Net Zero Building Retrofit Guides

Single Family Home

Sector-Specific Retrofit Guide

TORONTO

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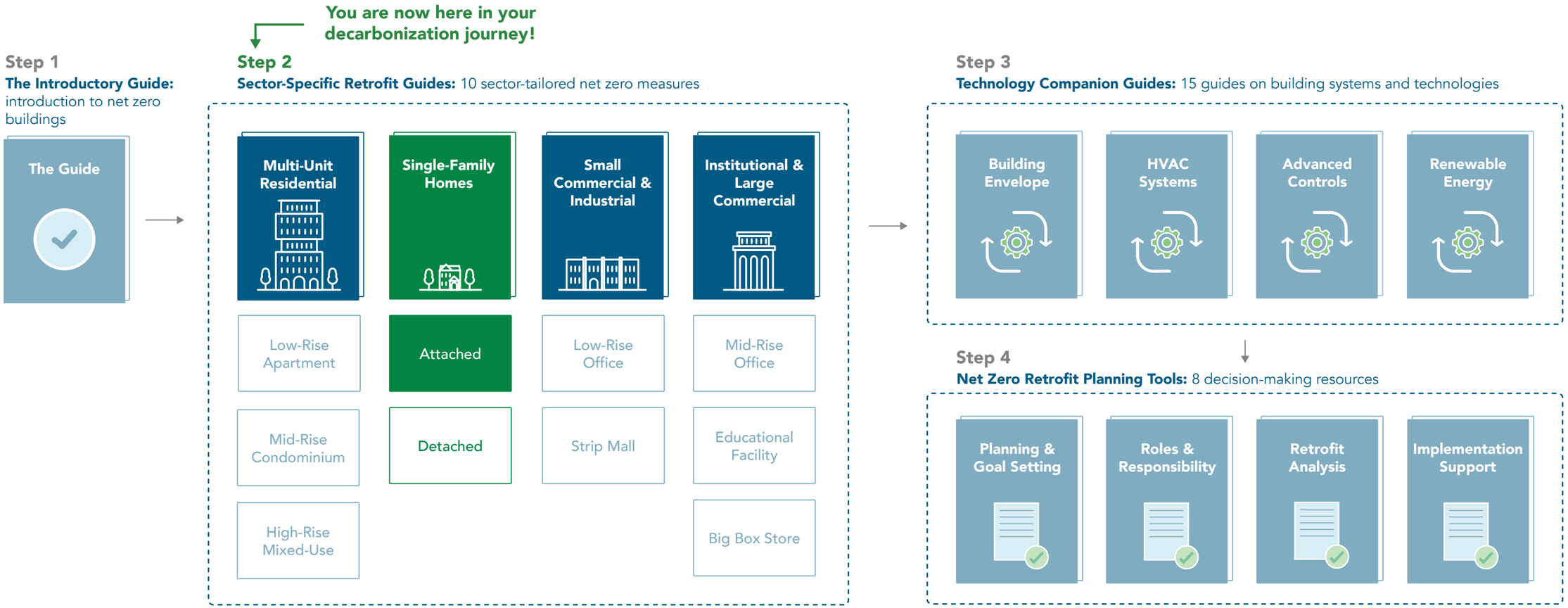
Navigating the Net Zero Building Retrofit Guides

Reducing Greenhouse Gas (GHG) emissions is a journey. It's also an opportunity to make your home more comfortable, healthier, valuable, and resilient to extreme weather events. Successfully arriving at your net zero destination requires careful planning and the right travel companions to ensure a smooth trip.

The City of Toronto's **Net Zero Building Retrofit Guides** include a range of documents designed to support home and building owners reduce GHG emissions from their buildings.

1. **The Introductory Guide** introduces the topic of "net zero buildings." The guide's goal is to familiarize all home and building owners with Toronto's net zero goals and concepts.
2. **The Sector-Specific Retrofit Guides** highlight net zero measures tailored to each building sector and type. These guides provide direction to identify, plan, and implement retrofit projects specific to your building.
3. **The Technology Companion Guides** provide technical information about building systems and technologies related to net zero measures and retrofits.
4. **The Net Zero Retrofit Planning Tools** provide decision-making resources to help home and building owners prioritize their retrofit projects. The tools include needs assessments, checklists, and support for contractor selection.



