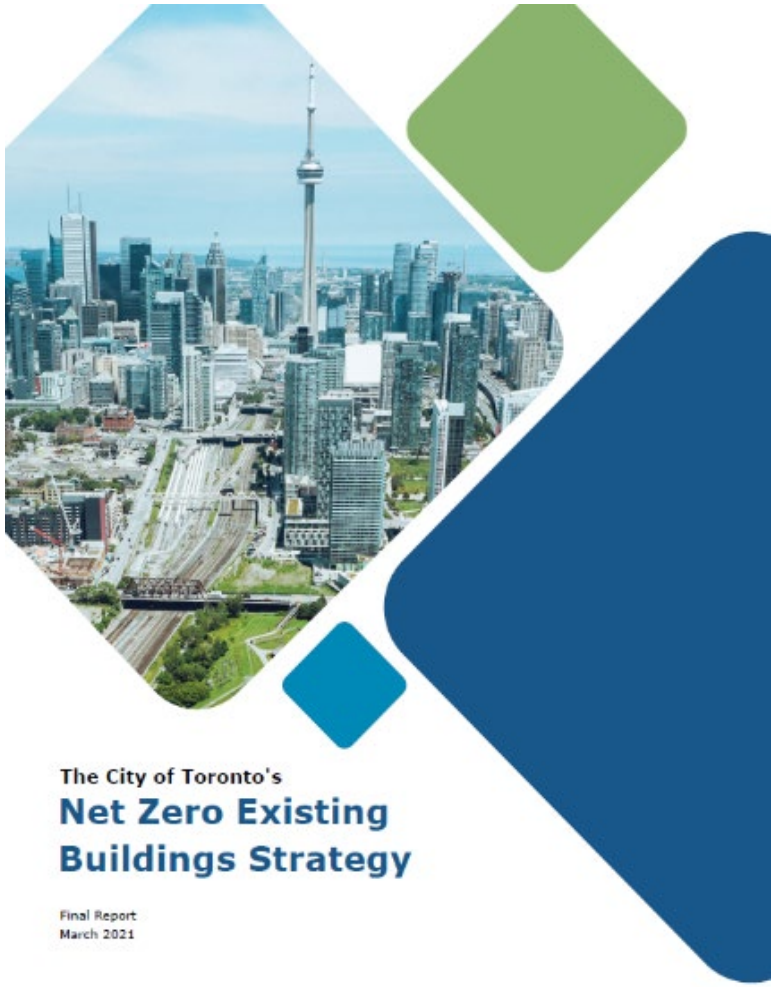
City of Toronto's Net Zero Existing Buildings Strategy



Municipal Engineers Association Conference

November 17, 2022

TORONTO

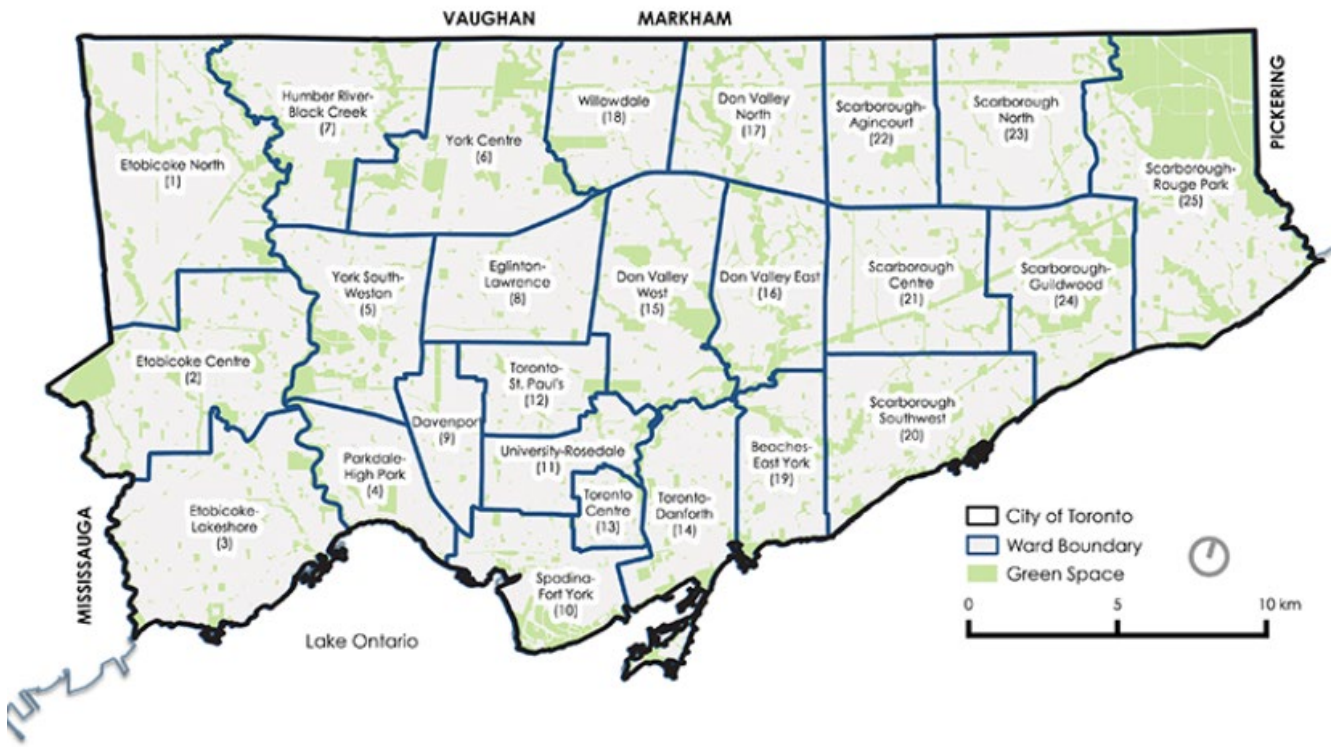
Land Acknowledgement

- We acknowledge the land we are meeting on is the traditional territory of many nations including the Mississaugas of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee and the Wendat peoples and is now home to many diverse First Nations, Inuit and Métis peoples. We also acknowledge that Toronto is covered by Treaty 13 with the Mississaugas of the Credit.

