

Woodstock Community Heat Pump System

Final Report

CHA Project Number: 076481.000

Prepared for:



17 Columbia Circle | Albany, NY 12203-6399

Prepared by:



One Park Place, 300 S State St #600,
Syracuse, NY 13202
Phone: (315) 471-3920

July 2, 2024

Revised July 30, 2025

NOTICE

This report was prepared by CHA Consulting, Inc. in the course of performing work contracted for and sponsored by the New York State Energy Research and Development Authority (hereafter “NYSERDA”). The opinions expressed in this report do not necessarily reflect those of NYSERDA or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation of endorsement of it. Further, NYSERDA, the State of New York, and the contractor make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any process, methods, or other information contained, described, disclosed, or referred to in this report. NYSERDA, the State of New York, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

NYSERDA makes every effort to provide accurate information about copyright owners and related matters in reports we publish. Contractors are responsible for determining and satisfying copyright or other use restrictions regarding the content of reports that they write, in compliance with NYSERDA’s policies and federal law. If you are the copyright owner and believe a NYSERDA report has not properly attributed your work to you or has used it without permission, please email print@nyserderda.ny.gov.

Information contained in this document, such as web page addresses, is current at the time of publication.

TABLE OF CONTENTS

List of Figures 4

List of Tables 5

Contacts..... 6

Glossary 7

Executive Summary 9

1.0 Establish Baseline Conditions..... 14

 1.1 Utility Analysis 23

 1.1.1 Electricity 23

 1.1.2 Fuel 23

2.0 Develop Energy Profile..... 25

3.0 Energy Sources and Conceptual Design 32

 3.1 Energy Model: Optimal Combination of Resources..... 32

 3.1.1 Analyze and determine the available capacity during a year of each type of resource available to leverage as thermal sinks/sources. 32

 3.1.2 Assess the implications of thermal storage, either at a centralized activity or at numerous disparate locations, or both. 34

 3.1.3 Assess the implications of sizing the clean thermal energy resources as first-call to meet a fraction of the overall thermal load up to an economically optimal point and supplementing with a conventional thermal system as second-call to be able to meet the most extreme demand during a year. 35

 3.1.4 Determine optimal number and site layout of the ground loop heat exchanger (GLHX) borefield. 38

 3.1.5 Identify any sub-grade infrastructure that would impact bore field design. 40

 3.1.6 Integrate baseline system and desired mechanical system alternatives for comparison. 45

 3.1.7 Determine energy impact for each system alternative. 45

 3.2 Develop Conceptual Design of Community Heat Pump System 46

 3.3 Heat Transfer Medium Options 46

4.0 Perform Economic and Financial Analysis..... 48

 4.1 Estimated Annual Utility Costs for the System 48

 4.2 25-Year Life Cycle Cost Model..... 48

4.3 Business Model Options 60

4.4 Sensitivity Analysis 62

5.0 Conduct Permitting & Regulatory Review 68

5.1 Identify Authorities Having Jurisdiction 68

5.2 Estimated Permitting Approval Timeline 69

5.3 Identify Potential Risk for Restrictions/Delays 69

5.4 Identify Unique Regulatory Obstacles..... 69

Conclusions..... 73

LIST OF FIGURES

Figure 1. Aerial View or Site Map..... 13

Figure 2. Interval Profile – Electric 15

Figure 3. Interval Profile - Fuel 16

Figure 4. Monthly Load Profiles..... 26

Figure 5. Design Week Load Profiles..... 28

Figure 6. Design Day Load Profiles 29

Figure 7. Annual Load vs Occupancy – Retail..... 30

Figure 8. Annual Load vs Occupancy - House..... 31

Figure 9. Available Capacity of Bore Fields (Tons)..... 34

Figure 10. Ground Loop Design Report Summary..... 36

Figure 11. Thermal Load Range Total Hours – Total Site 36

Figure 12. Thermal Load Range Total Hours – Tinker 37

Figure 13. Thermal Load Range Total Hours – Rock City..... 37

Figure 14. Thermal Load Range Total Hours – Mill Hill..... 38

Figure 15. Bore Field Layout: Comeau Property (Top), Andy Lee Field (Bottom)..... 39

Figure 16. Water District Wellhead Protection Overlay..... 41

Figure 17. Aquifer Location to Comeau Property Borefield 42

Figure 18. Hourly Total System Demand (Borefields and Customer Systems)..... 43

Figure 19. Monthly Proposed System Electricity (Borefields and Customer Systems)..... 43

Figure 20. Annual Proposed System Electricity 44

LIST OF TABLES

Table 1. Thermal Source and Distribution Costs.....	11
Table 2. Customer System Costs	12
Table 3. Customer System Energy.....	12
Table 4. ASHP Customer System Costs	13
Table 5. Building Summary.....	14
Table 6. Envelope Improvements Impact on Peak Loads and Energy	17
Table 7. Baseline Environmental Footprint (2023)	18
Table 8. Baseline Annual Customer System Utility Rates and Costs (2022-2023).....	19
Table 9. Reference Building Types (For Modeling Purposes)	22
Table 10. Total Customer Annual Electric Usage	23
Table 11. Total Customer Annual Fuel Usage.....	24
Table 12. Design Loads	27
Table 13. Annual System Energy to Operate.....	44
Table 14. Annual Utility and Operation Costs (Year 1).....	48
Table 15. Opinion of Probable Cost	49
Table 16. Net Present Value – Combined Customers’ Perspective.....	52
Table 17. Net Present Value – Municipal’s Perspective.....	53
Table 18. Net Present Value – ASHP Alternative	54
Table 19. Net Present Value – Combined Customers’ Perspective – Phase A.....	55
Table 20. Net Present Value – Municipal’s Perspective – Phase A	56
Table 21. Net Present Value – Combined Customers’ Perspective – Phase B.....	57
Table 22. Net Present Value – Municipal’s Perspective – Phase B.....	58
Table 23. Net Present Value – Combined Customers’ Perspective – Phase C.....	59
Table 24. Net Present Value – Municipal’s Perspective – Phase C.....	60

Table 25. NPV (in thousands) – Inflation Rate Sensitivity (Customer Perspective)..... 62

Table 26. NPV (in thousands) – Finance Rate Sensitivity (Customer Perspective)..... 63

Table 27. NPV (in thousands) – Inflation Rate Sensitivity (Municipal Perspective)..... 64

Table 28. NPV (in thousands) – Finance Rate Sensitivity (Municipal Perspective) 65

Table 29. NPV (in thousands) – Inflation Rate Sensitivity (ASHP Alternative)..... 66

Table 30. NPV (in thousands) – Finance Rate Sensitivity (ASHP Alternative) 67

CONTACTS

NYSERDA

Project Manager

Scott Smith

Program Manager, Clean Heating and Cooling

17 Columbia Circle | Albany, NY 12203-6399

scott.smith@nyserda.ny.gov

CHA Consulting

Project Manager

Ryan Voorhees

Project Team Leader

Office: (315) 257-7189

rvoorhees@chacompanies.com

Senior Engineer

John Tesh

Senior Engineer

Office: (518) 453-8797

JTesh@chacompanies.com

Engineer

Charles Walck

Project Engineer

Office: (315) 257-7171

cwalck@chacompanies.com

GLOSSARY

8,760: Engineering term representing the annual hours used to determine engineering load calculations.

AHJ: Authority Having Jurisdiction - governmental or non-governmental entities responsible for enforcing building codes, fire codes, and other regulations in a given jurisdiction

Ambient Temperature Loop: The distribution piping between the borefield and customer systems

ASHP: Air Source Heat Pump

ASHRAE: American Society of Heating, Refrigeration, and Air Conditioning Engineers

BCR: Benefits-to-Cost Ratio – the ratio of project monetary benefits to project monetary costs. A ratio greater than one represents a viable project.

Btu: British Thermal Unit – a measure of heat representing the quantity of heat required to raise the temperature of one pound of liquid water by one degree Fahrenheit. MMBtu is one million Btus.

Capacity Index: Ratio of the total capacity of the indoor units to the capacity of the outdoor unit in a customer heat pump system

CO₂: Carbon Dioxide gas

COP: Coefficient of Performance – ratio of useful heating provided per unit of energy input

DES: District Energy System

Design Day: a period of time with the maximum conditions that an HVAC system is designed.

Discount Rate: The interest rate used to determine the present value of future cashflows. Determines if the investment will be worth more than the capital requirement needed to currently fund the project.

DOE: Department of Energy

EER: Energy Efficiency Ratio – a mixed unit ratio of the cooling capacity in British Thermal Units (BTUs) to the power input in Watts (W)

Electric Resistance Heat: Heater that uses a metal coil heated by electricity using the internal resistance of the metal.

GLHX: Ground Loop Heat Exchanger

GHX: Ground Heat Exchanger

GPM: Gallons per minute

GSHP: Ground Source Heat Pump, which is a water source heat pump designed to operate at a wider range of temperatures.

HVAC: Heating, Ventilation, and Air Conditioning

IRA: Inflation Reduction Act

kWh: A measure of electricity defined as a unit of work or energy measured as one kW of power expended for one hour

LBS: Abbreviation for pounds.

LCCA: Life Cycle Cost Analysis

LPG: Liquid Propane Gas

MBH: Thousand Btu per hour – a measure of the size or load on an air conditioning or heating system

NYISO: New York Independent System Operator

NYSERDA: New York State Energy Research and Development Authority

NIST: National Institute of Standards and Technology

NPV: Net Present Value – the difference between the present value of cash inflows and the present value of cash outflows over a period of time

OA: Outside Air

O&M: Operation and Maintenance

One-Pipe System: One central piping loop acting to supply and return fluid to the heating/cooling source

Overburden: The soil and/or unconsolidated rock layers above the solid bedrock.

PON: Program Opportunity Notice

PSC: Public Service Commission

PTAC: Packaged terminal air conditioner

PV Analysis: Present Value is the current value of a future sum or stream of cash flows

RSMeans: Construction estimating database

SEQRA: State Environmental Quality Review Act - requires all local, regional, and state government agencies to equally examine the environmental impacts along with the social and economic considerations for a certain project, or action, during their discretionary review

SPDES: State Pollutant Discharge Elimination System

Ton (T): A unit of measurement for capacity to move heat (1 Ton = 12,000 BTUs per hour)

VRF: Variable refrigerant flow

EXECUTIVE SUMMARY

As a result of the passage of the Climate Leadership and Community Protection Act (CLCPA) of 2019, mandating an 85% economy-wide carbon reduction, there has been a focus on how to decarbonize building heating at scale. At the recommendation of the Climate Action Council Scoping Plan, thermal energy networks offer an important pathway to scale up zero-emission heating and cooling in buildings, while transitioning the highly skilled gas workers into a similar energy sector. This study aims to provide a district energy solution that would supply low-carbon heating and cooling at scale to the Town of Woodstock (ToW).

CHA Consulting, Inc. (CHA) has furnished this scoping study under NYSERDA's Community Heat Pump Systems Program Opportunity Notice (PON) 4614 Category A: Site Specific Scoping Study to investigate the feasibility of an ambient loop district energy system using ground heat exchangers as the primary source of energy. This scoping study focuses on the central corridor through the Town of Woodstock (ToW), consisting of Mill Hill Road, Tinker Street, and Rock City Road, which has the highest density of buildings. The selected route consists of Residential and Commercial zoned districts with 170 buildings of diverse types: houses, restaurants, apartments, retail, a school, and community buildings. The ToW owns unpaved parking lots and a large recreation area, Andy Lee Field, which are spaces potentially available for boreholes. The Town of Woodstock also owns paved parking lots which could similarly be used, however, at a slightly higher implementation cost. To reduce the cost of installing underground infrastructure, the Tinker Street distribution system installation may be able to coincide with the Tinker Street bridge and sidewalk replacement project planned to begin construction in 2027.

The Town of Woodstock is a New York State DEC bronze star Climate Smart Community (CSC) and a Clean Energy Community. The Town of Woodstock continues to be a leader and provide replicable examples demonstrating how a small town can embrace community energy responsibility through exploring various community system options and their value propositions compared to individual building heat pump systems.

The Woodstock community ground source heat pump project aims to provide a thermal energy utility that allows for excellent performance and price stability. If feasible, a non-profit entity such as the Municipal water department is expected to be responsible for operations and maintenance of the thermal production and all related components of the system. The water department currently has monitoring and billing for water services for each of the off-takers, and municipal entities typically have long term financing options over private entities. The Water Department is also best suited to maintain and service the community heat pump thermal fluid.

