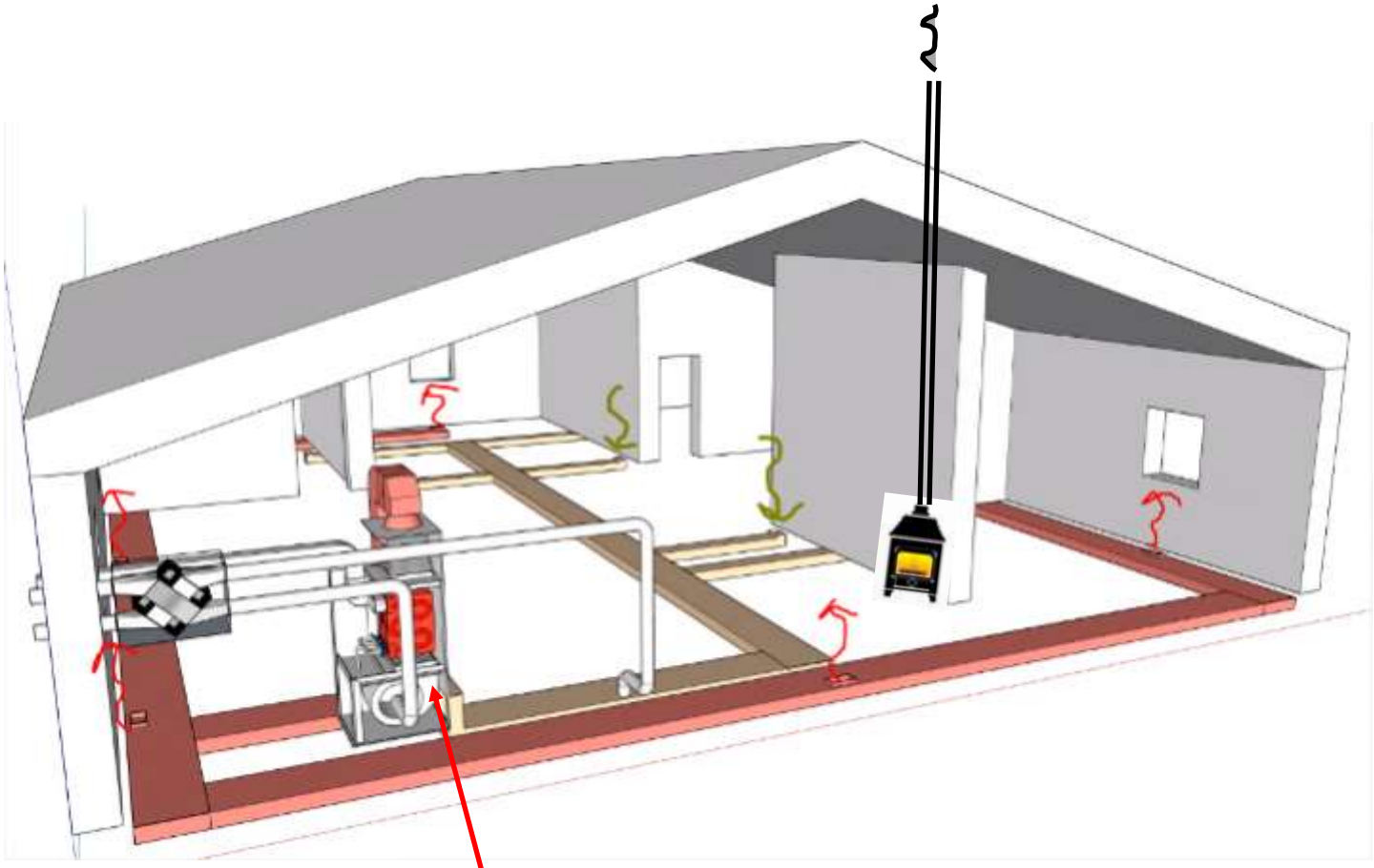
# BOOKLET 3: HEATING

## NORTHERN HOUSING TECHNICAL GUIDE



**Furnace (Primary Heating)**

→ TAILORED FOR REMOTE NORTHERN ONTARIO COMMUNITIES

## DISCLAIMER

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## The story of heating in the north

Historically, fire was the only one option for heating homes. In cold climates, our ancestors simply kept fires burning inside their home or shelters to stay warm during the cold months of the year. The homes or shelters they built were made specifically to work well with a continuously burning fire. They had an opening at the top for smoke to escape, allowed outside air to flow inside for fresh air and to feed the fire, and had no significant insulation, so that the people inside would not overheat (as open fires produce extreme amounts of heat). This approach to heating and simple shelter construction worked very well for our nomadic hunter-gatherer ancestors, and even today, in the form of hot tents used by trappers, or yurts in wilderness areas that people visit during vacation.

