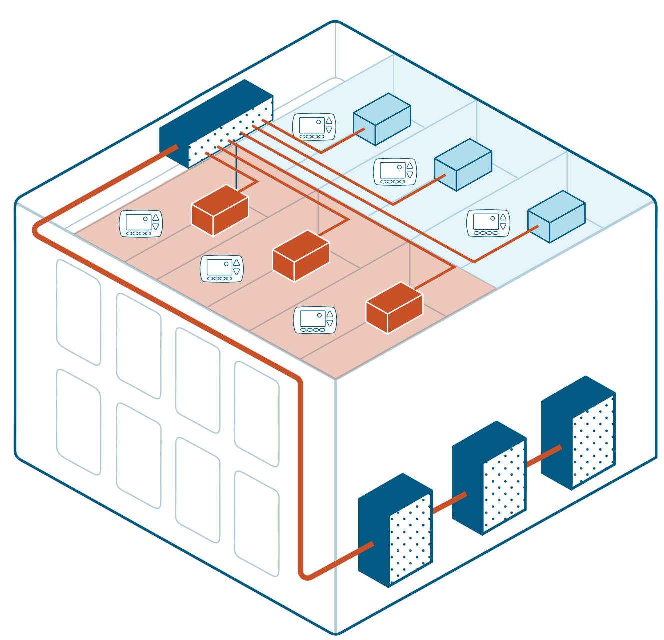
Net Zero Building Retrofit Guides

Air Source Heat Pumps For Large Buildings

Technology Companion Guide



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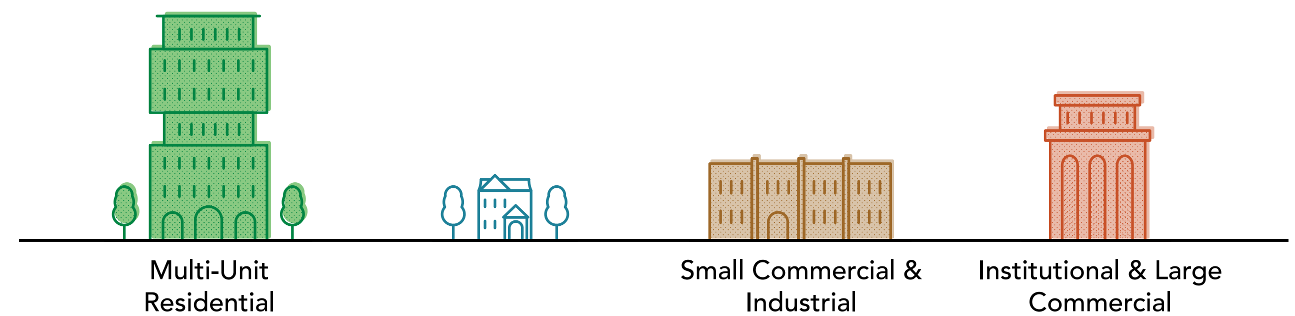

Co-benefits	Resilience	Indoor Air Quality	Occupant Comfort	Property Value
	■■■□	■■■□	■■■■	■■■□

Impacts	Emissions Reduction	Utility Savings	Capital Cost	Maintenance Requirements
	■■■■	■■□□	■■□□	■□□□

