

# Decarbonizing Residential Energy Use Through Geoexchange Microgrids

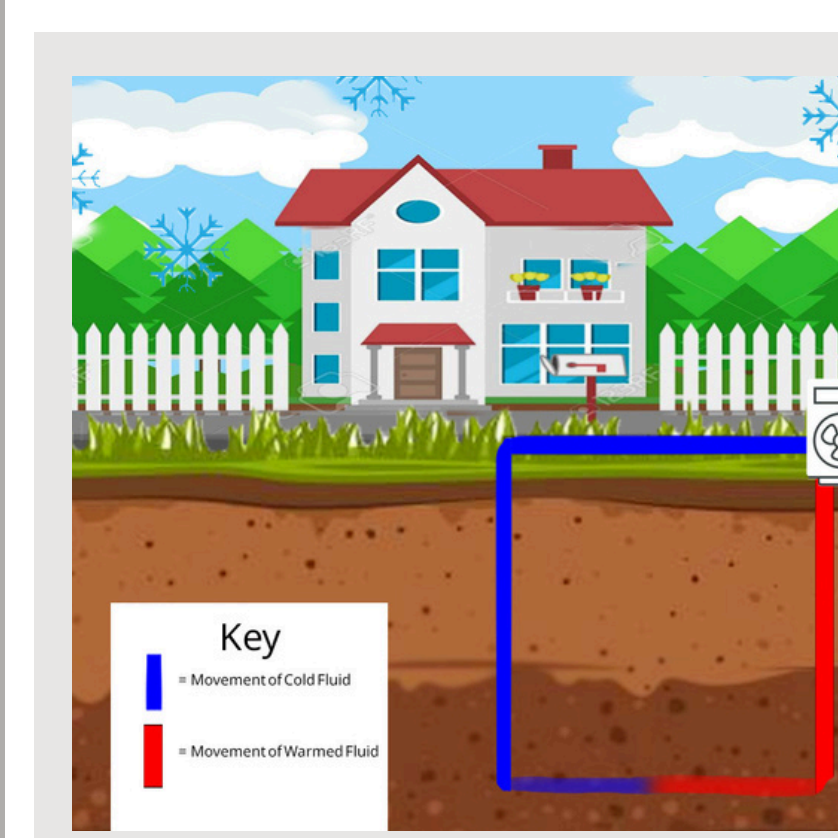
## 01. Background & Motivation

In 2017, Hanover committed to 100% renewable electricity by 2030 and carbon-neutral heating/cooling by 2050. Sustainable Hanover (SH) and Dartmouth College are leading local decarbonization initiatives. This project is one branch of that focused on heating and cooling in local residences.

## About the System

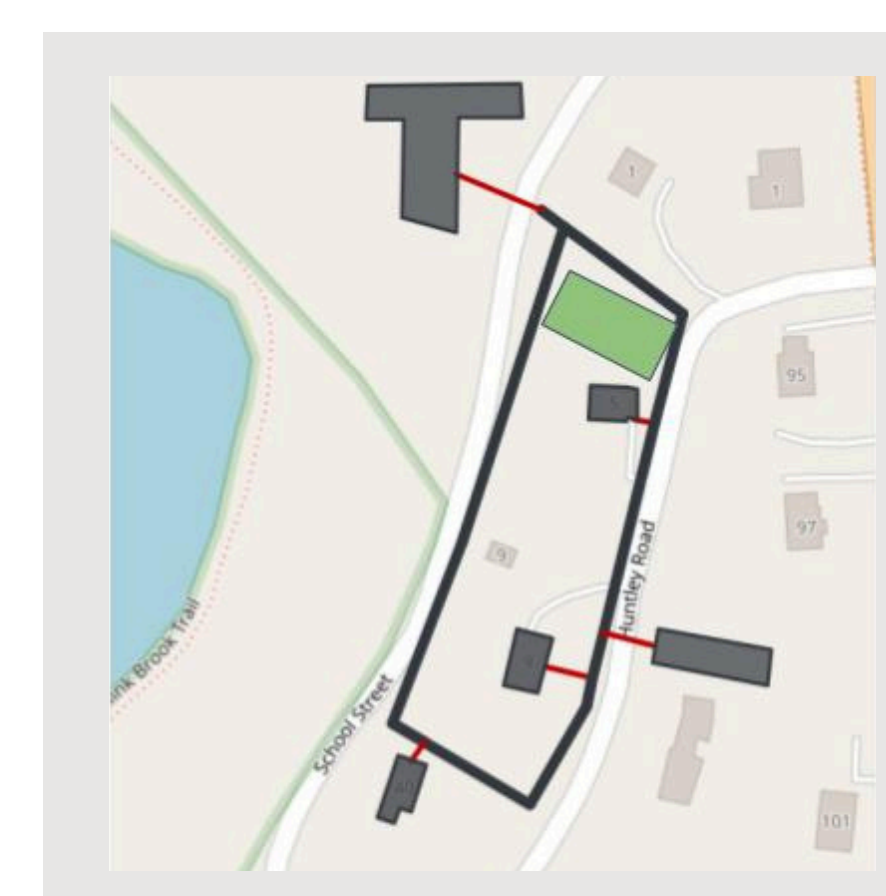
A series of pipes, called a ground loop, is buried underground and filled with a water or antifreeze solution. In the winter, this fluid absorbs heat from the earth and carries it into the building. Inside, a heat pump compresses the warm fluid to raise its temperature further and distributes the heat through the building. In the summer, the process is reversed—the system pulls heat from the building and transfers it back into the cooler ground.

