The PSPC process for setting low-carbon design targets

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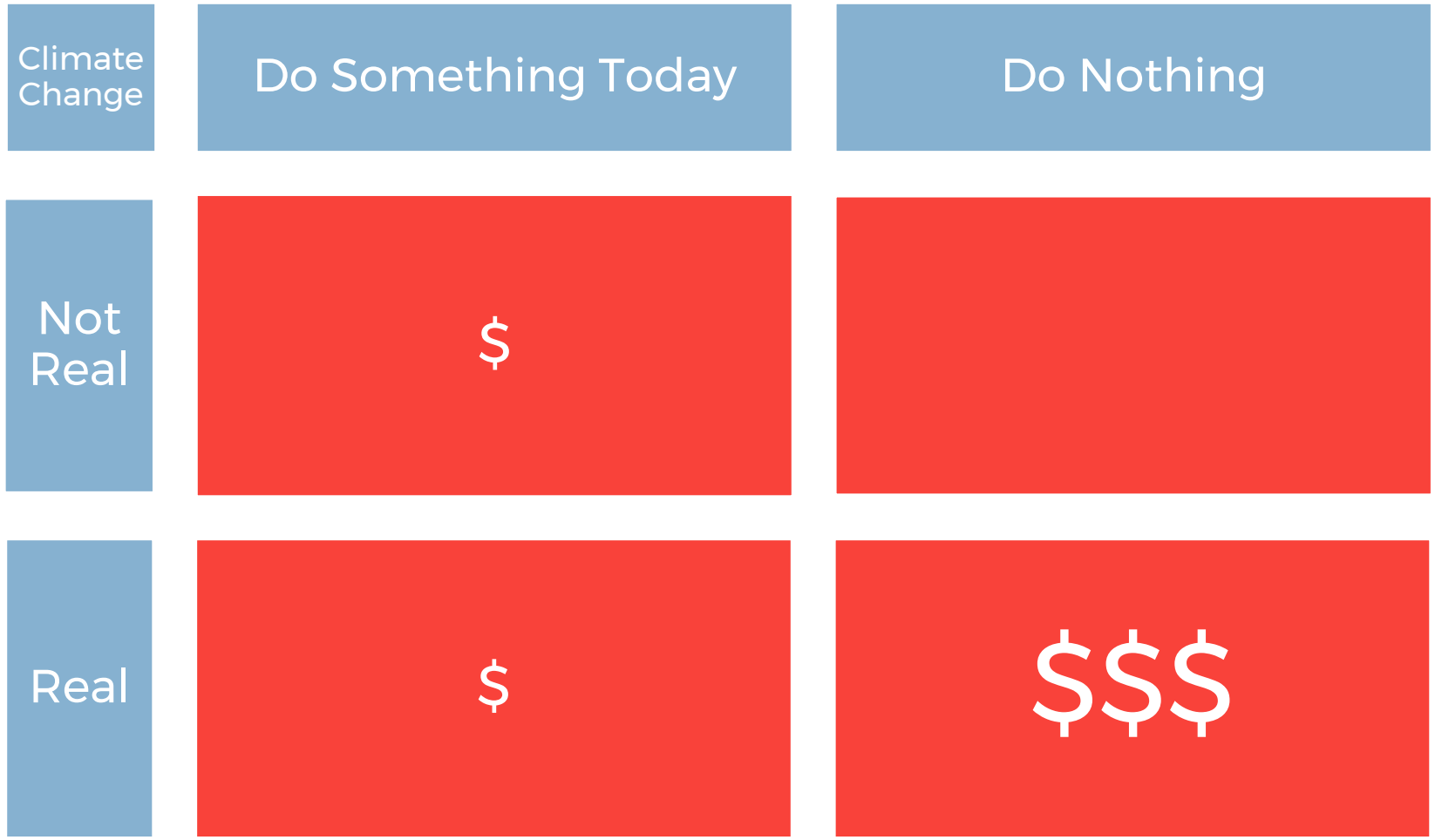
Outline

1. Drivers
2. Key Concepts
3. Methodology
4. Sample GHG Reduction Measures
5. Study Results
6. Conclusion

1. Drivers

Can we make a business case for Carbon Neutral Buildings?

Future Financial Impacts with Climate Change



Drivers

PARIS AGREEMENT

PARIS2015
CONFÉRENCE DES NATIONS UNIES
SUR LES CHANGEMENTS CLIMATIQUES
COP21·CMP11

*Limit temperature increase to **2.0 °C***

PAN-CANADIAN FRAMEWORK

on Clean Growth and Climate Change

Canada's Plan to Address Climate Change and Grow the Economy

***30% reduction** on emissions*

Ontario's Climate Action Goals

* below 1990 greenhouse gas emission levels
** based on the 2016 National Inventory Report

https://www.ontario.ca/page/climate-change-action-plan

Federal Commitments

Greening Government Strategy:

—***By 2050: 80% reduction*** *in GHG emissions from facilities and fleet relative to 2005*

—***By 2022****: all new facilities will be* ***net-zero carbon ready***

PSPC's Real Estate Portfolio:

—*Goal to achieve* ***carbon neutral*** *footprint by 2030*

2. Key Concepts

Natural Gas vs. Electricity in Ontario

	Energy Cost	GHG Emissions
Electricity	$ $ $ $	
Natural Gas	$	

Natural gas has **4-5x** more GHG emissions than electricity (right now)

Electricity costs **4-5x** more than natural gas (right now)

Definition of Carbon Neutrality

ZERO CARBON BALANCE

Emissions

Green Power

Direct

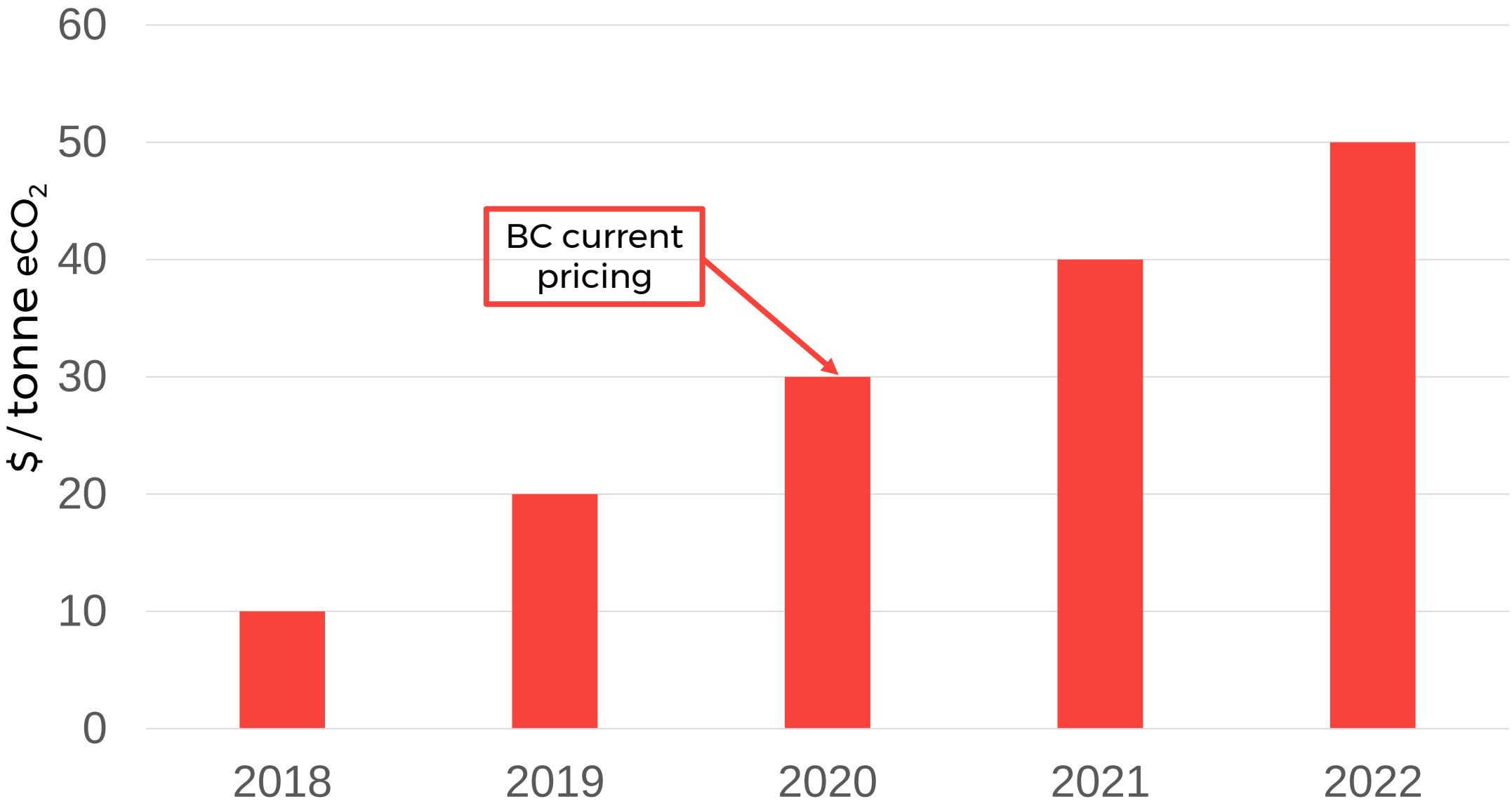
Indirect

Biomass

Offsite

Onsite

Federal Government's Plan for Carbon Pricing



Carbon Pricing

CLIMATE POLICY

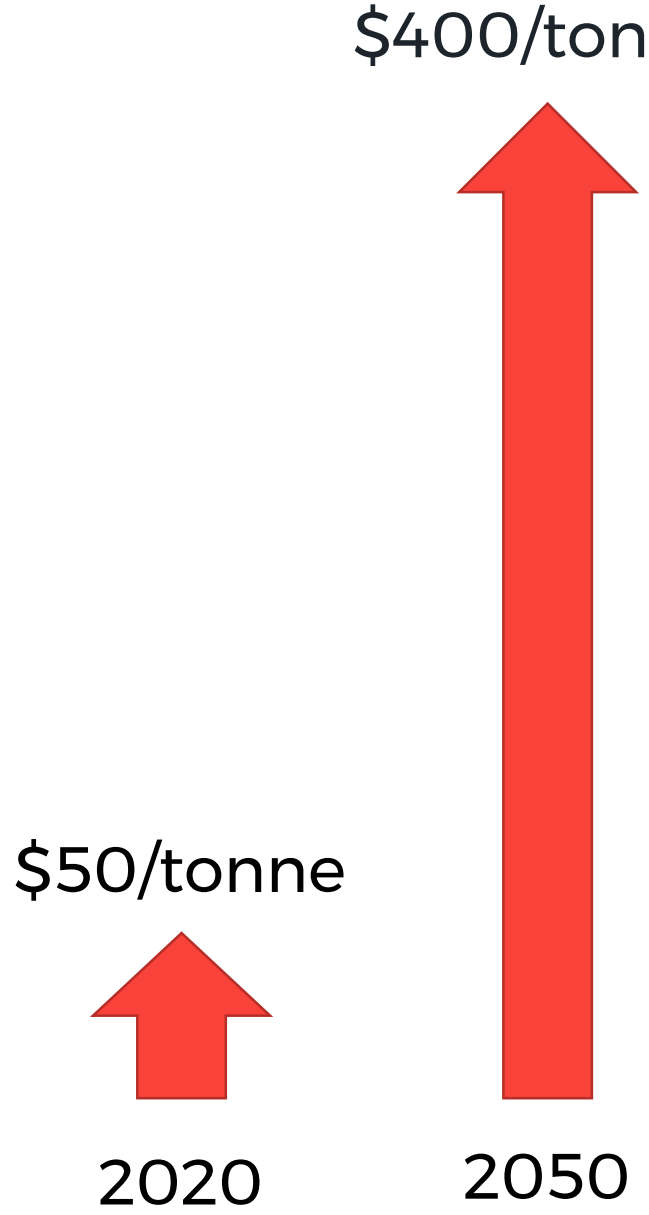
A roadmap for rapid decarbonization

Emissions inevitably approach zero with a "carbon law"