This report details the following tasks included in the overall scoping study:

- Task 1: Establish Baseline Conditions

Site data was reviewed to develop an energy model for the site that models each building type discretely, addresses each building type construction age, electrical and thermal energy systems, and calibrates to available billing and metering data. Hourly interval profiles are then used to estimate the baseline environmental footprint, equipment costs, replacement costs, size baseline and proposed heating/cooling plant equipment, and forecast increases in electrical loading. Further, lifecycle costs and a sensitivity analysis regarding the assumptions used throughout this task assess the relative impact of each assumption on the analysis.

- Task 2: Develop Energy Profile

A thermal modeling approach is used to explore clean energy options for the site that models each building and facilitates subsequent modeling of various building aggregations and discerns the timing and quantities when both heating and cooling are simultaneously required.

- Task 3: Determine Optimal Energy Source and Develop Conceptual Design

The technical and economic viability of using clean thermal energy resources consisting of ground source boreholes as the potential thermal sinks and/or sources was explored. Potential borefield locations throughout the Town of Woodstock were identified and a potential selection and feasibility design based on these selections was analyzed.

The conceptual design of the system has three primary components:

- Geothermal Heat Exchanger

This Geothermal Heat Exchanger (GHX) represents an array of closed loop, vertical, geothermal boreholes that serve as the primary thermal source for heating and thermal sink for cooling. The individual boreholes are connected through horizontal piping to a pipe manifold, which is then connected to the main distribution system. This part of the system is also inclusive of the borefield pump stations, distribution pump stations for each of the three streets, and the distribution loop pumps.

- Distribution System / Ambient Loop

The distribution system is the main piping loop connecting the stakeholders, customers, and producers of energy on the system. This is also called an ambient temperature loop, in reference to the fact that loop temperature is influenced only by the energy exchanges of the client connections. There does not exist any thermal mechanical maintenance on this loop.

- Customer Systems

Individual consumers of energy on the system. In the district geothermal system, the heating and cooling end use is generated by customer-owned ground source heat pump equipment that is connected to the district system.

- Task 4: Economic and Financial Analysis

An economic and financial feasibility analysis was performed on a centralized ground-source heat pump solution. The preferred scenario included an estimated annual utility cost, construction cost estimate, service life considerations, operation and maintenance cost, replacement costs, and potential incentives or tax credits. Financial metrics over the 25-year life cycle cost analysis period included net present value (NPV) and a benefit-to-cost ratio (BCR). A positive NPV and a BCR greater than 1 represent positive overall cashflow and a viable project. For this study, the total cost of the system over the 25-year period was also considered. The analysis considered inflation and energy escalation rates, financing over a 20-year period, and a sensitivity analysis was performed on these rates. Carbon reduction calculations were also performed. The analysis was divided showing the benefits from the customer perspective and the municipal perspective, per the selected business model.

- Task 5: Permitting and Regulatory Review

This section addresses any regulatory issues that may materially impact the feasibility of the project. A project of this type requires permits and approvals from federal, state, and local government agencies and departments. This section discusses permit requirements and government agencies responsible for issuing them, timeframe, potential risk for delay, and other potential obstacles. A list of stakeholders that should be made aware of the project has been developed.

Total installation cost of the district system, inclusive of the thermal sources and distribution system, if it were to be undertaken as a single phase, is estimated at \$26,400,000. If eligible for all available federal and state incentives, this cost reduces to a net cost of \$15,300,000. Cost estimates and financial assumptions can be found in Task 4. Phasing of major capital projects is recommended and based on conversations it is proposed that Phase A be Rock City Road, Phase B be Tinker Street, and Phase C be Mill Hill Road. Estimated cost breakdown by phase is estimated as follows:

Table 1. Thermal Source and Distribution Costs

Thermal Source and Distribution Costs			
Total Cost	Phase A	Phase B	Phase C
\$26,400,000	\$12,000,000	\$9,600,000	\$4,800,000

The customer base represents the 170 individual building owners of the single-family houses, multi-family apartments, hotels, small offices, restaurants, etc. that will connect to the thermal system. The estimate of the total cost to retrofit the customer buildings is \$4,500,000, which

reduces to \$2,700,000 if fully eligible for the IRA federal tax credits¹. The Town of Woodstock should engage a tax professional to investigate whether each phased component project is eligible for the tax credit. And how direct pay options can be applied. Average retrofit costs per customer after tax credits over all customers are approximately \$16,000 per customer but is highly variable based on the individual circumstances of each potential customer.

Table 2. Customer System Costs

Customer System Costs			
Total Cost	Phase A	Phase B	Phase C
\$4,500,000	\$1,200,000	\$1,600,000	\$1,700,000

Total aggregate annual electrical energy consumption required to operate all customer systems is approximately 2,080,000 kWh at a cost of \$612,000, to be paid to the electrical utility through normal billing processes. Any additional thermal utility fee used to pass costs along to customers is yet to be determined and is dependent on the project cost, financing arrangement, ownership structure and the extent that installation costs are passed through to the customer. These costs, along with operation and maintenance costs and eventual equipment replacement costs, are included in the 25-year life cycle cost analysis of Appendix D and Section 4.2. The table below shows the breakdown of the energy (kWh) and energy costs by phase.

Table 3. Customer System Energy

Customer System Energy and Energy Costs				
	Total	Phase A	Phase B	Phase C
Energy (kWh)	2,080,000	520,000	760,000	800,000
Energy Cost	\$612,000	\$153,000	\$224,000	\$235,000

The 25-year net present value of the system including design and construction costs as well as direct benefits (avoided capital and operation costs of individual building owners, avoided fuel and electric costs) is estimated at \$900,000 and \$100,000 for the customer with and without the tax credit, respectively, and \$2.5 million and -\$10.7 million for the system owner with and without the tax credit, respectively. Refer to Task 4 for assumptions and sensitivity analysis of financing terms and discount rates. This system owner costs are to be spent on the annual energy required to operate the ambient loop pumps, to pay maintenance staff and personnel annual salaries, system training, and system maintenance materials.

Indirect benefits of the system include the social cost of the carbon emissions avoided during the 25-year study period as defined by the NYS Department of Environmental Conservation (DEC). An NPV of \$2.0 million in avoided carbon emissions was calculated for the customer systems; however, this cost of carbon is damages-based and is for decision-making purposes rather than being monetizable.

¹ <https://files.climatemaster.com/lc028-climate-master-commercial-federal-tax-incentives-brochure.pdf>

The district project could face several challenges including coordination with existing subsurface utilities, securing commitments from future customers, project financing for customer retrofits, permitting and regulatory hurdles, and construction materials costs. Solutions to each of the challenges listed will be the focus of the detailed design, which is a follow-on phase to the feasibility analysis covered in this report.

Figure 1. Aerial View or Site Map



For comparison, an analysis was performed for the electrification alternative of individual air source heat pumps (ASHPs). The estimate of the total cost to retrofit the customer buildings is \$9,300,000 without considering any potential tax credits or incentives. The ASHP approach has a more favorable overall financial return, but faces electrical utility capacity limitations that were not considered as part of the cost and should be evaluated by Central Hudson (electric utility).

Table 4. ASHP Customer System Costs

ASHP Customer System Costs			
Total Cost	Phase A	Phase B	Phase C
\$9,300,000	\$2,500,000	\$3,300,000	\$3,500,000

1.0 ESTABLISH BASELINE CONDITIONS

The baseline conditions represent the current state of the target building heating, cooling and ventilation systems. It also represents the business-as-usual case, where no electrification efforts are undertaken and the current fuel choices are carried forward. Equipment is replaced on a typical schedule for that equipment type.

- *Describe the basis for a baseline condition and describe the characteristics of such baseline conditions.*

The central corridor through the Town of Woodstock consists of Mill Hill Road, Tinker Street, and Rock City Road. The route consists of residential and commercial zoned districts with houses, restaurants, apartments, retail space, and municipal buildings. The Town of Woodstock has many public structures, some of which are Town of Woodstock owned; others are owned by other municipal or non-municipal entities. The Town of Woodstock also maintains large recreation fields, a community center, and parking lots. An elementary school is located at the south end of the potential district on Route 375.

Buildings are typically heated with boilers or furnaces using either propane or fuel oil, with most smaller structures using a form of radiator/baseboard heating. Cooling is available in some but not all buildings with the use of window mounted PTAC units or split AC systems. Central AC systems are generally nonexistent, except for the rooftop units at the supermarket and CVS, and the existing air source VRF system at the community center that was installed several years ago. The following is a summary of the total count and area for each building type.

Table 5. Building Summary

Building Type	Sum of Gross Floor Area (sq. ft)	Parcel Count
Full-Service Restaurant	36,068	10
Multi-family low-rise apartment	86,074	34
Primary School	46,385	1
Single-family detached house	87,721	53
Small Hotel	6,671	2
Small Office	37,513	8
Stand-alone Retail	201,738	62
Undeveloped		11
Grand Total	502,170	181

- *Review utility bills as available.*

Utility bills were made available by the building owners for five potential buildings within the scope of this project. The utility bills were intended to serve as a sample of the primary building types that will be studied. Utility bills provided, however, only represent multi-family low-rise apartments and stand-alone retail. The utility bills are a small sample of the potential buildings and used to compare the accuracy of the modeled load profiles discussed later in this section of the report. The annual cooling and heating consumptions from the load profiles for each building were

calibrated as needed with a correction factor to better match the annual utility data. Section 1.1 provides additional detail on the provided utility data and a discussion of the reasonableness of the load profile estimation of usage.

- *Develop interval profiles for electrical and propane or fuel oil utility use (if meter data available), such profiles shall be at hourly intervals or more-granular resolution and shall represent at minimum an 8,760-hour continuum (365 days).*

The following graphs depict the interval profiles (isolated for cooling and heating and not inclusive of all utility bill consumption) for both electricity usage (Figure 2) for cooling and fuel usage (Figure 3) for heating at hourly intervals over a full year, based on modeled data. Both were estimated with the aid of a sample of utility bills provided to CHA (i.e., correction factors discussed above). Both profiles behave as expected, with the cooling peaking in the summer months and the peak heating occurring in February.