## 06. Different Systems and Components



System layout showing energy flow in a residence

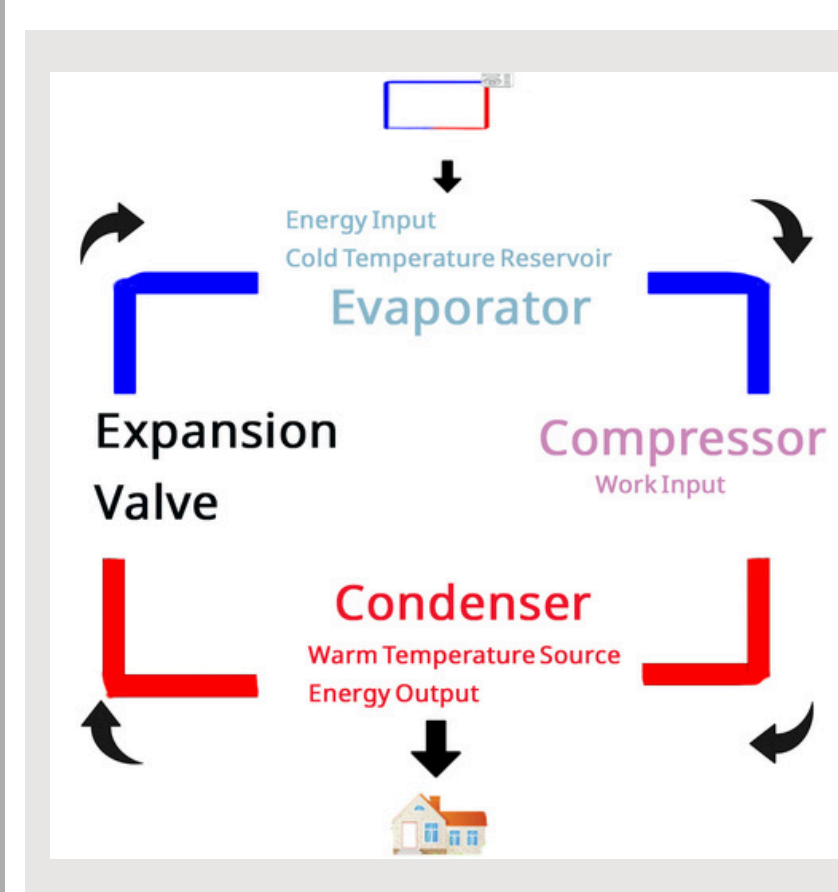
- If building new, geothermal installation can be a lot simpler, use air-duct heating/cooling
- Potential costs savings for working in terms of these microgrids will vary wildly from neighborhood to neighborhood depending on things such as house spacing, availability of land for drilling, contractor availability & experience, etc.
- GSHPs can achieve efficiencies of upwards of 400% (4 times as much energy comes out as heat than electricity was put in) as opposed to 90% for modern boilers.
- This works because ground maintains a mostly constant temp below the frostline



