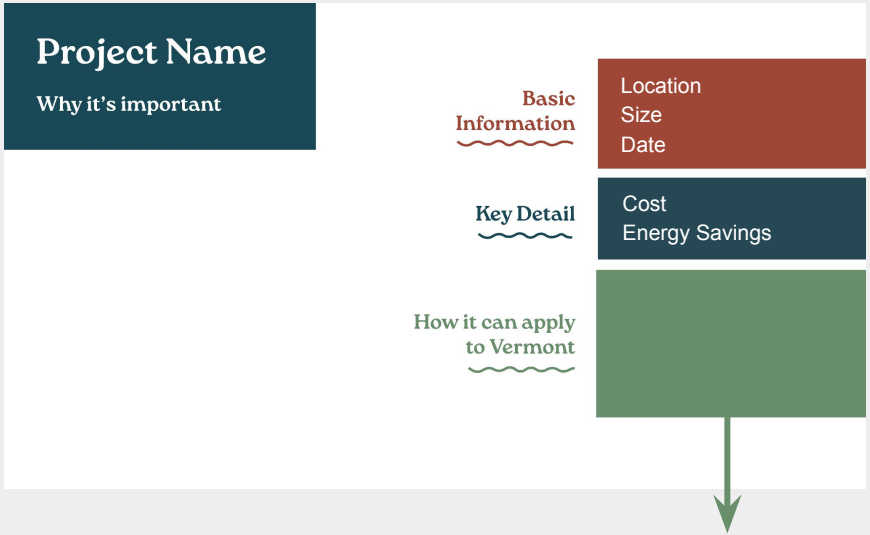
Case Study Guide



Features considered for how a project can apply to Vermont:

- In Vermont
- Colder Climate
- Rural Community
- Revitalization Project
- New Construction
- Retrofit
- Multiple Technologies
- Wastewater Heat
- Municipally Owned
- Single Building
- Neighborhood Scale
- Residential
- College Campus
- Phased Construction
- Future Expansion
- Resilience
- Open Loop

VERMONT COMMUNITY THERMAL NETWORKS

Introduction

This collection of case studies includes examples of Thermal Energy Networks (TENs) at work in communities across North America, from urban and rural neighborhoods to college campuses and single buildings. The examples show an array of approaches, and each relates in some way to the thermal needs and opportunities present in Vermont communities.

This project responds to the need for greater knowledge of what TENs can look like and how they can be built in different contexts. It also highlights the difficulty of finding information on key data such as system costs and performance metrics, in part because most private owners don't readily share details with the public. The information collected here is a start to help communities, developers, and individuals see some of the possibilities of what TENs can look like, how they're operating, and the many ways in which they can benefit communities.

TENs are designed to fit a particular location, geology, and cluster of buildings. The customized nature of each system contributes to their high level of efficiency, but also means that, while we can learn from similar conditions of existing systems, each new network must be developed based on local opportunities and needs.

Case Study Further Reading and Sources

Zero Place

Ground source heat pumps can be combined with other green technologies to achieve zero emissions.

Location: New Paltz, NY
Size: 63,320 sq. ft.
Operating Since: 2022

Project Cost: $10,547,313

Features:

- Colder Climate
- New Construction
- Multiple Technologies
- Single Building

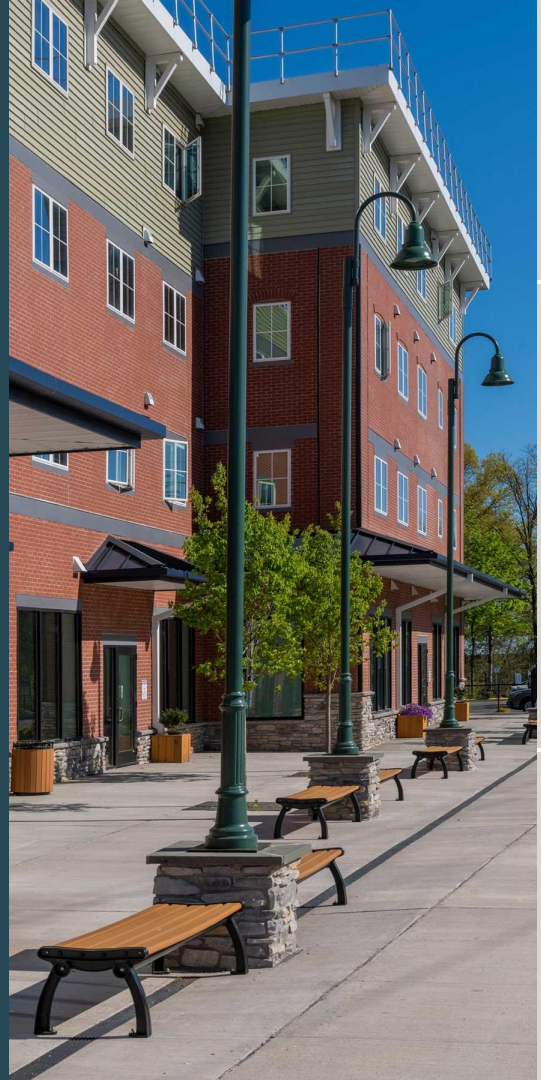
Zero Place is a single multi use building.