Figure 2. Interval Profile – Electric

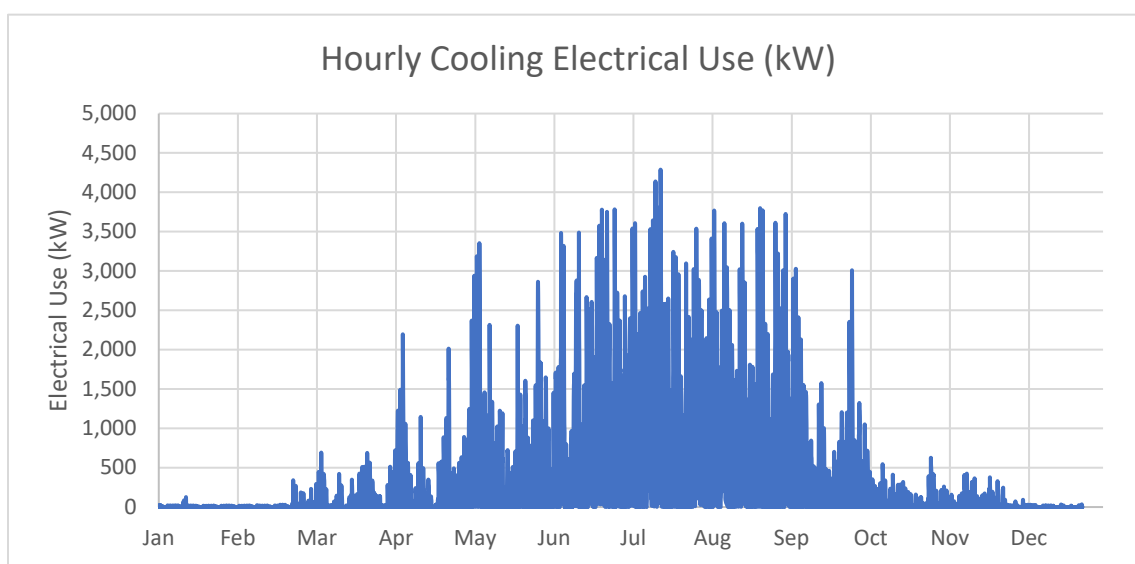
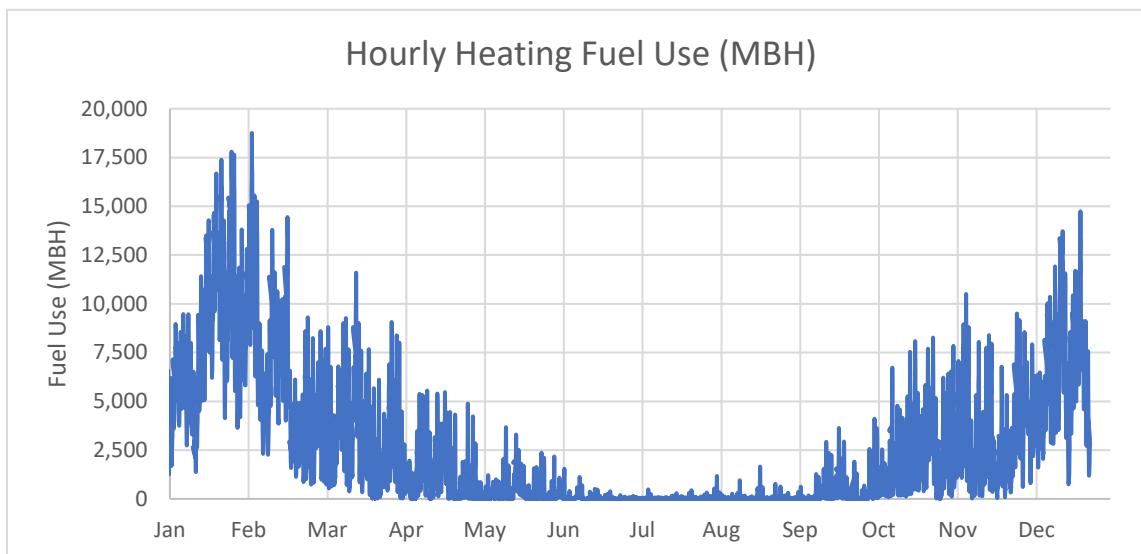


Figure 3. Interval Profile - Fuel

There is opportunity to reduce these thermal loads through the equipment efficiency improvements of the analyzed district energy system. Prior to the implementation of the district system, thermal loads can be decreased by improving building efficiency. The buildings in Woodstock are generally older wood frame structures with suboptimal building envelopes (poor insulation, window leaks, etc.), and envelope improvements could reduce the heating and cooling loads. At the onset of the project, for each property included in this project, an energy analysis of the property's thermal envelope should be performed with results communicated to the property owner. Once improvement recommendations are communicated, the owners can seek potential funding opportunities and make improvement decisions.

Load reductions were estimated by updating the insulation levels and infiltration rates in the DesignBuilder models and reproducing the hourly simulated load profiles. The three building types making up most of the buildings are Stand-Alone Retail, Midrise Apartment, and Single-Family Homes. The models were revised for these three building types to estimate the load reduction. The percent reduction for these building types for peak heating, peak cooling, total heating energy, and total cooling energy are shown in the table below. Average percent reduction across all cases are shown in the last row.

Table 6. Envelope Improvements Impact on Peak Loads and Energy

	Stand-Alone Retail	Midrise Apartment	Single Family Home
Peak Heating Reduction	7.3%	34.1%	9.7%
Peak Cooling Reduction	5.6%	22.9%	14.9%
Heating Energy Reduction	5.1%	33.3%	23.6%
Cooling Energy Reduction	5.2%	34.1%	3.4%
AVERAGE	6%	26%	13%

Envelope improvements can vary in complexity from basic to a deep retrofit, or “superinsulation.” According to the Lawrence Berkely National Laboratory report on “The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes”, median net site energy savings for the basic category are approximately 20% and for the superinsulation category are approximately 64%. The results of the revised models are representative of the basic category.

As with the load reduction, implementation costs for building envelope improvements vary depending on the level of retrofit. Median costs per square foot of floor area are provided for both basic and superinsulation categories in the above-referenced report. The costs considered are for attic insulation, house envelope sealing, and wall insulation. Costs for the sum of these categories for both levels of retrofit per square foot are as follows:

- Basic Retrofit: \$2.86 per ft²
- Superinsulation Retrofit: \$11.66 per ft²

These result in a total building retrofit cost of approximately \$1,400,000 for a basic retrofit and \$5,900,000 superinsulation retrofit levels, respectively.

- *Use these interval profiles to estimate the baseline annual environmental footprint (at a minimum the CO₂-equivalent footprint attributable to energy consumed from all sources including grid-supplied electricity, and if feasible also the site-emitted criteria pollutants)*

A baseline CO₂ equivalent footprint attributable to the NYISO electricity and on-site fuel consumption in 2023 is calculated using the DOE’s greenhouse gas equivalencies calculator². Total cooling and heating consumptions are cumulative for all buildings and were determined from

² <https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator>

the estimated thermal load profiles developed. Fuel emissions are the result of both (1) consumption for heating and (2) distribution leakage. The distribution leakage typically accounts for a 3.5% factor of total consumption³.

Table 7. Baseline Environmental Footprint (2023)

Cooling			Heating			Total
Energy (kWh)	Factor (lbs/kWh)	CO ₂ (lbs)	Energy (MMBtu)	Factor (lbs/MMBtu)	CO ₂ (lbs)	CO ₂ (lbs)
1,709,790	1.56	2,667,272	26,635	116.6	3,105,641	5,772,913

- *Develop baseline modeled equipment costs.*

Baseline equipment for this study encompasses the heating and cooling equipment at each building included in potential list of system connections and is not yet considering the community water-source heat pump system proposed later in this report. Parcel data developed as part of the initial data collection for the study application included heat and fuel type, and whether or not the buildings have central air. Cooling equipment was estimated based on both a building roof survey using satellite images and street view mapping. Baseline equipment costs included new equipment costs for boilers, furnaces, condensing units, window AC units, and split systems in addition to operation and maintenance costs. HVAC replacement and maintenance costs are based on engineering experience, vendor data, and cost estimating reference guides (RS Means). Total year one energy, operation and maintenance, and replacement costs are estimated at \$1.5 million, an average of \$8,800 per customer (based on 170 participants). The replacement cost does not represent replacing all equipment in year one. Rather 10% per year for cooling equipment and 4% per year for heating equipment is assumed to be replaced and the first year represents these percentages.

See the baseline life cycle cost analysis **in Appendix D** for this initial total cost and the cost over the life of the equipment.

- Total Energy Cost: **\$1,350,000**
- O&M Cost: **\$69,000**
- Replacement Costs: **\$67,000**
 - Heating Equipment: \$34,000
 - Cooling Equipment: \$20,000
 - Combined Equipment: \$13,000
- **Total Cost: \$1,500,000**

³. “How Green is Blue Hydrogen” by Robert W. Howarth and Mark Z. Jacobson.

- *Estimate construction costs for the replacement of existing HVAC with code-conforming in-kind equipment.*

This is taking into consideration the aging customer systems currently installed will need replacing and as a baseline will be done with in-kind equipment that is code-conforming and not the water-source heat pump system proposed later in this report. There are no boreholes or distribution system. Replacement costs of the existing HVAC equipment are the same as the developed baseline equipment costs. To account for the fact that replacement will likely occur in the future, a general inflation rate 3% per year was applied as part of the baseline life cycle cost analysis. It is estimated that 10% of the full cooling equipment replacement cost and 4% of the full heating equipment replacement cost is performed per year.

- *Establish baseline electricity and thermal energy utility costs using published utility tariffs and/or existing data.*

Natural gas service is not available in the region. Utility providers in the Woodstock region include Central Hudson, HOP Energy, and Paraco Gas. Central Hudson Gas and Electric (CHG&E) supplies only electricity to Town of Woodstock. In other regions, CHG&E typically supplies both natural gas and electric. Other independent energy contractors and companies such as HOP Energy and Paraco Gas deliver fossil fuels such as fuel oil and/or propane.

The sample of utility rates including months between 2022 and 2023 were averaged by building type (multi-family low-rise apartments, single-family detached houses, stand-alone retail, etc.) and were used to assess energy savings based on building type for the other connected buildings whose utility information is unknown. See Section 1.1 for annual consumption, cost, and rates for the provided buildings. The annual electric cooling and thermal energy costs for the entire set of buildings were estimated using these average utility rates and the corresponding annual cooling and heating energy estimated from the thermal profiles for the customer systems.

Table 8. Baseline Annual Customer System Utility Rates and Costs (2022-2023)

	Utility Rate	Utility Costs
Existing Thermal Energy	\$30.02/MMBtu	\$501,529
Existing Electrical Energy	\$0.274/kWh	\$849,986

- *Generate life cycle cost for baseline consisting of maintaining the baseline energy system and operating it for a 25-year term.*

Life cycle cost analyses (LCCA) provide the cost of ownership of the baseline equipment over the 25-year life of the system. The costs that are incorporated into the life cycle analysis are shown below and details are provided in Appendix D.

Electricity and Fuel Costs of System Operation

Projected fuel price indices over the LCCA were based on the handbook published by the National Institute of Standards and Technology (NIST) and assumes a general price inflation rate of 3%. Also, a system efficiency degradation of 0.25% per year representing energy increases each year was also used in the analysis.

Replacement Costs

Based on ASHRAE life expectancy, it is assumed that HVAC equipment of the existing customer systems has a useful lifespan of 10-25 years depending on the equipment. For example, a window unit lifespan is 10 years, while a boiler lifespan can be 25 years or more. It is reasonable to assume that the boilers, furnaces, and existing cooling equipment have varying age and would need replacement before the total life expectancy. To account for this, it is assumed that the cooling equipment replacements occur at a 10% rate each year and heating equipment replacements occur at a 4% rate each year. This results in approximate per year replacement costs of \$32,800 for cooling, \$19,500 for heating, and \$12,400 for combined heating and cooling equipment.

Present Value (PV) Analysis Results

The PV analysis provides a current value of the projected future total costs of ownership of the baseline systems in all buildings potentially connected to the proposed district system over a 25-year period. This provides a single value in today's dollars so that it can be more readily compared to other scenarios (i.e. the proposed system) for business decisions. Ultimate comparison to the proposed system is part of Task 4. Future cashflows are brought to a present value based on a general inflation rate rather than a discount rate, since there is no comparison to a proposed scenario for business decision. The PV analysis of a 25-year span shows existing systems have a baseline scenario of \$53,200,000 using an inflation rate of 3%. The baseline cashflows are inclusive of furnace, boiler, and HVAC replacement costs, operation and maintenance costs, and electric and fuel costs. These represent a total of 170 developed buildings. Approximately 54% of the energy costs are represented by multi-family and single-family residential buildings and 46% by commercial buildings such as offices, retail, restaurants, hotels, and the supermarket. A present value analysis for the district system versus the existing equipment is provided in Section 4. The PV of the baseline scenario is calculated in Appendix D.

- *Develop a preliminary thermal model which will be used to size baseline and proposed heating/cooling plant equipment and energy source.*

Building load profiles were developed using DesignBuilder (a graphic user interface for EnergyPlus), which is a whole building energy modeling engine developed and maintained by the US Department of Energy (DOE). Heating and cooling loads were modeled using DOE reference models of various building types as inputs to the program. The DOE developed standard or reference energy models by aggregating thousands of the most common commercial buildings into building-type categories, age/construction, and climate zones to serve as an average representative

dataset for energy efficiency research to assess new technologies. DOE's modeling approach and assumptions are as follows⁴:

- Utilized most populous cities in each climate zone.
- Separated by post-1980 construction, and pre-1980 construction.
 - Differences between time periods are reflected in insulation values, lighting levels, and HVAC equipment types and equipment efficiencies per ASHRAE 90.1.
- Model inputs divided into four categories.
 - Program (location, total area, occupancy, ventilation, operating schedule, etc.)
 - Form (# floors, floor height, window fraction and location, shading, etc.)
 - Fabric (walls, roof, floors, infiltration, windows, internal mass, etc.)
 - Equipment (lighting, HVAC type, water heating, refrigeration, efficiency, controls)

Of the 16 building types represented in the DOE models, seven building types were considered for this study under these main categories:

1. Full-Service Restaurant
2. Stand-Alone Retail
3. Small Office
4. Primary School
5. Supermarket
6. Small Hotel
7. Midrise Apartments for the existing end-user buildings that are considered as potential connected loads.