Net Zero Existing Buildings Strategy

The City of Toronto

- Home to more than 2.9 million people whose diversity and experiences make it Canada's leading economic engine and one of the world's most diverse and livable cities.
- Capital of Ontario and the fourth largest city in North America, with a land area of approx. 641 km² (247 mi²).



Net Zero Existing Buildings Strategy

TransformTO

Toronto's Emissions Reduction Targets:

- ~~30 per cent by 2020~~ ✓
- 65 per cent by 2030
- ~~80 per cent by 2050~~

CLIMATE EMERGENCY

~~New Target of Net Zero Emissions before 2050~~

New Target of Net Zero Emissions before 2040

Toronto's Climate Action Strategy to reduce greenhouse gas (GHG) emissions while creating a low-carbon future for Toronto that is healthy, equitable and prosperous for all

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Net Zero Existing Buildings Strategy

TransformTO Guiding Principles

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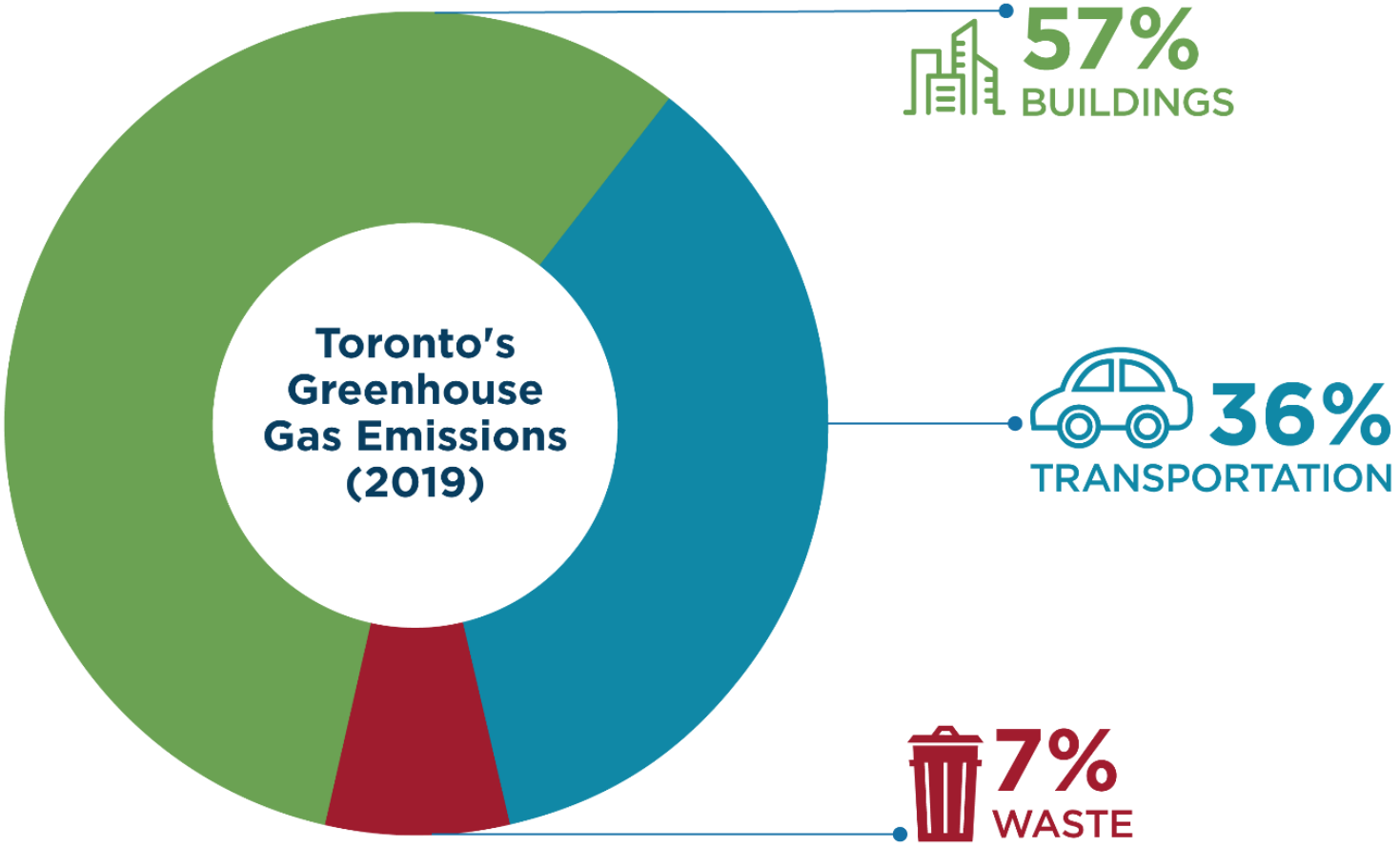
Net Zero Existing Buildings Strategy

Where do Toronto's emissions come from?