- 46 housing units
- 8,000 sq ft retail space
- Engineered to produce zero emissions

To meet their net-zero goals, Zero Place employs an array of systems which work in tandem to produce energy cleanly and use it efficiently.

These systems include:

- Ground source heat pump loops (15 wells) for heating, cooling, and hot water
- Solar panels for electricity
- Highly efficient construction (building envelope) and HVAC system that prevent energy loss



Resilient

During a complete grid outage, the building can maintain a temp of 50°F.

Affordable

10% of housing units are designated affordable.

Residents pay $0 in energy bills unless their energy consumption exceeds a designated threshold (more than 125% of expected need).

Popular

The building is now operational, and the apartments are highly sought after, with a waitlist currently in effect.

Colorado Mesa University

Ground source heat pump networks can create considerable financial savings over time.

Location: Grand Junction, CO
Size: 1.2 million sq. ft.
Operating Since: 2008

Energy Savings:

- Carbon footprint reduced by 17,742 metric tons of CO2 per year
- Saves 14,862,864 electric kilowatt hours per year
- Saves 705,986 therms per year

Features:

- **Colder Climate**
- **New Construction & Retrofit**
- **College Campus**
- **Phased Construction**
- **Future Expansion**

The CMU network serves a rapidly growing campus community.

- **The student population has quadrupled in the last decade.**
- **The system has expanded from 6 to 17 buildings and serves 11,000 students.**

Ground source heat pumps provide:

- Building heating and cooling
- Domestic hot water

What the students say:

“We’re talking about millions of dollars saved… and that’s translating directly back into students’ pockets… my tuition this past year was two percent cheaper because of the GeoExchange program!”

- Evan G. Piper, Student Trustee

Reliability

In its first 12 years of operation, this system:

- Never had to rely on its gas backup for heating/cooling
- Accrued no maintenance cost other than a heat pump bearing replacement

Long-Term Savings

- Saves the college $1.5 million in energy costs per year
- Has saved nearly $12 million since 2008
- Enables CMU to offer the second-lowest tuition rate in Colorado

Growth Opportunities

CMU is looking to expand their campus network into the local community. Prospects include City of Grand Junction buildings and Grand Junction High School.

Whisper Valley

Pairing ground source heat pump networks with solar can create resilience to storms and extreme weather events.

Location: Austin, TX
Size: 2,067 acres
Operating Since: 2020

Energy Savings:

- Homes use 25% of the energy used in a standard, code-compliant home.
- Ground source heat pumps reduce heating and cooling energy demand by up to 70%.

Features:

- **New Construction**
- **Multiple Technologies**
- **Phased Construction**
- **Resilience**
- **Neighborhood Scale**

Whisper Valley is a master-planned development in the Austin area.

The neighborhood is being built in 4 phases and is designed to eventually encompass residential areas, business districts, schools, an EMS center, parks, and trails. As of 2023, Phase 1 (residential development) is nearly complete.

Uses a ground source heat pump network for heating, cooling, and hot water, with solar for electricity.

The system is designed and operated by a private company.

Resilient

During Texas Winter Storm of 2021, most communities lost power and heat. Whisper Valley did not. The ground source heat pump system, paired with solar for electricity, maintained constant temperatures throughout the storm.

Efficient

Over 30 years, one Whisper Valley home is expected to save CO_2 emissions equivalent to:

- 45.8 vehicles driven for one year
- 23,868 gallons of gasoline consumed
- 27+ million smartphones charged

Ball State University

Choosing a ground source heat pump network over gas can create financial returns.

Location: Muncie, IN
Size: 5.6 million sq. ft. and more than 47 campus buildings
Operating Since: 2014

Emissions Reductions:
Carbon footprint reduced by 60%

Features:

- Retrofit
- College Campus
- Phased Construction

Decision Making

The Ball State University system is one of the largest ground source heat pump networks on a college campus in the United States.