Net Zero Building Retrofit Guides Document Navigation

A Typical Attached Single Family Home

This Sector-Specific Retrofit Guide

What This guide includes actionable solutions for reducing GHG emissions from the **Single Family Home** sector. The guide provides a seven-step roadmap to get to net zero, based on typical building systems, energy and GHG savings potential, costs, and co-benefits.

Where This guide is tailored for a typical **Attached Single Family Home** located in the City of Toronto, based on the characteristics in the table to the right. The solutions in the Systems and Retrofit Measures table on Page 6 may be applicable to a broader range of buildings in the sector such as semi-detached homes, row houses, stacked houses, and townhouses.

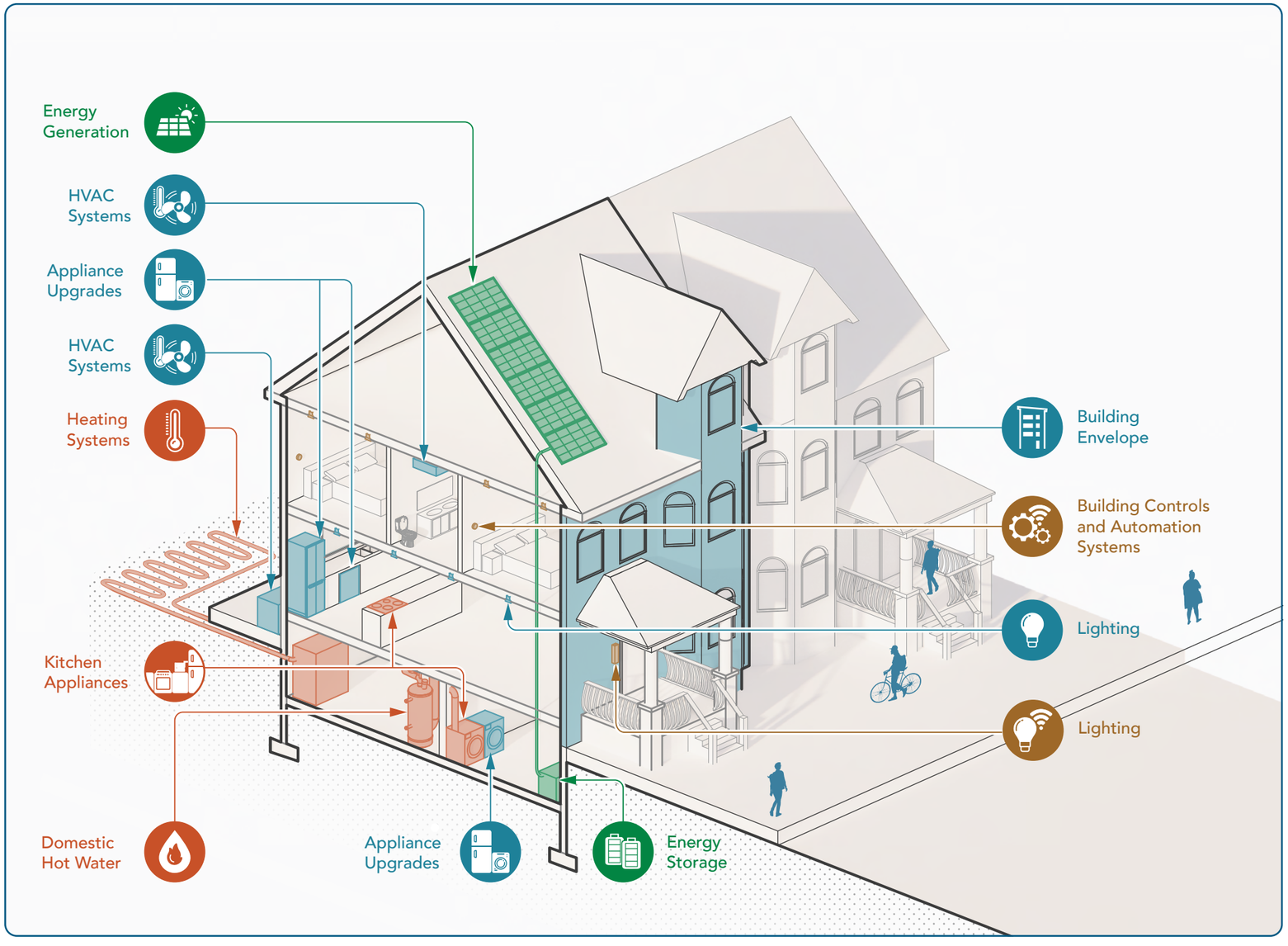
Who This guide is designed for **Single Family Home** owners.