Single-Family Detached House is a common building type in the community that is not a DOE reference building and a DesignBuilder template was therefore used to create a model. The Supermarket had its own DesignBuilder model made for a “post-1980” supermarket as it was recently rebuilt. Reference models used for the remaining baseline buildings were selected as “pre-1980” based on typical building construction in Woodstock. A list of the reference models used for the basis of the buildings are as follows.

⁴ In depth model details can be found in the report titled “U.S. Department of Energy Commercial Reference Building Models of the National Building Stock” <https://www.nrel.gov/docs/fy11osti/46861.pdf>

Table 9. Reference Building Types (For Modeling Purposes)

Building Type	Floor Area (ft ²)	# Floors	# Buildings
Full-Service Restaurant	5,500	1	15
Stand-Alone Retail	24,962	1	51
Small Office	5,500	1	10
Low - Midrise Apartment ¹	33,740	4	36
Primary School	73,960	1	1
Supermarket	45,000	1	1
Small Hotel	43,200	4	3
Single Family Detached House ²	1,675	2	53
		Total	170

1: Used for “multi-family low-rise apartment”

2: Reference building model taken from DesignBuilder template – not a DOE reference building

CHA transformed the reference models into energy models specific to this study for all potential buildings in the community district system using the following approach:

1. DOE models were selected as reference buildings that most closely matched building construction/materials as the buildings in Woodstock and 5A climate zone based on ASHRAE 90.1.⁵
2. The DOE model details were loaded into DesignBuilder software and model accuracy was verified by inputting standard climate zone weather conditions and comparing energy usage to the reference model. The accuracy of the model representation of actual cooling and heating loads is detailed further in the utility analysis on the next page. Although cooling loads were estimated with a reasonable percentage of total utility, a factor was applied to the model heating loads to more closely match fuel consumption for retail spaces.
3. 8,760 hourly simulations representing 365 days (including total heating and cooling loads) were performed using a profile of typical weather conditions in Woodstock. The simulations report heating and cooling loads and energy use energy to create each. Using typical weather conditions for the area reduces the impact of a potentially atypical year represented in a selection of utility bills.
4. A space ratio was applied to scale energy usages based on the building’s actual floor area compared to the DOE reference model. Some buildings contained multiple building types and the space ratio was applied proportionally (e.g., retail on ground floor and office space on upper floors).

Individual building profiles can be used to size equipment and can be shown visually as needed for project implementation. However, analyzing the community as an aggregated district system is the focus of the feasibility study and details are shown in Task 2.

⁵ <https://www.energy.gov/eere/buildings/commercial-reference-buildings>

1.1 UTILITY ANALYSIS

Utility bills were provided by five of the proposed community’s building owners. The collected bills spanned from May 2022 through May 2023. Central Hudson is the supplier of electricity. HOP Energy, Paraco Gas, and other suppliers provide fuel in the form of oil and or LP gas.

The utility bills are a small sample of buildings and can be used to compare the model-predicted energy usage versus actual energy usage. There may be unique factors influencing energy usage for individual buildings that can deviate from the model. However, if the load profiles show a trend of overstating or understating actual usage across our sample, the representative models can be adjusted with a factor to reflect actual loads more accurately. For this study, it is preferred to err as an understated energy model, which would be more conservative in the resulting cost/benefit analysis.

1.1.1 Electricity

A total of 12 months of data was available for the utility data provided. However, out of the five buildings that provided utility data only two included electrical data in addition to the fuel data. Annual consumption totals and blended electric rates for each building are shown in Table 10 below.

Table 10. Total Customer Annual Electric Usage

Building	Utility Bills			Load Profiles	
	Annual Consumption	Annual Cost	Blended Rate	Cooling Energy	Cooling Percent of Utility
	(kWh)	(\$)	(\$/kWh)	(kWh)	(%)
Stand-Alone Retail					
Building 1	2,962	\$966	\$0.33	1,611	54.4%
Building 4	61,120	\$13,535.50	\$0.22	16,148	26.4%

The resulting comparison of the annual cooling consumption from the load profiles to the annual utility bills is also shown in Table 10. Cooling energy typically ranges between 20% and 30% of the total electrical consumption. Therefore, the percentages demonstrate that the load profiles are reasonable with the small sample of utility bills given. One of the two buildings falls within this range. However, there is not enough of a sample of buildings to apply an overall adjustment factor for all buildings to account for the other building exceeding the typical range. Variances can be a result of equipment age and efficiency differences, control quality, and weather variations of the utility bill year.

1.1.2 Fuel

The number of months provided for propane and oil consumption and cost depends on when the fuel was delivered and is therefore a close representation of the actual site consumption. Please note, gallons of propane and fuel oil have been converted to MMBtu using the conversion rate of

91,452 Btu per gallon and 138,500 Btu per gallon, respectively. Annual consumption totals and blended \$/MMBtu rates for each building are shown in Table 11 below.

Table 11. Total Customer Annual Fuel Usage

Building (Fuel Type)	Utility Bills				Load Profiles	
		Annual Consumption	Annual Cost	Rate	Heating Energy	Relative Percent of Utility
	(gal)	(MMBtu)	(\$)	(\$/MMBtu)	(MMBtu)	(%)
Stand-Alone Retail						
Building 1 (Propane)	1,179	108	\$3,135.23	\$29.08	50	-53.6%
Building 4 (Oil)	1,618	224	\$6,712.90	\$29.95	501	123.8%
Building 3 (Oil)	1,107	153	\$4,518.83	\$29.46	28	-82.1%
Building 5 (Oil)	1,081	150	\$4,482.48	\$29.93	130	-13.2%
Mid-Rise Apartment						
Building 2 (Propane)	283	40	\$1,266.63	\$31.67	16	-59.8%

The resulting comparison of the annual heating consumption from the load profiles to the annual utility bills is also shown in Table 11. It should be noted that although the utility bills for 11 Tinker Street are for that isolated building, the parcel data used for model generation is for 1-11 and 13 Tinker Street as one parcel. It was assumed that the total modeled usage is evenly distributed across each building, but the actual allocation is unknown. The relative percentage of the actual utility consumption was averaged across each building, resulting in an adjustment to the energy models for retail spaces which increased the load profile by a factor of 1.17. Variances can be a result of equipment age, type, and efficiency differences considered in the reference building models compared to actual, and weather variations of the utility bill year.

2.0 DEVELOP ENERGY PROFILE

- *Create representative space-by-space and small block load models that incorporate planned building geometry, gross square footage, and space utilization.*

The space-by-space and small block load models for this analysis are considered to be each individual building in Woodstock community. The model development assumptions and methodology are described in Section 2. These individual models are the basis for aggregating the profiles such that potential phasing and design decisions can be made.

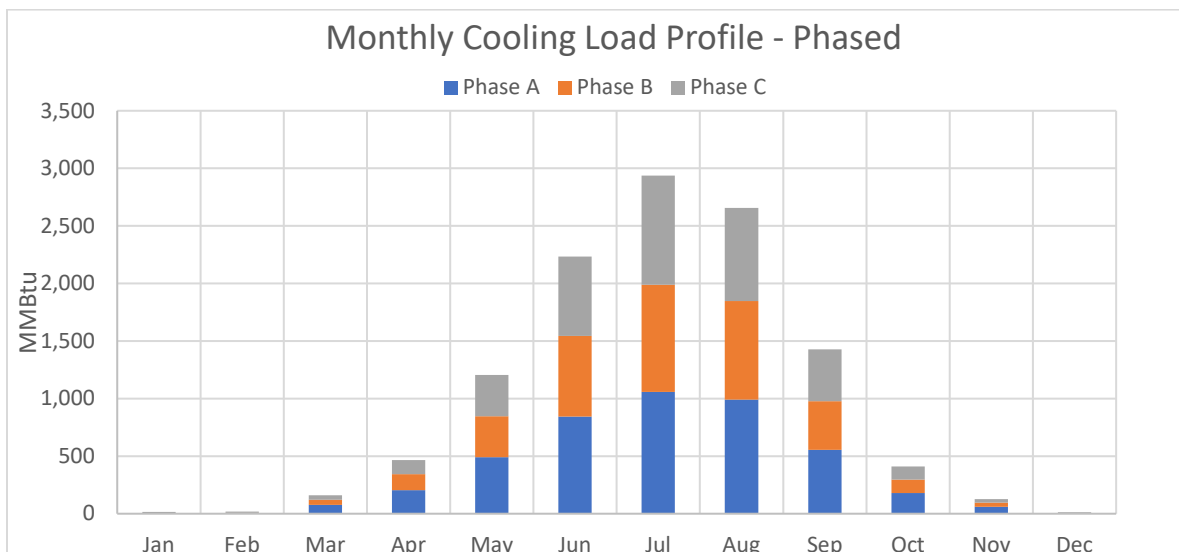
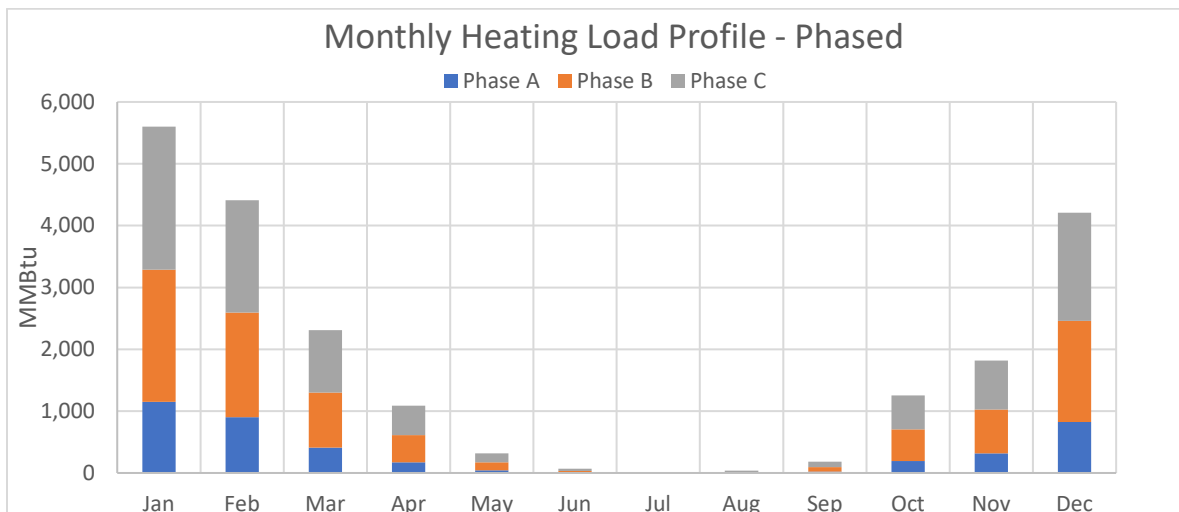
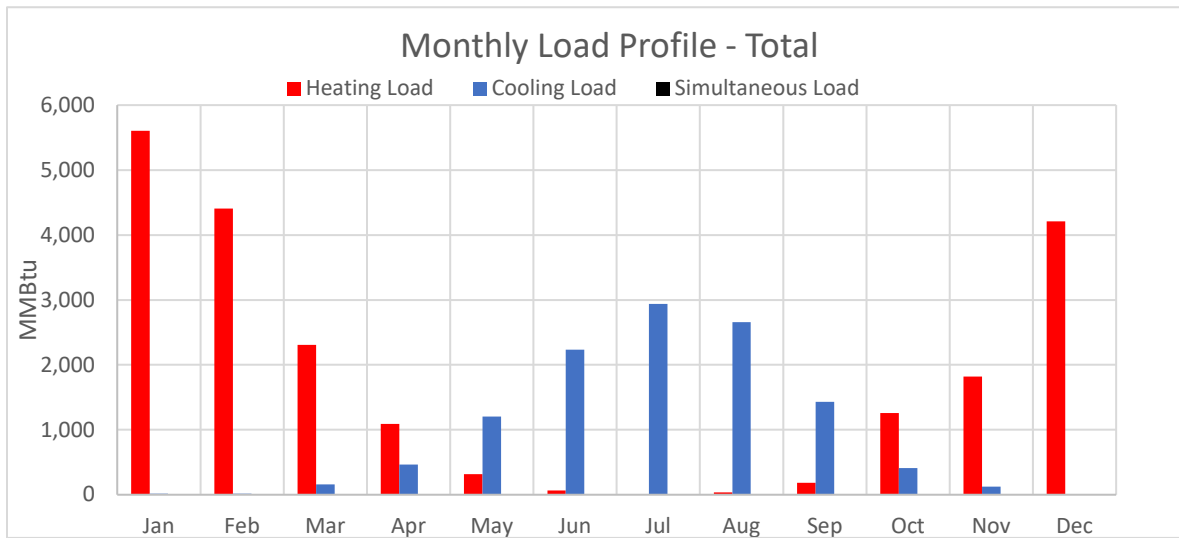
The preliminary thermal models developed in Section 2.0 are hourly energy models based on DOE reference buildings and include variables such as climate zone, space type definition and assignment, and scaling based on building square footage. Load profiles were represented as the total monthly energy consumption, hourly loads over the span of a design week, and hourly loads over the span of a design day.