The Thermal Energy Network on this campus includes a "Ground Source Geothermal Heat Pump" network and waste heat capture from the computer lab cooling and ventilation systems.

When the University learned that their old coal-burning heating system was no longer functional, they explored a few options for new systems: Gas, a Circulating Fluidized Bed Fossil Fuel Boiler, and a "Ground Source Geothermal Heat Pump" system.

Although the Ground Source system was most expensive to install, the school decided that it was a financially savvy choice since it would incur fewer costs down the road.

They were right: the school saves over $2M per year in energy costs.

Fuel Source Options Evaluated

Compared to existing coal-fired boiler

Category	Circulating Fluidized Bed Fossil Fuel Boiler	All Natural Gas Boiler	Ground Source Geothermal Heat Pump
Cost	High	Low	Highest
Change in Carbon Emissions	No change	50% decrease	~50% decrease, depending on fuel mix of local utility
Maintenance Cost	High	Low	Low
Emission Control Equipment Needed	Yes	No	No
Fuel Considerations	Alternative fuel capable	High fuel costs	Electric power dependent

Sources of financial return:

- Lower maintenance costs
- Avoided permit costs
- Avoided coal-ash disposal costs: approximately $200,000 annually

(Source: BSU)

Champlain College

An open loop ground source heat pump network can heat and cool both old and new buildings while keeping costs down.

Location: Burlington, VT
Size: 272,900 sq. ft.
Operating Since: 2008

Reliability:

The system's workhorse pump lasted 16 years and is the only component that has needed replacement. The system has conditioned buildings reliably through many Vermont summers and winters.

Features:

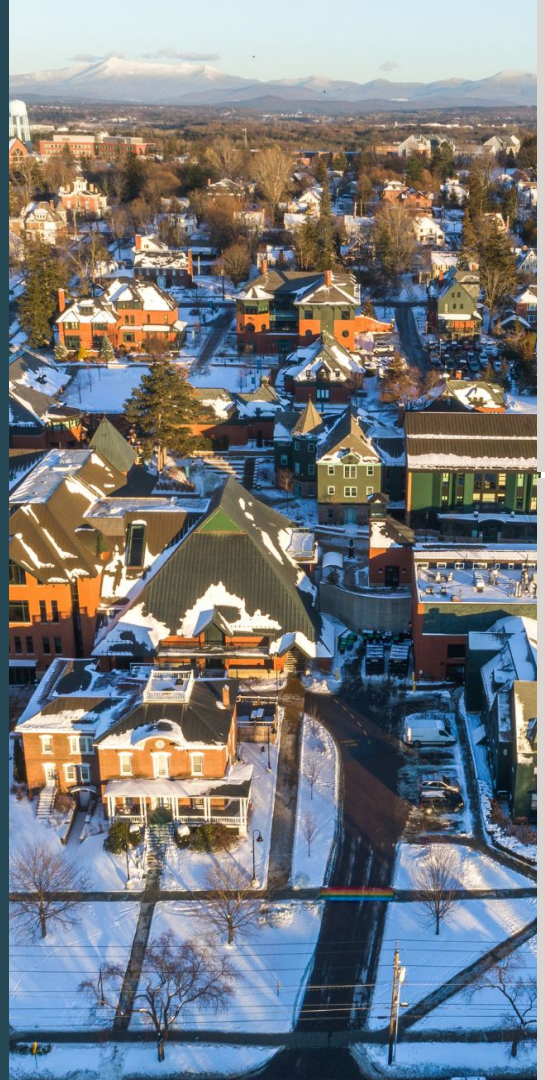
- In Vermont
- Retrofit
- College Campus
- Phased Construction
- Open Loop

Champlain College is a small campus with 9 buildings heated and cooled by ground source heat pumps.

Buildings include:

- College welcome and admissions center
- Student services building
- Auditorium
- Five dormitories

Some buildings are new construction, but several have been retrofitted to use ground source heat pump low-temperature heating and cooling.



Retrofit-friendly

Many of the buildings on Champlain College's system were built over 100 years ago. In at least one retrofitted building, a steam heating system has been retrofitted to work with ground source heat pumps. This is uncommon, but can be done with some smaller steam units. The building is cooled using the same ground source loop, but with separate indoor units.

Affordable Open Loop

Open loop systems are less expensive to install than closed loop systems because they require less drilling, but they depend upon access to an underground aquifer.

An open-loop system:

- **Draws and filters water from pump wells**
- **Runs it through heat exchangers to either heat or cool the building**
- **Injects the water back into the groundwater system through a discharge well.**

Burlington can be a favorable location for reaching reliable underground aquifers.