When This guide should be used before and during a building retrofit project or when creating a Net Zero Plan.

The other guide in the Single Family Homes sector pertains to **Detached Single Family Homes**.

Characteristics	Description
Building Sector	Single Family Homes
Building Type	Attached Single Family Home
Height	3-storey structure
Vintages	1990 construction
Space Types	Bedrooms, kitchens, living areas, garages, basements and attics
Building Envelope	• Double glazed vinyl framed windows • Wood frame partially insulated with batt insulation • Gable roof
Typical Equipment	• Water heaters (storage tank or tankless) • Central furnace • Central air conditioner • Operable windows
Management Practices	Managed by owner
Utility Payment Structure	• Heating: Owner Paid • Cooling: Owner Paid
Building Fuels & Emissions Sources	• Domestic Hot Water: Natural Gas • Heating: Natural Gas • Cooling: Electricity
Peak Energy Demand	Occurs in the early morning, evenings, and weekends, when people are at home

Pathways to Net Zero



Building Systems Involved in Net Zero Retrofits

This diagram maps out potential locations for building systems and relevant retrofit equipment. This is not intended as a guide for exact configurations of systems.

From the **Introductory Guide**, net zero retrofits fall under four categories:

Load Reduction strategies aim to improve your home's energy efficiency to minimize energy demands.

Electrification strategies focus on replacing equipment that relies on natural gas or other fossil fuels with electrical equipment. Converting your home's space heating system from fossil fuels to electricity is the most important step in reducing a home's operational emissions. Heating in our northern climate accounts for an outsized portion of a typical home's energy use.

Advanced Control strategies leverage technology and automation to minimize energy waste.

Renewable Energy Generation and Storage strategies focus on generating and storing energy on your home's site from renewable sources. This can reduce your home's reliance on the electrical grid and reduce your operational emissions from electricity.

Systems and Retrofit Measures

The Systems and Retrofit Measures table on the following page presents retrofit measures to replace or enhance the building's existing systems. These measures will help improve the overall performance of your home. In the table, each existing system is paired with recommended measure(s) based on the characteristics of the **Attached Single Family Home** as described on Page 3.

Given the home's vintage, replacing the envelope components is not recommended. Consider implementing retrofit measures once the envelope's service life has ended. The recommended measures can also be applied to semi-detached homes, row houses, stacked houses, and townhouses, as part of the broader building sector.

For more specific design information on the proposed retrofit measures, please refer to the **Technology Companion Guides** to further facilitate decision-making.

What's In the Table?

Building Systems

The items in the Building System column represent systems involved in net zero retrofits.

Load Reduction

- Building Envelope
- Lighting
- HVAC Systems
- Appliance Upgrades

Electrification

- Heating Systems
- Domestic Hot Water
- Gas Appliances

Advanced Controls

- Building Controls and Automation Systems
- Lighting Controls

Renewable Energy Generation and Storage

- Energy Generation
- Energy Storage

Key Metrics

To help you in decision-making, the table provides key metrics related to emissions, energy, and cost for each retrofit measure.

- **Greenhouse Gas Intensity (GHGI) Reduction (%)** indicates an estimated range for reduction in GHG emissions per square foot compared to the existing system's performance and fuel type.
- **Energy Use Intensity (EUI) Reduction (%)** indicates an estimated range for energy use reduction per square foot compared to the existing system's performance.
- **Upfront Cost Premium ($/ft²)** indicates an estimated range for the incremental cost of retrofitting a building system, or combination of building systems, to a net zero retrofit solution compared to the minimum code compliant system.

Co-benefits

Co-benefits represent positive impacts on other areas of value. An icon in the table demonstrates a significant benefit in the category.

- **Resilience** refers to an improved ability to resist and recover from changing weather and extreme storms caused by climate change.
- **Indoor Air Quality** refers to the quality of air (pollutant levels, fresh air, temperature, and humidity) inside a building, directly impacting human health.
- **Resident Comfort** refers to creating indoor spaces where occupants feel comfortable (temperature, noise levels, lighting, and a sense of security).
- **Property Value** refers to improvements in a property's market value.