Proposed schematic of School Street micro-grid, with bore field in green



Proposed schematic of Kingston Road micro-grid, with bore field in green



The typical refrigeration cycle of a heat pump in heating mode

## 07. What does this look like?



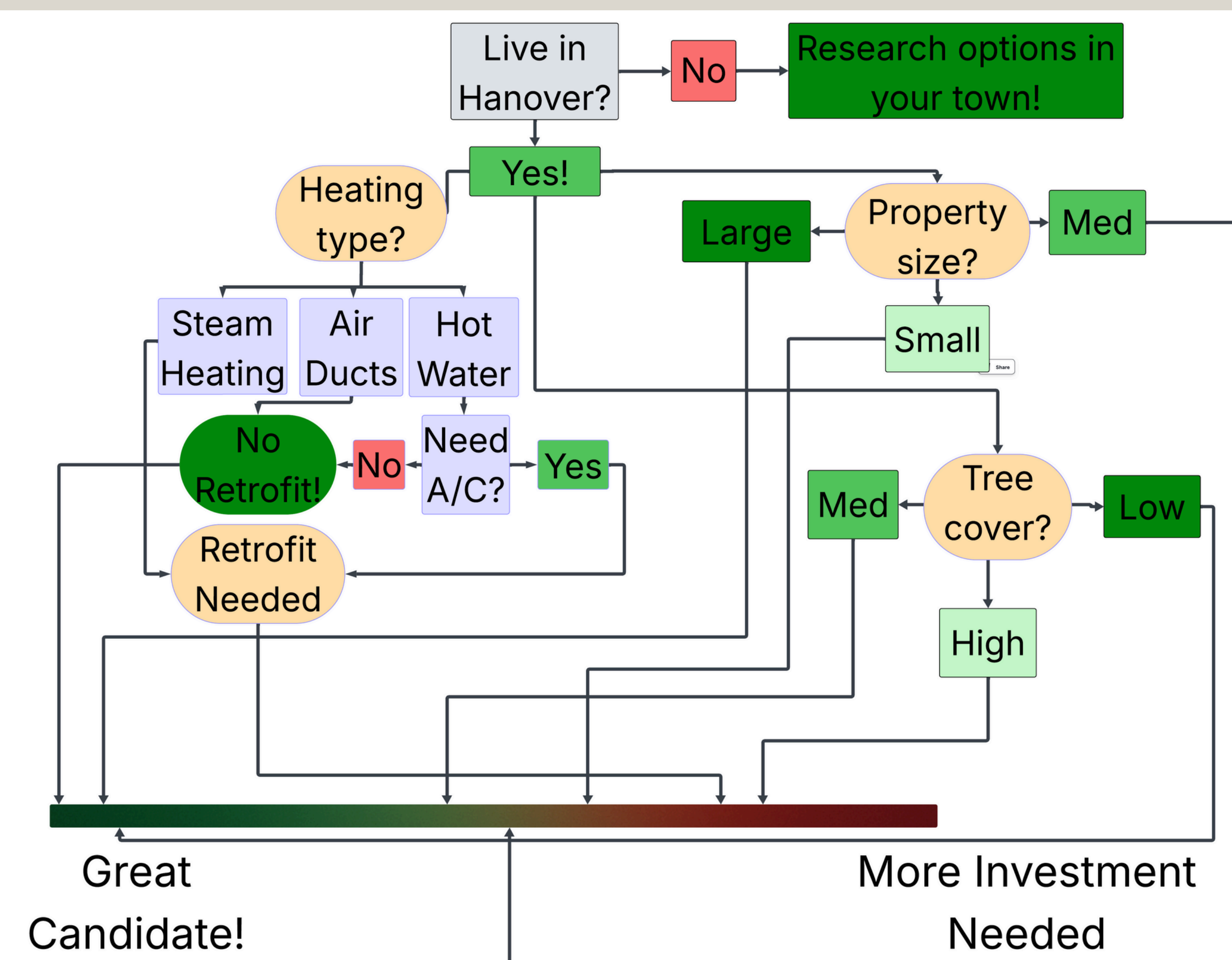
- Vertical ground loops installed in the yard
- Piping underground to garage or utility room
- Indoor geothermal heat pump unit (resembles a large furnace)
  - Provides heating and cooling through forced air or radiant floor systems
  - Water to air or water to water system, depending on ductwork or radiant heating
- Circulator pumps to balance temperature and distribute flow