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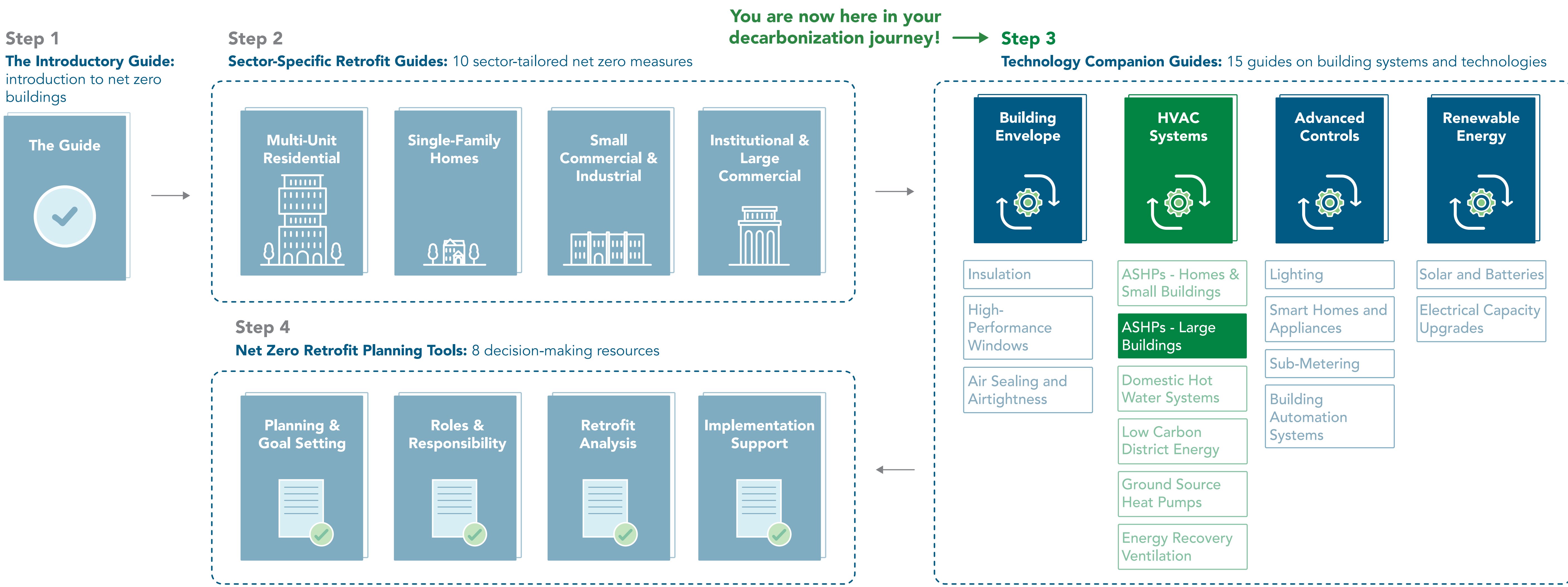
Navigating the Net Zero Building Retrofit Guides

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 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 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.