- *Create aggregate thermal profiles per implementation phase as applicable, and for the entire development at full build-out.*

The space-by-space and small block load models developed for each reference building that were scaled to fit each building result in hourly profiles that can then be aggregated into any grouping desirable for analysis. Aggregation is performed for the entire community and if later tasks require additional variations, the individual models can be aggregated as required. Phasing aggregation is currently presented as Phase A for Rock City Road, Phase B for Tinker Street, and Phase C as Mill Hill Road.

A district system approach is benefited by simultaneous loads. Heat removed from buildings with cooling loads can offset a portion of the heating load during the shoulder months (spring and fall months). There are no buildings in this district configuration that have a substantial amount of heat rejection and thus the simultaneous loads (heat rejection from cooling being used to supplement heating requirements at the same time) and load flattening are minimal. Any simultaneous loads are only a fraction of the overall heating or cooling loads and are therefore not discernable in Figure 4 below. The small amount of load flattening is due to the increased efficiency of the system. Attracting commercial and mixed-use building types that have more substantial heat rejection, such as a data center, process factory or commercial office building, or refrigeration systems at the supermarket, could provide system benefit during the heating seasons. The graphs below show the aggregated monthly load profiles. The highest monthly load occurs in the month of January for heating, and July for cooling. The load profiles are presented both as the total and by phase.

Figure 4. Monthly Load Profiles



Design of the proposed system is based on hourly load profiles during design days. Hourly profile graphs for all buildings combined across the entire year can be found in the load profile calculations. Hourly variation of the design days and the week containing the design day are more useful in demonstrating peak operation. Energy consumption, peak loads, and average loads during design days and weeks for heating and cooling are summarized in the following table.

The reliance in the baseline methodology of using DOE reference buildings does tend to overstate the magnitude of the of the peak load due to building warmup for commercial buildings, since the models are defined using similar occupancy and usage schedules. In practice, building warm up periods will have variation in start times, duration, and intensity due to differences in business hours. Therefore, peak loads aggregated by the models below are therefore conservatively estimated.

Table 12. Design Loads

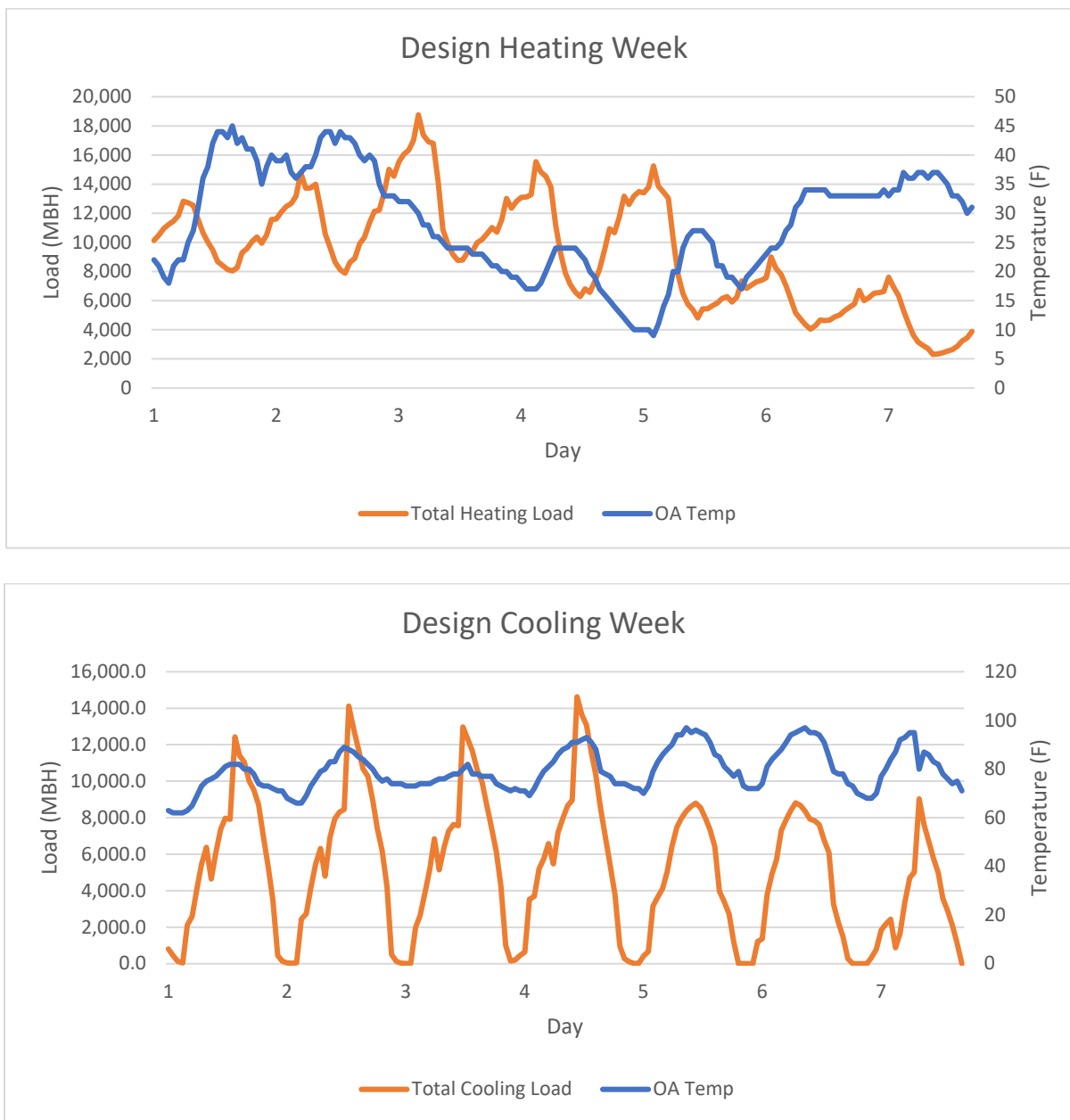
	Design Week	Design Day
Total Heating (MMBtu)	1,561	307
Total Cooling (MMBtu)	857	153
Peak Heating Load (MBH)	18,758	
Peak Cooling Load (MBH)	14,629	
Avg Heating Load (MBH)	9,294	12,786
Avg Cooling Load (MBH)	5,101	6,382

The following graphs represent the hourly load variation for all buildings during design weeks. Heating design weeks generally occur in the second week of January or up to the second week of February. Cooling design weeks typically occur around July 4th and can occur as late as week of August 12th. For the load profiles used in this analysis, the specific time periods are as follows:

- Heating Design Week: February 2nd through February 8th
- Heating Design Day: February 5th
- Cooling Design Week: July 16th through July 22nd
- Cooling Design Day: July 19th

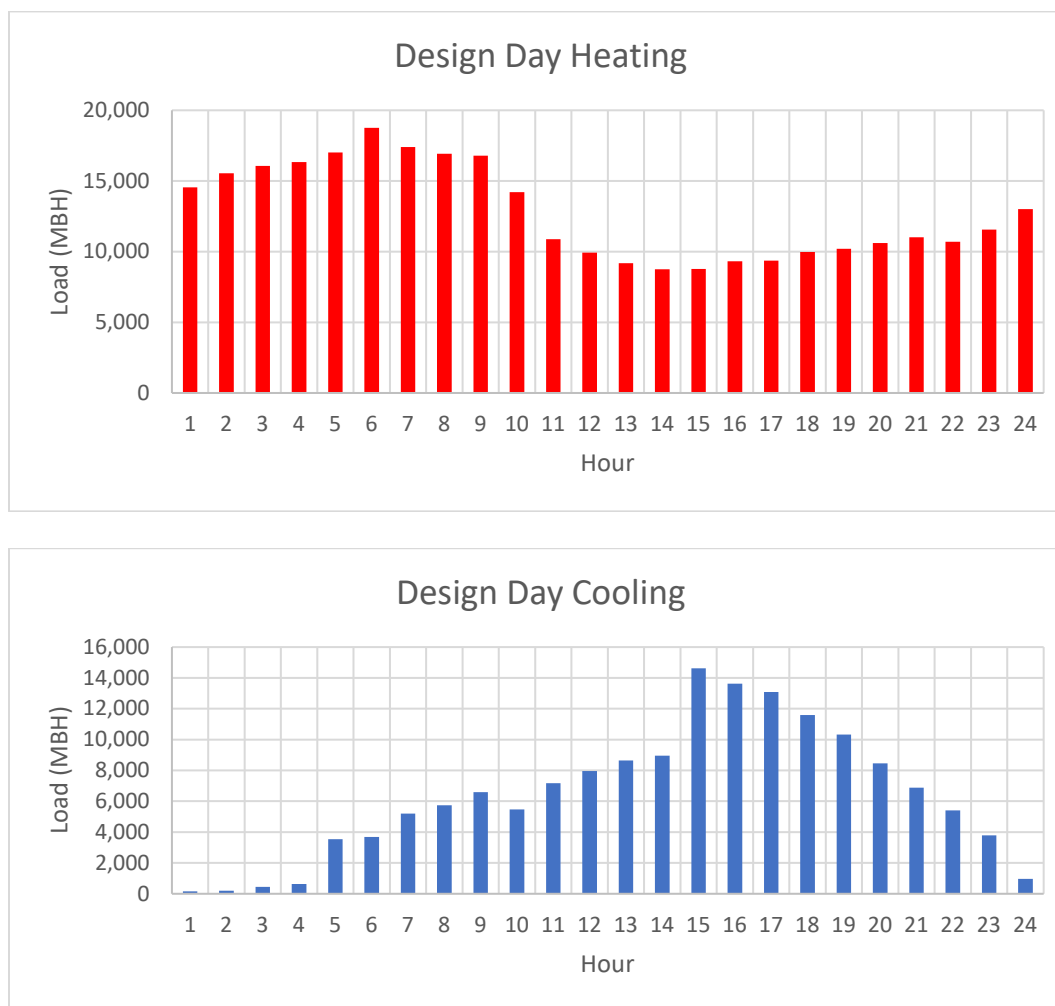
While several different building types are included in the profile, the peaks tend to be driven by the needs of the retail spaces and apartments due to their relative size and the number of buildings that comprise the entire community.

Figure 5. Design Week Load Profiles



The following graphs represent the hourly load variation for all buildings during design days. Peak heating load occurs in the morning at 9:00am around a typical morning warmup cycle for commercial buildings and before the outdoor air temperature typically starts to rise. An increase in cooling load can be seen during typical occupancy hours for commercial buildings as well, with the peak load occurring during the afternoon.