### Additionally

- Strong insulation in house and piping
- Shut off valves installed and accessible
- Digital control panel for easy access
- Thermostats linked to system
- All pipes, valves, and electrical circuits clearly labeled
- Raised door entries (flood mitigation)
- Backup power source



## 08. "Is this for me? And, if so, what does that look like?"



### Model and Cost (For Our Example Sites)

Drilling cost: \$175,000 (for ~14 ~130m boreholes)  
Heat pump & connection: \$20,000 (x5)  
Air duct conversion (if desired): \$20,000 (x?)

**\$275,000 total**  
**\$55,000 (+\$20,000) per home**  
Pay for itself in 20-25 years

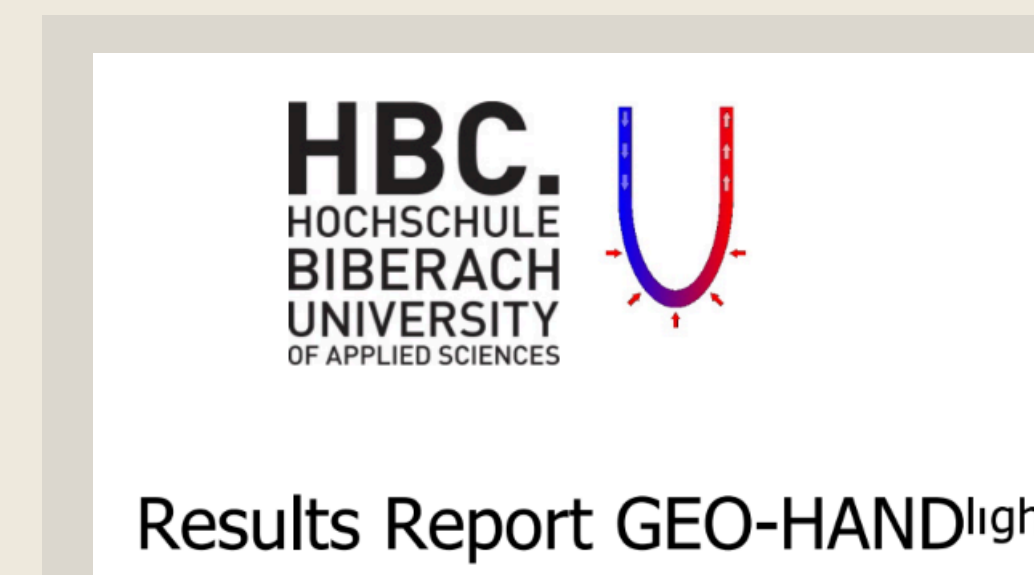
Note: Typical life of a heat pump is 25 years. Typical life of an underground fluid loop and equipment is at least 50 years.

### How do we know?

We extrapolated rough characteristics completed projects in this area and combined that with heating and energy use data from our test house to develop rough estimates of the cost and size. We then compared this with measurements we got from the software model GEO-HAND.

## 09. Acknowledgements and Key Resources Used

We would like to acknowledge Jentry Campbell, Judi Colla, Yolanda Baumgartner, Chris Kennedy, Jennie Chamberlain, Dan Bernstein and the members of Sustainable Hanover for their support of this project. Additionally, we acknowledge the use of tools by the following research groups.