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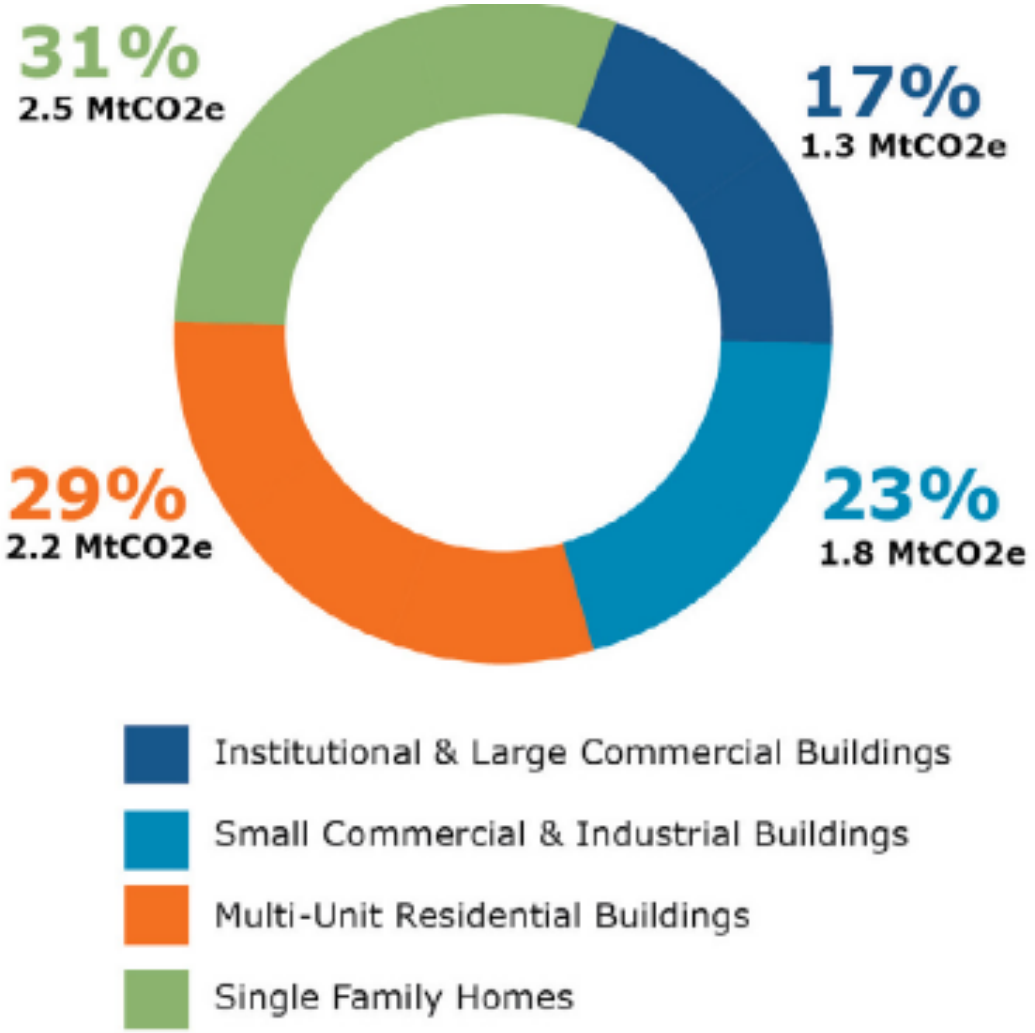
Net Zero Existing Buildings Strategy

GHG emissions breakdown by building sector



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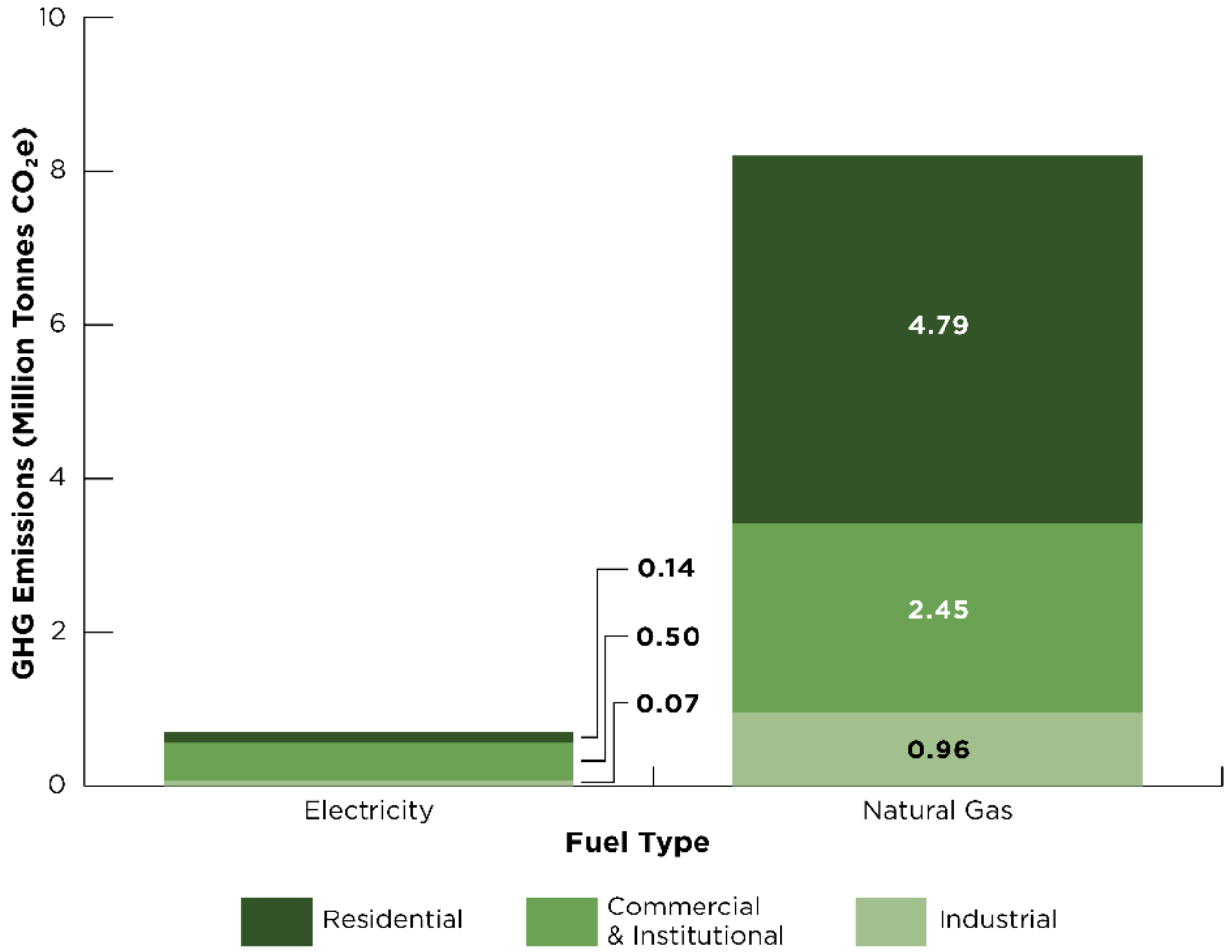
Net Zero Existing Buildings Strategy