Hula

Large-scale renovations can use ground source heat pumps and other technologies to achieve net zero emissions.

Location: Burlington, VT
Size: 150,000 sq. ft.
Operating Since: 2021

Won “Best of the Best” in Commercial Building Design & Construction at the 2022 Better Building By Design energy conference

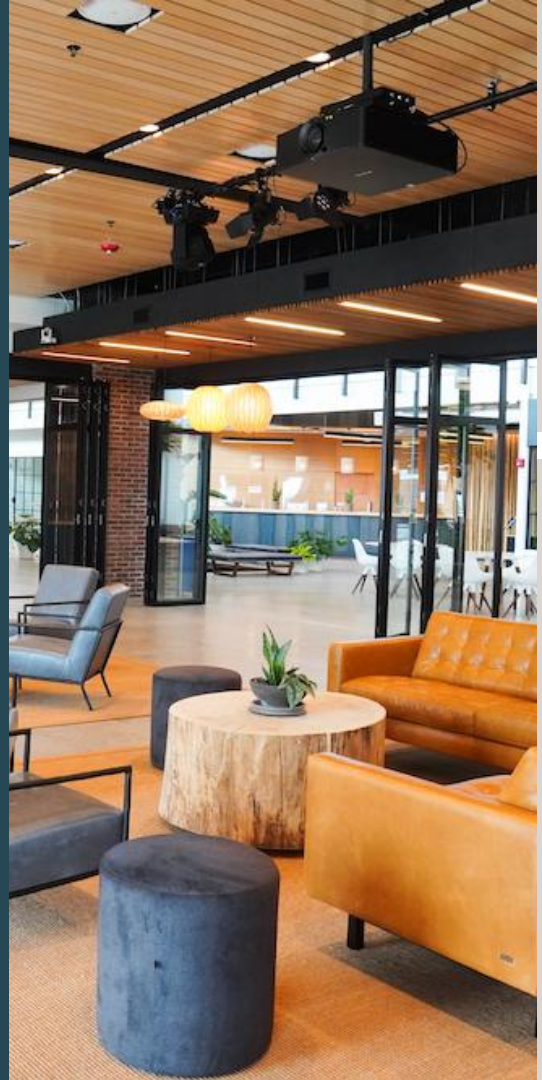
Features:

- In Vermont
- Retrofit
- Multiple Technologies
- Phased Construction
- Open Loop

Hula coworking space is housed in a refurbished oven factory on the shores of Lake Champlain.

Net zero emissions system features:

- Open loop ground source heat pump heating, cooling, and hot water
- Solar panels for electricity
- Highly efficient construction and building envelope
- Heat capture system for kitchen exhaust
- Heat pumps placed throughout buildings to distribute heating and cooling efficiently
- Includes 2 buildings and is expanding to serve more