Figure 6. Design Day Load Profiles



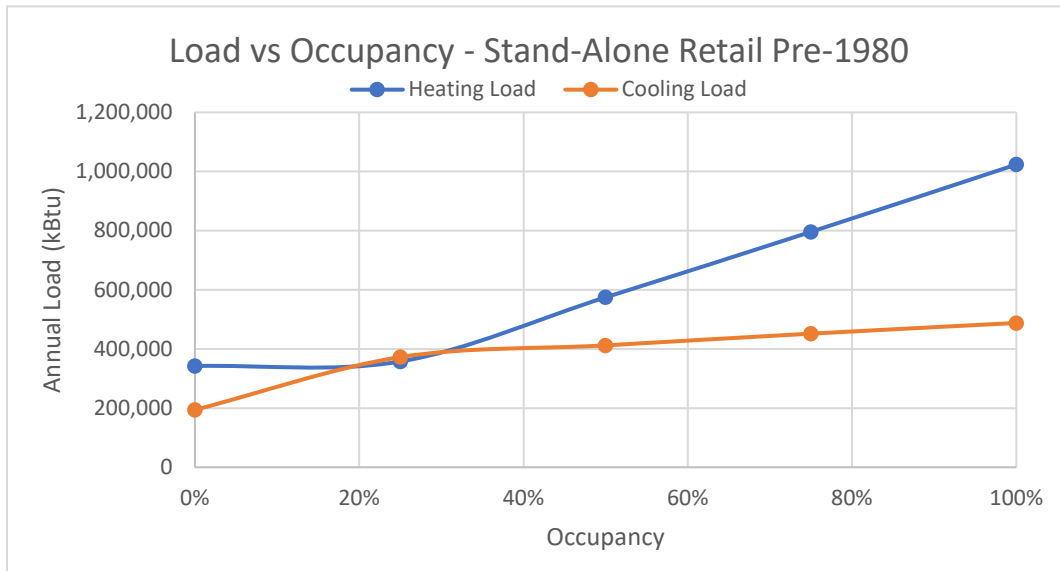
- *Perform a sensitivity analysis regarding the assumptions used throughout this task to assess the relative magnitude of impact each assumption has on the analysis output.*

A sensitivity analysis was performed based on altering occupancy rates in two building types: Pre-1980 Stand-Alone Retail and Single-Family Detached House. These two building types were chosen since they represent 64% of the total buildings.

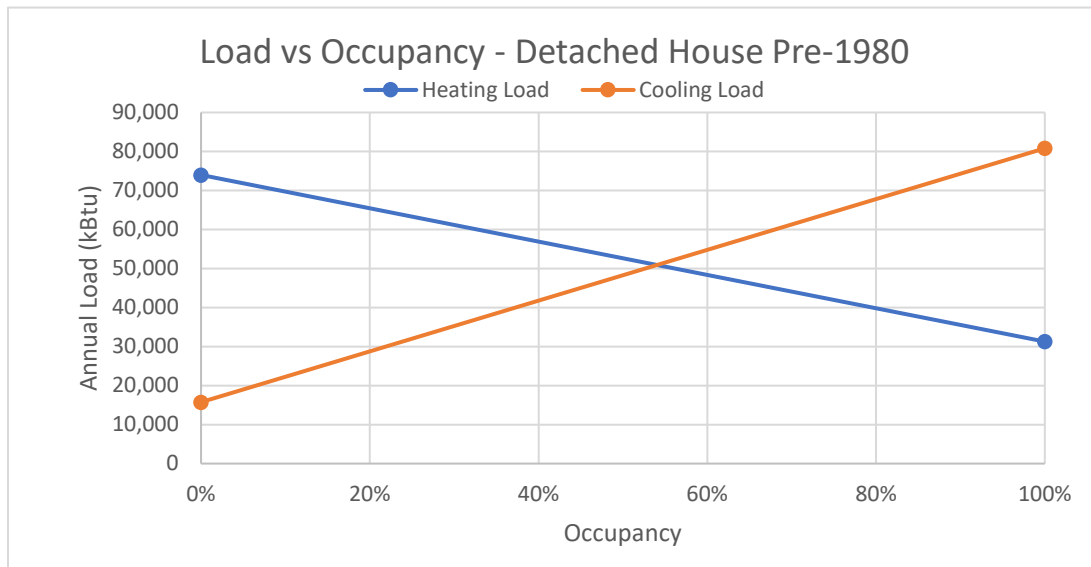
Occupancy rates from 0-100% were modeled at increments of 25% of the full occupancy density of the reference model for the retail space. Unoccupied was modeled with a constant setback temperature (never a need to be at occupied temperature), minimal ventilation, lighting and plug loads turned off, and no internal heat gain from people or equipment. It was assumed that a retail space will operate at full setback schedules (when people are gone for the night), and lighting and plug loads are present no matter the occupied levels when people are present. Ventilation will vary as required with total occupancy. Occupancy was varied by taking percentages of the full occupancy density rather than progressively making individual zones unoccupied, as it is likely

that each zone of a retail space will be operational with some level of occupancy during operation. The detached house analysis considered only the impact of fully occupied versus fully unoccupied. Fully unoccupied is represented by constant setback temperature, lighting and plug loads off (nothing plugged in, and no internal heat gains such as heat given off by people, lighting, appliances, etc.).

Figure 7. Annual Load vs Occupancy – Retail



The retail building with the pre-1980 construction has a significant decrease in heating load for a fully unoccupied scenario with a large amount of heating still required due to envelope losses. Occupancy has a greater effect on heating load which can be attributed to increased ventilation requirements and a higher heating setpoint. Cooling loads are more significantly impacted by implementing a lower cooling setpoint when the building first becomes occupied with only a slight increase in load from internal loads.

Figure 8. Annual Load vs Occupancy - House

As anticipated, there is an increase in cooling load when a detached house becomes occupied. However, internal loads from people and appliances appear to offset the heating requirements of an increased setpoint.

3.0 ENERGY SOURCES AND CONCEPTUAL DESIGN

This task explores the technical and economic viability of using clean thermal energy resources consisting of air, ground source vertical boreholes, or ground source horizontal boreholes, whether standalone or in combination, as potential thermal sinks and/or sources.

3.1 ENERGY MODEL: OPTIMAL COMBINATION OF RESOURCES

3.1.1 Analyze and determine the available capacity during a year of each type of resource available to leverage as thermal sinks/sources.

The energy model considers the resource available for the thermal sink/source to be borefields serving an ambient temperature loop. This ambient temperature loop (distribution system) will be piped and routed throughout the district, with individual interconnections for customer systems (ground-source heat pump systems, pumps, individual circulation pumps, and connection piping).

Alternative Thermal Source non-viable

There exists a municipal water treatment plant (1442 Sawkill Rd, Kingston, NY 12401) and wastewater treatment plant (2441 NY-212, Woodstock, NY 12498) that could be utilized for energy sources and sinks, but whose potential sources are not considered due to:

- Remote in location to the borefield
- The wastewater treatment plant is small and averages 250,000 gal per day, which is only enough to offset about 20 boreholes.
- A small building to house a pump, storage tank, and heat exchanger are needed, close to the wastewater plant.
 - There is no town-owned property in a location that would be suitable
 - Large percentage of the sewer flow would need to be diverted presenting further infrastructure challenges.

Ground Source Boreholes

Vertical boreholes provide a passive source of heat absorption and heat rejection from the ground. At the time of the borefield modeling, NYS DEC regulations were still in place for wells deeper than 500 feet and a 495-foot-deep bore was proposed to stay outside of those regulations. Those regulations are the same provisions that cover oil and gas drilling and have since been removed for boreholes greater than 500 feet as of September 2023. Deeper boreholes may lower drilling costs by reducing the number of boreholes that equipment must be moved and reset for. Borehole length has actually been reduced to 420 feet with the use of a double u-bend design, minimizing the total borehole length.

Horizontal piping loops were part of the discussion with Woodstock but are not considered as a viable thermal sink/source for the area. Two DEC water well completion reports were obtained to determine the depth to bedrock and ground makeup. These well logs were completed in January 2020 and April 2021, and are located on Elwin Quarry Road and Upper Byrdcliffe Road in Woodstock. Logs show that there is only 5 feet of overburden before bedrock. To be successful, horizontal loop fields require at least 8 feet of overburden.

- Vertical Borehole Layout
 - Spacing 20' on center in a grid pattern for boreholes typically provides an optimal trade-off between land area and performance. Generally, it provides an optimal borefield heat exchanger for either heating or cooling load-dominant project.
 - The borehole layout for this project utilized an “offset weave” pattern where the columns of boreholes are staggered in an offset pattern using the dimensions of 20'x15'x30' separation. A total of 522 boreholes between the Comeau Property and Andy Lee Field, in this arrangement, will fully support the existing Woodstock loads through a ground-source heat pump process. Other locations and combinations of locations can be utilized to meet the total demand if particular locations are found to be infeasible or cost prohibitive.
- Geology
 - A thermal conductivity test has not been completed at this time. However, ground composition details were available from the two discussed well reports. on the previous page. These wells are 240 feet deep and therefore do not cover the entire length of the proposed boreholes. Starting at 5 feet, the ground consists mostly of different types of sandstone with two layers of shale.
- Grout
 - The thermal conductivity of the ground is the limiting factor for the rate of energy exchange between the borehole tubing and the ground connection. Typically, a grout having identical thermal conductivity characteristics of the ground is specified. Grout is a mixture of water, sand, and bentonite that lines the entire length of each borehole with the borehole piping through the center to stabilize the piping, seal the hole, and provide proper thermal conductivity. Although this project does not have a developed test borehole with a thermal conductivity test, existing drilling logs of surrounding geothermal projects were reviewed and used to create a typical geology for that of the Town of Woodstock.

- A graphite-enhanced bentonite grout having thermal conductivity value between 0.9 and 1.2 Btu/hr-ft-°F will provide maximum thermal connection between the earth and the boreholes and is selected depending on the load profile. Profiles with sharper peaks and valleys require a faster response from the ground connection and therefore utilize higher conductivity grouts which are more expensive. In this case, the load profiles are not sharp peaks and valleys, and therefore the ground connection requires a slower response time. A grout having a thermal conductivity value of 0.9 Btu/hr-ft-°F was used in the modeling due to profile characteristics.

The different options considered are the potential combinations of bore fields. Each bore field location was analyzed for potential capacity and percentage of overall load requirement. Total capacities (tons) are shown in the figure below. The optimal combination selection and justification is detailed in Section 4.1.4.

Figure 9. Available Capacity of Bore Fields (Tons)



3.1.2 Assess the implications of thermal storage, either at a centralized activity or at numerous disparate locations, or both.

Thermal storage is a design method to address seasonal variation or additional flexibility if loads are not aligned. The use of borefields already utilizes a form of thermal storage by adding the rejected building heat in the summer to the ground which will increase the ground temperature. In the winter, this stored energy can be pulled from the ground to heat the buildings. In its simplest form, additional thermal storage can be done by adding water accumulation tanks to heat or cool a larger mass of water. Adding thermal storage would come at a significant capital cost, so the benefits must be assessed before incorporating storage into the concept design. Initial modeling

of the district system provided balanced results, and the volume of the district distribution piping provided sufficient volume and mass of water. The balanced results represent the fact that there is neither excessive heat being added to or removed from the ground, which is unsustainable over time. Therefore, no additional storage is included in the conceptual design analyzed in this feasibility study.

- 3.1.3 Assess the implications of sizing the clean thermal energy resources as first-call to meet a fraction of the overall thermal load up to an economically optimal point and supplementing with a conventional thermal system as second-call to be able to meet the most extreme demand during a year.

Ideally, the system will not rely on fossil fuel to meet the thermal load requirements. The system is sized to meet the thermal load requirements of all the buildings. With the connected capacity total of the customer systems (ground source heat pumps) chosen to meet peak system load, the system is further sized conservatively with a capacity index of 1.0. This means that the model assumes the capacity of the customer system heat pump equipment is matched to the capacity of current customer systems and assumes that all internal peak loads will occur simultaneously. This was done simply to show that if a system with these design criteria is feasible, future detailed design can reduce costs by incorporating a capacity index less than 1 which is closer to the sizing of a full system design.

As shown in the histograms of Figures 11-14 showing ranges of total customer system loads and their corresponding total annual hours in each range, peak loading is only a small fraction of the total operational time. Design day conditions for heating and cooling are defined by ASHRAE as the temperature conditions that occur 0.4% of the year (about 35 hours). Feasibility with this worst-case scenario condition will allow room for reduction of the bore field size and cost given future detailed design. At the current bore field size, the system is thermally balanced and not expected to overheat and overcool the ground temperature over a 15-year period, as indicated by zero change in ground temperature in Figure 10. The soil ground temperature parameter in the full summary details a temperature of 52.5°F. Peak unit inlet and outlet temperatures are the distribution loop temperatures into and out of the heat pumps. During winter heating operation, it can be seen that the temperatures remain above freezing. See Appendix A for full detailed 15-year projection indicating borefield energy transfer and borefield ground temperature fluctuation.