GHG emissions from buildings

by fuel and building type



City Programs for Existing Buildings

Support, Guidance & Enablement

- Navigation & Support Services
- BetterHomesTO
- Renewable Energy
- Sustainable Towers Engaging People (STEP)
- Green Will Initiative (GWI)

Financing

- Energy Retrofit Loans (ERL)
- Home Energy Loan Program (HELP)
- High-Rise Retrofit Improvement Support Program (Hi-RIS)

Policy

- Existing Buildings Emission Strategy
- Toronto Green Standard (TGS)

Incentives

- HELP
- Deep Retrofit Challenge

Net Zero Existing Buildings Strategy

Overview

- Comprehensive strategy to identify a set of actions for the City to take to achieve net zero emissions by 2050 in existing buildings city-wide.
- Key component of the overall TransformTO Net Zero update (Dec 2021) in response to the City's Climate Emergency Declaration (Oct 2019).
- Developed in coordination with the CREM's Zero Carbon Plan for City-owned buildings.
- The Existing Buildings Emissions Strategy Includes:
  - Detailed technical analysis and modelling of Toronto's building stock and pathways to achieving net zero emissions by 2050
  - Recommended package of actions needed to achieve the modelled net zero scenario
  - High level implementation plan and timelines

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Strategy Development

This Strategy was developed seeking to strike a balance between speed and feasibility.

Considerations included:

- GHG emissions reductions
- Economic implications
- Realization of co-benefits, including, resilience, health, equity and local economic development.

Net Zero Existing Buildings Strategy

Key Findings

- **Over 80% emissions reductions are possible across TO's building stock**
  - Net zero emissions not technically and financially feasible from building retrofits alone
  - Offsets or other measures will be needed.
- **Fuel switching and a clean electricity grid are the most significant requirements**
  - Emissions from Ontario's electricity means no path to zero emissions
  - Emissions will increase over next decades (reduced nuclear gen.)
  - Further electricity grid decarbonization is required.
  - Natural gas can no longer have a significant role in building heating systems
  - Renewable natural gas (RNG) can only offset ~10% max of gas use

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Net Zero Existing Buildings Strategy

Key Findings

- **Building envelope upgrades are costly but necessary**
  - These also deliver co-benefits of health, resilience and local economic impact.
  - Help lower peak electricity demand requirement as buildings electrify
- **Retrofits are a significant net investment for building owners**
  - Financial supports and co-investment by all levels of government and the private sector will be needed to enable market transformation.
- **Voluntary measures are not enough, mandatory requirements are necessary**
  - The City does not have all of the authorities needed to implement the strategy in full.
  - Support of the province will be necessary.

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Net Zero Existing Buildings Strategy

Key Findings

Modelled Economic & Emissions Impacts:

- **Reduce overall sector-wide emissions by ~82%**
  - Baseline year of 2016 to 2050
  - Cumulative emissions reductions of ~ 149 Mt.
- **Increase local building retrofit economic activity by 87%**
  - From $162 B to $302 B cumulative
  - Double annual investment, from $5.4 B per year to $10 B per year.
- **Create an estimated additional 7,000 direct, full-time jobs**
  - Jobs in local construction, energy services and supportive work

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Key Findings

Expected Co-Benefits (examples):

- **Improved comfort** via improved airtightness and insulation to retain heat in winter and mechanical systems that provide spaces with cooling in the summer
- **Improved occupant health** through the provision of enhanced ventilation control and filtration
- **Improved resilience** by extending building habitability during power outages and extreme weather events i.e. passive survivability
- **Lowering, or at least maintaining, energy costs to tenants** even when fuel switching
- **Increasing numbers of local jobs** in a green retrofit economy

Net Zero Existing Buildings Strategy

Existing Buildings in Toronto

- 1,267 Large/High-Rise Institutional, Commercial and Industrial
- 6,162 Multi-Unit Residential Buildings
- 32,561 Small/Low-Rise Institutional, Commercial and Industrial
- 436,117 Singe Family Homes