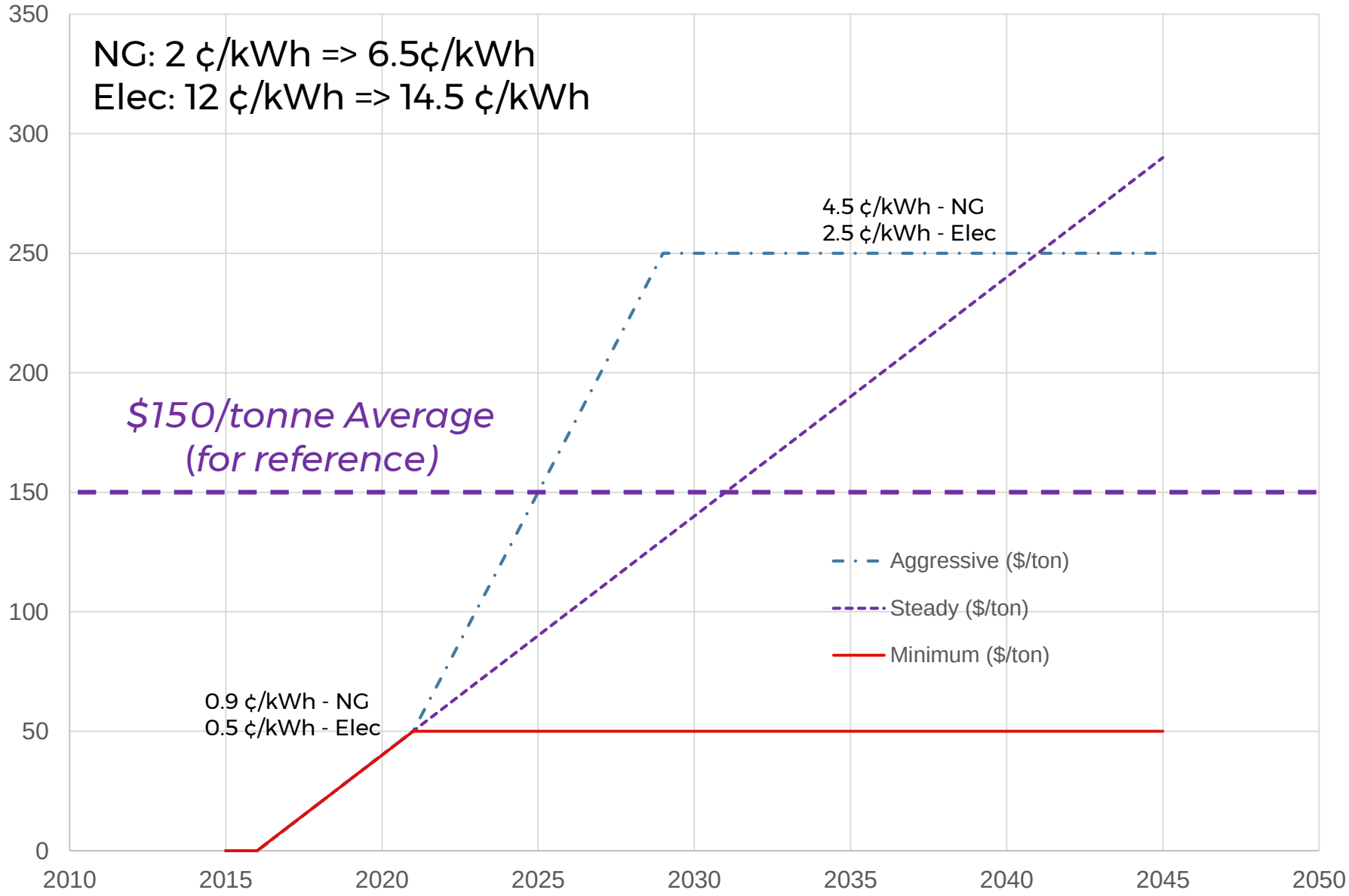
By **Johan Rockström,[1] Owen Gaffney,[1,2] Joeri Rogelj,[3,4] Malte Meinshausen,[5,6] Nebojsa Nakicenovic,[7] Hans Joachim Schellnhuber[1,5]**

Although the Paris Agreement's goals (*1*) are aligned with science (*2*) and can, in principle, be technically and economi- pose framing the decarbonization challenge in terms of a global decadal roadmap based on a simple heuristic—a "carbon law"—of halving gross anthropogenic carbon-dioxide (CO_2) emissions every decade. Complemented by immediately instigated, scalable carbon removal and efforts to ramp down land-use CO_2 emissions, this can lead to net-

Science, 2017, 355:6331, pp 1269-71

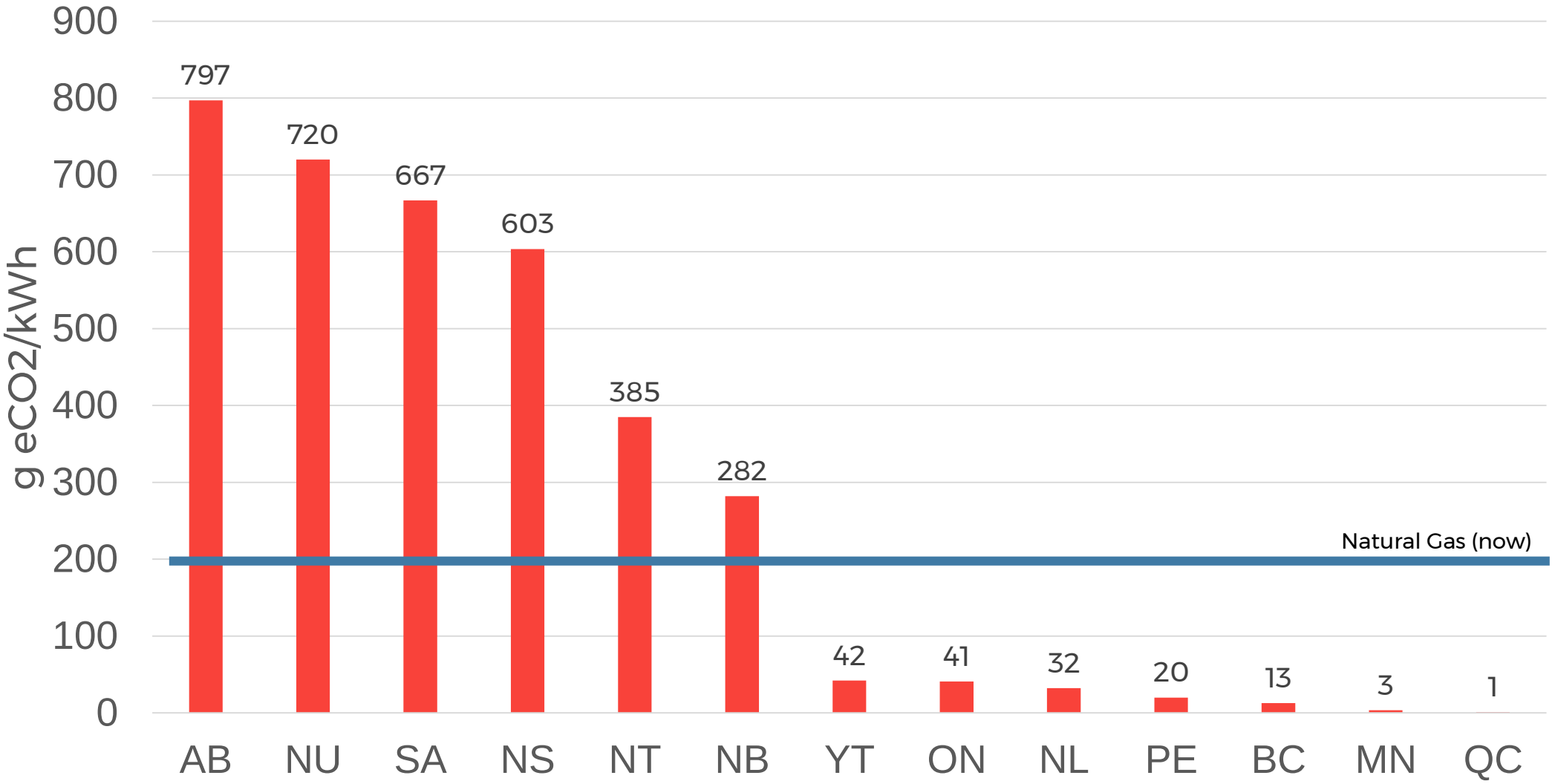


Carbon Pricing after 2022?



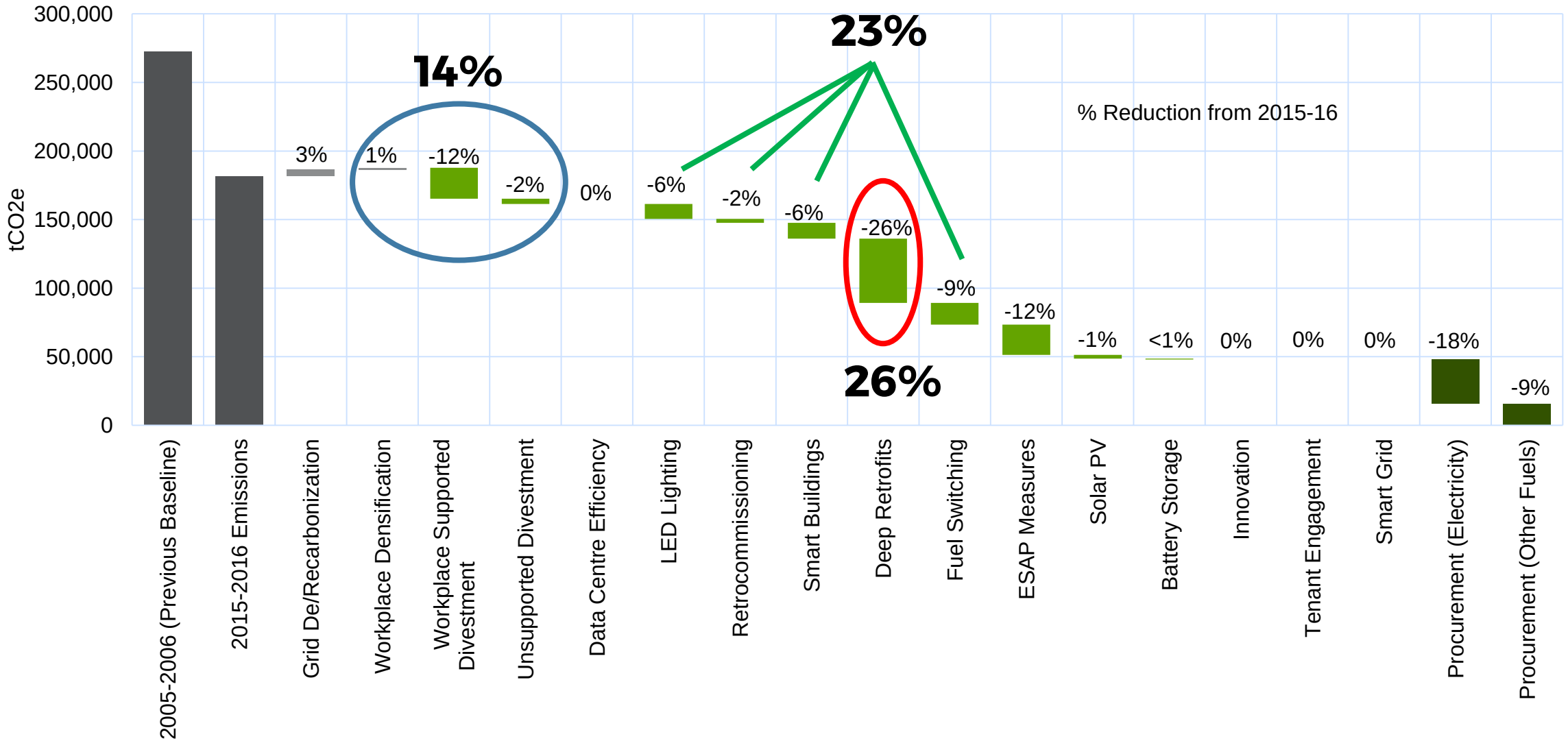
Source: National Round Table on the Environment and the Economy

Electricity Grid Carbon Intensity Province-by-Province (2015)



2. Methodology

Portfolio Level: PSPC National Perspective



PSPC's Priorities for Carbon Neutrality

Efficiency first

Strategic fuel switching
Installation of renewables on-site

Procurement of off-site renewables (e.g., RECs)

Process Followed

(Multi-Disciplinary Project)

Process Followed
(Multi-Disciplinary Project)

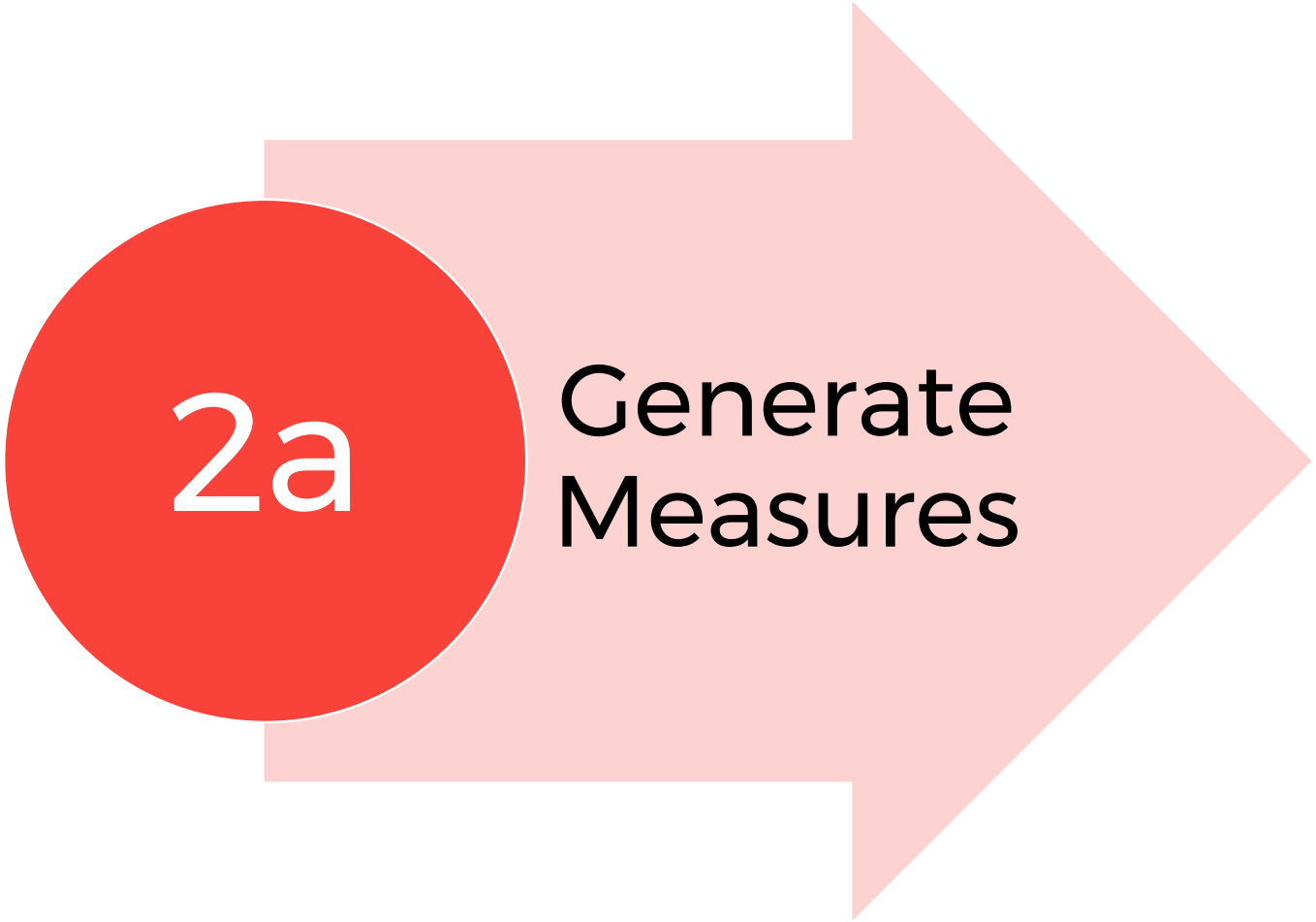
1

- Define Code Reference
- Define Minimum

Option 1: Minimum Departmental Commitments

- 24%-28% better than NECB 2015
- LEED v4 BD+C Silver/Gold Certification
- PSPC Technical Reference for Office Buildings