Figure 10. Ground Loop Design Report Summary

Design Method:	<i>Monthly</i>	COOLING	HEATING
Total Bore Length (ft):		252420.0	252420.0
Borehole Number:		601	601
Borehole Length (ft):		420.0	420.0
Ground Temperature Change (°F):		N/A	N/A
Peak Unit Inlet (°F):		67.2	38.7
Peak Unit Outlet (°F):		76.1	33.1
Total Unit Capacity (kBtu/Hr):		14084.0	15077.4
Peak Load (kBtu/Hr):		14084.0	15077.4
Peak Demand (kW):		836.4	1072.3
Heat Pump EER/COP:		16.8	4.1
Seasonal Heat Pump EER/COP:		17.6	4.2
Avg. Annual Power (kWh):		6.39E+5	1.27E+6
System Flow Rate (gpm):		3521.0	3769.4

Figure 11. Thermal Load Range Total Hours – Total Site

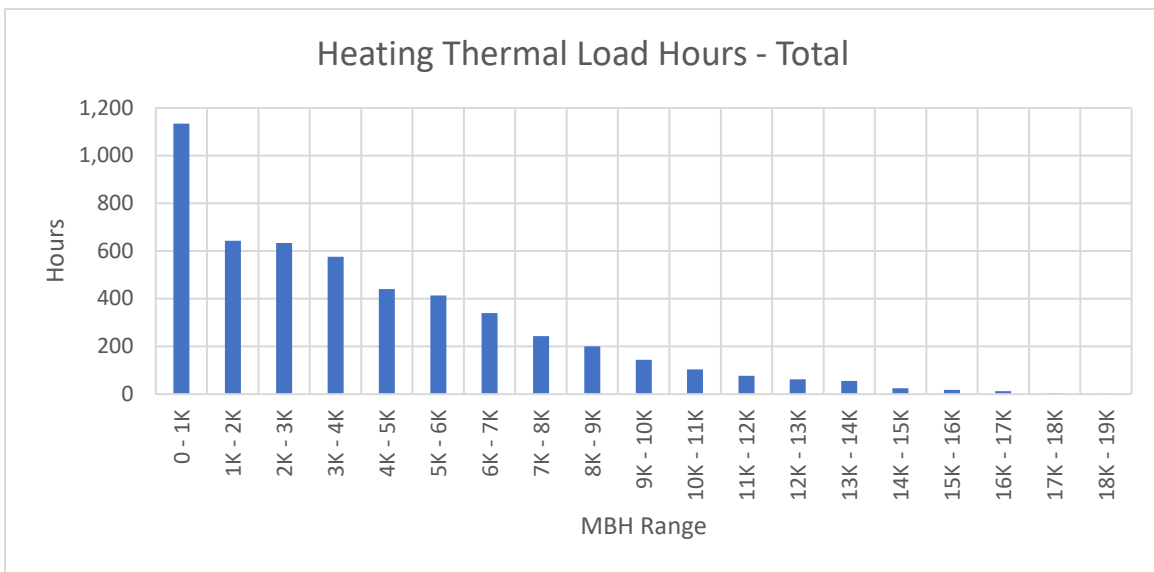


Figure 12. Thermal Load Range Total Hours – Tinker

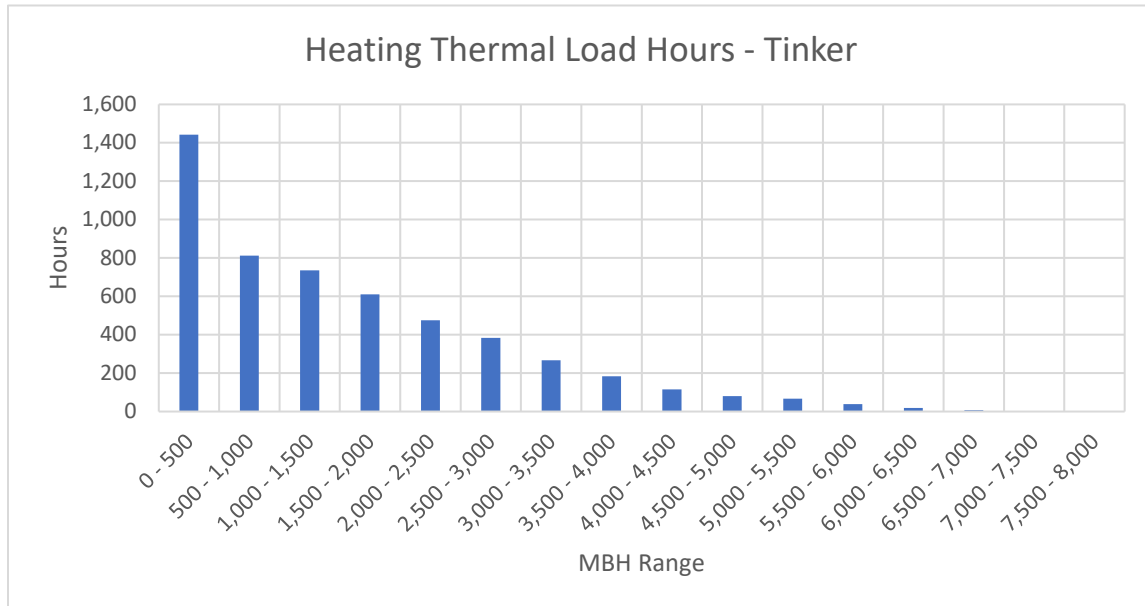


Figure 13. Thermal Load Range Total Hours – Rock City

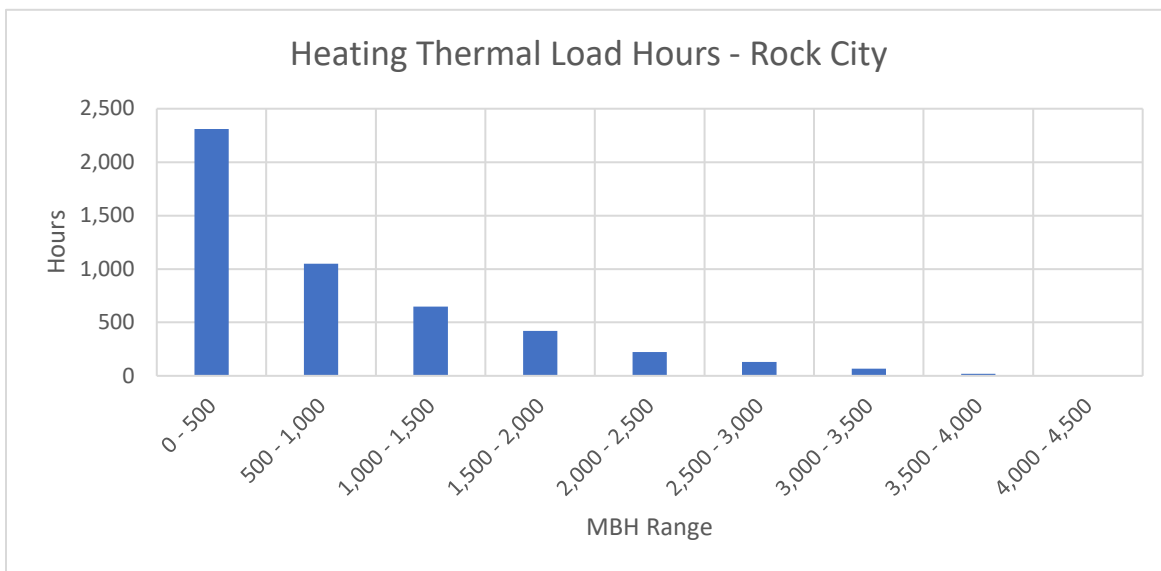
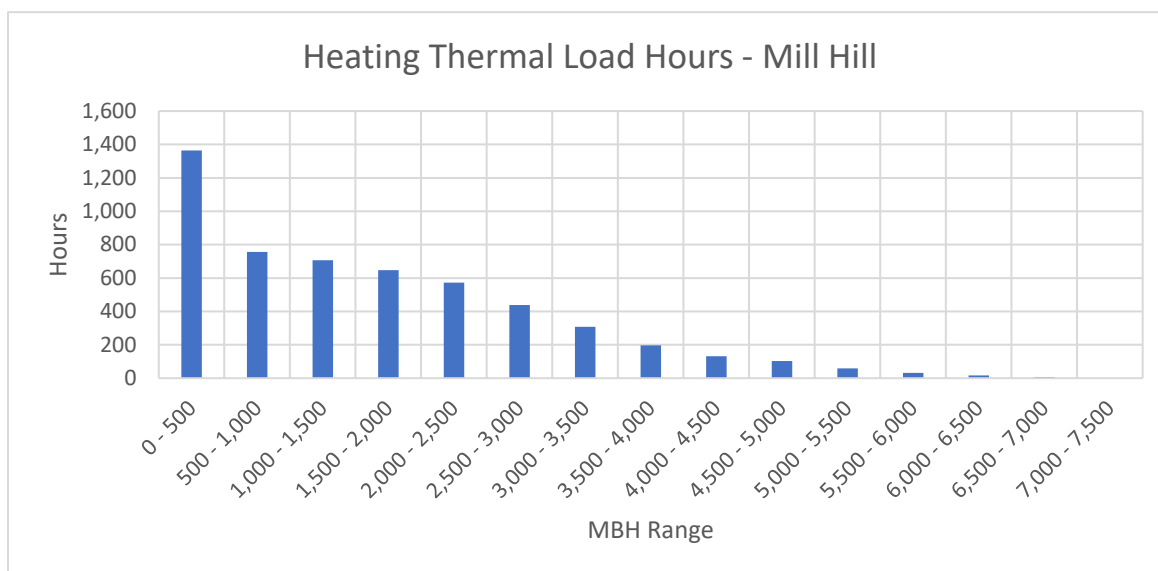


Figure 14. Thermal Load Range Total Hours – Mill Hill

3.1.4 Determine optimal number and site layout of the ground loop heat exchanger (GLHX) borefield.

Multiple site locations were considered for the borefields after identifying potential open green spaces. The primary location considered due to the size of available space was the soccer fields (Comeau Property), with a secondary location of Andy Lee Field behind the community center (yellow locations in Figure 9). These locations are adequate in providing the required ground connection to support the modeled aggregated thermal loads with a minimal number of remote fields or locations and are also town-owned, making operational efforts and billing centralized. It also streamlines any land rights or acquisition process. Installation in only two fields that are Town of Woodstock owned will have fewer potential obstacles to project completion. However, the locations also require a larger pumping distance to provide loop water to each system branch. Another concern regarding the Comeau Property is potential use of the aquifer at this location and the desire of the Town of Woodstock to protect this resource.

To create a more balanced community system, multiple smaller bore fields were identified that could serve each of the three main streets (Tinker Street, Mill Hill Road, and Rock City Road). Each field is shown in purple in Figure 9. In addition to being a more balanced system, multiple fields along each street allow for reduced pumping energy and a phased implementation approach to alleviate the magnitude of initial costs. However, many of the smaller bore field locations are privately owned which could be an obstacle towards installation and operation. This scenario provides the potential for improved community buy-in and ownership, but could complicate operational efforts and billing for system usage due to different land ownership.

Figure 15. Bore Field Layout: Comeau Property (Top), Andy Lee Field (Bottom)



Noise disturbances during the drilling of these borefields may be of concern. For jobs of this magnitude, it can be expected that four rigs will be on site drilling one borehole per day per rig. For approximately 30.5 weeks, noise levels around Andy Lee Field and the Comeau Property will be elevated. The Comeau property has a small number of residential properties approximately 100 feet north through a tree line but is otherwise more remote than Andy Lee Field. Andy Lee Field is more closely located to residential properties on the north side and adjacent to the community center which will impact the noise levels of more people than the Comeau Property.

3.1.5 Identify any sub-grade infrastructure that would impact bore field design.

There are minimal utilities or sub-grade infrastructure at the site of the proposed bore fields. The bore field locations are in open green fields, such as the soccer fields, or parking lots. Parking lots will likely need to consider the electrical infrastructure of any lighting fixtures in the lots. There will be nothing sticking up from the ground in the middle of either the fields or parking lots. Coordination with the Town of Woodstock and parking lot owners will be conducted during design. As previously mentioned, the Comeau Property is within the location of an aquifer that the Town of Woodstock has shown interest in the future and therefore has a need to protect this resource. Considering the lifetime expectancy of geothermal HDPE materials and the manner in which they are tested and installed, the aquifer will not be harmed by this effort. Figure 16 shows the overlay of the Town of Woodstock's water district and the potential water supply sites of concern indicated by the red oval.