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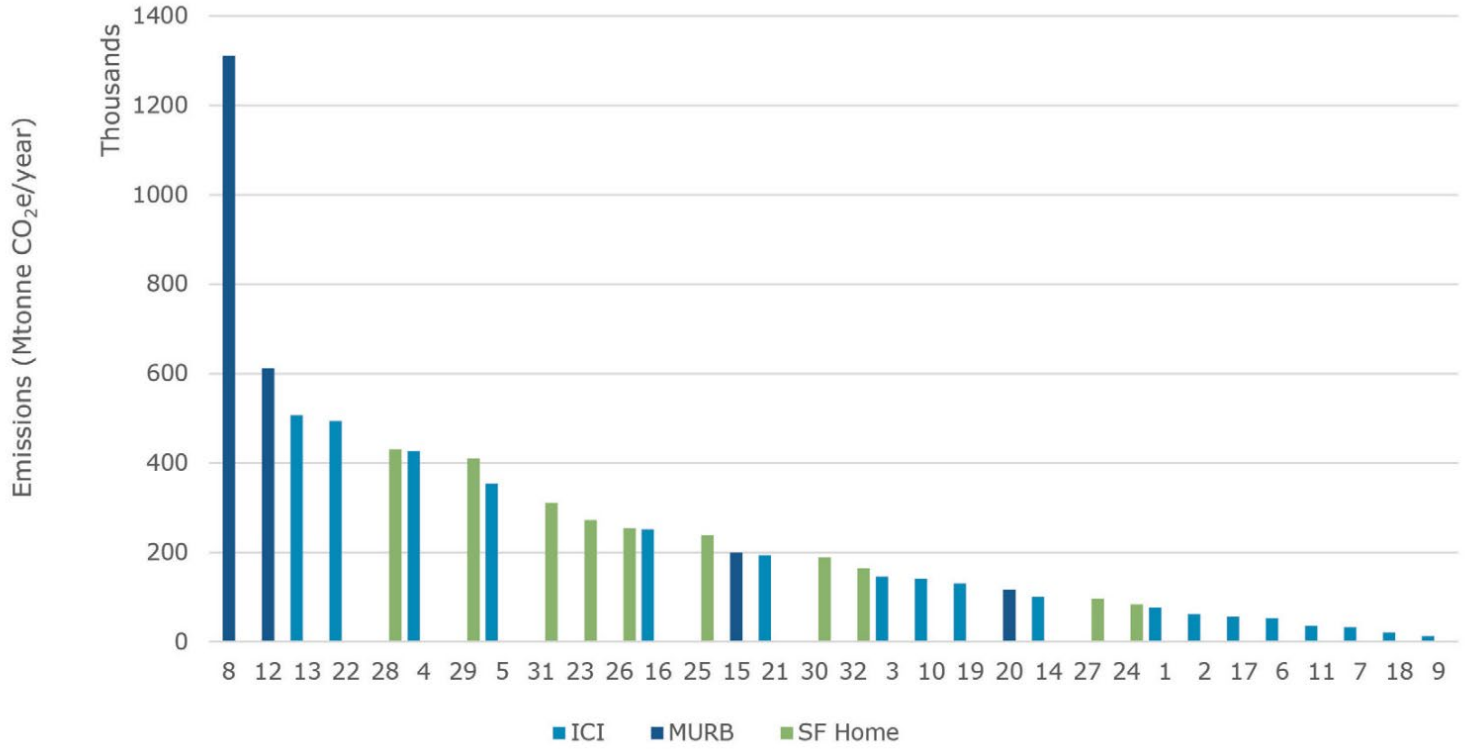
Breakdown of Emissions by:

- Sector
- Energy source
- Energy profile:
  - Facility principal operation type (e.g. MURB vs. hotel, office vs. retail)
  - Facility usage patterns (e.g. operating hours, occupancy patterns)
  - Size (e.g. larger buildings vs. smaller buildings)
  - Vintage (e.g. older v. newer buildings), and
  - Ownership model (e.g. condo vs. rental)
- Energy End Use and System Details (e.g. enclosure, HVAC, user-driven)

Net Zero Existing Buildings Strategy

Breakdown of Emissions by:

- Analysis of Toronto's building stock divided into 32 clusters
  - First two clusters are MURB representing 25% of Toronto's building emissions
  - First 6 clusters represent 50% of Toronto's building emissions



Path to Zero Emissions (Existing Buildings)

Five key building systems:

- User-driven loads and occupancy controls
- Enclosure
- HVAC Delivery
- HVAC Plant
- Renewable Energy

System-level actions

- Within each of these five categories, strategy breaks down actions, level of effort and resultant impact on reducing emissions:

	Level 1 represents a minimum level of investment
	Level 2 represents a level of improvement equivalent to typical new construction
	Level 3 represents a “best in class” and most aggressive investment in performance that can be made for a given system based on market-ready technology and know-how

Net Zero Existing Buildings Strategy

User-driven loads

Sub-System	MURB	High-rise ICI
Lighting	Re-lamp with equivalent **LEDs**	
	LED fixtures and **occupancy-based controls**	
	—	**Daylighting controls**, where relevant
Appliances & Equipment	Energy Star appliances	Sector-specific, but **Energy Star equivalent equipment** selection (e.g. low-flow fume hoods, office equipment, etc.)
	Top 10% of Energy Star appliances	**Energy recovery from equipment** (e.g. refrigerated casework in grocery stores, pool dehumidification & heating integration, etc.)
	Select appliances that **reduce** need for **penetrations** and supplementary ventilation (high-spin front load washers + heat pumps dryers, etc.)	**Maximum energy recovery from equipment** where feasible (e.g. process exhaust in laboratories and kitchens, etc.)
Occupancy-based Controls	Smart thermostats, remote sensors	Upgrade **BAS** to include/integrate/use **occupancy info**
	Variable-speed furnace with ultra-low fan speed	Variable-speed pumps and fans and Commissioning/ Re-commissioning of equipment and distribution systems

User-driven loads

- Usually cost effective and practical
- Minimum level of investment is likely already in capital plan for Facility
- Engagement with occupants is needed to enable full potential

Net Zero Existing Buildings Strategy

Enclosure

Sub-System	MURB	High-rise ICI
Walls	Upgrade walls from the inside, avoiding condensation risk	New insulation in interior walls with air sealing
	Re-clad or over-clad building with additional insulation	Re-clad exterior walls + additional insulation and sealing
	Re-clad building with significant additional insulation	—
Roof	Maximum insulation without change to parapets **(R-15 to 20)**	
	Maximum feasible roof insulation, affecting parapets **(R-30 to 40)**	
Windows	Best **double** glazed, low-e + argon Improved aluminum frames (e.g. >13 mm thermal break)	
	Best **triple** glazed, low-e + argon Best aluminum frames (e.g. >19 mm thermal break) or fiberglass frames	