Process Followed
(Multi-Disciplinary Project)

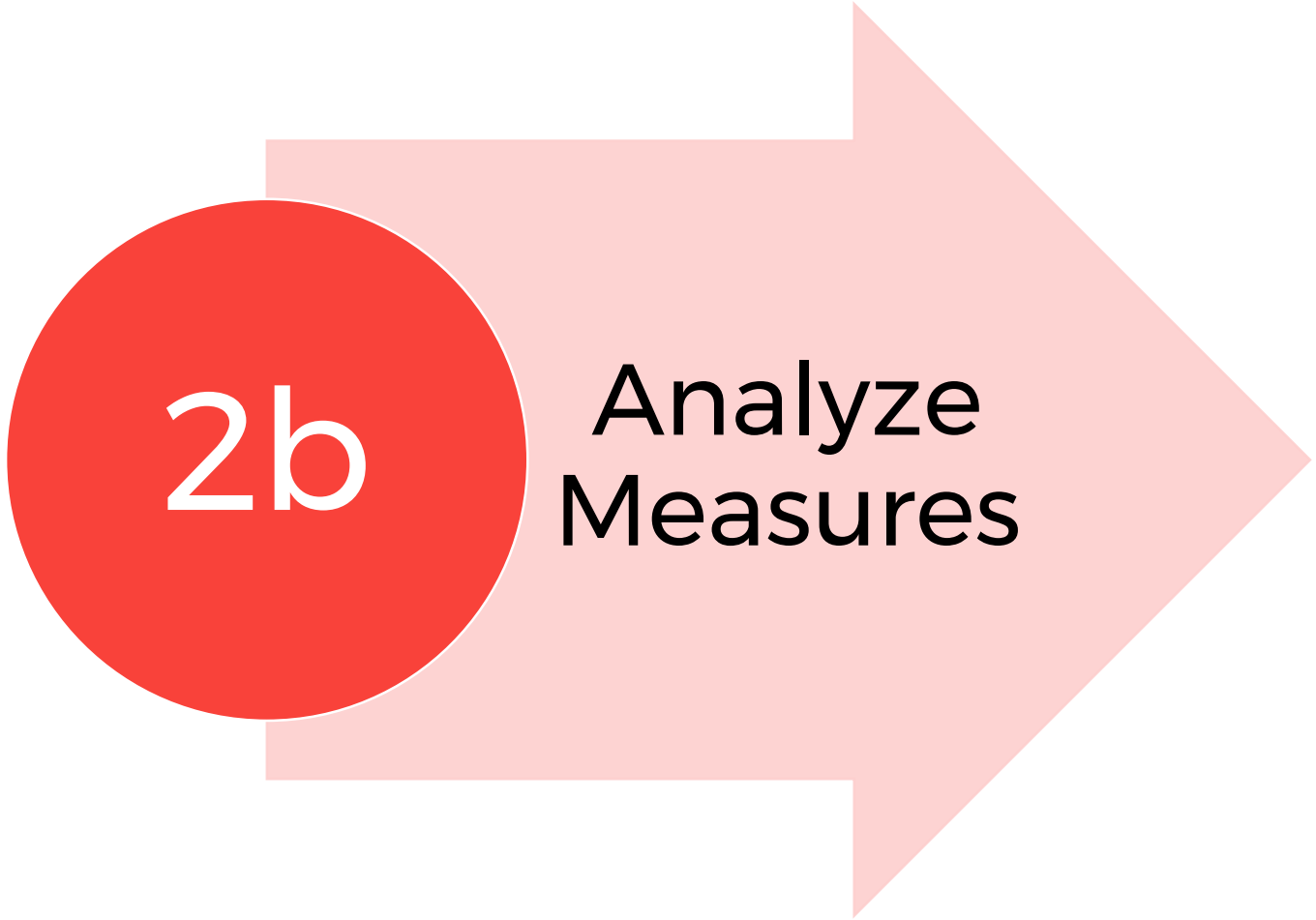


30-40 Measures

- Enclosure
- Space
- HVAC – Delivery
- HVAC – Plant
- Renewable Energy

*Including "**Moonshot**" Ideas.*

Process Followed
(Multi-Disciplinary Project)



Detailed Analysis

- *GHG Reduction Potential*
- *Energy Savings*
- *Financial Metrics*
- Occupant Health & Comfort
- Cost & Operational Risk
- Schedule Impact

Process Followed
(Multi-Disciplinary Project)

3

Package and Analyze Options

Option 2
Design to achieve Cost-Neutral (25 years – NPV) GHG Reductions

Option 3
Design to Achieve Maximum GHG Reductions

Option 4
Hybrid GHG Emissions and Reductions Design

Best value for YOUR money.

Performance Metrics

Thermal Energy Demand Intensity (TEDI)

Unit: kWh/m²

Indicates enclosure & HVAC delivery perf.

$$\frac{Heating\ load}{Gross\ floor\ area}$$

Total Energy Use Intensity (TEUI)

Unit: kWh/m²

GHG Intensity (GHGI)

Unit: kg eCO_2/m²

Incremental Capital Cost

Incremental Life Cycle Cost

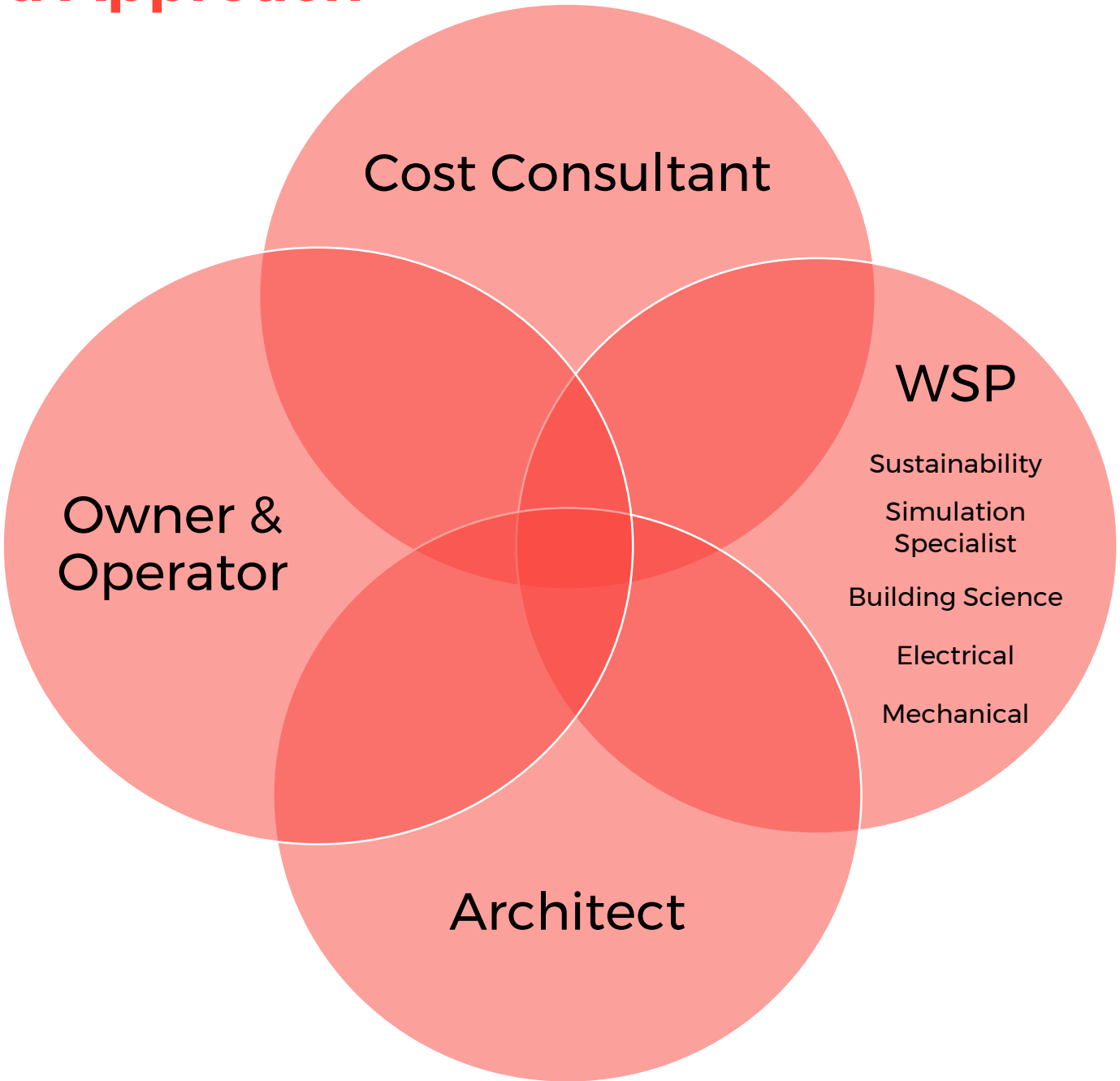
Incremental Life Cycle Costing (LCC)

25 year study

Variables assessed:

- *Inflation*
- *Discount rate*
- *Capital cost (and replacement cost)*
- *Operations and Maintenance (O&M) costs*
- *Energy cost and future increases*
- *Carbon price*

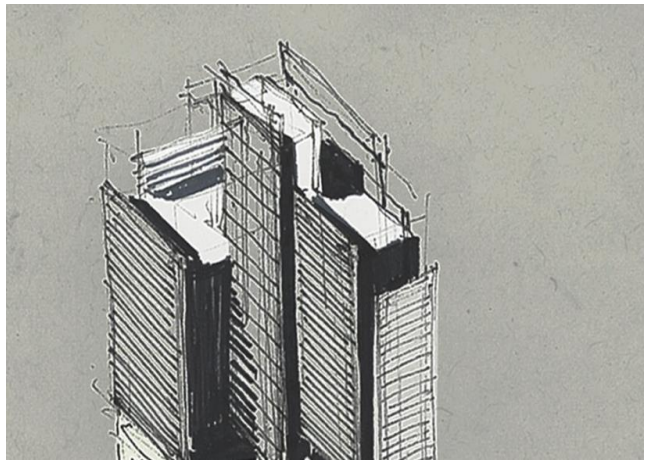
Integrated Approach

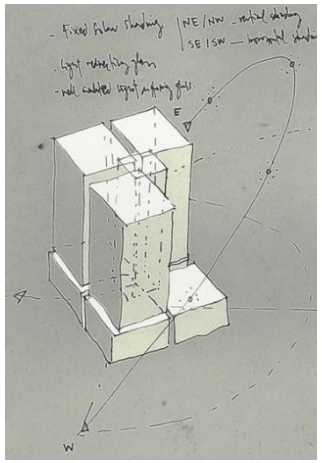


Case Study 1: Major Retrofit Ottawa, ON

Space Type	Commercial office
Size	72,000 m^2 10 Storeys
Min. Targets	➢ LEED v4 Silver ➢ 40% reduction in carbon

Case Study 2:
New Construction / Expansion
Vancouver





Space Type	Commercial office
Size	96,600 m^2 36 Storeys
Features	➢ Use of Wood ➢ Central Atrium ➢ Major Expansion
Min. Targets	➢ 2025: 100 ekWh/m^2 ➢ LEED v4 Gold

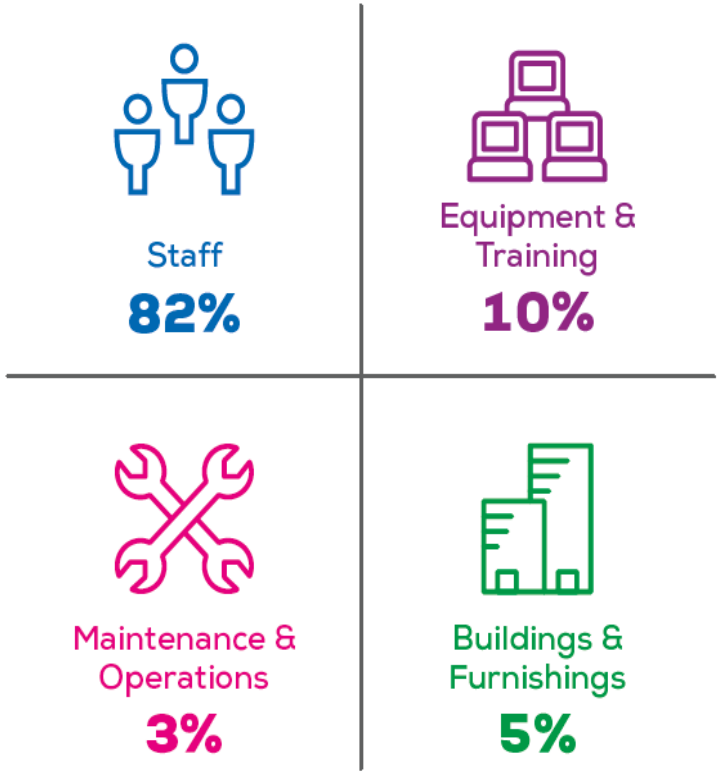
kasian
WSP

2. Measures

New Building

Space Measures – Future Workplace

Use the buildings part of the budget to enhance the salaries and benefits part of the budget.