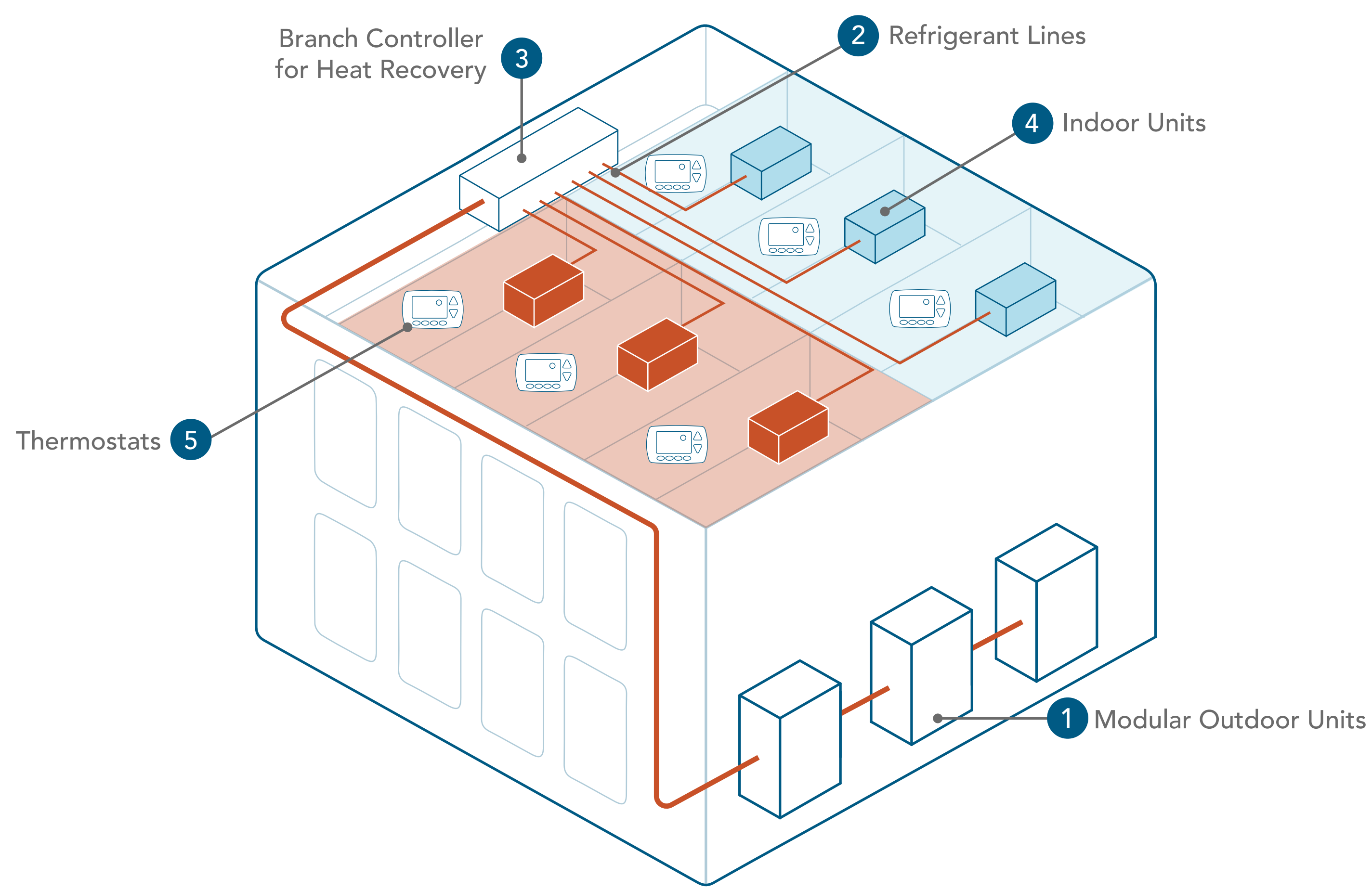


Net Zero Building Retrofit Guides Document Navigation

Air Source Heat Pumps For Large Buildings

What Is This Technology

Air Source Heat Pumps (ASHPs) are energy-efficient systems that transfer heat between the outdoor and indoor air using refrigerant. ASHPs are able to reduce reliance on fossil fuels and improve energy efficiency of heating and cooling systems. There are many different applications of ASHP which are often referred to by different names, such as heat pumps, ductless splits, and Variable Refrigerant Flow (VRF). These systems are very common due to their adaptability to different types of buildings. They can also meet a variety of needs including aesthetics, comfort, noise sensitivity, or space constraints. In cold climates, ASHPs still need to be supplemented with additional heating options.



Retrofit technology explained

How ASHPs Works

In the winter, ASHPs extract heat from outside air and bring it inside to warm the building. In the summer, ASHPs work in reverse to remove heat from inside to cool the indoor space. Here are the key components of an ASHP in large buildings:

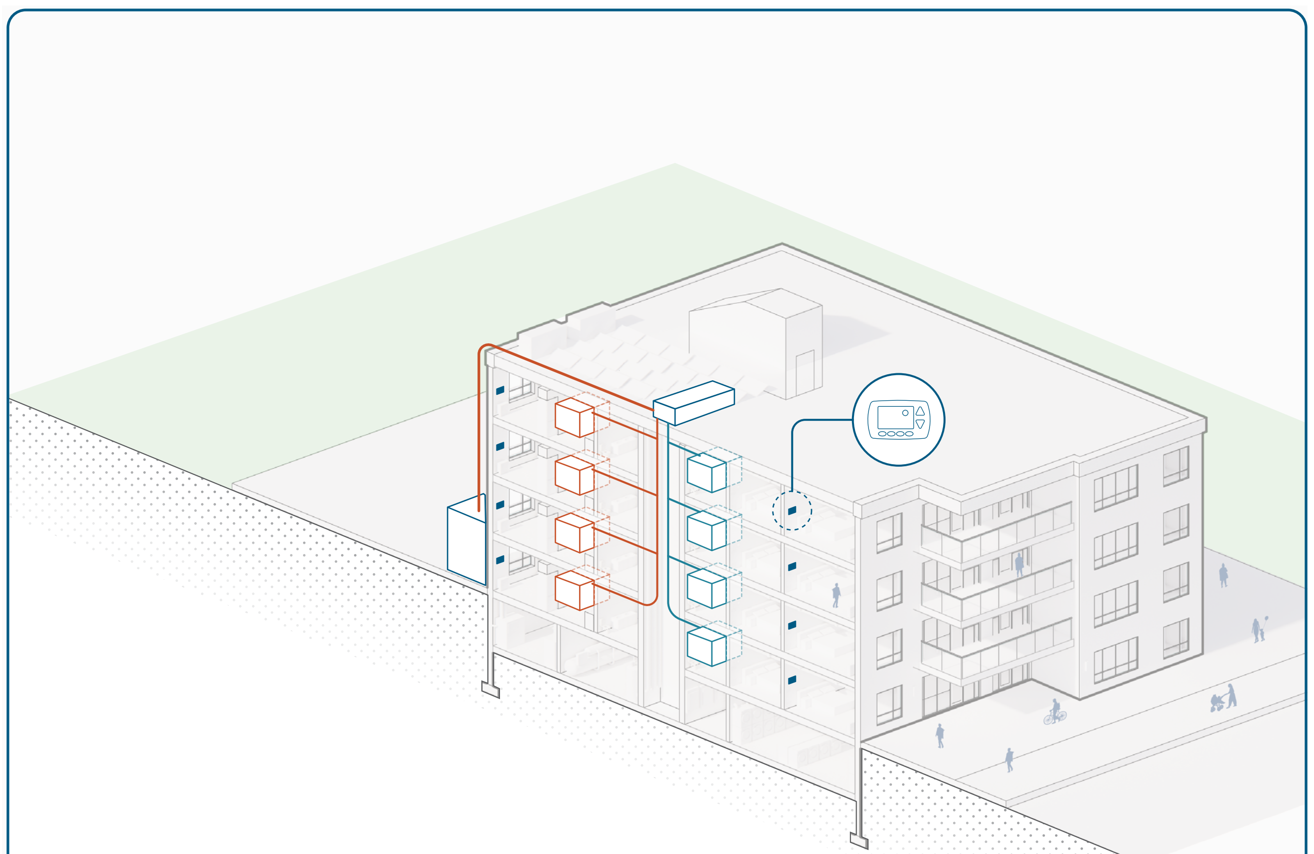
1. Modular outdoor units, which transfer heat between the outside air and the HVAC system in the building.
2. Refrigerant lines, which connect the outdoor unit to indoor units . The refrigerant is the means which absorbs heat from one area and releases it to another.
3. Branch controllers, which allow VRF systems to simultaneously heat and cool different spaces and optimize energy efficiency by recovering heat from one space to be used in another.
4. Indoor units, which sit in the spaces and provide heat or cooling based on the occupant needs.
5. Thermostats, which allow you to control the temperature in the space.

