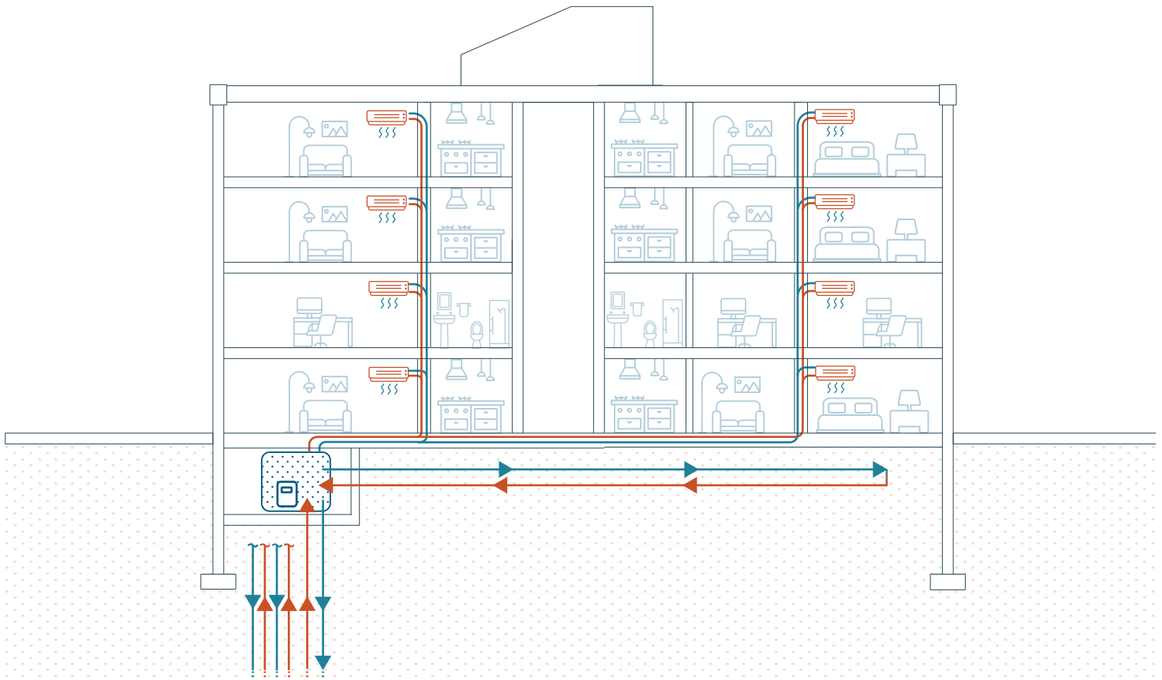
Net Zero Building Retrofit Guides

Ground Source Heat Pumps

Technology Companion Guide



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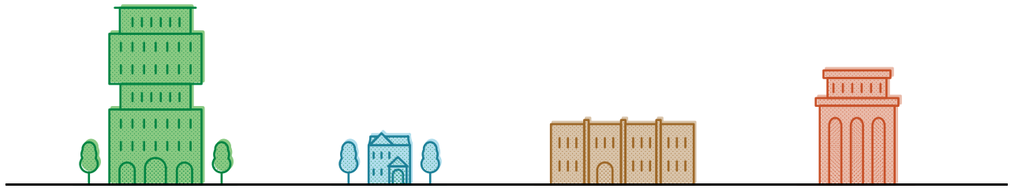