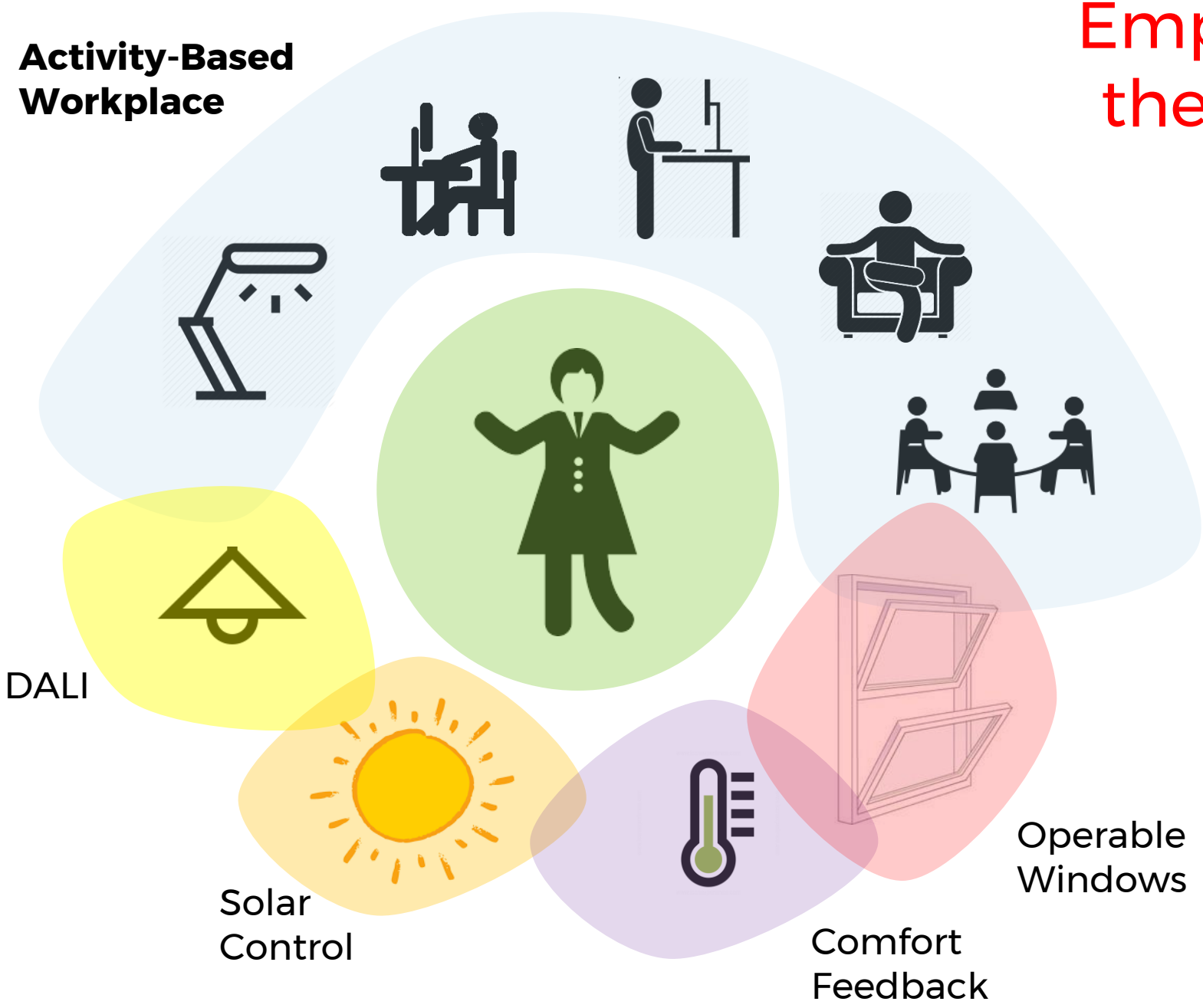


Brill, Weidemann, & BOSTI Associates, 2001

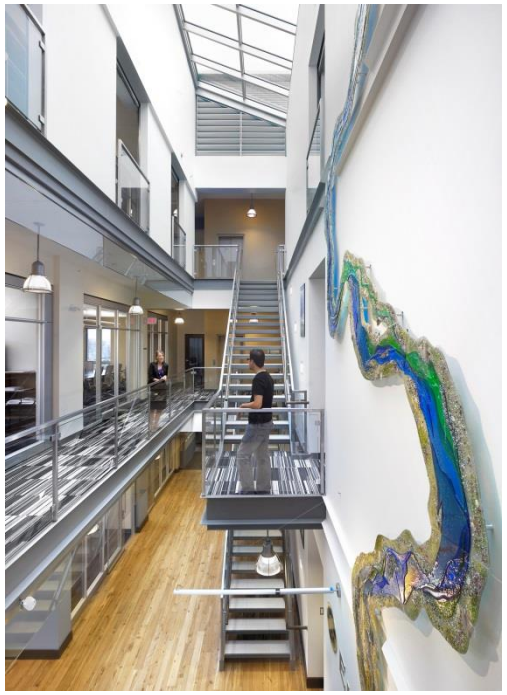
Space

Empower the User

Activity-Based Workplace

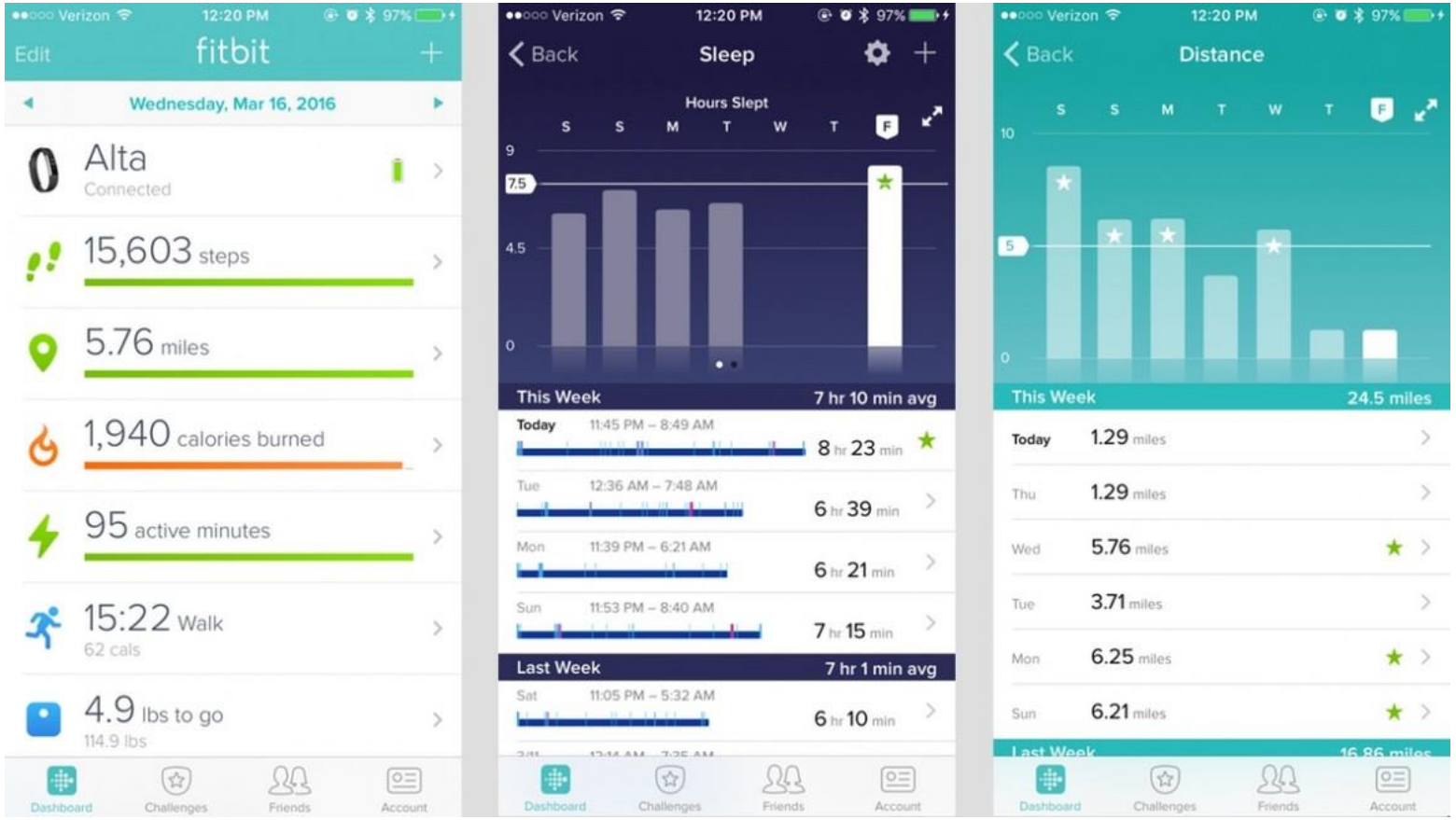


Space



Space

Empower the User



Overall performance (R-Value) matter's most!

— *Window-to-wall ratio (WWR)*

— *Window performance*

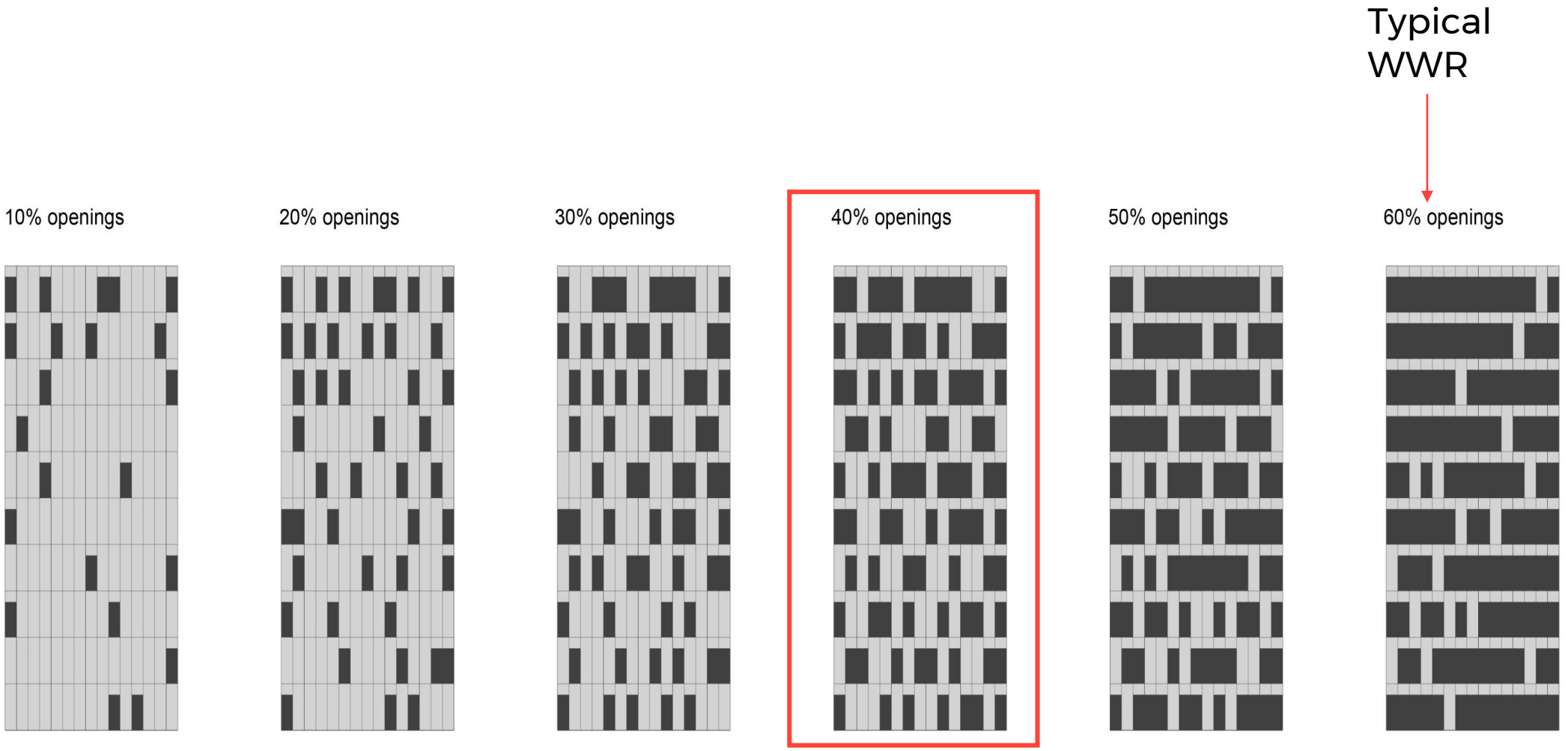
— *Opaque wall performance*

— *Thermal bridging*

Aim for overall min. average of R-6 to R-10
Many office towers are around R-3

Enclosure

Overall performance (R-Value) matter's most!