When to Retrofit This System

ASHP retrofits are complex and can be disruptive. It is best to consider this retrofit when your HVAC systems reach their end of life, and if you are undertaking major building renovations, expansions, or deep energy retrofits.

Why Retrofit This System

ASHPs offer a sustainable alternative to conventional heating and cooling systems. They significantly reduce emissions through fuel-switching, using electricity rather than natural gas. They also reduce a building's energy consumption as ASHPs require less energy input than natural gas heating systems. ASHPs are flexible systems that come in several configurations to meet unique comfort and aesthetic needs. By reducing your 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:
ASHPs provide reliable heating and cooling with high energy efficiency.

Indoor Air Quality:
ASHPs 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:
ASHPs are able to 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 and energy-efficient ASHP system can make the property more appealing to buyers and tenants.

Impacts

Emissions Reduction:
ASHPs 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:
ASHPs 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 ASHPs.

Capital Cost:
The initial installation cost of ASHPs can be higher than traditional systems, but the energy savings over time may offset this investment.

Maintenance Requirements:
ASHPs are low maintenance systems. They require routine filter changes and cleaning 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, have relatively low efficiencies, and lack modern control features. ASHPs are a retrofit solution that can be applied to a variety of existing systems to reduce emissions and improve efficiency, comfort, and control.

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

Chiller and Boiler System

Large commercial, residential, and industrial buildings typically use a central boiler for heating, along with a chiller and cooling tower to deliver hot or chilled water to fan coil units which in turn heat or cool the air in the space.

Retrofit: Convert to low-temperature hot water to use heat pumps instead of chillers and boilers. These air-to-water heat pumps, typically located on the roof or beside the building, transfer heat from outside air to the building's heating and cooling water. Supplementary heat is required to heat the building on the coldest days.

Packaged Terminal Air Conditioners (PTACs)

PTACs are common in hotels, retirement homes, and older multi-unit residential buildings. These systems provide heating, cooling, and ventilation through the walls, with each dwelling unit having its own separate system.

Retrofit: Upgrade existing PTAC systems to benefit from improved efficiency. Modern PTACs with heat pump and heat recovery technology enable more efficient, all-electric operation.

Packaged Rooftop Unit

Packaged rooftop units usually sit on the roof and supply heating, cooling, and ventilation to the building through ductwork. They use gas burners for heating and refrigerant for cooling.

Retrofit: Replace your rooftop unit with a rooftop heat pump, which offers the same functionality but uses a built-in heat pump for heating and cooling. Rooftop heat pumps can replace traditional systems one-to-one and be added to older buildings, schools, and residential buildings with simple heating systems like perimeter radiators, which often lack cooling systems.

Air Handling Units with Variable Air Volume (VAV) Boxes

VAV systems are used in buildings that need to be flexible for different occupants or spaces. They often work with other systems like chillers and boilers, or rooftop units. VAV systems provide different amounts of heating, cooling, and ventilation to various parts of a building.