*A hot tent heated by a fire in the centre*

*A hot tent heated by a wood stove*

There are issues with this traditional approach:

- It relies on burning lots of wood.
- Keeping the fire burning is labour intensive and requires waking up in the middle of the night to tend to the fire.
- If you leave home for more than several hours, the fire will die down and everything in the tent will freeze. As a result, the dwelling cannot have plumbing for water.
- This approach is generally limited to relatively small shelters with no interior walls.
- Living conditions in these traditional dwellings are now considered by many people with families to be too rough, compared to modern standards.

**As modern housing and construction approaches developed, so did approaches to heating that are more compatible and safer with modern house construction. This guide presents these modern approaches.**

**Note: it is still very common to encounter a modern house heated in a traditional way, which can be problematic, depending on the context. Common issues with heating a modern house in a traditional way are discussed on the next page.**

## The story of heating in the north—continued

**Differences between traditional shelters and modern homes:**

Modern homes are highly insulated to conserve energy and hold heat longer.

Traditional wood stoves will easily overheat a room and the entire house if the house is small.

Modern homes are airtight to conserve energy, and to avoid moisture/mould issues associated with uncontrolled air leakage.

**A traditional wood stove needs to be direct-vented to prevent smoke getting pulled into the room by the exhaust fans or ventilation system.** (See the ventilation booklet in this series for safety concerns).

Modern homes have interior partition walls that separate the different rooms of a house. If a house is heated with only one wood-burning stove, there will be large temperature variations. The room with the stove will need to be uncomfortably hot if the stove is expected to warm the rest of the house, and the rooms far away from the wood stove will typically still be uncomfortably cold.

Modern homes have fresh water and wastewater plumbing, which means the house needs to be heated continuously through the cold months of the year to prevent the water pipes from freezing. If the house is heated with only a wood-burning stove, someone needs to be home to keep the fire burning. If the occupants leave the house for more than several hours or a full day and the fire goes out, the pipes could freeze and get damaged or leak.

**A traditional wood-burning stove remains an excellent way to heat a house for specific situations that will be discussed further. If heating is to be primarily by wood stove, additional measures should be taken in the house construction to manage the issues listed above.**

**For many houses and situations in remote northern communities, there are better ways to provide primary heat other than wood stoves, although they are common in some places. This guide recommends that you first consider other heating options before assuming a wood-burning stove is the best.**

## READ THIS BOOKLET IF YOU NEED TO:

1. **Learn about approaches to house heating to avoid overheating and cold spots in a house.**

2. **Decide which type of heating approach to use for a new* *comfortable, efficient, and reliably heated* house in northern Ontario.**

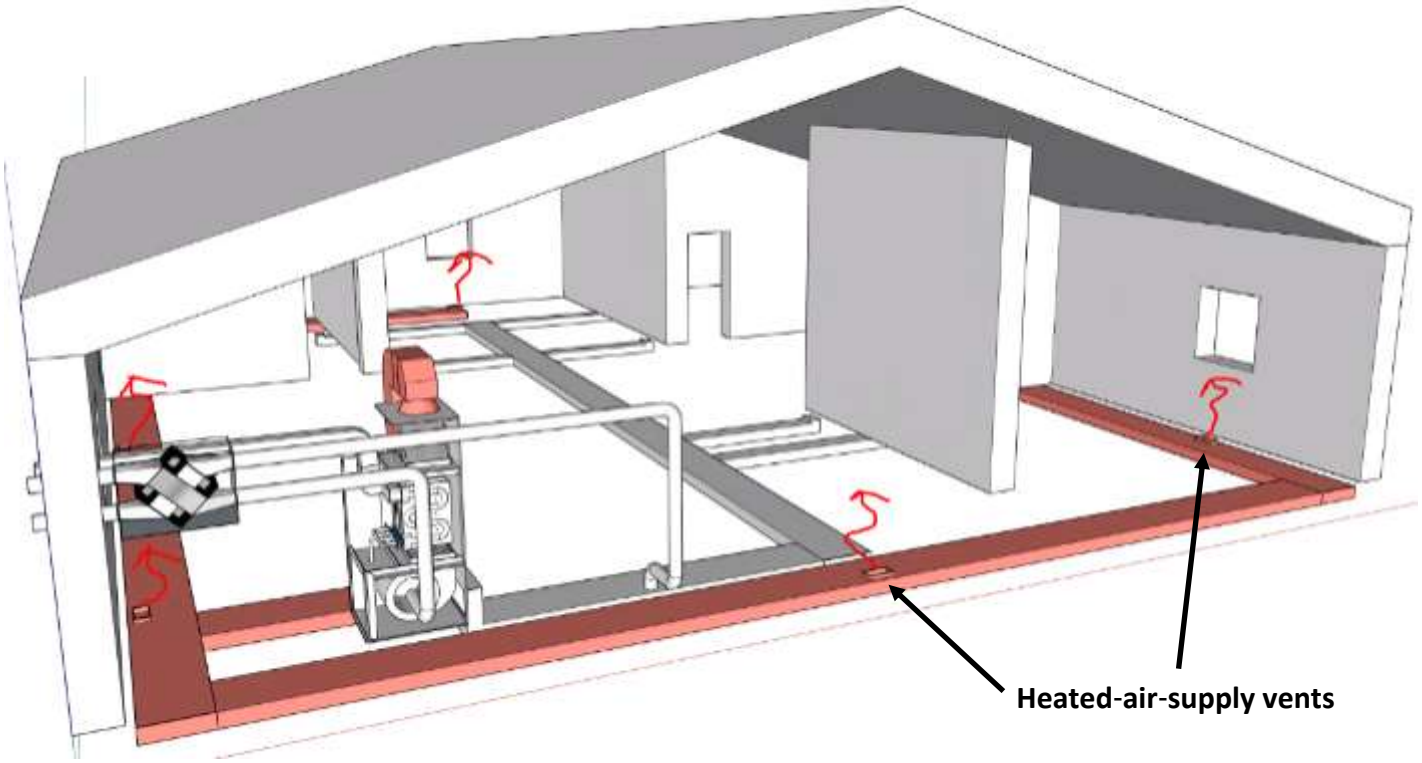
3. **Know more about the critical elements that make up a proper heating system.**