Co-benefits

Resilience | Indoor Air Quality | Occupant Comfort | Property Value

Impacts

Emissions Reduction | Utility Savings | Capital Cost | Maintenance Requirements

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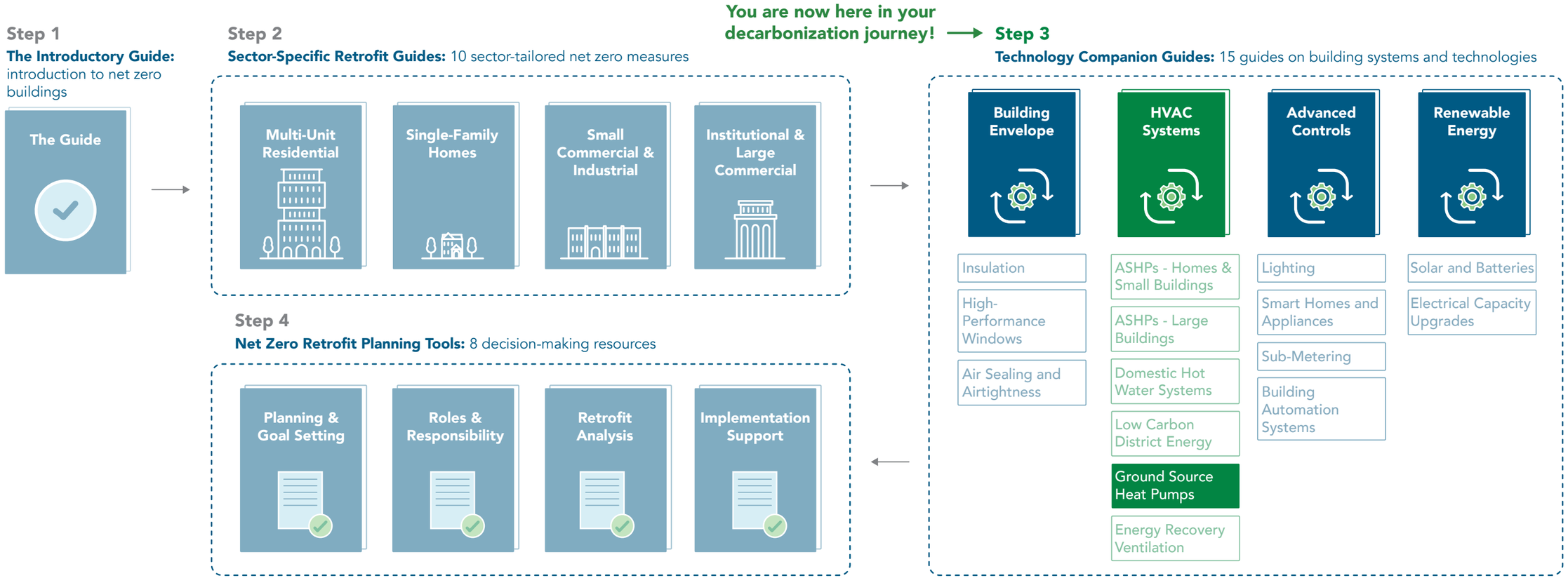
Navigating the Net Zero Building Retrofit Guides

Reducing Greenhouse Gas (GHG) emissions is a journey. It's also an opportunity to make your building 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 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 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 owners prioritize their retrofit projects. The tools include needs assessments, checklists, and support for contractor selection.