Renovated Building Envelope

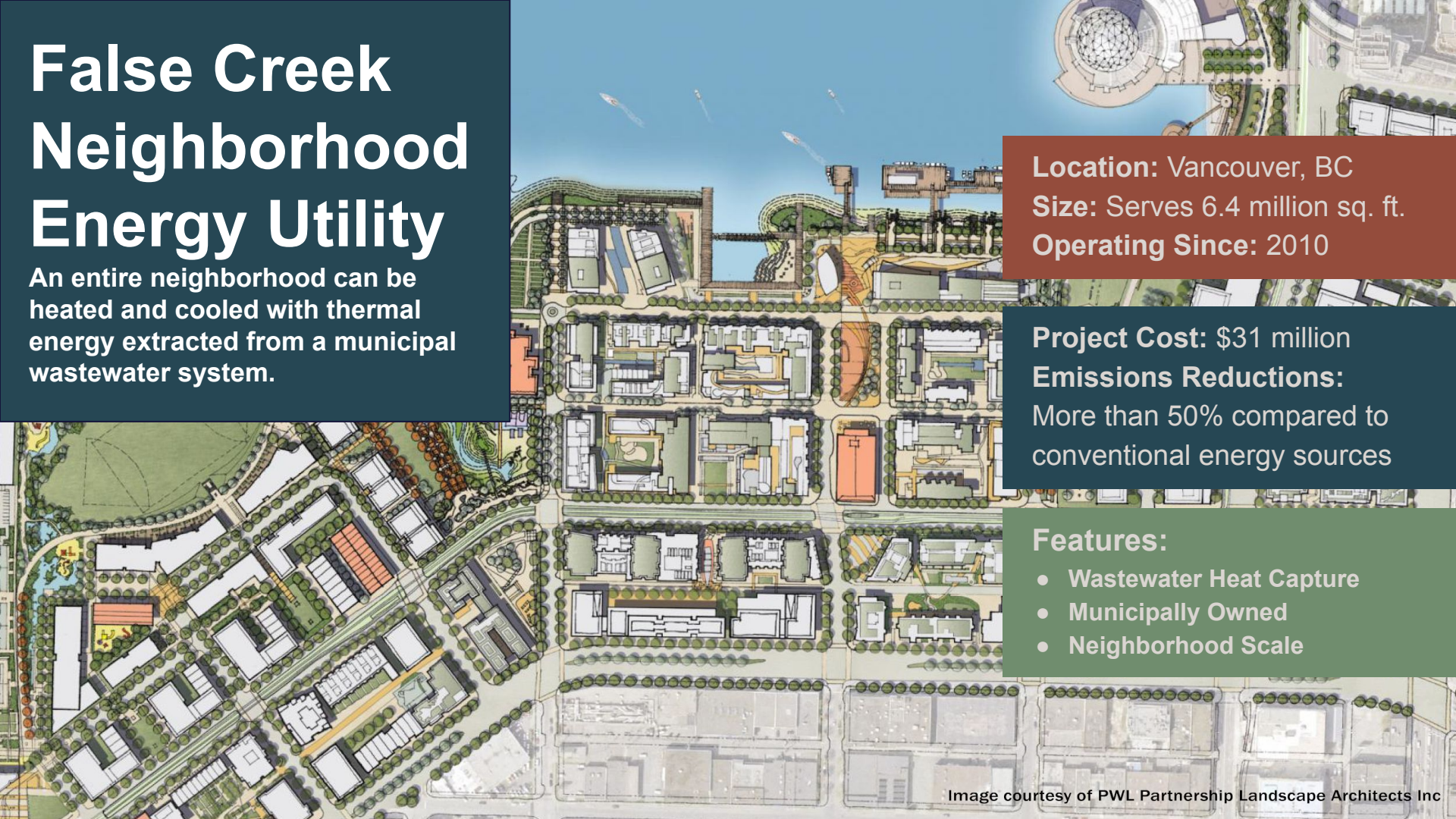
When renovating the oven factory, engineers paid special attention to the efficiency of the building's insulation. This is key when making retrofitted buildings viable for ground source heating and cooling.

Efficient Temperature Control

The buildings are equipped with many small scale indoor heat pumps which work together to transfer warm and cool air throughout the building. If, for example, one side of the building receives heat from direct sunlight, the system will distribute that solar heat to the shaded rooms of the building as needed before tapping into the ground source loop for warmth.

False Creek Neighborhood Energy Utility

An entire neighborhood can be heated and cooled with thermal energy extracted from a municipal wastewater system.



Location: Vancouver, BC
Size: Serves 6.4 million sq. ft.
Operating Since: 2010

Project Cost: $31 million
Emissions Reductions: More than 50% compared to conventional energy sources

Features:

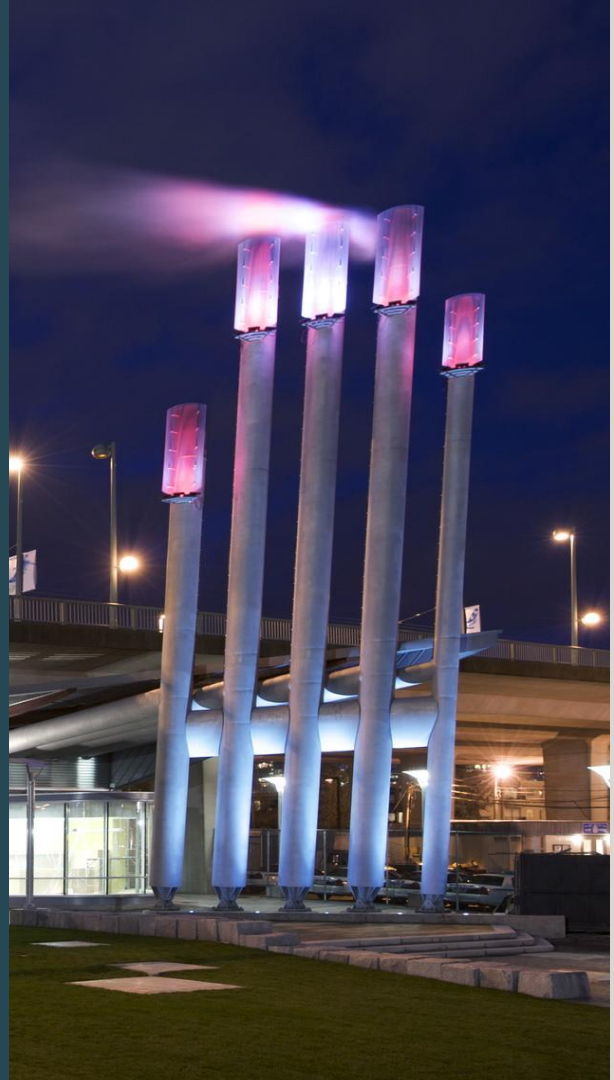
- Wastewater Heat Capture
- Municipally Owned
- Neighborhood Scale