4. **Learn more about suitable housing approaches in northern Ontario.**

*Traditional house heating*

* Although this booklet is for new housing, concepts can also apply to the rehabilitation of existing homes.

*Comfortable, efficient, and reliably heated: The ultimate goal is to advise on housing approaches most likely to result in healthy living conditions and community well-being (i.e. avoid uncomfortable temperatures and moisture problems, last a long time, and minimize heating costs).* ***Selecting a heating approach best suited to your house and community will result in greater occupant comfort and efficient use of energy.***




*Forced-air-supply ducts with vents circulating heated air to the different rooms of the house*

## HEAT DISTRIBUTION: Getting the heated air to where it is needed

The heat distribution approach that best suits the house and community context needs to be considered before selecting a heating approach, as certain types of heating are more limited in distributing heat throughout a house. For example, a basic wood-burning stove in a large house, with many rooms, will not be able to properly heat a distant room even if the room with the stove is kept uncomfortably hot.

### 1) Single-point source

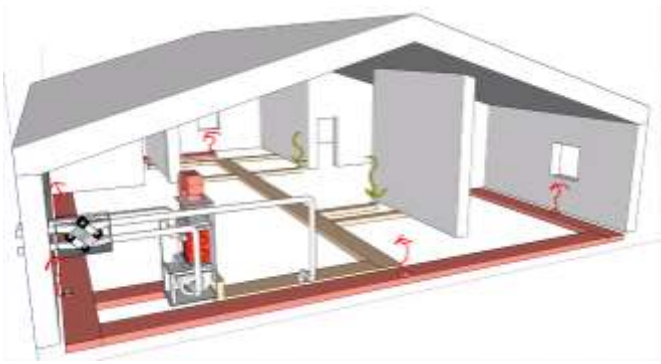
*A small, uninsulated open-format cabin with a central wood-burning stove*

### 2) Multi-point source

*A typical electric baseboard heater that would located in each room of a house*

## HEAT DISTRIBUTION: Getting the heated air to where it is needed

**Forced-air ducting from a furnace: a form of multi-point heating**

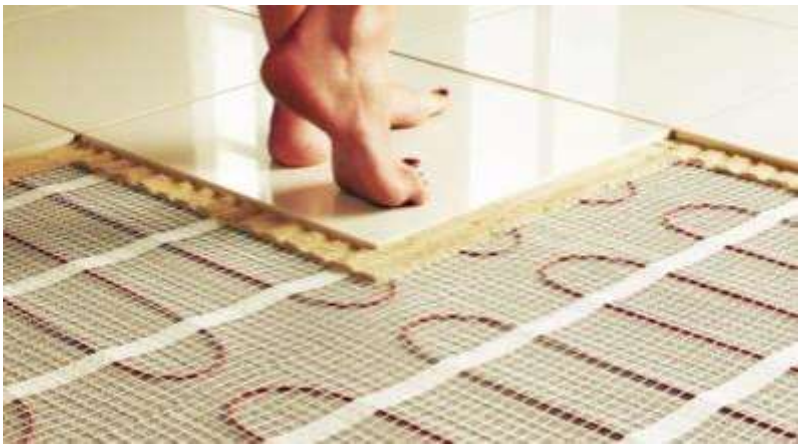


*Forced-air-distribution ducting connected to a furnace*

*Air-distribution ducting installed in a floor service cavity*

**3) Radiant floor areas**

*Hydronic radiant-heat flooring*



*Electric radiant-heat flooring*

## HEAT DISTRIBUTION: Single-point-source heating

**Single-point-source heating:** With a wood stove

**If there is an abundant, sustainable supply of firewood, a wood-burning stove is recommended as the primary heating source (assuming the point below applies).**