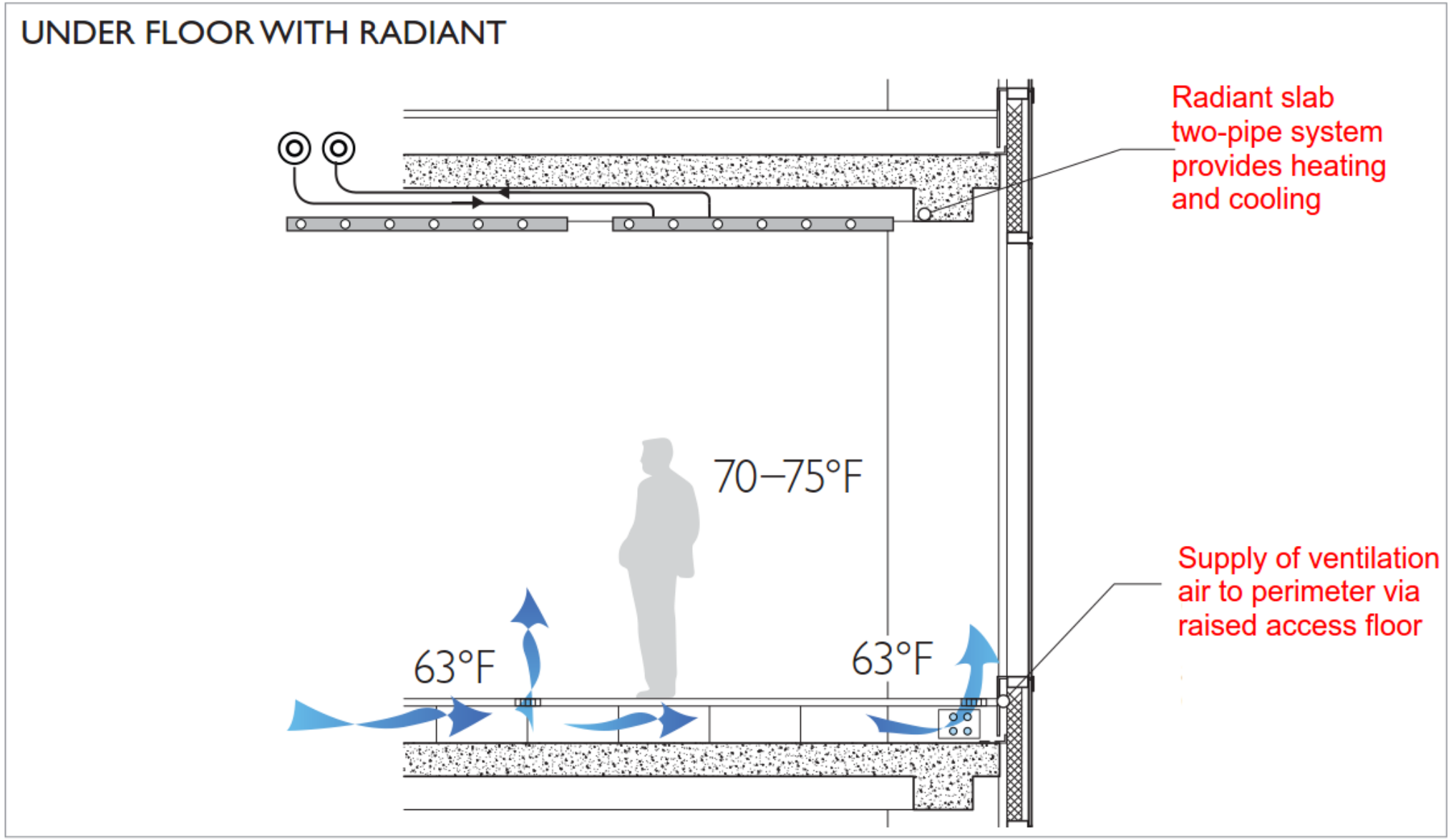


General HVAC Trends

1. Separate systems for separate purposes/usage patterns (e.g. core and perimeter systems in office)
2. User-responsive
3. Very low power (i.e. fans and pumps)
4. Low-exergy or “Near-temp”: high-temp cooling, low-temp heating

HVAC - Delivery

Under Floor Ventilation w/ Radiant slab/panels

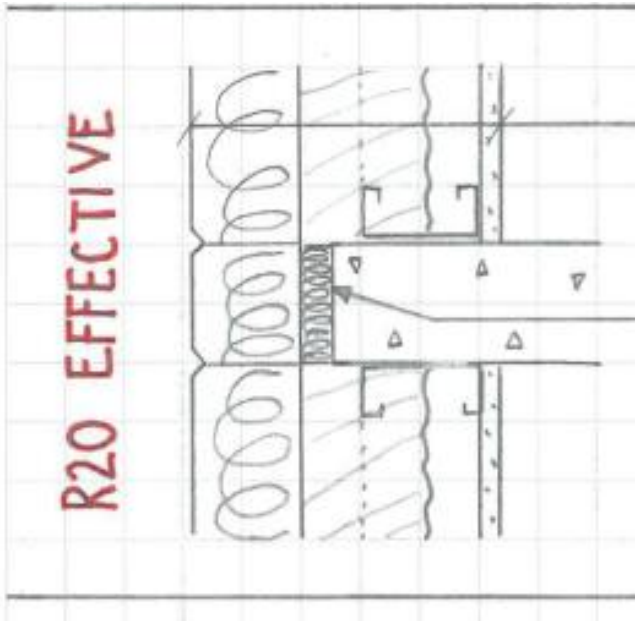


Linking HVAC with Envelope

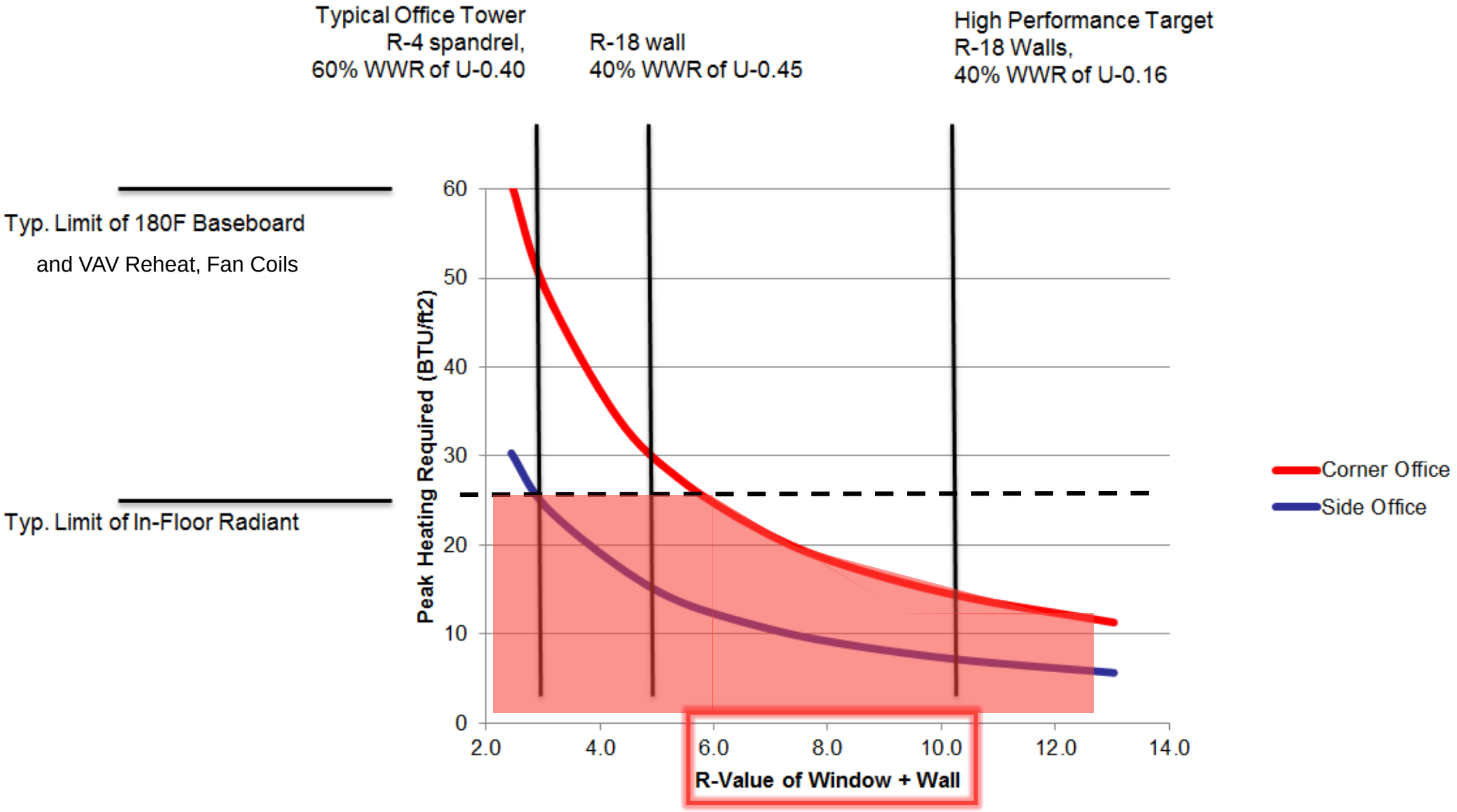
Improved envelope reduces HVAC sizing

Results in HVAC capital cost savings

Good enclosures required for high performance HVAC



Enclosure Performance and HVAC – Heating



Plant Options Summary

Boiler:

- *Natural Gas (94% efficient)*
- *Biomass (85% efficient)*
- *Electric (100% efficient but expensive!)*

Heat Recovery Chiller

- *Data Centers*
- *Exhaust air*

Air-source Heat Pump:

- *Average COP Heating: 2.5-3.0*
- *Average COP Cooling: 4.0-5.0*

Geo-exchange system:

- *Average COP Heating: 3.5-4.0*
- *Average COP Cooling: 5.0-6.0+*

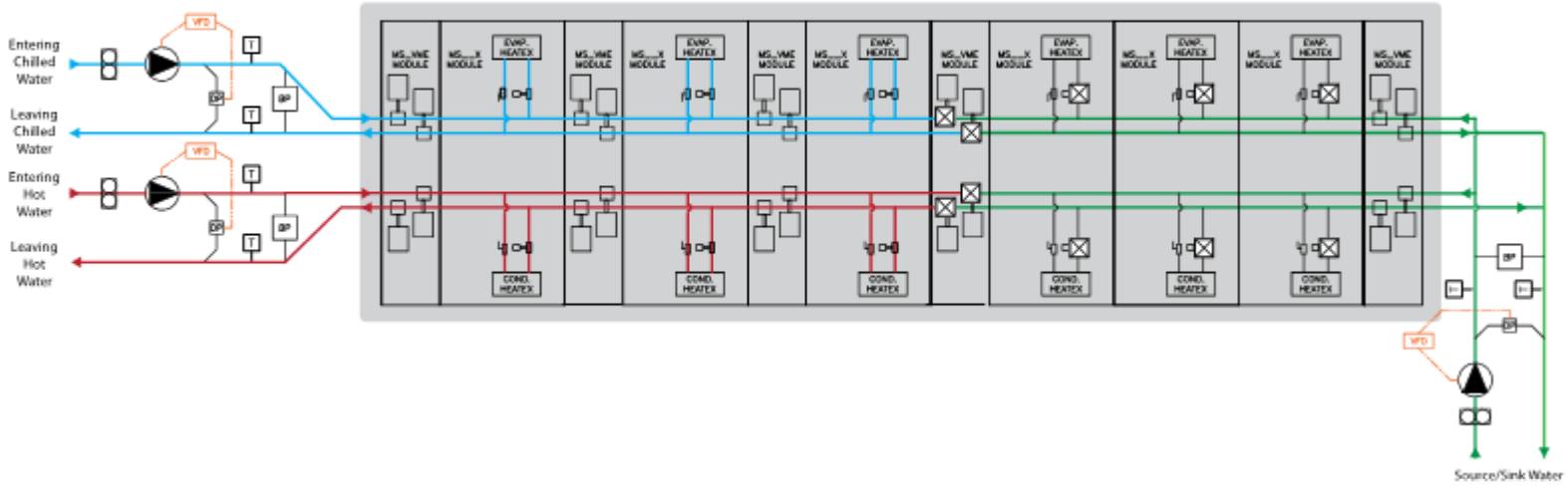
HVAC Plant

Plant Options Summary

MULTISTACK

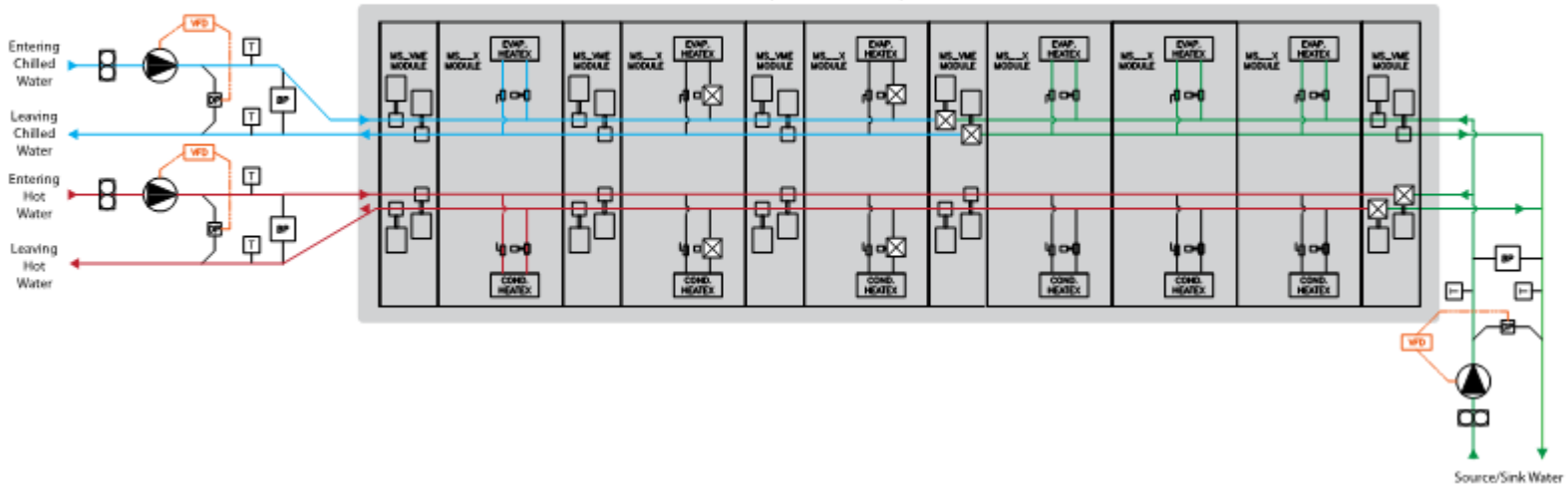
Simultaneous Mode

3 Cooling, 3 Heating



Heating Dominant Mode

1 Cooling, 4 Heating

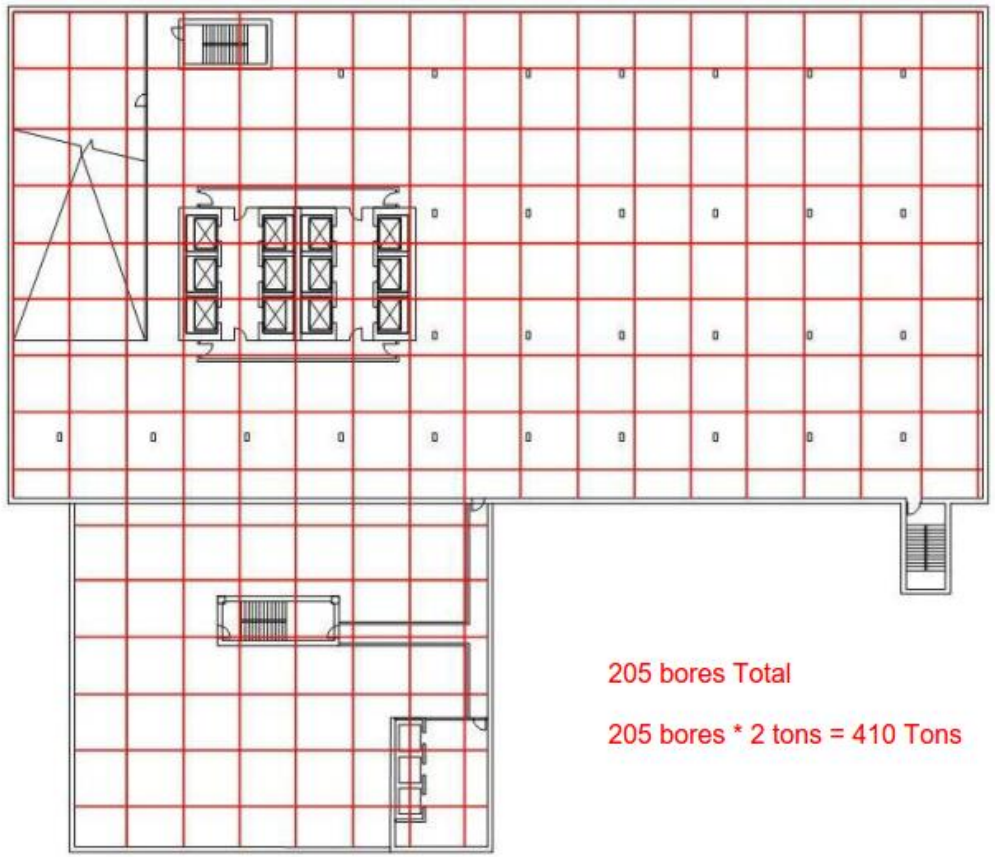


HVAC Plant

Geothermal

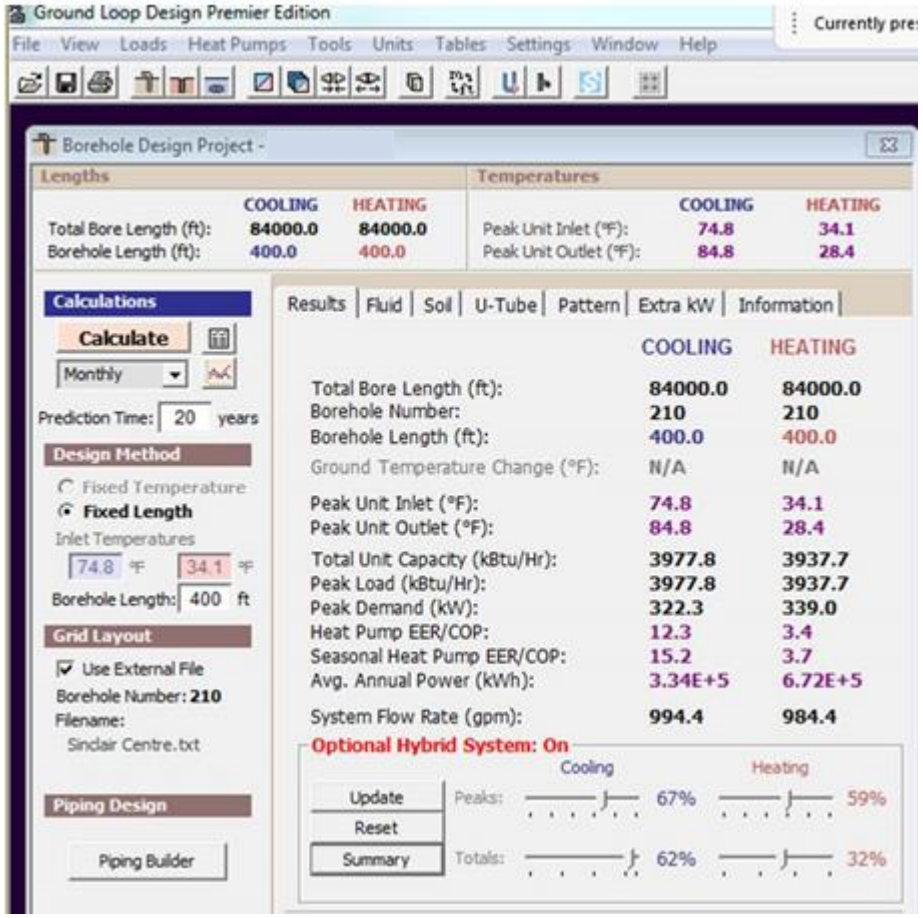
Ground Source

*The assumption is the excavation site containing the ground source loop will include the Parking lot and new B2 mechanical only.



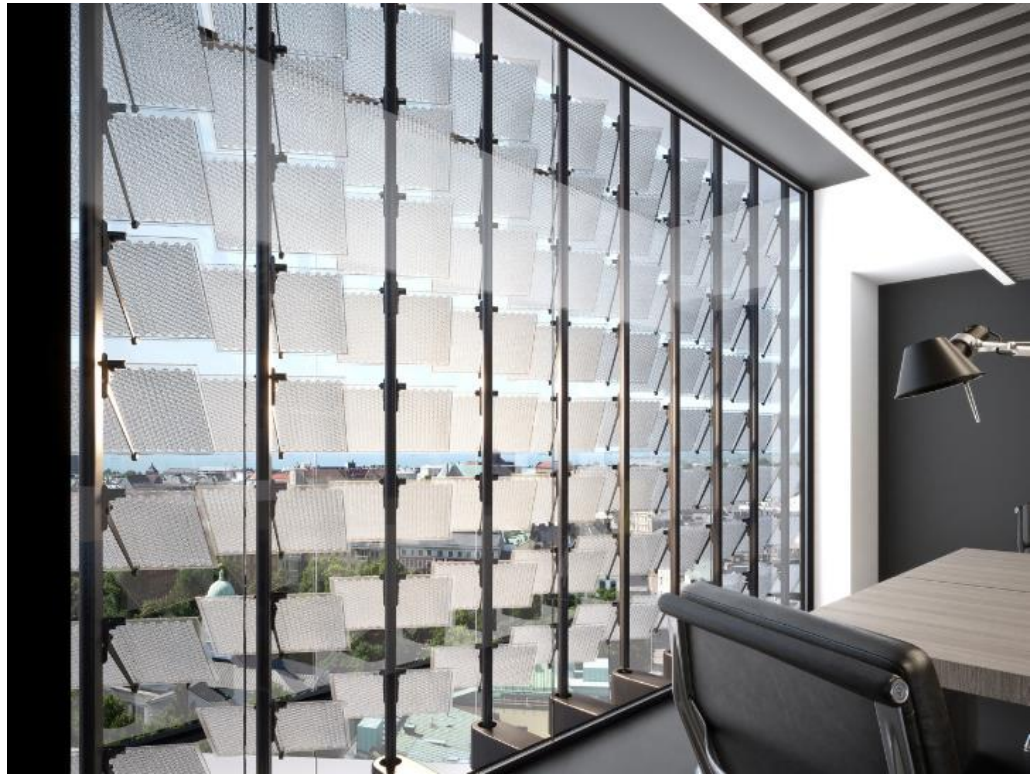
205 bores Total

205 bores * 2 tons = 410 Tons



Photovoltaics

Rooftop



Building Integrated

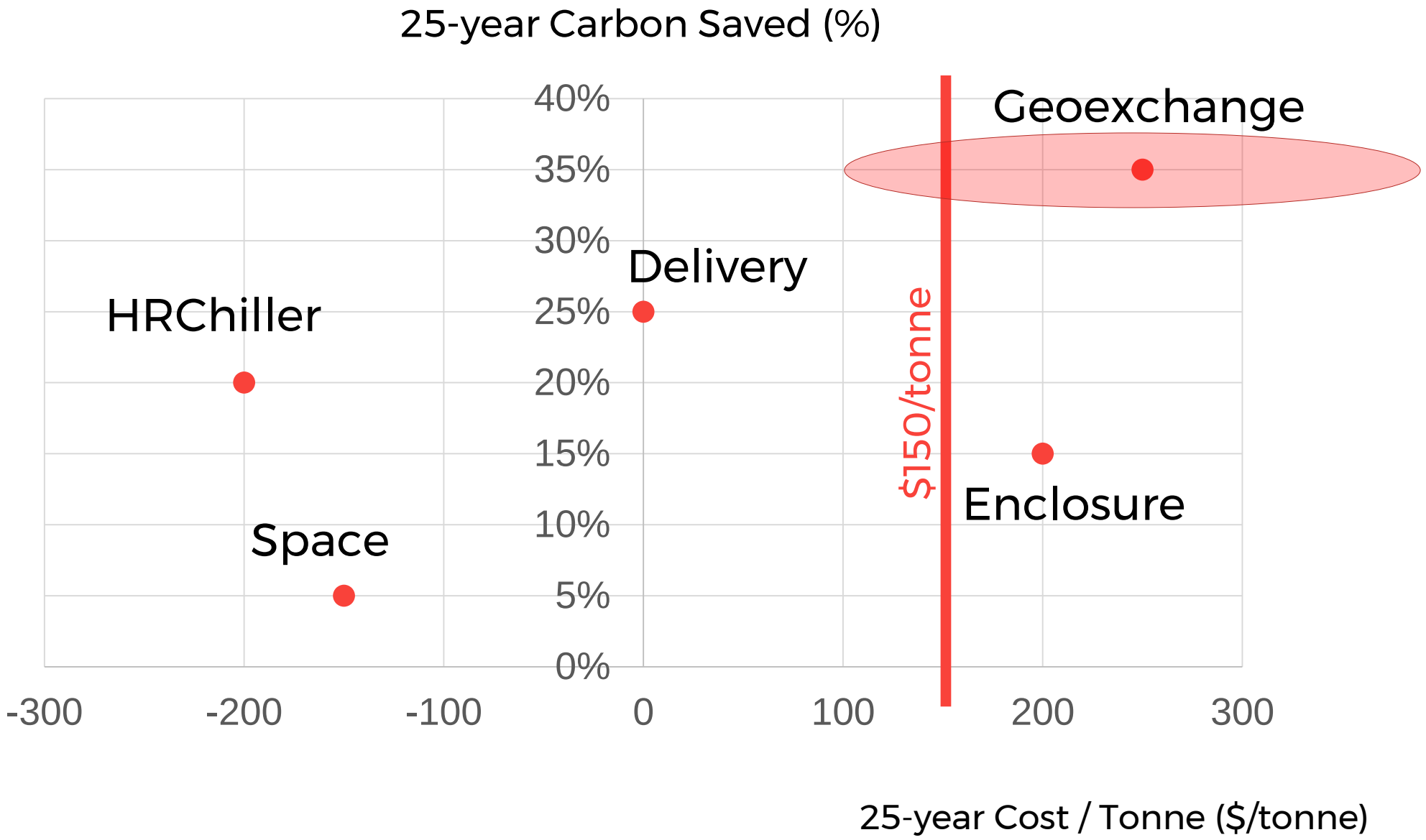
“Moonshots”

1. **New innovations in existing industries**, especially Canadian-made (e.g. Morgan Solar panels)
2. **Uncommon and/or newer products or systems** (e.g. phase change materials, electrochromic glass, hybrid VRF)
3. **Uncommon sources/sinks for heating and cooling** (e.g. lakes, rivers, waste-water)
4. **New sources of low-carbon energy** to the buildings industry (e.g. hydrogen fuel cell, wind generation, biogas generation)
5. **Load-shifting technologies** (e.g. batteries, flywheel, thermal storage)
6. **Carbon capture** (e.g. algae)

What opportunities exist in the geo-exchange industry?

3. Results

CAUTION! SOMEWHAT SPECULATIVE!!