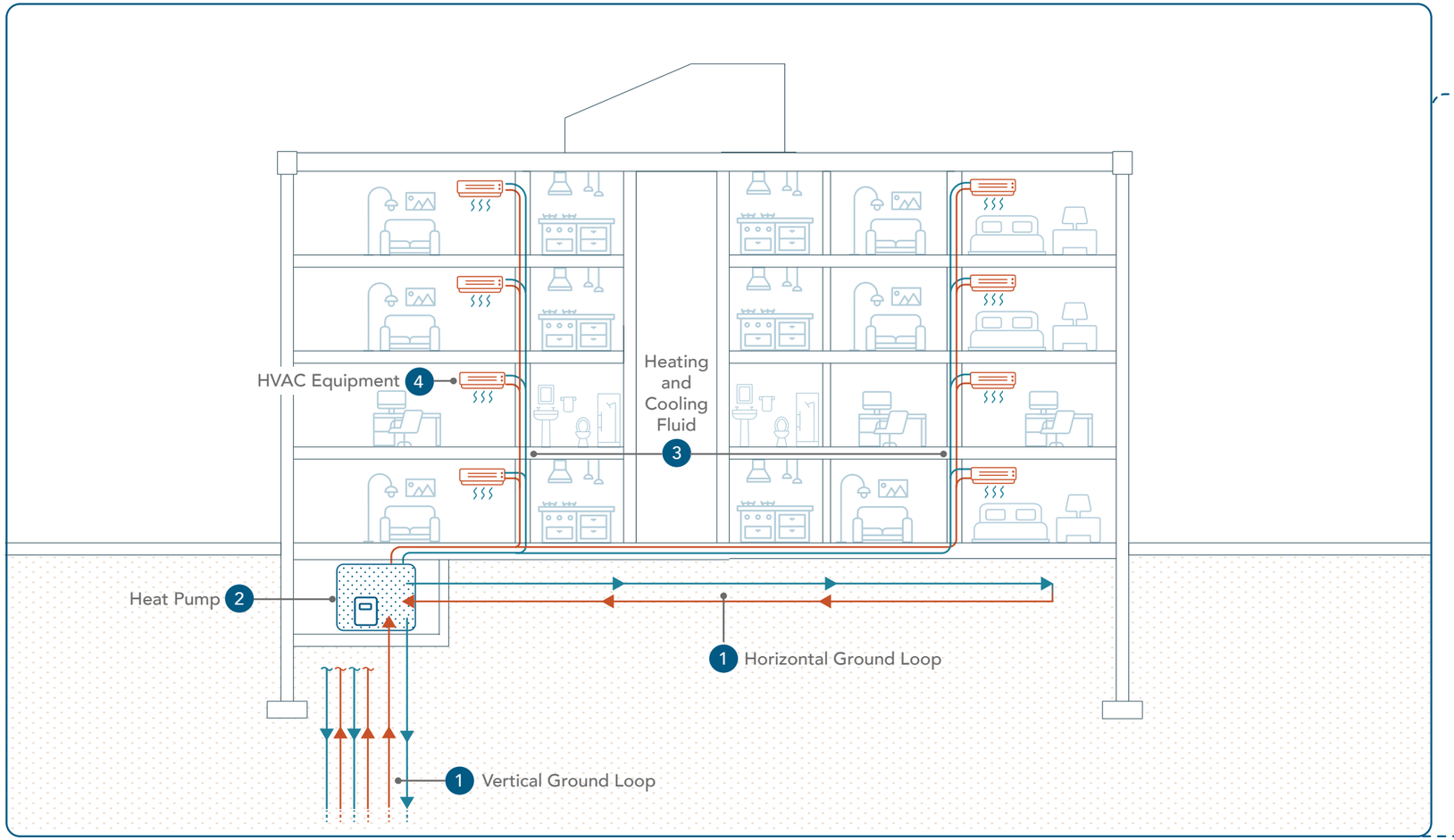


Net Zero Building Retrofit Guides Document Navigation

Ground Source Heat Pumps

What Is This Technology

Ground Source Heat Pumps (GSHPs) are energy efficient systems that transfer heat between a ground loop and a building. They use the stable temperature of the ground as a source of heating and cooling. Because the ground loops are buried underground, they are not impacted by extreme weather events such as cold snaps and heat waves. Not only do GSHPs use energy more efficiently than traditional systems, they also reduce GHG emissions by using electricity rather than natural gas.



Retrofit technology explained

How GSHPs Work

GSHP transfer heat between the ground and the inside of a building to heat and cool. Here are the key components of a GSHP:

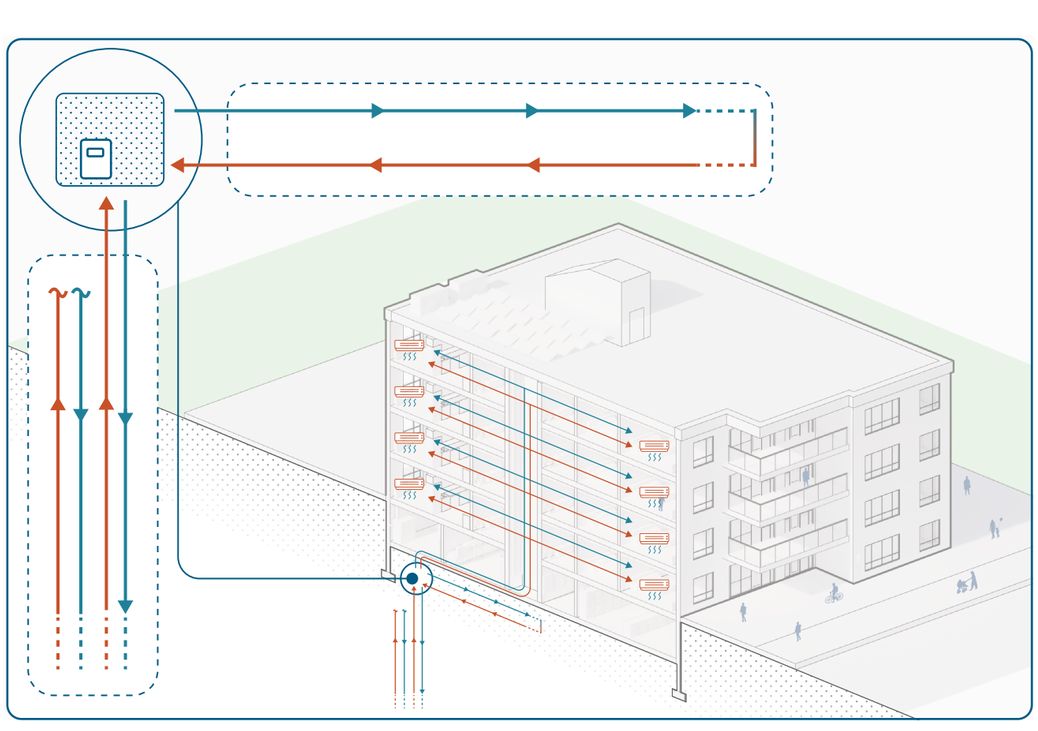
1. A ground loop, which is a network of pipes buried in the ground to circulate water. The water filled pipes absorbs heat in summer and releases heat in winter. Ground loops can be vertical or horizontal.
2. A heat pump unit, which moves heat between the ground loop and the building HVAC system. The ground loop stays relatively warm in the winter, and relatively cool in the summer.
3. Heating and cooling fluid, which moves around the building in pipes to HVAC equipment. GSHPs can be used with hot and chilled water systems, variable refrigerant flow systems, and even forced-air systems.
4. Fan-coils and other HVAC equipment, which deliver heating and cooling to the spaces.