Where Do the Values Come From?

The data is based on the CaGBC study *Making the Case for Building to Zero Carbon 2019* and *the City of Toronto's Net Zero Existing Buildings Strategy 2021*. It was adjusted to reflect the characteristics of this building type, as follows:

- GHGI and EUI Reduction data were adjusted to consider building age and to capture improved efficiency over time.
- Upfront Cost Premium data was updated to represent 2023 prices.
- Scenarios where cumulative GHGI Reductions or EUI Reductions are greater than 100% represent opportunities for buildings to be net energy producers based on Energy Generation & Storage potential.
- The envelope cost premium information is based on modified National Energy Code of Canada for Buildings 2011 baseline building.

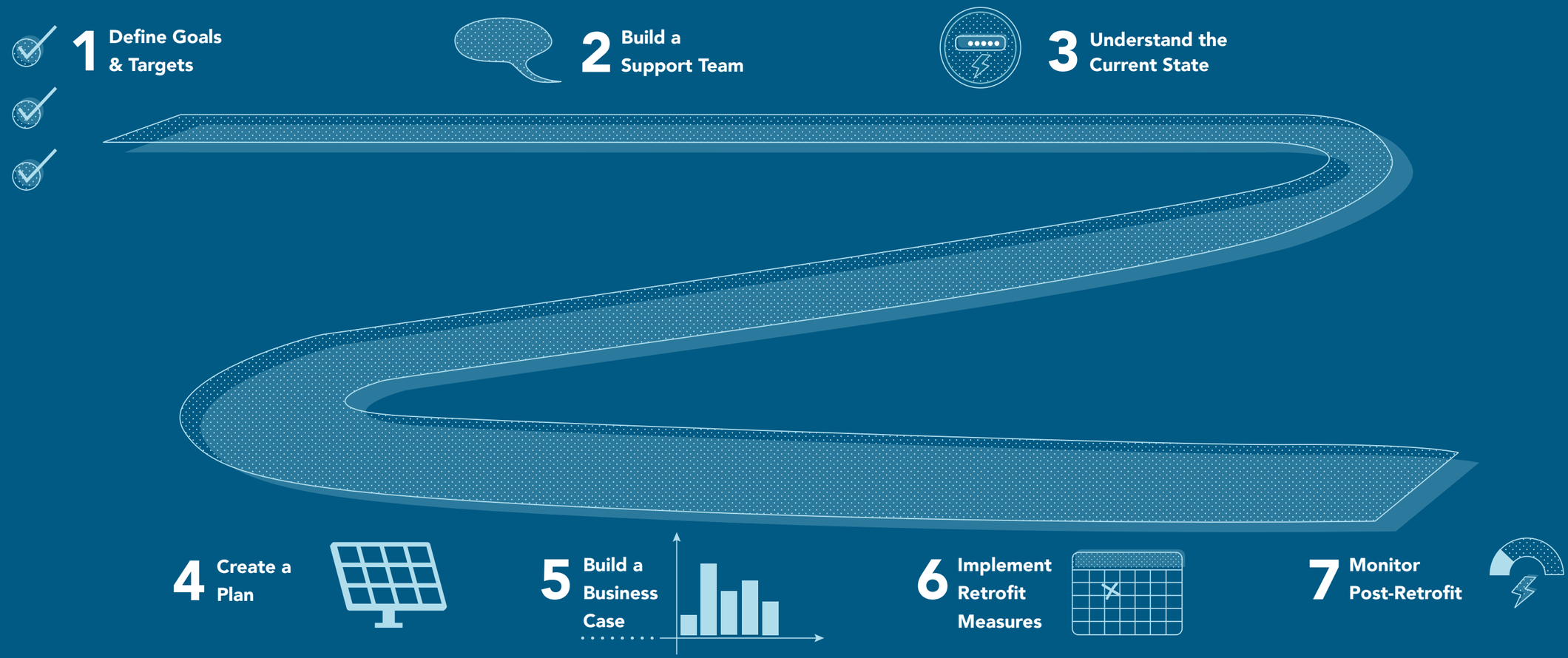
Systems and Retrofit Measures

Existing Building Systems and Equipment		Net Zero Pathways - Load Reduction, Electrification, Advanced Controls and Renewable Energy Generation & Storage							
			Key Metrics			Co-benefits			
Building System	Equipment Baseline	Retrofit Measure	GHGI Reduction (CO_2e/ft^2)	EUI Reduction ($ekWh/ft^2$)	Upfront Cost Premium ($/ft^2)	Resilience	Indoor Air Quality	Occupcant Comfort	Property Value
Building Envelope	Double glazed vinyl framed windows	High-performance windows with enhanced air sealing	**1% to 10%**	1% to 10%	$1 to $10	↓		☺	$
	Wood frame partially insulated with batt insulation Gable roof	High-performance windows with enhanced air sealing and additional or new wall and attic insulation	**1% to 10%**	1% to 10%	$1 to $10	↓		☺	$
Domestic Hot Water	Water heaters (storage tank or tankless)	Electric water heater	**11% to 20%**	11% to 20%	$1 to $10				$
Heating Systems	Central furnace	Air source heat pump Ground source heat pump	**Up to 45%**	Up to 45%					$
HVAC Systems - Cooling	Central air conditioner								
Building Controls and Automation Systems	Thermostats	Smart thermostats						☺	
HVAC Systems - Ventilation	No mechanical ventilation	Central energy recovery ventilator	**1% to 5% increase**	1% to 5% increase			≈		$
		Local energy recovery ventilator					≈		$
Gas Appliances	Gas range	Electric and induction range	**5% to 20%**	1% to 10%	$1 to $5		≈		
	Gas clothes dryer	Heat pump and electric dryer					≈		
Appliance Upgrades	Refrigerators, dishwashers, and clothes washers	Energy efficient appliances	**1% to 10%**	11% to 20%	By appliance				
Lighting and Lighting Controls	Interior and exterior light fixtures (incandescent, halogen, fluorescent, etc.) and bulbs	Energy efficient LED fixtures and bulbs			0$				
	Manual switches	Exterior lighting motion sensors							
Renewable Energy Generation and Storage	No energy storage	Battery storage	**Minimal solar is 1% of grid makeup**	None	$800/kW to $1,000/kW	↓			$