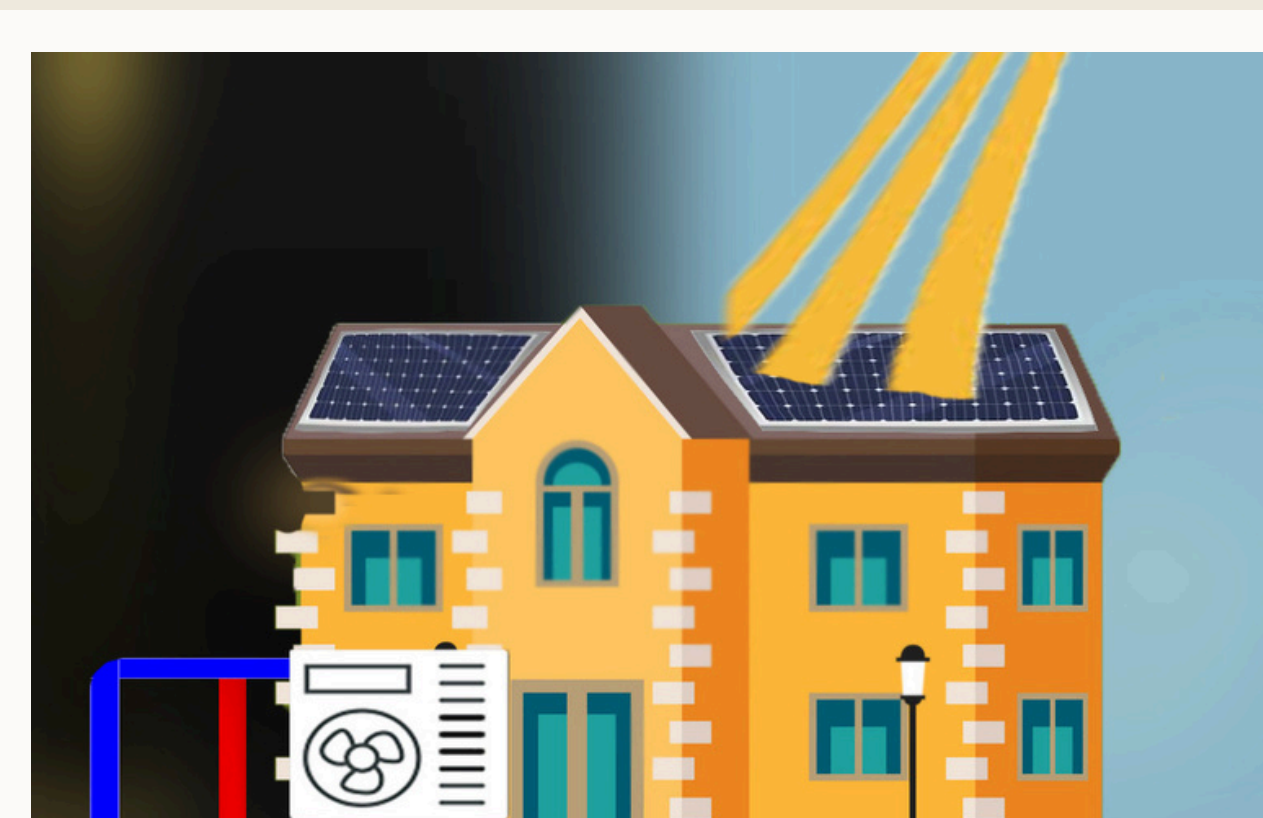


## 02. Objective

To explore the feasibility of geothermal exchange systems for individual homes

### How?

- Model and estimate:
  - Heating/cooling capacity
  - Infrastructure needs (e.g., boreholes, pumps)
  - Emissions reductions
  - Installation and lifecycle costs



Our ideal decarbonized home would have a combination of renewable energies such as solar and geothermal

## 04. Methodology

A retrofit involves replacing or supplementing traditional heating (like oil or propane furnaces) with a ground-source heat pump system vs a new build design

### System Components

- **Vertical boreholes** (100–500 feet deep) in the yard or shared green space.
  - **Closed-loop piping** carries fluid to exchange heat with the ground.
  - An **indoor heat pump** replaces or supplements the existing furnace or AC.
- Optional shared "micro-district" setup:** a small network serving 3–6 homes reduces cost per household.

## 03. Why Geothermal?

- Low operational emissions
- Works for heating *and* cooling
- Long system lifespan (20–50 years)
- Potential to replace oil/propane heating
- Cost-effective over time
- Pairs well with other renewable energies such as solar

### Outputs and Impact

- Detailed energy and emissions modeling
- Infrastructure specs
- Lifecycle cost analysis

## 05. How it might be implemented

### 1. Site Survey & Geological Assessment

- Determine drilling feasibility and optimal layout.

### 2. System Design

- Size based on home heat loss, square footage, and local climate.
- Shared boreholes and equipment when possible.

### 3. Permitting & Coordination

- Utilities and local government approvals, especially for shared infrastructure.

### 4. Installation

- Drill boreholes
- Install piping, pumps, and indoor heat exchange units.

### 5. Commissioning & Monitoring

- Test system efficiency
- Monitor energy savings and comfort levels