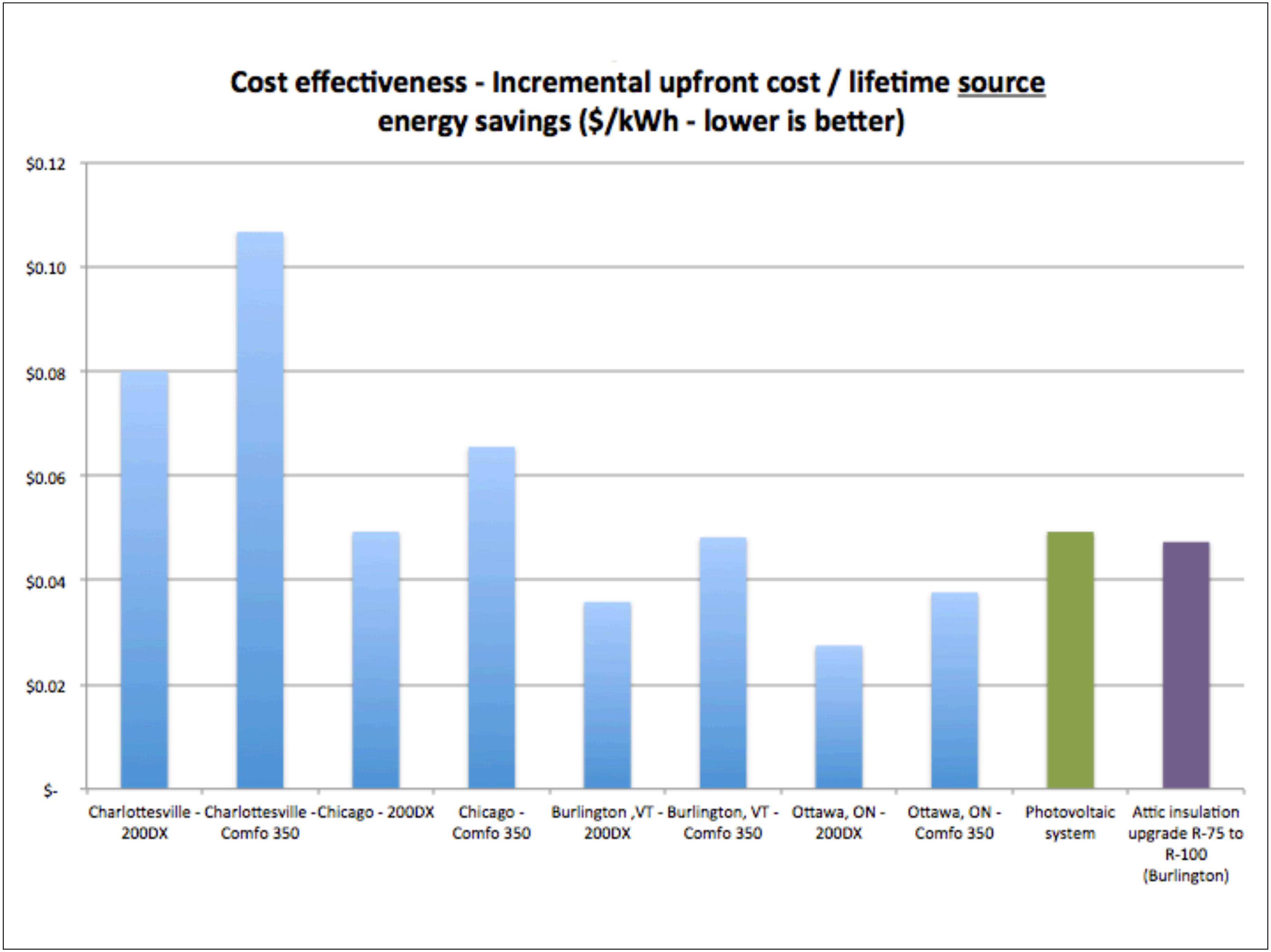


Cost Effectiveness: Incremental upfront cost / lifetime site kWh savings
($/kWh - lower is better)
$0.35
$0.30
$0.25
$0.20
$0.15
$0.10
$0.05
$-
Charlottesville - 200DX
Charlottesville - Comfo 350
Chicago - 200DX
Chicago - Comfo 350
Burlington ,VT - 200DX
Burlington, VT - Comfo 350
Ottawa, ON - 200DX
Ottawa, ON - Comfo 350
Photovoltaic system
Attic insulation upgrade R-75 to R-100 (Burlington)


Cost effectiveness - Incremental upfront cost / lifetime source energy savings ($/kWh - lower is better)
$0.12
$0.10
$0.08
$0.06
$0.04
$0.02
$-
Charlottesville - 200DX
Charlottesville - Comfo 350
Chicago - 200DX
Chicago - Comfo 350
Burlington ,VT - 200DX
Burlington, VT - Comfo 350
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Conclusions:

1. Typical PH HRV/ERV systems do not appear to be particularly cost-effective in the milder climates

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2. We should remove our Passive House blinders and take a closer look at other ventilation options

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3. HRV/ERV manufacturers should "stay in the game" by offering lower cost, lower capacity systems that are more appropriate for the ventilation airflows in modest houses

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Conclusions:

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4. PHIUS certification metrics should not have a de-facto mandate for cost-ineffective mechanical systems. Develop an envelope-only annual heating/cooling demand standard. Relegate mechanical systems to the PE standard only.

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2. We should remove our Passive House blinders and take a closer look at other ventilation options

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Known issues with exhaust systems:

1. Random distribution

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3. House depressurization (safety + health)

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Known issues with exhaust systems:

1. Random distribution
2. Problems with passive air inlets
3. House depressurization (safety + health)
4. House depressurization (building assembly durabilty)

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Known issues with exhaust systems:

1. Random distribution
2. Problems with passive air inlets
3. House depressurization (safety + health)
4. House depressurization (building assembly durability)
5. Discomfort from cold airflow

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Next steps - Charlottesville, VA case study:

4-bedroom spec. house, 2100ft^2

Spring 2013 completion

$360,000 listing price (average $$/ft2 for Charlottesville)

9.0kWh/ft^2 Primary Energy (modeled based on TFA)

Monitor vent. energy use + temp, RH, CO_2 in closed rooms

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Thank you for your attention!

Original paper available for download at:

https://www.dropbox.com/s/mnioslatvohmfam/Exhaust%20ventilation%20v.%20ERV%20Report%20-%20120929.pdf

Questions?

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