	No renewable generation	Solar thermal for hot water	**10% to 20%**	11% to 20%	$26 to $50	↓			$
		Solar PV for electricity generation	**1% to 5%**	1% to 10%		↓			$

Steps to Achieve Net Zero

Transitioning to net zero is urgent, but you can start small and take incremental steps. You do not need to do everything all at once. Given the numerous options and pathways as described on Page 4, it is important to carefully plan your retrofits by considering your homes unique characteristics and needs.

Next is a seven-step roadmap to achieve net zero, from setting goals, to implementing and monitoring retrofit measures.



1 Define Goals & Targets

Why? Goals and targets will provide direction for your project, support effective use of resources, and define success.

How? Think about how your home works for you now and how energy usage might affect that.

- Are your utility bills too expensive?
- Is your house too hot or too cold?
- Do you want to reduce your environmental impact?

Building Owner

The good news is that changing how your home uses energy can help make your home more comfortable, save money, and reduce GHG emissions.

So, set objectives that can help you achieve your energy and comfort goals while reducing GHG emissions. Think about strategies to reduce energy use, switch to high-efficiency electric appliances, and eventually generate your own energy.

Start with long-term targets and work backward to identify short-term targets.

What Are Some Examples of Long-Term and Short-Term Targets?

Long-term

- Transition away from natural gas
- Reduce your emissions by X% by 20XX
- Reduce your hydro bills by Y%
- Start to generate your own renewable energy

Short-term

- Switch to high efficiency electric appliances
- Upgrade your HVAC system
- Get new high-performance windows
- Switch to LED Lighting
- Improve your home's envelope

2 Build a Support Team

Why? Key professionals will provide the necessary technical support to ensure that all aspects of your net zero retrofit are expertly managed, helping you achieve your project goals and targets.

How?

Building Owner

Consult and hire key professionals such as:

- energy/carbon advisors and auditors,
- architects,
- engineers,
- contractors, and
- tradespeople (electrician, HVAC contractor, plumber, solar and home battery installer).

For larger whole-house renovations, such as envelope upgrades, consider hiring an architect to help plan the project.

Get multiple quotes to compare price, schedule, and value. Ensure that the quotes and terms are clear (job description, payment terms, schedule) and dated. Finally, verify that the selected contractors and consultants are qualified.

What to Look For?