**Is best suited for small houses with no or minimal interior partition walls (open format). All areas of the house need to be relatively close to the heat source and have a direct path to the heat source. Faraway areas or areas behind a partition wall will not receive enough heat.**

*A wood-burning stove in the centre of an open-format home*

**A wood-burning stove can easily overheat a house. This is especially true if the house is highly insulated and the stove is too large for the intended space.**

**If a wood-burning stove is being used to heat a small open-format house, a stove size (capacity) should be selected that will reduce overheating. At least one operable window should be located on each side of the house, so that in the spring and fall seasons when it is not very cold, the temperature in the house can be more easily managed.**

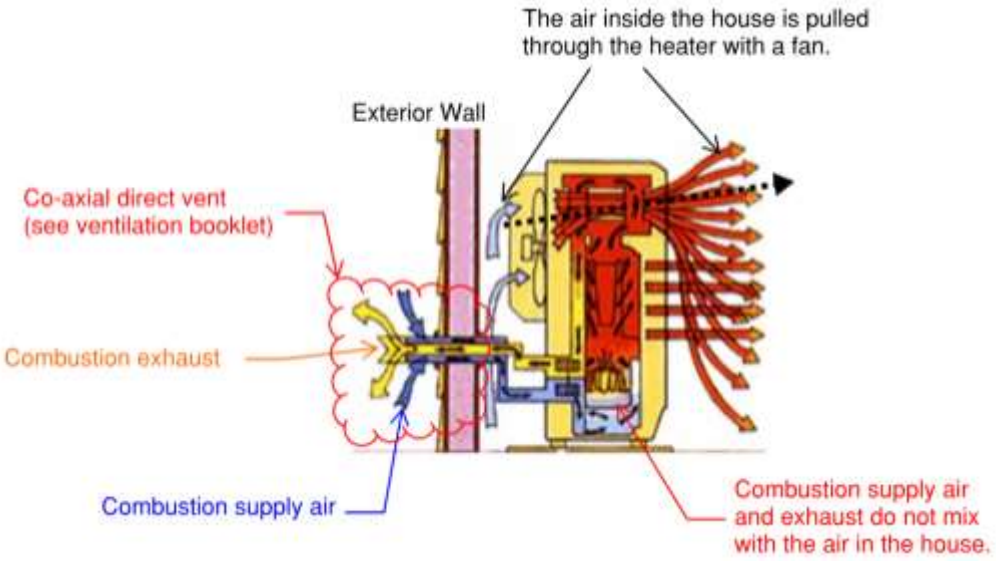
*A mini stove for a small cabin*

## HEAT DISTRIBUTION: Single-point source heating—continued

### Single-point-source heating: with an oil-burning unit heater

Although a wood stove in a small cabin is a classic example, this approach can also apply to a small oil-burning heater that does not have distribution ducting and simply blows warm air out from where it is located, as shown in the image below.

*An oil-burning unit heater (Toyo)*




*How the oil-burning unit heater works and needs its combustion gases (smoke) to exhaust through an exterior wall*

**An oil-burning heater will not supply nearly as much heat as a wood stove. If code-minimum insulation is used in the construction of the house, there is the risk that the house will not be sufficiently warm from the oil-burning heater.**

**As heat output is easily controlled by the oil-burning heater's thermostat, they are well-suited to *highly insulated house construction,* where they help conserve energy and keep the house comfortably warm for longer periods of time.**

**This is best-suited for small houses with no or minimal interior partition walls (open format). All areas of the house need to be relatively close to the heat source and have a direct path to the heat source. Faraway areas or areas behind a partition wall will not receive enough heat.**

## HEAT DISTRIBUTION: Multi-point-source heating

**Multi-point-source heating:** with electric baseboards in each room of the house

**If there is an abundant, sustainable supply of electricity in the community, electric baseboard heating is recommended as the primary heating source only when combined with highly insulated house construction, as the initial cost of the equipment is low, installation is simple, reliability is high and maintenance is minimal (see Booklet 7). However, it may be very expensive to operate in homes that are not energy-efficient.**

Electricity generated by a hydroelectric dam is sustainable and can be very reliable, even through the coldest and darkest winter months, depending on the local hydrology. For example, Yukon Housing Corporation has had success installing electric-resistance heating (electric baseboards and electric furnaces) in their highly energy-efficient housing where heating demand is very low.

*The hydroelectric generation dam in Whitehorse, Yukon*

**Power outages and shutdowns of the electrical grid are common in remote northern communities. If heating in a house is primarily with electric baseboard heaters, a backup method of heating the house should be included in the house construction.**

**A wood-burning stove is a recommended backup/secondary heat source, for when there are power outages, if firewood is readily available and abundant.**

**If firewood is not readily available, the electric baseboards can be kept running during a power outage with a mobile power generator. Ensure manufacturer requirements are followed with respect to capacity, wiring hook-up, safety, etc.**

*A mobile generator connected to a house*

## HEAT DISTRIBUTION: Multi-point-source heating

**Multi-point-source heating:** multiple wood stoves/oil heating units in the rooms of a house

**If electricity is generated by a diesel-burning power generation plant, electric baseboard heating is not recommended as the primary method of heating.**

It is more energy-efficient and more reliable to heat with a furnace that burns the diesel/oil directly. If you're in a community where diesel generators provide electricity, they'll need to burn about three times more fuel to power electric baseboard heaters than an oil-burning heater.