New Building

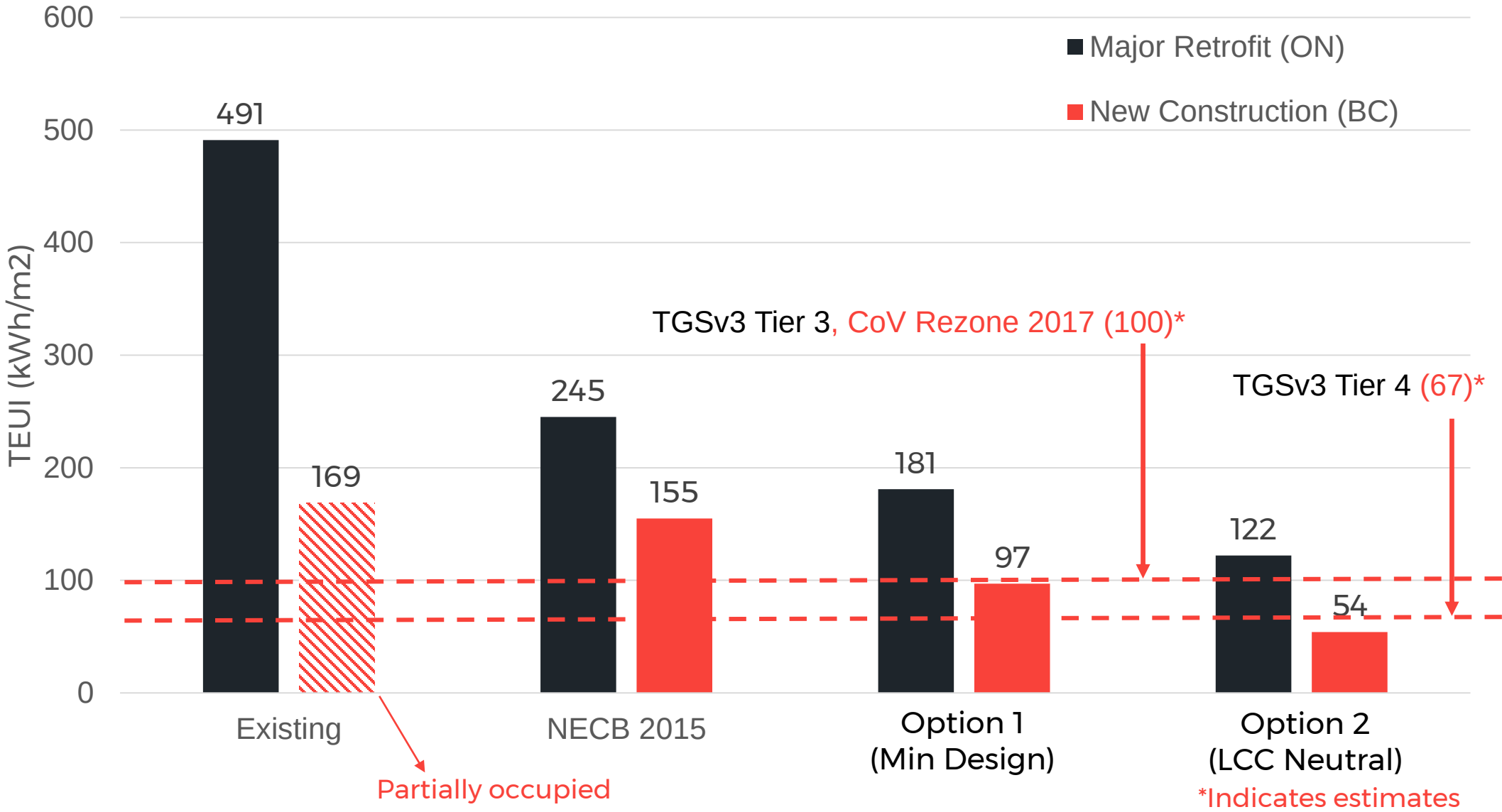
Results – Package Summary

Item	NECB 2015	Option 1 Min Design	Option 2 LCC Neutral	Option 3 Max. GHG Reduction	Option 4 Hybrid
Enclosure	40% WWR R-5	60% WWR R-5	40% WWR R-11	40% WWR R-11 Electrochromic Daylight redirect	40% WWR R-11 Electrochromic SW Fixed shading
Space	Fluorescent	LED	LED	LED User Feedback DALI control Direct/Indirect Ltg Desk plug shut-off	LED User Feedback DALI control
HVAC – Delivery	VAV System	High performance VAV with DCV	Core VAV Perim. HRV (0.75) Radiant Slab	Core UFAD Perim. UFAD HRV Radiant Slab Atrium Lung Natural Ventilation	Core UFAD Perim. UFAD HRV Radiant Slab Atrium Lung Assist Nat. Vent.
HVAC - Plant	Gas Boiler (83%) Centrifugal Chiller	Cond. Gas Boiler (92%) Mag. Bearing Chiller	Cond. Gas Boiler (92%) Heat Recovery Chiller	Central heat pump Geo-Exchange Biomass Peak Boiler	Central heat pump Geo-Exchange Gas Peak Boiler
Renewables	No PV	No PV	No PV	Rooftop PV BIPV 11% Total energy use	Rooftop PV BIPV 5% Total energy use

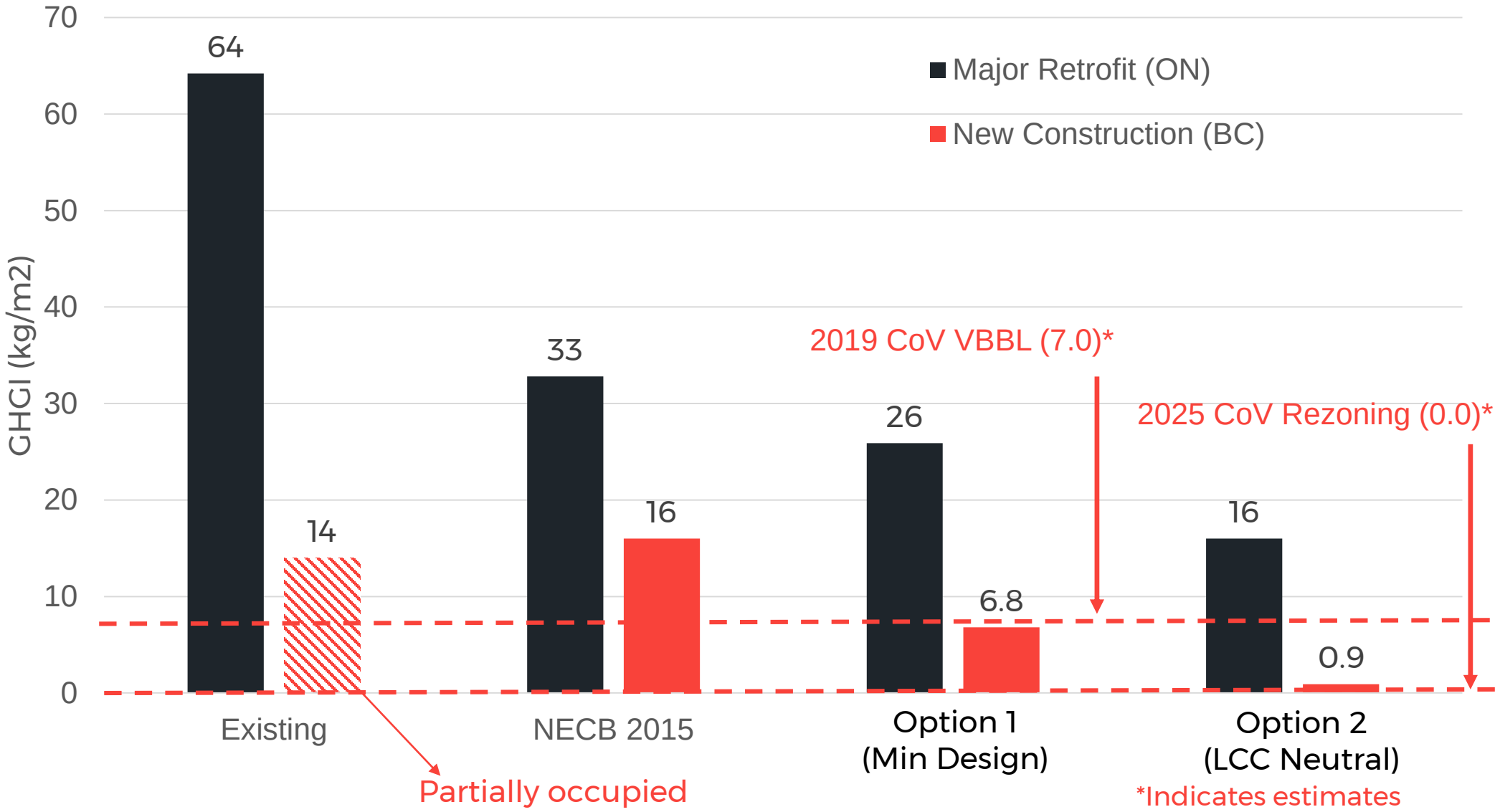
Comparative Features – Option 2 (LCC Neutral)

Item	New Construction (BC)	Major Retrofit (ON)
Enclosure	40% WWR R-10.8 Advanced Solar Control (Electrochromic glass)	33% WWR Overall R-8
Space	LED Advanced lighting control	LED Advanced lighting control
HVAC – Delivery	Core UFAD Perim. UFAD HRV Radiant Slab	Core VAV Perim. DOAS HRV Perim. Active beams
HVAC - Plant	Heat Recovery Chillers Gas Condensing Boilers Magnetic Bearing Chiller	Exhaust Air Heat Recovery Chillers District Energy HW and CHW
Renewables	No PV	4% PV generation rooftop

Results – Total Energy Use Intensity (TEUI)



Comparative Results - GHGI



Comparative Financial Results

Option 2 (LCC Neutral)
Low Carbon

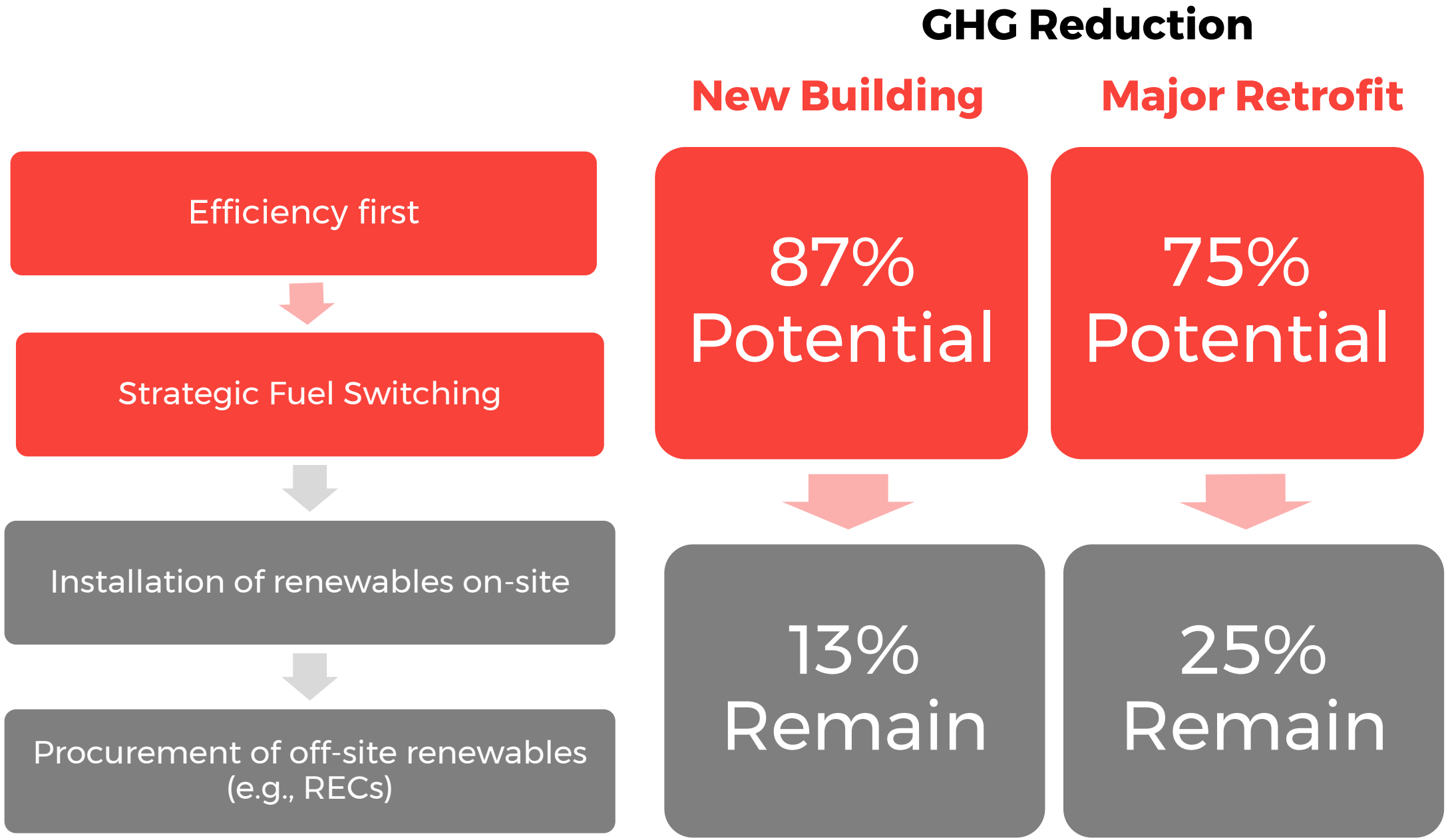
	New Construction (BC)
Incremental Capital Cost (year-2026)	0.7%
Incremental LCC (year-2026)	-0.6%
Carbon Savings	87% vs. Opt 1 (82% vs. Existing)

Comparative Financial Results

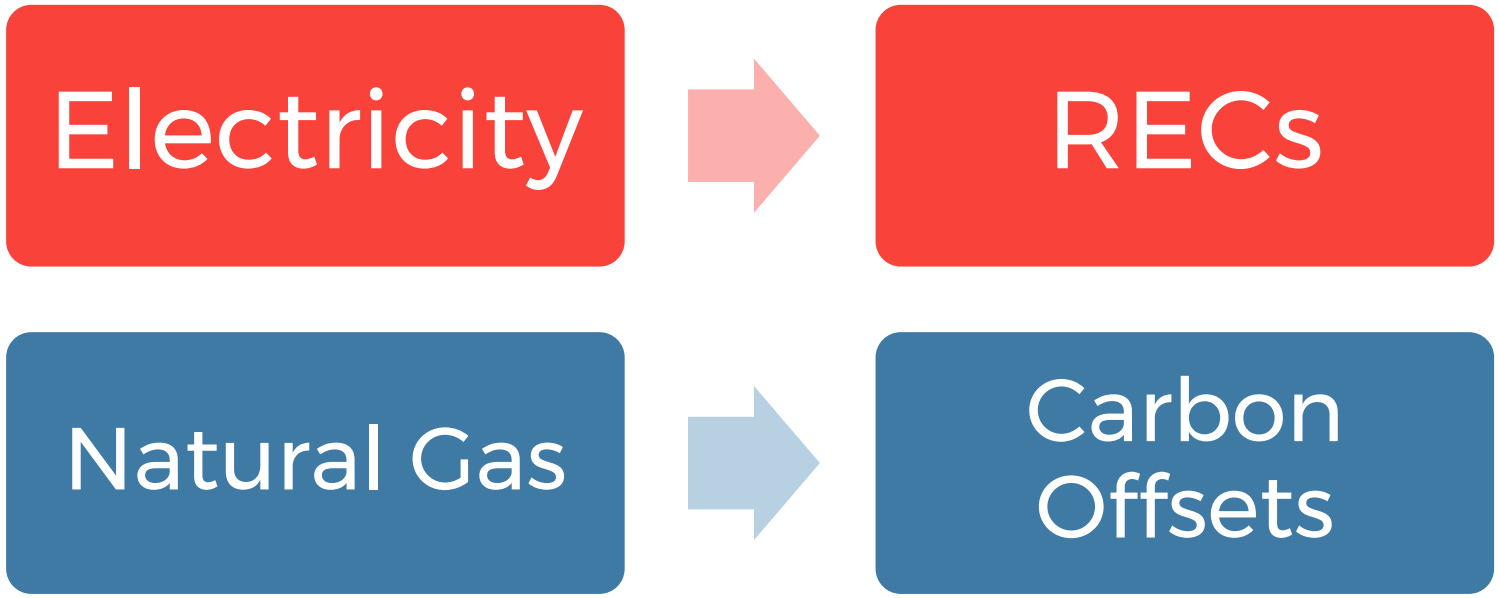
Option 2 (LCC Neutral)
Low Carbon

	New Construction (BC)	Major Retrofit (ON)
Incremental Capital Cost (year-2026)	0.7%	2.5%
Incremental LCC (year-2026)	-0.6%	0.3%
Carbon Savings	87% vs. Opt 1 (82% vs. Existing)	38% vs. Opt 1 (75% vs. Existing)

Gap to Zero Carbon



Renewable Energy Credits (RECs) and Offsets



Two options: buy from Canada or USA?