Experience

Search for experts in home energy savings and auditing with knowledge in building construction standards.

Licenses

In Toronto, contractors and consultants need a license, Harmonized Sales Tax (HST) number, and workers' insurance.

Energy and carbon auditors should have relevant certifications, such as Registered Energy Advisors, Certified Energy Managers, Certified Energy Auditors.

Professionals need to be registered with their respective professional bodies:

- For **engineers**, the Professional Engineers Ontario.
- For **architects**, the Ontario Association of Architects.

Contractors need a City of Toronto Trades License, either as a building renovator or as a construction sub-trade (heating, plumbing, insulation, roofing, etc.).

Ask for references from friends and family and get feedback about the work they've had done.

See also: The Government of Canada - A Homeowner's Guide for Building or Renovating for more tips!

3 Understand the Current State

Why? Evaluating the current conditions will help in making well-informed decisions and provide a starting point from which to measure progress.

How?

Building Owner

Help your hired Support Team by gathering the key information they'll need.

Support Team

Your hired Support Team will first undertake a building condition assessment to understand current conditions.

Then, they will carry out an energy and GHG emissions audit by:

- reviewing utility bills,
- inspecting equipment and systems,
- consulting with building operators, and
- analyzing energy use data, such as utility bills.

This will help to identify energy use, GHG emissions, equipment conditions, energy efficiency improvements, and possible retrofit measures.

Where Do GHG Emissions Come From?

GHG emissions come from gases that warm the Earth's atmosphere and are measured in in carbon dioxide equivalent - CO_2e.

Scope 1 emissions are from direct on-site fossil fuel combustion, such as from natural gas fired boilers and furnaces.

Scope 2 emissions are from indirect off-site fossil fuel combustion for electricity generation. The Ontario electrical grid is relatively green, but some of its energy is generated using GHG emitting sources.

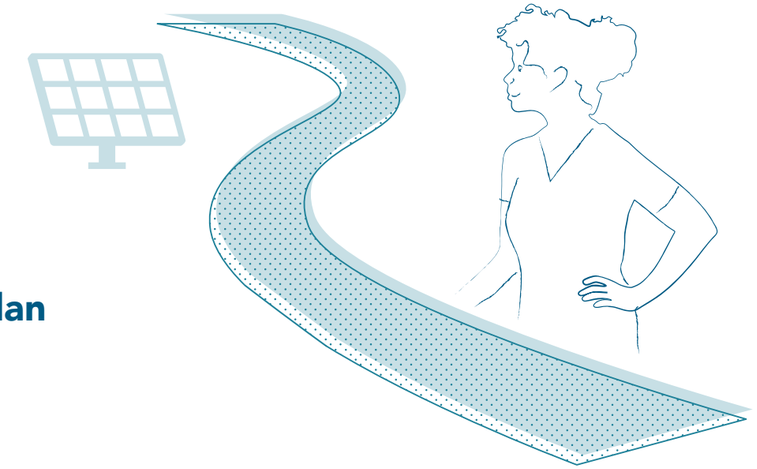
To lower your GHG impact, switch from natural gas to electrical equipment and reduce your electricity use. Note that each kWh of electricity emits approximately 30g CO_2e, while natural gas emits 181g CO_2e.

About Your Home

Following are some useful pieces of information to share with your Support Team to help them understand your home better.

- What year was your home built?
- Do you have any planned retrofit projects?
- What is the condition of the foundations, envelope, and windows?
- Have any systems reached their end-of-life and need replacement?
- Are there spaces in the home that are drafty or seasonally uncomfortable?
- Are there any hazardous building materials or substances (asbestos, lead paint, lead pipes)?

4 Create a Plan



Why? A comprehensive plan will help effectively and efficiently deliver your goals.

How?

Building Owner

With the help of your hired Support Team, use the findings from Step 3 to develop a comprehensive plan to implement retrofit measures aimed at reducing GHG emissions and achieving a net zero home.

Retrofit measures can be considered to fall under the following categories:

1. Load Reduction: improve energy efficiency and reduce energy use
2. Electrification: reconfigure systems and electrify systems partially or fully
3. Advanced Controls: optimize and minimize energy consumption by leveraging technologies
4. Renewable Energy Generation and Storage: install renewable energy systems

Carefully plan your retrofit project's timeline and milestones to achieve desired results.