It would be technically possible to have multiple wood stoves or oil-heating units in the different rooms of a house. However, this approach would use up valuable space in different rooms of the house. Multiple wood stoves would be challenging and onerous to keep burning, and it would be difficult to control the temperature. Multiple oil-heating units would work better than multiple wood stoves, as the temperature in each room would be much easier to control and they don't require nearly as much effort and attention to keep them running. However, an oil-burning furnace with forced-air ducting will be more efficient and is much better paired with a ventilation system for the house.

**The use of multiple wood stoves in a house is not recommended, as there are more efficient and manageable ways to heat larger houses with interior partition walls and many different rooms.**

**The use of multiple oil-burning unit heaters in a house is not recommended, as there are more efficient and effective ways to heat houses with interior partition walls and many different rooms that are also well suited to including proper ventilation in a house.**

**An oil, propane, wood-pellet, or wood-burning furnace connected to forced-air ducting is recommended for houses with interior partition walls and many different rooms that would otherwise require multi-point heating to ensure comfortable and balanced temperatures throughout the house. Additionally, the furnace and ductwork can be used by the ventilation system to avoid common ventilation issues.**

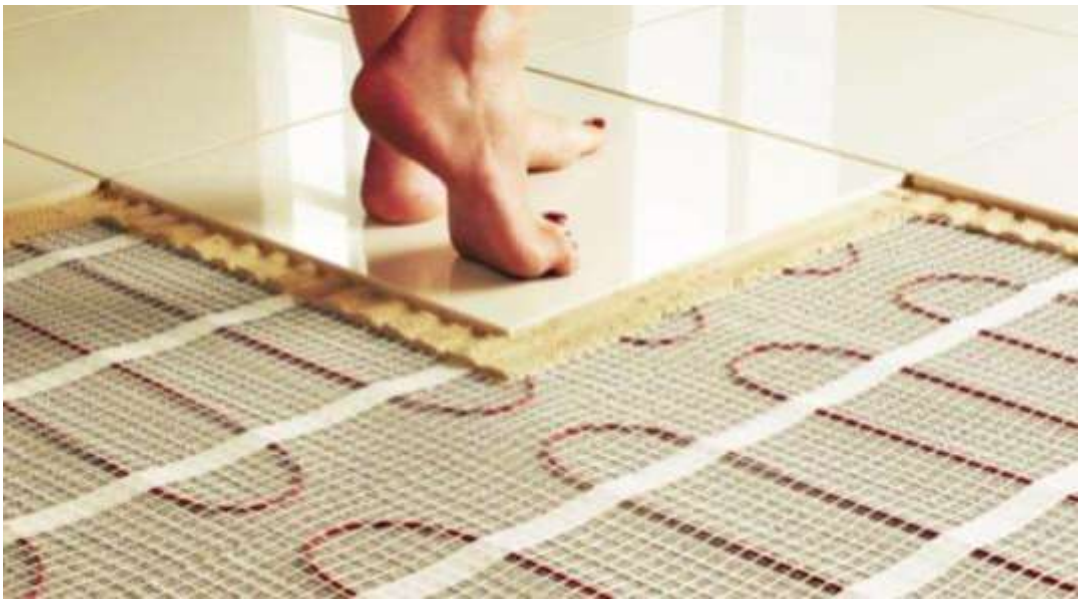
*A basic wood-burning furnace that connects to air ducts*



## Radiant floor areas: electric or hydronic?

**There are two main types of radiant floor area heating: electric and hydronic. Both involve a heat conductor (wire or pipe) installed under the floor or floor finish.**

Electric radiant floor area heating is generally not recommended to heat the overall house, as it uses a lot of electricity and there are more efficient ways to heat a house. It is considered a luxury feature specific to warming floors, typically involving ceramic or stone surfaces, such as in bathrooms that tend to feel cold. The electrical heat trace heats the floor surface so that it is warm and comfortable to walk on with bare feet. In the event that the electric radiant heat should fail, replacement can be a substantial problem.



*Electric radiant-heat flooring*

**Electric radiant-floor area heating is considered a luxury feature, and is not recommended for the north, due to the high cost of electricity.**

**"Warm floor" construction with a service cavity under the floor finish is recommended as a more efficient way to improve floor temperature comfort (see Booklet #7).**



## Radiant floor areas: Hydronic

Hydronic radiant-floor-area heating involves laying 1/2" plastic pipe (PEX tubing) under the floor and circulating hot water through the pipes. Hydronic heating is a very efficient and customizable approach, but is also the most expensive and technically complex system to install. Repairs and troubleshooting issues can also be complex. The piping needs to be connected to a hot-water boiler, and there is typically a manifold panel to connect the pipes. Additional hydronic pipe can also connect to wall-mounted radiators or to a hydronic radiator inside a duct.