Image courtesy of PWL Partnership Landscape Architects Inc

False Creek NEU is a large-scale municipal wastewater heat capture system that serves a neighborhood built in a former industrial area.

Heat pumps capture thermal energy from a Vancouver wastewater system at a pumping station. A network of pipes moves that energy throughout the neighborhood.

The system supplies 70% of the neighborhood's yearly energy demand.



Municipally Owned

- The project demonstrates commercial viability of clean heating and cooling to the private sector.
- Costs are covered by utility revenue, not taxpayer dollars, and the City receives a return on its investment.

Fast Construction

- System was built quickly to align with the 2010 Winter Olympics in Vancouver
- 5 year project duration
- Public ownership enabled faster approval and greater access to grants and low-cost financing

Aesthetics

Clean energy doesn't need to be an eyesore in our communities! False Creek is meant to be seen by the public as an art installation. LEDs on the facility's stacks indicate how high the public energy demand on the system is at that moment- they glow red for high demand and blue for low demand.

Green Streetscapes

Revitalization projects can attract new business and residents to rural towns by creating access to clean heating and cooling infrastructure.

Location: West Union, IA
Size: 330,000 sq ft
Operating Since: 2012

Project Cost:
$10.2 M (for full project)
$2.3 M (for ground source network)

Features:

- Rural Community
- Retrofit
- Revitalization Project
- Future Expansion
- Neighborhood Scale

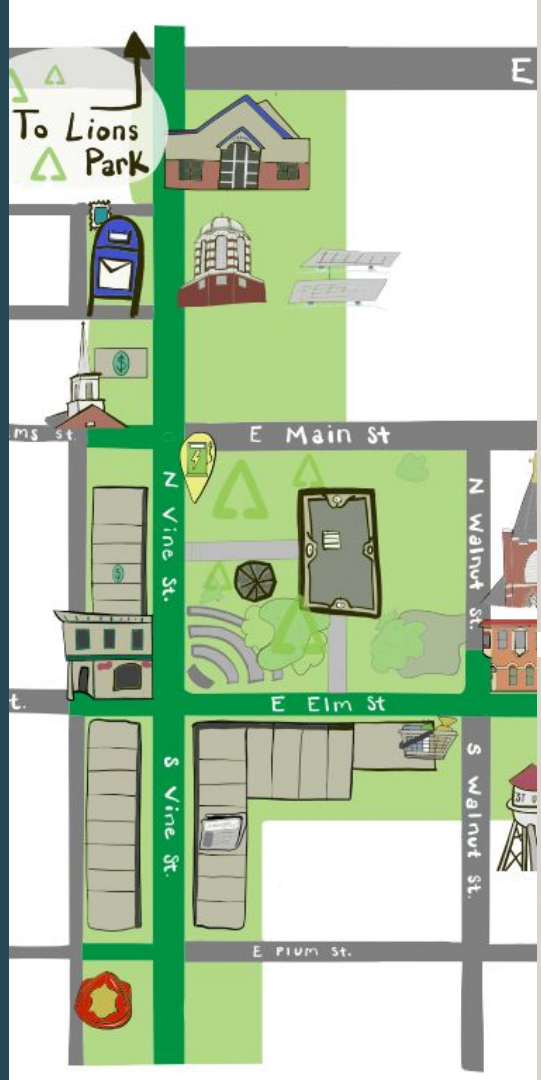
Green Streetscapes is a municipal revitalization project in downtown West Union, Iowa.

Project includes:

- **Ground source heat pump network:** 132 vertical wells under the courthouse lawn
- **Replacement of existing streets with porous paving**
- **Bioswales to handle flood water**
- **Civic plaza**
- **Sidewalks and street lighting**

The new ground source heat pump network can serve up to 60 buildings in the downtown area. As of 2023, it serves 12 customers who pay a monthly bill based on their energy use.

New participants must install their own indoor heat pumps in order to tap into the network. The town created financial incentives and tools to help new participants afford upfront costs.