When to Retrofit This System

GSHP retrofits are best done during major building renovations. They require a high up-front investment and infrastructure changes but offer long-term energy savings and emission reductions. This retrofit should be considered by default when your related existing equipment reaches end of life.

Why Retrofit This System

GSHPs are very energy efficient and have a long system life expectancy. They significantly reduce emissions through fuel-switching, using electricity rather than natural gas. They also reduce a building's energy consumption as GSHPs require less energy input than natural gas heating systems. By reducing energy consumption, you can decrease reliance on utilities and protect yourself from rising energy costs, all while lowering GHG emissions.



Typical locations in a building associated with this technology.

Below are co-benefits and impacts to help you better understand this technology.

Co-benefits

Resilience:
GSHPs are less impacted by extreme weather, and provide reliable and efficient heating and cooling, reducing reliance on external energy sources.

Indoor Air Quality:
GSHPs are electric, so they do not rely on the burning of fossil fuels. Therefore, there is less risk of pollutants or carbon monoxide affecting your indoor air quality.

Occupant Comfort:
GSHPs can maintain space temperatures more responsively due to their ability to both heat and cool spaces, improving temperature control and occupant comfort.

Property Value:
Upgrading to a modern, energy-efficient, low carbon GSHP system can make the property more appealing to buyers and tenants.

Impacts

Emissions Reduction:
GSHPs replace natural gas with electricity to heat your building. Converting space heating systems from fossil fuels to electricity is the most important step in reducing a building's emissions.

Utility Savings:
GSHPs replace natural gas with electricity to heat your building. You will see reductions in your natural gas bill. You may see your electrical bill increase, but will likely see overall utility savings due to the high efficiency of GSHPs.

Capital Cost:
GSHPs have high installation costs. This is mainly because of the complexity of the installation, which involves drilling into the ground to bury the ground loop piping.

Maintenance Requirements:
GSHPs are low maintenance systems, as there is no outdoor equipment which reduces wear and tear. They require filter changes and periodic status checks to maintain efficiency.

Types of Systems and Retrofit Solutions

There are a variety of HVAC systems that might be found in your building. Older systems often rely on natural gas, which have relatively low efficiencies and lack modern control features. Upgrading to GSHPs can modernize these systems, reducing their carbon emissions while simultaneously improving their efficiency and resiliency.

Here are some typical HVAC systems for existing buildings and how to retrofit them:

Chiller and Boiler System

In many large commercial, residential, and industrial buildings, a central boiler provides heating to the building through hot water piping. A chiller and cooling tower work together to provide cooling through chilled water piping. Piping delivers the hot and chilled water to fan coils within the spaces which in turn heat or cool the air in the space.

Retrofit: Convert the heating system to a low-temperature hot water system and update heating elements, if necessary. Replace the central chiller, cooling tower, and boiler system with a GSHP.

You may need to maintain some existing cooling and heating equipment to meet peak demands. Supplementary electric heat can eventually replace gas boilers to eliminate reliance on natural gas.