*Hydronic radiant-heat flooring*

*Hydronic heater designed to heat air inside duct*

*Hydronic boiler equipment with pipe manifold*

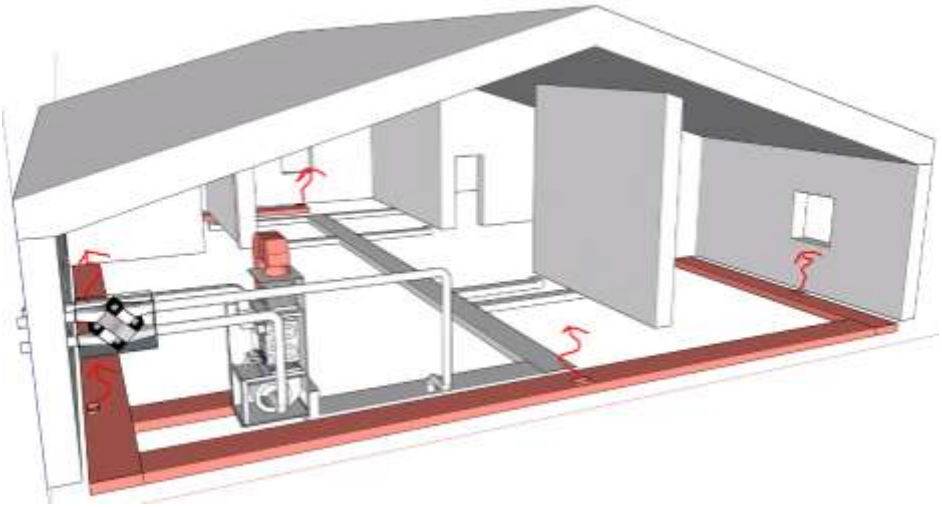
**Hydronic heating is not recommended for small houses in the north. It is much better-suited to large buildings, where there is a dedicated worker trained and employed to make sure the heating system is operating and maintained properly. The system needs to be designed accordingly for the environment.**

**Consider heating with an oil or wood-burning furnace connected to forced-air ducting in larger houses with interior partition walls and many different rooms that require multi-point heating to ensure comfortable and balanced temperatures throughout the house. Additionally, the furnace and ductwork can be utilized by the ventilation system to avoid common ventilation issues.**

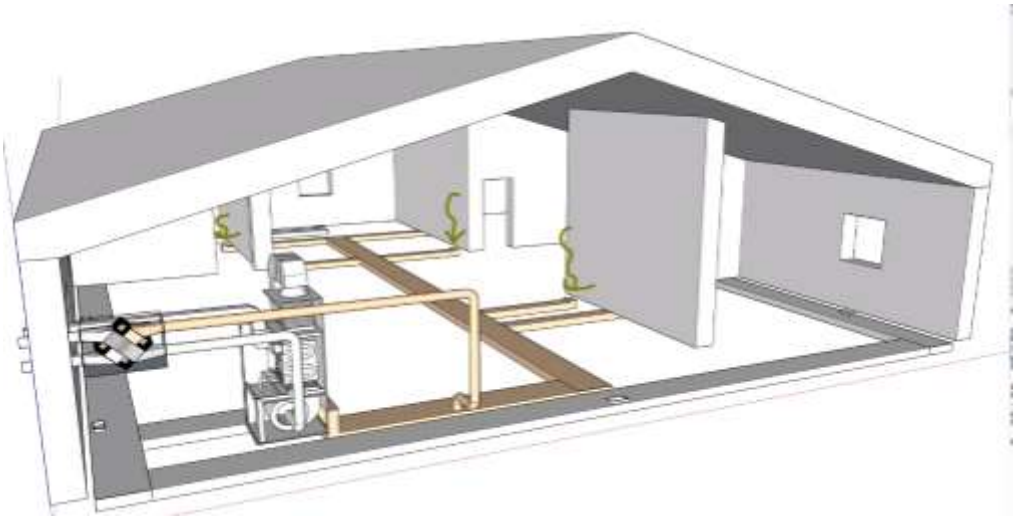
## HEAT DISTRIBUTION: Forced air ducting

### Furnace with forced-air ducting: Supply and return ducts

A good way to heat a home is with a furnace that pushes warm air to where you need it. If there is an abundant supply of wood, a combination wood/oil furnace would let you burn wood when people are home, and switch over to oil when the wood fire goes out. If you don't have wood, an oil-burning furnace is a good alternative that will move air around the house and keep each room at the temperature you want, once you get it balanced. With a furnace, you'll need to design your duct system so that the warm air supply flows out of the floor and up over windows and exterior walls, and the return air is pulled ideally from each bedroom, common gathering spaces, and possibly the middle of the home (e.g. hallways).