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Enclosure

- Air sealing and air tightness testing is low cost and effective
- Thermal bridging critical to consider
- As improvements are made, cooling loads become dominant over heating
  - Window selection (solar heat gain coefficient) important
  - Shading

Net Zero Existing Buildings Strategy

HVAC Delivery

Sub-System	MURB	High-rise ICI
Heat (HRV) and Energy (ERV) Recovery from Ventilation	Add HRVs/ERVs to suites (when recladding and air-sealing suites)	Add variable-flow energy recovery to existing HVAC delivery
	Partially centralized ERVs with staged flow and occupancy control	DOAS with HRV as part of like-for-similar delivery upgrade per below
	Fully ducted, centralized ERVs with variable flow	Oversized, VAV DOAS with ERV with new distributed delivery system per Level 3 below
Variable-speed, Near-temp System Configurations	One variable-speed 4-pipe fan-coil or heat pump per suite	Smart upgrade of existing delivery systems to maximize variable flow
	Separate heating and cooling systems with variable flow and large radiative surfaces	Transform existing systems to zonal or near-zonal delivery with VAV DOAS
	Reconfigure HVAC systems to have DOAS and zonal delivery systems	VAV DOAS + fully zonal delivery with large radiative surfaces

HRV – Heat Recovery Ventilator
ERV – Energy Recovery Ventilator

VAV – Variable Air Volume
DOAS – Dedicated Outdoor Air System

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HVAC Delivery

- Challenge to retrofit high-temperature heating system:
  - Retrofitting piping and duct work to near-temperature delivery
  - Load reductions can help avoid these costly changes
  - Heat pump technology that enables higher temperature delivery
- Overlap with other planned facility renewal
  - i.e. MURB: add ERVs when overcladding
  - i.e. High Rise: phased refurbishment (inc. enclosure) aligned with tenant turn-over can result in reclaimed space (from HVAC)

Net Zero Existing Buildings Strategy

HVAC Plant

Sub-System	MURB	High-rise ICI
Fuel Switching	Add balcony-mounted heat pumps or replace central chiller with heat pump	Heat recovery chiller system serves 20-40% of heat needs
	Distributed low-ambient heat pumps or full central heat pump replacing boilers, chillers and DHW	Full central, cold climate ASHP system that minimizes need for natural gas back-up
	Distributed or centralized ground-source heat pumps	Full, central ground source heat pump system OR central biomass heating
Energy Recovery	—	IT cooling loads collected together and connected to centralized equipment
	Drain water heat recovery as preheat to centralized heating or domestic hot water	Special heat recovery systems especially for large, distributed cooling loads (e.g. dehumidification in food stores or museums)
	Solar hot water as pre-heat, especially for highly glazed buildings with larger than normal heating loads or large domestic hot water loads.	

HVAC Plant

- With envelope measures, peak demand reduced
  - Less equipment required (i.e. heat pump instead of chiller)
  - Move to smaller, modular equipment (adds resilience and saves space)
- In high density areas, limited roof/outdoor space may limit installation of geo-exchange or additional fluid coolers thus limiting fuel switching
  - Instead connect to low emissions central plants or energy sharing nodes
- High temperature systems can be challenge to fuel switch
  - Higher temperature heat pumps (i.e. two stage, etc.)
  - Series-connected heat pump pre-heat and top up from either gas-fired (short/medium term only) or electric resistance heating

Net Zero Existing Buildings Strategy

Renewable Energy

Sub-System	MURB	High-rise ICI
Photovoltaics (PV)	Roof-mounted -fixed PV systems, racked or ballasted, angle not optimized	
	Maximum roof-mounted design, including additional racking and/or minimizing roof-mounted HVAC systems	—
	Parking shelter/awning systems	Façade-integrated PV systems
Zero/Low Emissions Co-generation/ thermal networks	Where appropriate, consider a connection to low-carbon central energy nodes	
	—	Investigate zero/low-carbon thermal networks or co-generation (with carbon capture, RNG) for high-temp heating and back-up requirements
	—	Where prudent, consider expanding zero-emission plants to support adjacent facilities.
Demand Response (DR) & Thermal Storage	Thermostats that allow for remote control and demand response (DR) setback	BAS with DR-ready capability
	Battery storage and DR systems aligned with smart charging for electric vehicles	
	Thermal storage to balance heating and cooling diurnally and seasonally and improve efficiency and peak demand of both heating and cooling energy services	

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Renewable Energy

- Solar PV helps improve payback (long-term energy investment)
- Demand response also needed to limit required grid expansion (Envelope improvements also help limit peak demand)
- Tie building electrical improvements with fuel switching and electric vehicles
  - EV cost savings can help make building measures more cost effective
- Plan for electrification when undergoing electrical service upgrades

Net Zero Existing Buildings Strategy

Facility-level actions

Like-for-Similar (LFS)	• Aligning targeted measure-level improvements with systems and equipment that are expected to require replacement in a 30-year window of service life (windows and roof) • Captured in typical 30-year capital plans (where applicable)
LFS + Easy Fuel Switch (LFS+FS1)	• Start with Like-for-similar, add 1 or 2 (max) other measures/improvements (approx. Level 1 enclosure) • Implement level 1 fuel switch (with gas support/backup)
LFS + Full Fuel Switch (LFS+FS2)	• Start with Like-for-similar, add 1 or 2 (max) other measures/improvements (approx. Level 1 enclosure) • Level 2 Fuel Switch (i.e. cold climate ASHP, minimal gas backup required) • DHW fuel switch (ASHP)
Fuel Switch Ready (FSR)	• Enclosure improvements and upgrades needed to ready the facility for future fuel switching • Level 2 HVAC delivery upgrades, including heat recovery
Zero Carbon Ready (ZCR)	• Start with Fuel Switch Ready • Implement level 2 fuel switch (cold climate, minimal gas back up required) including DHW fuel switch
Max Site Potential (MAX	• Level 3 enclosure upgrades (maximum) • Best HVAC upgrades • Fuel switch with geo-exchange, including DHW fuel switch