Retrofit: Consider VRF systems for buildings needing flexibility. As an ASHP system, VRF provides variable heating and cooling to interconnected indoor units, allowing simultaneous heating and cooling, and heat recovery for reuse across different areas. This ensures efficient operation and customized temperatures throughout the building.

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 help you implemnent an ASHP retrofit:

1. Identify the existing heating, ventilation, and cooling systems:
   - Do you have gas furnaces or baseboard heaters?
   - Do you have air conditioning?
   - Do you have a ventilation system that brings outdoor air into the building?
2. Optimize your systems. Consider adding an energy recovery ventilator and envelope improvements alongside an ASHP retrofit to optimize your HVAC system. Addressing these needs will reduce your overall heating and cooling needs, so that you can right-size your ASHP.
3. Hire experts, like HVAC engineers and ASHP specialists, to design and plan your retrofit. Your experts will help you with the following steps.
   - Conduct an energy audit. Look closely at how your building uses and loses energy.
   - Develop a detailed plan for the installation, including the location of your outdoor and indoor units.
   - Check if your building requires electrical capacity upgrades to accommodate the new system.
   - Install the new ASHP system according to the Ontario Building Code.
   - Test and adjust the system to make sure it operates properly.
4. Set up a regular maintenance schedule with filter replacements and system checks to ensure your system continue to perform efficiently and reliably.

How do Refrigerants Affect Global Warming?

Refrigerants are chemicals used in heat pumps and air conditioners to help cool or heat spaces. They work by absorbing heat from one area and releasing it in another, typically undergoing a phase change from liquid to gas and back again. However, they can leak into the atmosphere and contribute to global warming.

Global Warming Potential (GWP) measures how much a refrigerant can warm the Earth compared to carbon dioxide (CO_2). Some refrigerants have a high GWP, meaning they can cause a lot of warming if they leak. When choosing refrigerants, it's important to pick ones with a low GWP to help protect the environment. Proper maintenance of equipment using refrigerants is also essential to prevent leaks and reduce their impact on climate change.

Opportunities

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

Domestic Hot Water

Look for opportunities to share equipment between domestic hot water and ASHP heating systems. This could involve using domestic boilers for emergency heating, or using ASHPs to preheat domestic water.

Building Controls and Automation Systems

Building automation systems monitor and optimize ASHP performance, ensuring efficient operation.

Energy Generation **Energy Storage**

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

Building Envelope

Optimize the efficiency of your building's HVAC system by improving your building envelope. Better airtightness and insulation will reduce the size and operating time of your ASHP.

Challenges and Solutions

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

Challenge 1: Supplementary Heat

Solution: ASHPs may not provide enough heat during the coldest winter days. To ensure adequate heating, consider additional heating options, such as electric resistance heaters, or keep your existing heating system as a back-up.

Challenge 2: Electrical Capacity Needs

Solution: Switching from natural gas to ASHPs will reduce natural gas usage but increase electricity usage. Plan ahead to see if your building's electrical service requires an upgrade.

Challenge 3: Compatibility with Existing Systems

Solution: Assess compatibility with existing HVAC equipment as some older systems may require significant modifications, such as converting the building to low-temperature hot water.

Challenge 4: Noise Concerns

Solution: Address compressor noise issues by choosing the right type for your needs. Consider the impact on occupants and neighbors. Work with your service provider to optimize the design and reduce noise.

Challenge 5: Permitting and Regulations

Solution: Follow local permitting processes and ensure compliance with Toronto's building codes and regulations. Your support team will be aware of these and help you navigate them.

Toronto's Climate Considerations

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

Supplementary Heat

To ensure your building has adequate heating throughout the winter, make sure to have a supplementary heating system, such as electric resistance heating.

Condensation Control

Insulate ductwork and pipes in unconditioned spaces to prevent condensation, which can lead to mold growth and damage.

Cold Weather Performance and Defrost Cycles

Choose cold-climate ASHP models that are designed to operate efficiently even at temperatures as low as -20°C, common in Toronto winters. Ensure the ASHP's defrost cycles are optimized to prevent freezing and maintain efficiency.

System Location

The placement of outdoor units is critical to prevent snow and ice buildup, which can obstruct airflow and reduce system performance. Ensure proper clearance and protection from the elements.

System Sizing

Properly size the ASHP to account for the peak heating and cooling requirements.

Ready!

You should now have a better idea of what **Air Source Heat Pumps for Large Buildings** 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
- Domestic Hot Water Systems
- Energy Recovery Ventilator
- Low Carbon District Energy
- Ground Source Heat Pumps

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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