*Supply air-ducting along the exterior walls with vents below windows*



*Return air-ducting in the middle of the house, away from exterior walls with vents at the base of interior partition walls*

## Heating-Appliance Selection: Recommended heating approaches


**Nested chimney: Incoming cold ventilation air (VA) is warmed by passing through an outer-jacket chamber that surrounds the hot chimney pipe that is filled with hot smoke (Fumes and Gases, FG).**

*A typical wood stove*

Approach #1: **Wood-burning stove**

- For small, open-format houses only.
- For communities with an abundant, sustainable supply of firewood.
- The combustion chamber should be direct vented (see ventilation booklet).
- Code-minimum insulation is recommended to avoid overheating the house.
- Operable windows are recommended on all sides of the house to manage over-heating in the shoulder seasons (spring and fall).
- A nested chimney is recommended to warm incoming fresh ventilation air.
- An HRV (heating recovery ventilation) or ERV (energy recovery ventilation is not needed with this approach. Exhaust fans and an air-inlet pipe that connects through the nested chimney would work well. A damper inside the air-inlet pipe in combination with switches for the exhaust fans could be used to control the ventilation rate and also manage overheating, to a degree.

*A basic wood-burning furnace that connects to air ducts*

Approach #2: **Wood-burning furnace that directly heats ventilation air**

- For houses with interior partition walls.
- For communities with an abundant, sustainable supply of firewood.
- The combustion chamber should be direct-vented (see ventilation booklet).
- Highly insulated house construction is recommended, to save firewood, given that the temperature in a house is more easily managed; overheating is less of a concern.
- An HRV or ERV is not needed with this approach. Exhaust fans and an air-inlet pipe that connects the heat ex-changer chamber in the furnace would work well with this heating ap-proach. A damper inside the air-inlet pipe in combination with switches for the exhaust fans could be used to control the ventilation rate.
- Manufacturer specifications for size and design need to be followed.

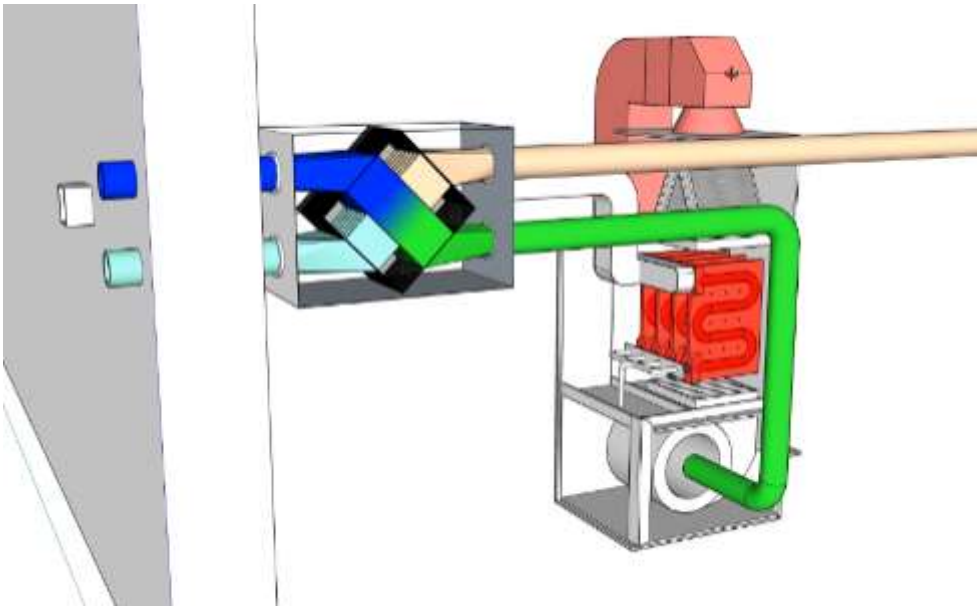

*A wood-burning furnace directly heating the ventilation air (blue)*

## Heating Appliance Selection: The recommended heating approaches—continued

*A combination forced-air furnace that can burn both wood and heating oil*

Approach #3: **Oil-burning forced-air furnace that can also burn wood.**

- For houses with interior partition walls.
- For larger houses with multiple bedrooms**.**
- For communities that need to rely on diesel heating oil, as firewood is not abundant.
- Wood-burning function is a backup to the automated oil-fired system.
- Electric baseboard heaters could also be used for backup emergency heating.
- The combustion chamber should be direct-vented (see ventilation booklet).
- Highly insulated house construction is recommended, to save both heating oil and firewood, given that the temperature in a house is more easily managed; overheating is less of a concern.
- An HRV or ERV should be used with this approach to conserve energy. The fresh air from the HRV/ERV should feed into the furnace and be warmed further before being distributed throughout the house (as shown below).