Refer to the information shared in this guide, as well as the **Technology Companion Guides.**

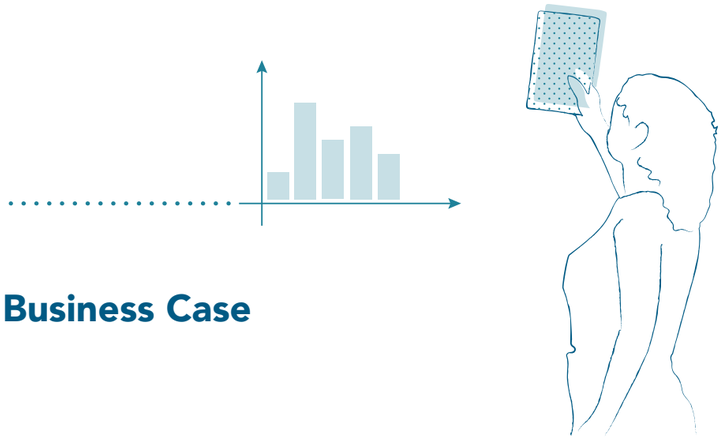
Things to Consider

Following are some helpful questions to help plan your retrofit project:

- Can upgrades be integrated into existing maintenance, replacement, or renovation schedules?
- What is the impact of retrofit measures on other building systems?
- How can project phasing be optimized to reduce redundancy and impacts at later stages?
- Is it more effective to implement retrofits all at once or in stages?
- How might future occupancy changes affect energy requirements?
- Are there zoning or permit considerations to comply with for the project?
- Will you need to disconnect your power?
- Will you have to vacate your home while the retrofits take place?

Enough Power?

When moving away from natural gas and updating to electrical equipment, you might need to increase your home's electrical capacity. It's important to talk to your Support Team and local electric company early in the process to find out if you can upgrade and how much it will cost.



5 Build a Business Case

Why? Understanding financial values and cost will help determine optimal net zero retrofit measures, maximizing the co-benefits such as reduced energy bills.

How?

Retrofitting a home is not simple and requires time and resources.

Work with your hired Support Team to quantify the costs and benefits of your project:

- Some costs can be avoided by, for example, scheduling regular maintenance with upgrades.
- Upgrading can provide a financial incentive by lowering your energy bills.
- Retrofits can bring more benefits than just saving on energy, like resiliency and increased property value.
- There can be opportunities for proceeding with net zero retrofits relative to planned like-for-like retrofits.

Compare options with a Life Cycle Cost Analysis (LCCA) to maximize savings and to determine estimated payback periods. Check out the LCCA tool as part of the **Net Zero Retrofit Planning Tools**.

Ask your Support Team for advice on possible financing and funding options to suit your project and financial needs.

Building Owner

Life Cycle Cost Analysis (LCCA) 101

Conducting an LCCA for building retrofits involves several steps:

1. Decide what changes you might make, like upgrading your heating system or adding better insulation.
2. Figure out the initial costs (buying and installing) and future costs (utility bills and maintenance).
3. Use a discount rate to convert future costs to today's value, because money now is worth more than money later. Think about the number of year to consider in your discounting.
4. Sum up all adjusted costs in today's value for each option to see their total costs over time.
5. Look at other financial metrics like payback time to decide which option is best.

Financing and Funding 101

Financing and funding options can include:

Incentives and grant funding

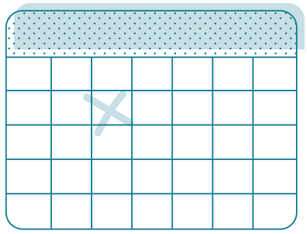
Homeowners completing low-carbon retrofits may be eligible for financial supports. To learn more, visit the City of Toronto's Better Homes: Green Resources for Residents website.

Traditional financing

Out of pocket or traditional borrowing from banks and credit unions are common. Examples include home refinance, renovation loans, and lines of credit. Some banks and credit unions also offer preferred rates and terms for energy-saving projects to support GHG reductions, or resilience investments.

Innovative financing

Low-interest financing may be offered by the government. For example, Toronto's Home Energy Loan Program (HELP) provides low-interest loans to cover the cost of energy-efficient home improvements. These innovative loans are repaid through your property tax bill and are tied to the property and not the homeowner. This means that if you sell your home, the new owner can take over the loan.