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Net Zero Existing Buildings Strategy

Facility-level actions

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- LFS package represents baseline for retrofits that would happen anyway (i.e. replacing single pane windows with double pane)
- LFS + Fuel Switch: reasonable investment for buildings unable to afford full decarbonization.
- Align with planned replacement of existing cooling equipment.
  - Some buildings may require more than level 1 enclosure measures

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Net Zero Existing Buildings Strategy

Facility-level actions

- FSR package appropriate for buildings with recent central plant equipment (or connected to low carbon district) and want to invest in facility
- MAX sets upper bounds for performance
- ZCR and MAX are very similar in performance
  - TEDI Performance aligns with EnerPHit

Fuel Switch Ready (FSR)	• Enclosure improvements and upgrades needed to ready the facility for future fuel switching • Level 2 HVAC delivery upgrades, including heat recovery
Zero Carbon Ready (ZCR)	• Start with Fuel Switch Ready • Implement level 2 fuel switch (cold climate, minimal gas back up required) including DHW fuel switch
Max Site Potential (MAX	• Level 3 enclosure upgrades (maximum) • Best HVAC upgrades • Fuel switch with geo-exchange, including DHW fuel switch

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Package Capital, Life-Cycle Costs and Incremental LCC/tonne

- Capital is the main decision-making tool of the real-estate sector.
  - Typically outweighs energy costs given current low cost of energy in Ontario
- Life-cycle cost reflects the total cost of ownership and the potential for investments to be cost-neutral over time.
- ILCC/tonne allows for decarbonization actions to be compared to one another across buildings and sectors.

Net Zero Existing Buildings Strategy

Cost Example:
MURB, circa 1990, 50-200,000ft²

Package	Capital Cost ($/ft2)	Life-Cycle Cost ($/ft2)	ILCC/ tonne ($/tonne)
LFS	30	78	—
LFS+FS-1	32	89	406
LFS+FS-2	37	87	172
FS Ready	47	84	183
ZC Ready	66	95	290
ZC Ready - no PV	63	96	326
Max Site	86	116	660
Max Site - w/o PV	84	118	704
Full Fuel Switch Only	17	78	3

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Net Zero Existing Buildings Strategy

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Full Fuel Switch Only	17	78	3

Close to announced 2030 carbon price of $170/tonne

Need to be here to reach target

No packages offer life cycle cost savings over LFS

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Net Zero Existing Buildings Strategy

Cost Example:
Large ICI, circa 1980, avg. 78,928ft²

Package	Capital Cost ($/ft2)	Life-Cycle Cost ($/ft2)	ILCC/ tonne ($/tonne)
LFS	68	205	—
LFS+FS-1	108	243	1,300
LFS+FS-2	123	270	878
FS Ready	109	228	360
ZC Ready	137	260	703
ZC Ready - no PV	136	261	711
Max Site	155	274	864
Max Site - w/o PV	155	274	872
Full Fuel Switch Only	73	221	217

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Net Zero Existing Buildings Strategy

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Full Fuel Switch Only	73	221	217

None are close to announced 2030 carbon price of $170/tonne

No packages offer life cycle cost savings over LFS

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Cost Effectiveness

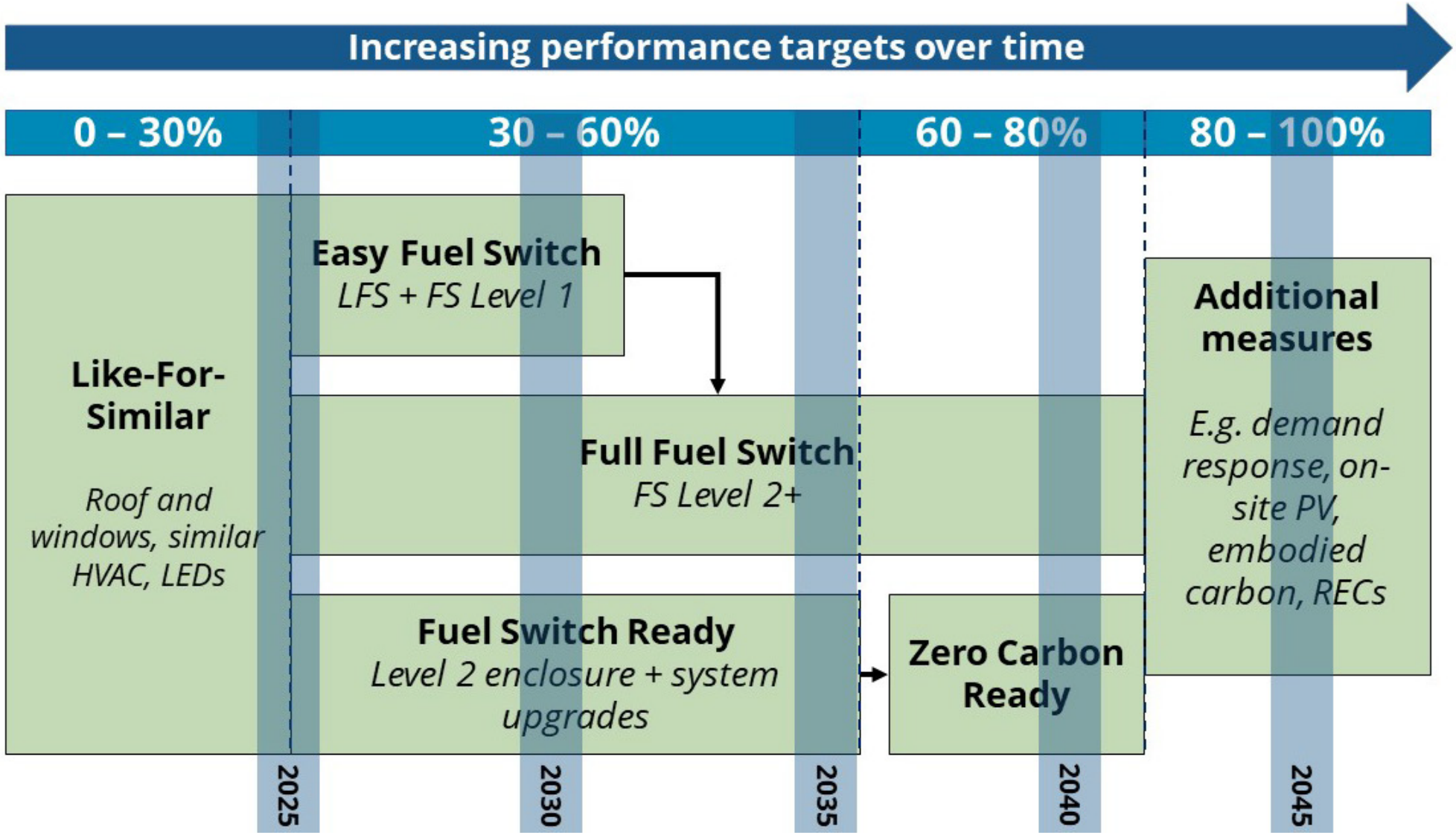
To generally enable cost effectiveness of packages:

- Higher carbon pricing (i.e. $300/tonne Federal shadow price)
- Lower capital costs (i.e. economies of scale, incentives, etc.)
- Both can enable cost effectiveness

- Progressive investment in fuel switching over time
  - FS-1/FS-2 packages only marginal increase in LCC (MURB)
  - As market matures and as regulations tighten
  - Start with less costly fuel switch for immediate equipment change-over
  - Include planning for a longer-term transition to a full fuel switch.

Net Zero Existing Buildings Strategy

City Level Actions



Summary of Recommended Actions from the Strategy

Purpose	Actions
Set requirements to assess building performance and create a path to net zero	1. Require annual emissions performance reporting and public disclosure for all existing buildings 2. Establish emissions performance targets 3. Require energy and emissions audits and tune-ups
Provide support and resources to make retrofits easier and more affordable	1. Provide integrated retrofit support 2. Expand and enhance retrofit financing 3. Support permitting and approvals processes for deep retrofits
Advocate and partner with other levels of government	1. Build awareness and capacity of home and building owners for emissions reduction strategies and supports 2. Support workforce development and training 3. Advocate for action at other levels of government

Net Zero Existing Buildings Strategy

Potential Implementation Timeline

	Near-Term (2022-2024)	Medium-Term (2025-2029)	Long-Term (2030+)
1. Data Reporting, Disclosure, and Labelling			
All Buildings >50,000 f2	Voluntary	Mandatory	
All Buildings >25,000 f2	Voluntary	Mandatory	
All Buildings	Voluntary		
Single Family (HERD)	Voluntary	Mandatory	
2. Performance Targets			
All Buildings >50,000 f2	Voluntary	Mandatory	
All Buildings >25,000 f2	Voluntary		Mandatory
All Buildings	Voluntary		Mandatory
Single Family	Voluntary		
3. Audits, Recommissioning, Retrofit Roadmaps			
All Buildings >50,000 f2	Voluntary	Mandatory	
All Buildings >25,000 f2	Voluntary	Mandatory	
All Buildings	Voluntary		Mandatory

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Net Zero Existing Buildings Strategy

Implementation Planning

- Analysis of approaches for introduction of actions
  - Voluntary basis first, transition over time to mandatory
  - Base mandatory on learnings and further engagement.
- Further consultation and engagement with stakeholders
  - Internal and external
  - Sign up to be notified of next consultations, e-mail bbp@toronto.ca
- Analysis of equity and housing affordability impacts
  - Development of implementation strategies that mitigate negative impacts and enable positive ones for equity-deserving groups.
- Identifying resourcing and financial implications for the City

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Net Zero Existing Buildings Strategy

Emissions Reduction Scenario For Toronto

- All older buildings will undergo an upgrade to enclosure and HVAC systems
- All buildings currently using natural gas-fired heating will undergo a fuel switch to electric heat pumps or alternative source of low emissions heating
- Rooftop solar PV will generate ~14% of electricity (for studied building stock)
- 80%+ emissions reductions are possible, but net zero emissions is not feasible (technically and financially).
- These measures do not have simple payback even with planned carbon pricing

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Net Zero Existing Buildings Strategy

Large/Hi-Rise Buildings

- Deep retrofits can:
  - Benefit tenant retention
  - Supporting corporate zero carbon mandates
- Deeper investment more worthwhile with lower cost capital available
- Either stronger carbon pricing or financial support (or both!) are required to enable all required investment

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City Programs for Existing Buildings

Support, Guidance & Enablement

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- Renewable Energy
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Incentives

- HELP
- Deep Retrofit Challenge

City Programs for Existing Buildings

Net Zero Existing Buildings Strategy recommended providing support and resources to make retrofits easier and more affordable:

- Provide integrated retrofit support
- Expand and enhance retrofit financing
- Support permitting and approvals processes for deep retrofits

Thank you!

- Questions?
- Contact us:
  - Sign up to be notified of future consultations on design and implementation of the Strategy.
  - For support on your building's path to net zero
  - Have your building portfolio join GWI to collaborate with peers and disclose performance

Contact:
Better Buildings Partnership
bbp@toronto.ca