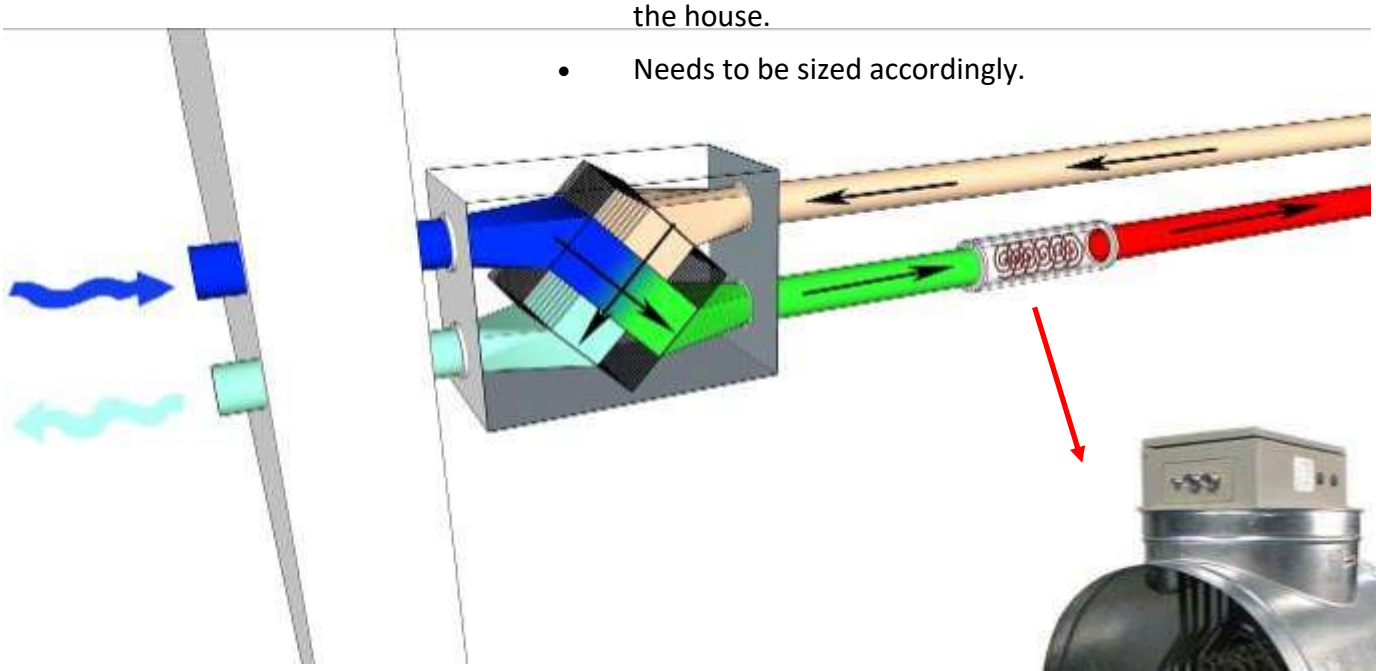
*Partially warmed outdoor air from the HRV connected to the furnace to be heated before being distributed throughout the house*

A typical electric baseboard heater that would located in each room of a house.

Approach #4: **Electric Baseboard**

*** For communities with an abundant supply of sustainable low-cost electricity (local hydro dam).**

- Baseboard heaters should be located in each room in the house and typically below windows.
- For any house size.
- Highly insulated house construction is recommended, to save energy.
- An HRV or ERV should be used with this approach to conserve energy.
- The fresh incoming ventilation air will still need to be warmed after it passes through the HRV or ERV. Electric duct heaters like the one shown below should be included in the construction of the house.
- Needs to be sized accordingly.



*HRV with an electric duct heater installed on the duct that carries fresh incoming ventilation air into the house*

*An electric duct heater*

## Final things to consider

**Energy:** For any home in the north, you need a lot of heat over the course of the year, and energy is expensive. To reduce the amount of energy used and to reduce yearly costs, always ensure the building is well insulated, airtight, and properly ventilated, and then select and install the most efficient systems possible.

**Freeze-up:** You need to make sure your heating system is reliable and maintained, or you run the risk of freezing your plumbing system, which can cause pipes to burst and lead to water damage to the home. You also need to make sure your intakes and exhausts are kept free from ice build-up, or you can end up with systems that don't work when you need them to. Electric heat tracing or hydronic heating systems, if you have a boiler, can sometimes be used to make sure air intakes and exhausts don't ice over.

*The exhaust and air intake for this furnace was frozen over*

This technical booklet was developed to help community decision makers and building officers choose among different technical options in the delivery of residential housing for First Nations communities in remote northern Ontario.

## IMPORTANT NOTE

This booklet is primarily focused on modern airtight house construction, although some traditional non-airtight approaches to housing are also discussed.

A mechanical ventilation system needs to be included in the design and construction of an airtight house. Refer to technical booklet #2 on ventilation.

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