6 Implement Retrofit Measures

Why? Implementation will consist of retrofitting and installing net zero retrofit measures to your home.

How?

Support Team

Your hired Support Team will:

1. Create design plans for each retrofit measure, by considering building codes and regulations, structural integrity, and compatibility with existing systems.
2. Help you identify or get necessary building permits
3. Make sure that qualified workers are ready to execute the work with a signed contract, and that necessary materials and equipment are available.
4. Regularly inspect the work to make sure it's done well and on time.
5. Test and commission the new systems to make sure everything works properly, once the work is complete.

Building Owner

In all cases, stay actively involved in the process:

- Regularly inspect the work and address any concerns directly with your Support Team.
- Make sure to get a signed contract detailing the work to be completed. Make sure the outcome of your retrofit matches what was agreed upon in the contract.

To close any permits, call and request the City to inspect the work.

Building Permit 101

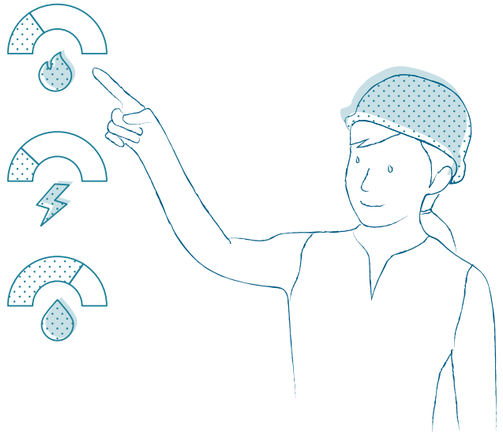
When renovating your home, some works known as 'Material Alteration' need a permit. This is to make sure everything follows building codes. Some examples are:

- Modification to the structure of your home,
- Installation of new or modification of existing mechanical, electrical, and plumbing services, and
- Partial changes in the use of your home, like running a new business that require renovations.

Permit Required	Permit Not Required
• Installing green roofs • Installing solar projects • Modifying heating or plumbing systems • Enlarging or relocating windows	• Recladding the house with non-combustible material other than brick or stone veneer • Replacing a boiler • Installing additional cooling systems, air cleaners, in-line humidifiers, or hot water tanks

For the full list of changes that need a permit, check the City of Toronto's website "When Do I Need A Building Permit". If your property is listed on the Toronto Heritage Register, you will need a Heritage approval before you start.

7 Monitor Post-Retrofit



Why? Ongoing monitoring will optimize energy savings, enable proactive maintenance, and provide valuable data for future projects.

How?

Building Owner

Following implementation, keep track of energy use and compare your energy savings against targeted goals and metrics.

Pay attention to the outcomes of your retrofit, like comfort and indoor air quality. If there are any issues, your Support Team or contractor can help verify that everything is working properly.

Follow the manufacturer's maintenance guidelines to maintain and repair equipment, so performance meets targets.

Next, always look for ways to further improve your home's overall performance in this net zero journey.

And Now What?

How can you measure and monitor energy use?

Where to Look

Firstly, look at your main utility meter from Toronto Hydro, as it gives your total energy consumption. Consider upgrading to a smart meter so you can see electricity peaks and trends in real-time.

Follow the Money

If you don't have smart meters, you can look at your monthly hydro bill to see how you compare with others in your area or to past bills. The last hydro bill of the year typically includes a summary of your annual energy usage. Compare this year's bill to last year's bill to confirm that you are moving in the right direction.

Spread the Word!

By implementing this guide's retrofit measures in load reduction, electrification, advanced controls, and renewable energy generation and storage, along with following the seven steps to achieve net zero, you are now on the right path to decarbonize your home.

Your experience can positively influence others. Tell friends and family about what you've learned and gained from your net zero journey.

Other resources in the Net Zero Building Retrofit Guides:

- The Introductory Guide
- Technology Companion Guides
- Net Zero Retrofit Planning Tools

For more information, please refer to these other City of Toronto resources:

- Net Zero Existing Building Strategy
- Transform TO Net Zero Strategy
- Better Homes: Green Resources for Residents
- SolarTO

Prepared for:

TORONTO

Prepared by:

ARUP

For larger buildings, condominiums and businesses, contact: bbp@toronto.ca

For homes and duplexes, contact: BetterHomesTO@toronto.ca homeenergyloan@toronto.ca