Revitalization

Like many rural communities, West Union suffers from decreased population growth.

This project hopes to attract businesses to the downtown with comfortable, clean, and affordable heating and cooling. The system will also create an increased demand for qualified solar and HVAC contractors.

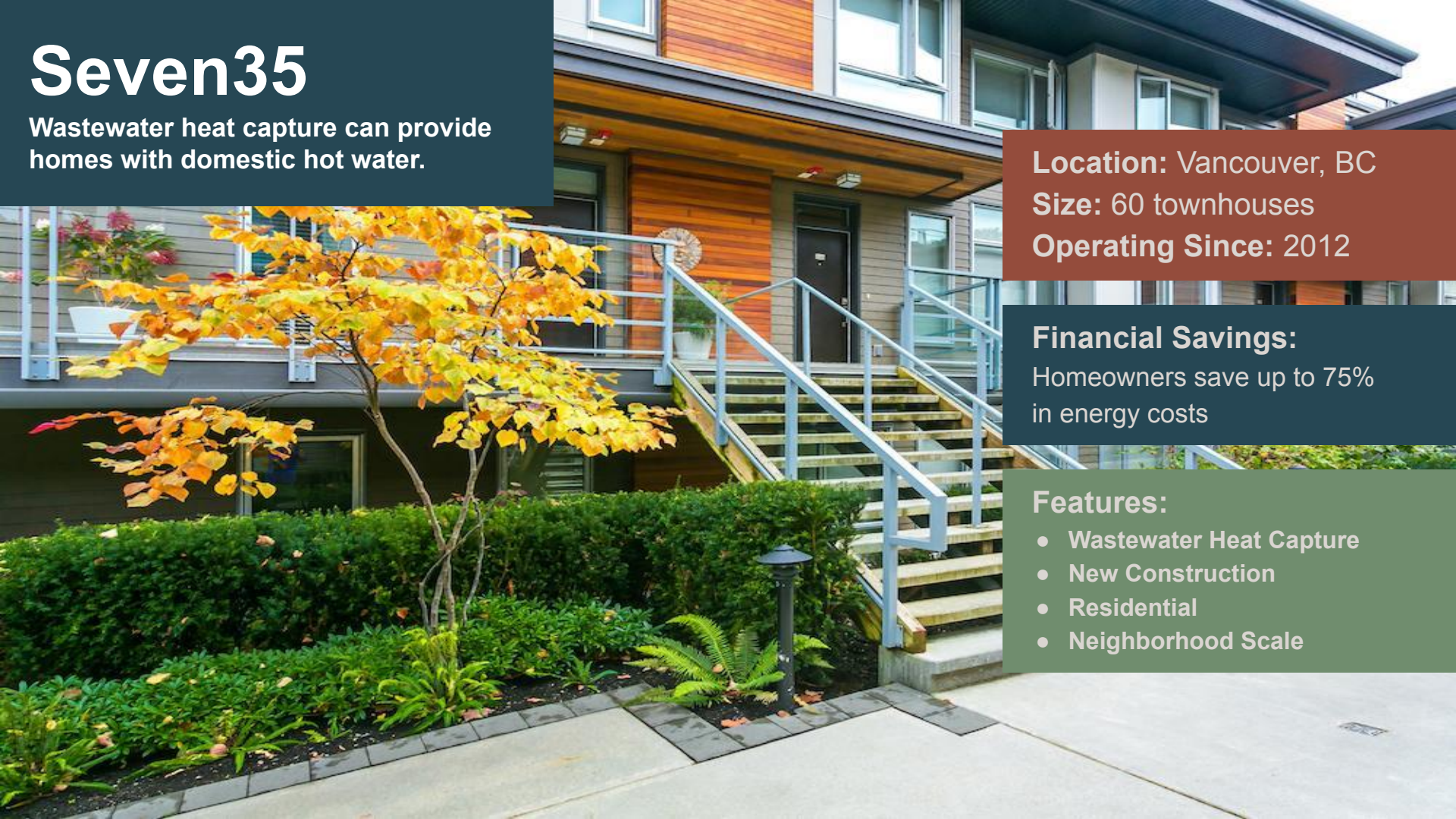
The revitalization aims to attract new residents and businesses, stimulate the local economy, and build community.

Rural Community

West Union has a population of approximately 2,700 and is the county seat of rural Fayette County, making it comparable in size and structure to many Vermont towns.

Seven35

Wastewater heat capture can provide homes with domestic hot water.