Perimeter Heating

Older office buildings, schools, and residential buildings have simple heating systems like perimeter heating radiators, and often do not have cooling systems

Retrofit: Add an efficient, flexible cooling and heating solution to your building. Install a variable refrigerant flow system connected to a ground source heat pump loop. Indoor units can be controlled based on different occupant needs and can recover heat from one space to serve another.

How to Implement

Before starting, refer to the **seven-step roadmap to net zero** in the **Introductory Guide** and in your **Sector-Specific Retrofit Guide**, to ensure your retrofit aligns with your overall strategy and goals. Here are a few steps to get you started with a GSHP retrofit:

1. Evaluate current heating and cooling systems, and building layout to determine feasibility.
2. Hire experts, like HVAC and civil engineers and GSHP specialists, to design and plan the retrofit. Your experts will help you with the following steps.
    - o Perform a detailed audit of the existing systems and infrastructure to identify necessary modifications and integration points.
    - o Install the GSHP system, including ground loops, heat exchangers, and necessary controls.
    - o Integrate the new system with existing building systems, test for performance, and adjust as needed.
3. Ground source heat pumps require maintenance by a specialized GSHP expert. Ensure your system is maintained regularly to maintain optimal efficiency.

How Does Adding or Removing Heat Affect Ground Temperature?

Adding or removing too much heat from the ground can change its temperature over time. This may reduce your GSHP system's efficiency over time. When designing the system, it is crucial to right-size it to ensure adequate heat return in the summer, meeting your building's cooling needs effectively.

How Much Space Does a Ground Loop Need?

Space constraints can be a challenge when doing a GSHP retrofit. You can explore different configurations to see which suits the needs of your building:

Vertical Ground Loops are better for urban areas with limited space. Boreholes are drilled up to 100m deep in the ground. They are more complex and more expensive to install.

Horizontal Ground Loops are best if you have a lot of open space beside your building. Horizontal loops are buried in trenches about 2 meters deep and are simpler and less expensive to install.

Opportunities

Evaluate how this retrofit can be integrated with the following building systems to maximize potential synergies and optimize overall performance.

Domestic Hot Water

Consider how GSHPs may be used to supplement domestic hot water systems or utilize waste heat, reducing energy consumption, GHG emissions and costs.

Building Controls and Automation Systems

Building automation systems can monitor and optimize GSHP performance, ensuring efficient and sustainable operation.

Energy Generation

Energy Storage

GSHPs in combination with on-site renewable energy sources and battery storage solutions can help to enhance sustainability and energy independence.

Challenges and Solutions

Adding a GSHP system to your building can be challenging. Below are some common challenges you may face and how to solve them.

Challenge 1: Ground Temperature Management

Solution: Manage ground temperature to prevent freezing or reduced efficiency. Design the system to let the ground recharge between heating and cooling cycles.

Challenge 2: High Initial Costs

Solution: Plan for high initial investments and develop a budget that includes contingency funds for unexpected expenses.

Challenge 3: Land Availability

Solution: Use vertical boreholes for ground-source systems if land is limited for GSHP installation. Toronto is quite densely developed, which may limit where you can install a system like this, particularly within existing buildings.

Challenge 4: System Complexity

Solution: Draw on the specialized knowledge and training of GSHP experts to manage the complexities of installing and configuring your system.

Toronto's Climate Considerations

Due to Toronto's climate, there are a few things to consider before implementing a GSHP retrofit.

Freeze Protection

Protect heat exchangers and other critical components from extreme cold to prevent damage and maintain system efficiency.

Pipe Insulation

Insulate water pipes and loop systems to prevent freezing and maintain efficient operation.

System Calibration

Regularly calibrate the GSHP to account for temperature variations and ensure accurate performance.

Ready!

You should now have a better idea of what **Ground Source Heat Pumps** are, their co-benefits and impacts, and how to implement them in your building given potential synergies and challenges!

Also check your building **Sector-Specific Retrofit Guide** for steps to achieve net zero and visit the other **Technology Companion Guides** to learn more about retrofit measures.

Other guides in the HVAC Systems Technology Companion Guides:

- Air Source Heat Pumps for Homes and Small Buildings
- Air Source Heat Pumps for Large Buildings
- Domestic Hot Water Systems
- Energy Recovery Ventilator
- Low Carbon District Energy

Other resources in the Net Zero Building Retrofit Guides:

- The Introductory Guide
- Sector-Specific Retrofit 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
- Toronto Green Standard
- Better Buildings Partnership
- Better Homes: Green Resources for Residents
- Energy & Water Reporting for Buildings

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