- *Canada is at least 2x more expensive*
- *Canadian RECs and offsets are used in the next example*

Comparative Financial Results

Option 2 (LCC Neutral)

Zero Carbon

	New Building		Major Retrofit	
	Low-carbon	Zero carbon	Low-carbon	Zero carbon
Incremental LCC (year 2026)	-0.6% →	-0.4%	0.3% →	0.8%
Carbon Savings	87% →	100%	75% →	100%

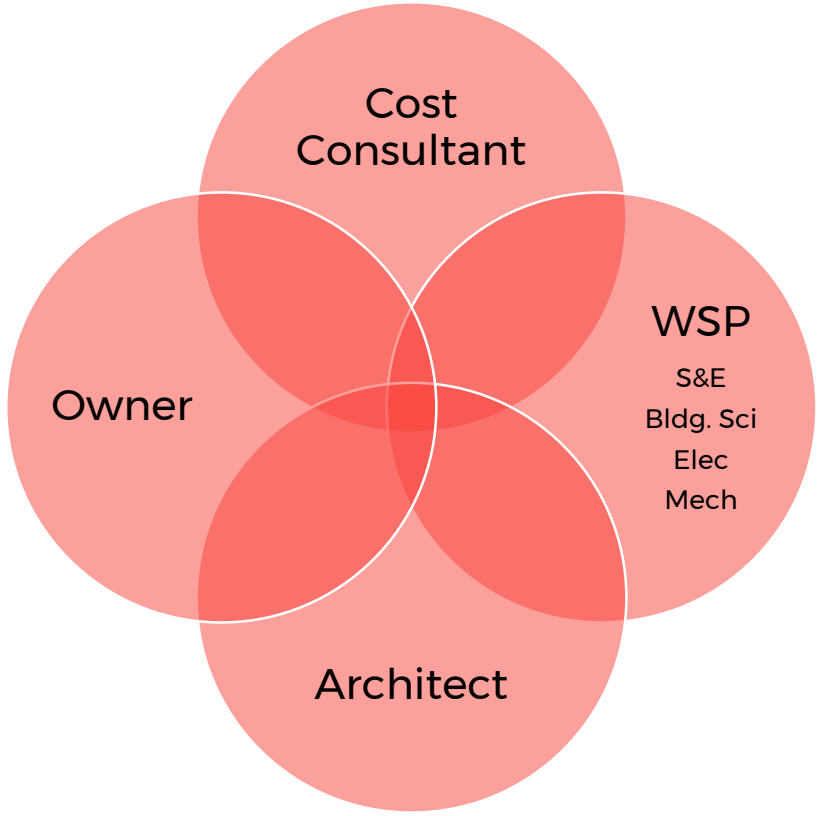
4. Conclusions

1. Technologies are Available Today

Efficiency first

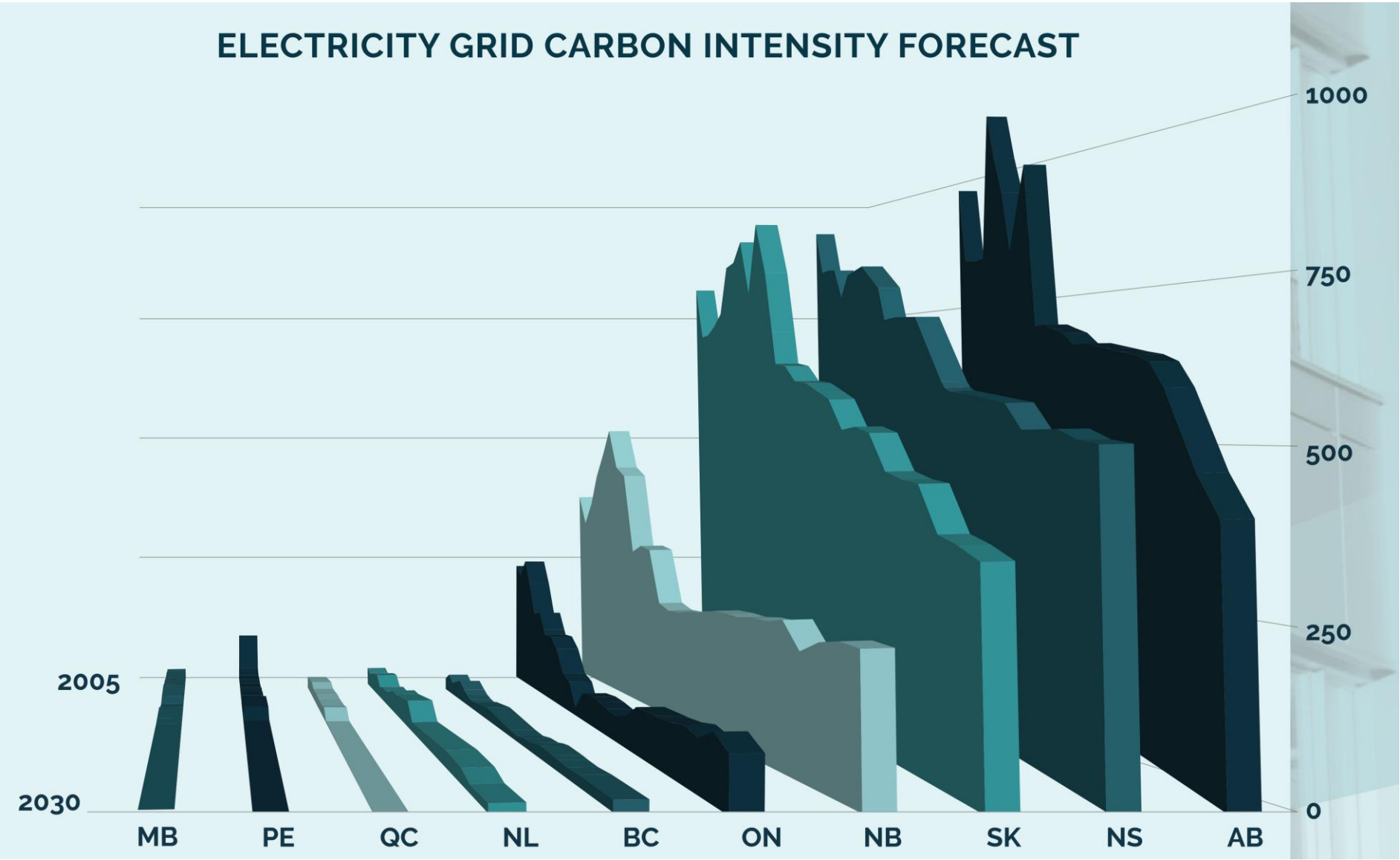
Strategic fuel switching
Installation of renewables on-site

Procurement of off-site renewables (e.g., RECs)



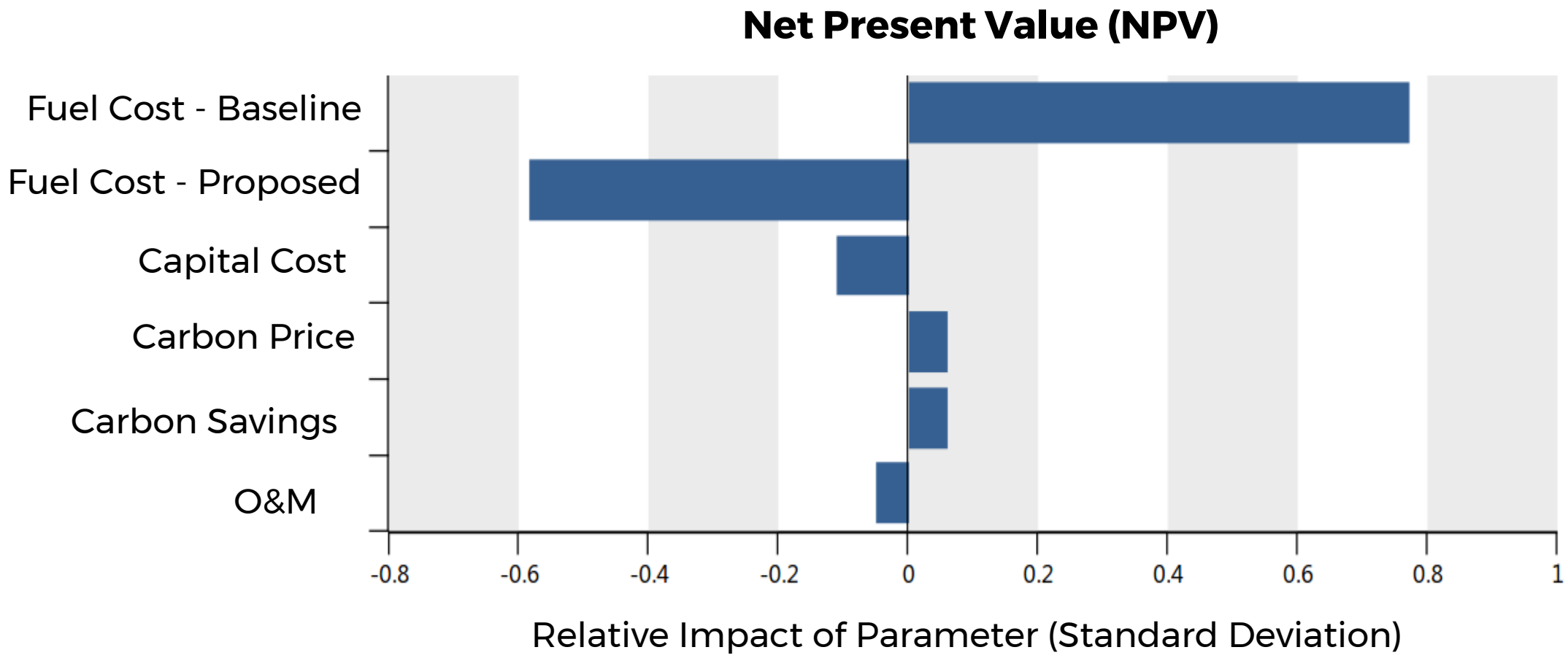
Envelope crucial to progress to passive HVAC systems

2. Location Matters



3. Energy Price Gap

Sensitivity Analysis for Option 2 (LCC Neutral)



3. Energy Price Gap

— Testing uncertain variables in long term forecasts is important

— Based on today's natural gas and electricity prices:
  — *The carbon price won't be the main driver in BC or ON*
  — *Carbon price needs to be well above avg. $150/tonne to make impact*

— Business case improves when baseline's become more stringent

Ontario	**Energy Cost**	**GHG Emissions**
Electricity	$ $ $ $	
Natural Gas	$	

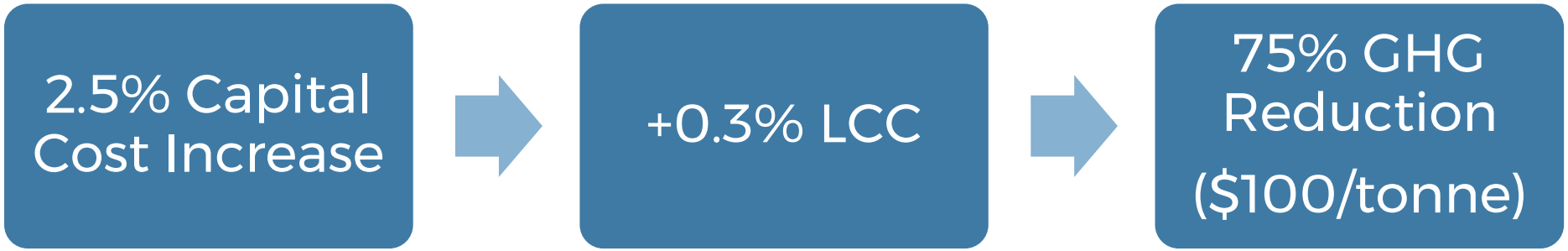
Can we make a business case for Carbon Neutral Buildings?

4. New Construction - Business Case Exists

Life-cycle view is important for carbon neutral business case

Connection needed between developer & rate payer

4. Major Retrofit- More Motivation Needed



Motivations:

- Commitment to Internal Policies / Goals
- Regulations (i.e. increasing baseline)
- Increase Carbon Pricing / Cap'n'Trade Schemes
- Public Perception (ex. Carbon Labelling)

Carbon Neutrality Conclusions

1. Technologies are available to achieve 75%-90% reduction on **most** commercial sites.

2. Location matters
   - *Climate dependent*
   - *GHG emission intensity in electricity grid*

3. Energy cost gap
   - *Natural gas vs. Electricity*

4. Business Case
   - *New Construction - business case already exists*
   - *Major Retrofit - more motivation required*

Thank you!

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