Location: Vancouver, BC
Size: 60 townhouses
Operating Since: 2012

Financial Savings:
Homeowners save up to 75% in energy costs

Features:

- Wastewater Heat Capture
- New Construction
- Residential
- Neighborhood Scale

Seven35 extracts heat from its own wastewater system to help heat its potable water.

How it works:

1. As wastewater leaves the building, heat is captured using a water-to-water heat exchanger.
2. The extracted heat is used to warm incoming domestic hot water to 125°F.
3. A gas boiler heats the water another 15° F to reach the target domestic hot water temp of 140°F.
4. Hot water leaving the building after use is run through the heat exchanger so that heat is reused again by the system.

Capacity: Average water usage per townhouse is 250 gallons/day at an average exiting temperature of 68°F.

Reliable

- Expected 25-40 year system life
- During the first two years of near-constant operation, this system sustained no outages and needed no maintenance beyond scheduled servicing.

Clean and Efficient

- Greenhouse gas production reduced by 90% (49.6 metric tons CO_2e/year)
- System uses 78% less energy input than an all-gas system requires
- Energy savings would be even higher if the system were providing space conditioning, since water-to-air thermal energy transfer is even more efficient than water-to-water. This could be an opportunity for future projects.

Weber State

The savings generated by an efficient system can be used to expand it.

Location: Ogden, UT
Size: 3+ campus buildings
Operating Since: 2015

Emissions Reductions:
Since 2007, Weber State has reduced its total greenhouse gas emissions by 42%.

Features:

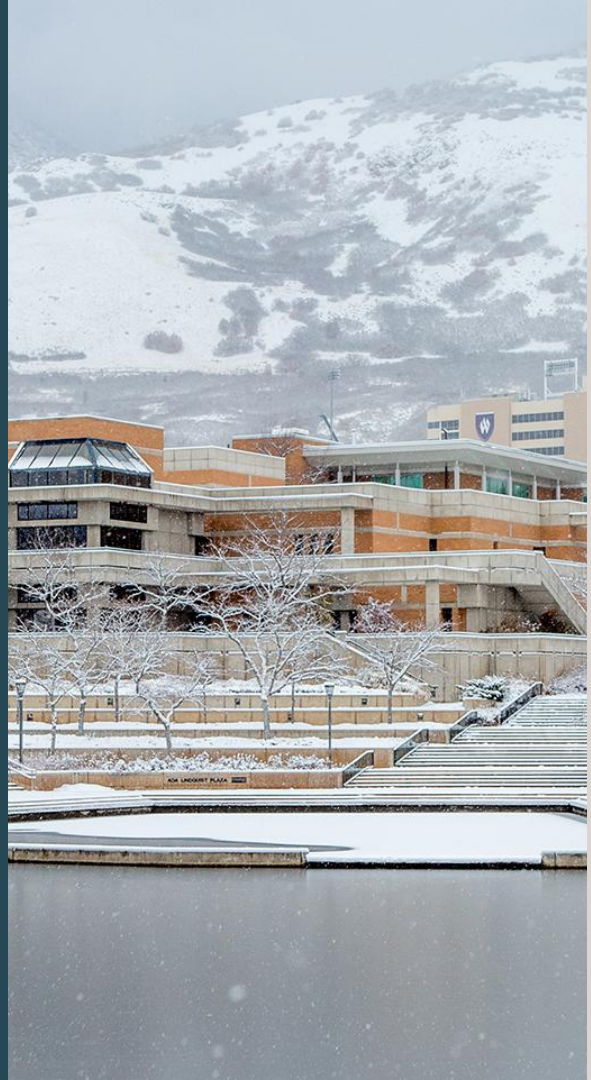
- Colder Climate
- Retrofit
- Multiple Technologies
- College Campus
- Future Expansion

Weber State has linked a ground source heat pump network to their traditional gas system to cut emissions and costs.

System components:

- **Gas boiler**
- **Ground source heat pumps to augment a boiler system (hybrid system)**
- **Variable Refrigerant Flow**
  - Alternative to traditional indoor ductwork.
  - Consists of thin pipes filled with refrigerant which control building temperatures.
- **Solar for electricity**

During the first 5 years of this hybrid system, energy input from the traditional boiler dropped by 93%.



Paying for Itself

Savings generated by the ground source network are accumulated and used to pay for new stages of the retrofitting process elsewhere on campus.

“We’re replacing systems in buildings that were due for mechanical renovations anyway.

New systems we’re installing are less expensive per square foot than just replacing the systems that were there previously.

We took our pledge to be carbon neutral by 2050 seriously and… will probably reach our goal 10 years ahead of schedule.”

– Jacob Cain, Operations Director