Figure 16. Water District Wellhead Protection Overlay

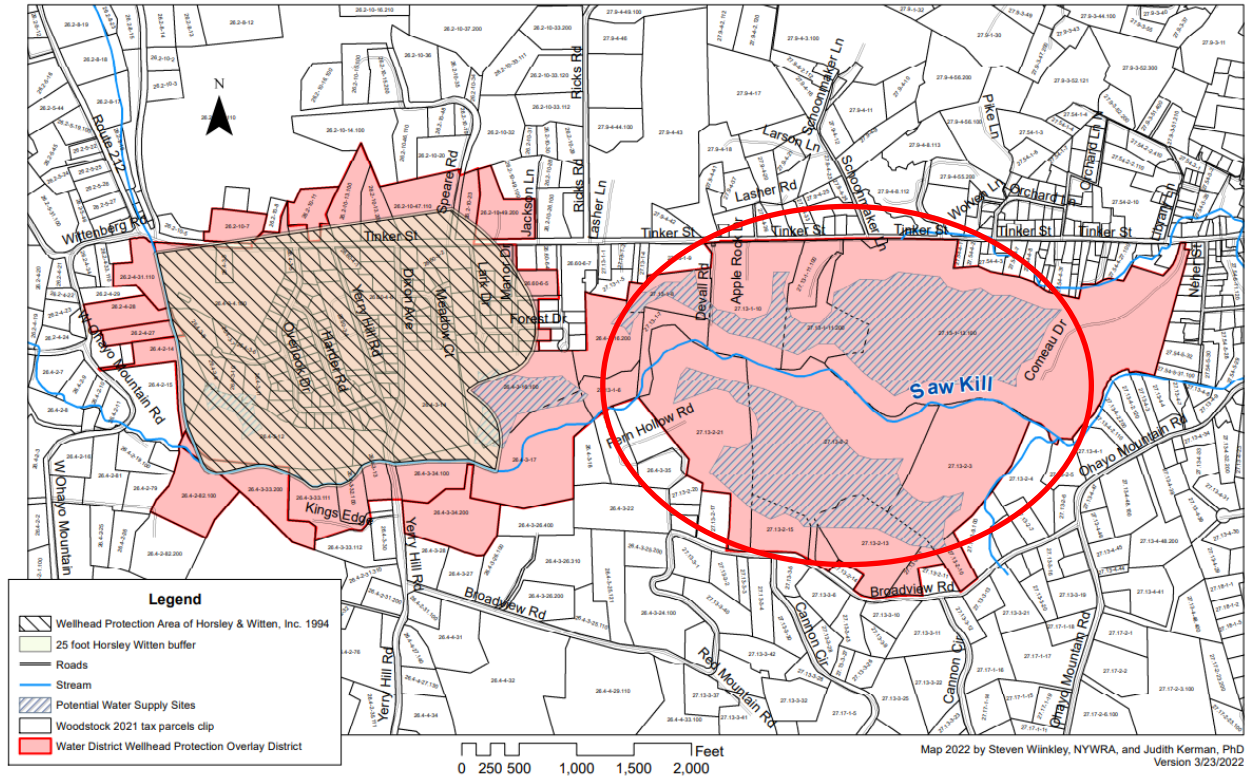


Figure 17 below shows the approximate location of the potential water supply sites circled in red in Figure 16 relative to the proposed borefield location at the Comeau Property. The impact on the portion of the watershed under the Comeau Property should be considered during the design stage of the next project phase and is discussed in Section 5 as a potential obstacle. The depth of the aquifer may be within the depth of the boreholes and will need further investigation.

Figure 17. Aquifer Location to Comeau Property Borefield



- *Analyze proposed system to obtain hourly intervals or more-granular resolution representing at minimum an 8,760-hour (continuous operation for one year) continuum and then integrate such results for display as monthly/annual energy consumption profiles.*

The preferred system design included equipment sizing options based on the district characterization. The System Calculator in Appendix E shows the loop pump (bore field system) and heat pump (customer systems) hourly demands for the hourly load profile and expands the profile to the required hourly heat absorption or rejection for the loop. Monthly energy for the loop pumps, heat pumps, and total energy is calculated and annualized. Total energy is also broken down by each of the three main streets in the community: Tinker, Rock City, and Mill Hill. The analysis is broken down by street for potential project phasing during implementation or the potential for multiple bore fields located throughout the community for optimal system balancing.

Quantity and rated size of pumps from the borefield system design allowed for the determination of pump speed and resulting pump demand of the borefield pump station pumps. The following figures depict the hourly total demand profile, and monthly and annual energy consumption profiles of the proposed borefield and customer system components. The hourly demand shows that the heat pumps require a larger electrical demand to meet the heating loads than to meet the peak cooling loads. This however does not represent a thermal imbalance of the borefield. The full ground loop design report shows the thermal balance of the borefield (no long-term change in ground temperature) and the electrical requirements of the customer system heat pump equipment is dependent on the seasonal equipment efficiencies.

Figure 18. Hourly Total System Demand (Borefields and Customer Systems)

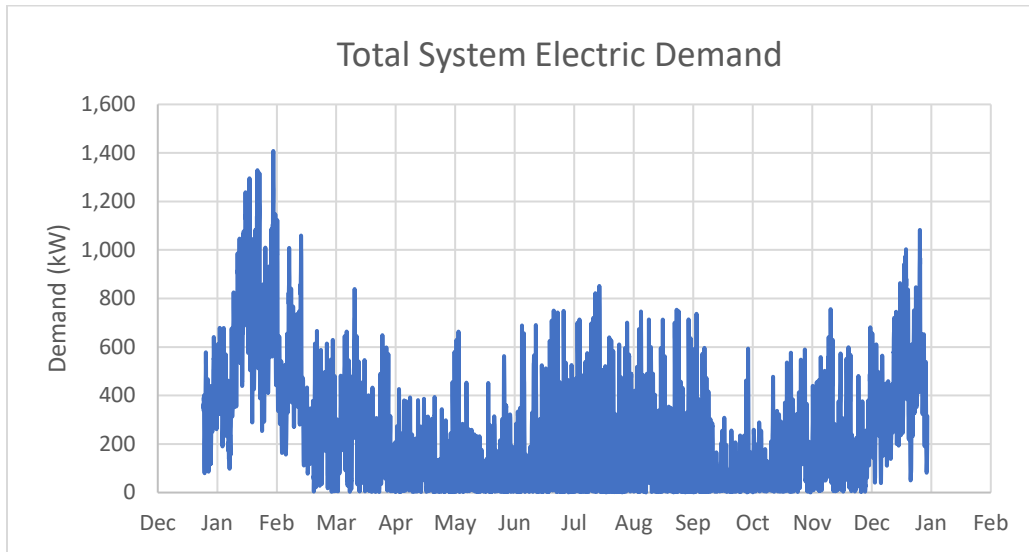


Figure 19. Monthly Proposed System Electricity (Borefields and Customer Systems)

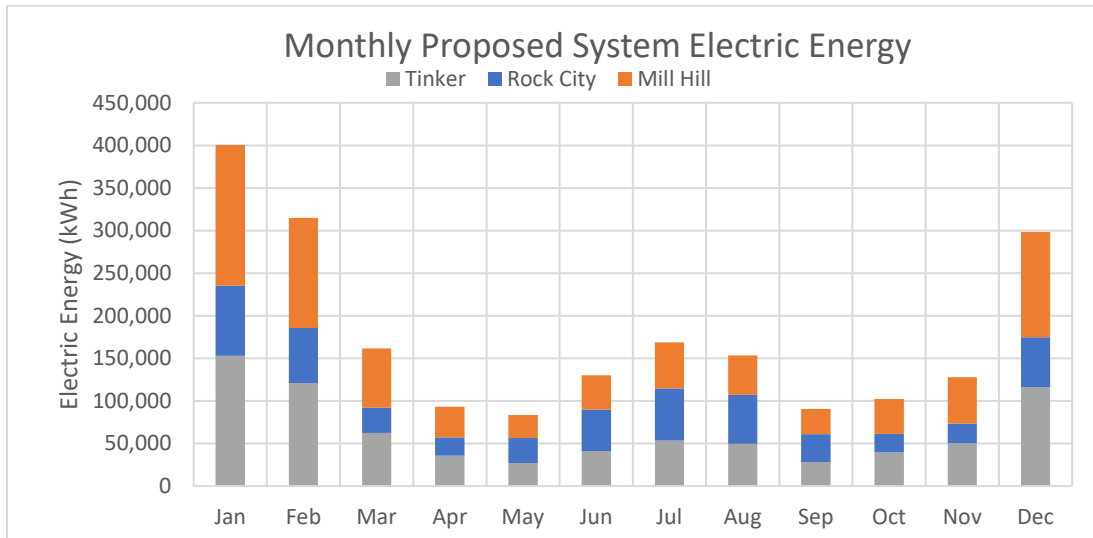
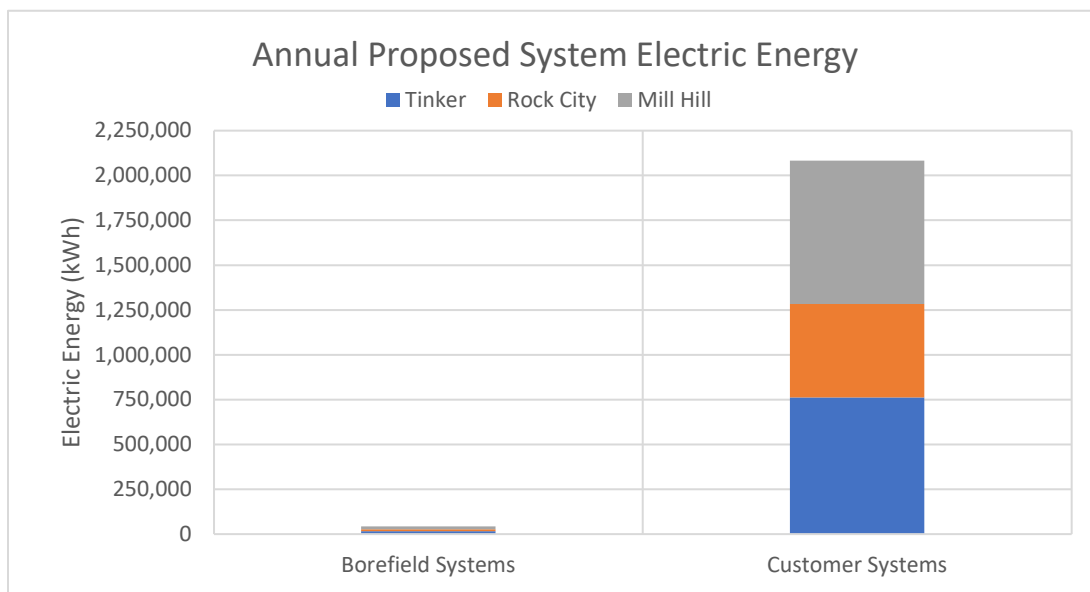


Figure 20. Annual Proposed System Electricity



The two primary components of total demand and energy are the loop pumps of the borefield system and customer system heat pumps in each building. As demonstrated in the graphs, the loop pump energy is insignificant compared to the consumption of the heat pumps. Tinker Street and Mill Hill Road have comparable total energy consumption each month, while Rock City Road has lower total energy consumption. As can be observed in the monthly profile of Figure 19, the cooling energy during the summer months is similar across all locations, but the heating requirements for the buildings on Rock City Road are lower across the shoulder and winter months. This is likely due to the distribution of building types between each street. Rock City Road has the lowest overall building area with the highest number of single-family homes which could contribute to the lower heating load across the heating season.

Table 13. Annual System Energy to Operate

	Loop Pump (Borefield) Energy	Heat Pump (Customer System) Energy	Total Energy
	(kWh)	(kWh)	(kWh)
Tinker	15,447	762,777	778,224
Rock City	10,724	520,097	530,821
Mill Hill	16,189	799,944	816,133
Total	42,360	2,082,818	2,125,178

The total energy equates to 7,251,107 kBtu (using 3.412 kBtu per kWh). The proposed system eliminates 26,635 MMBtu of fuel while increasing electrical consumption by 415,388 kWh of electricity (1,709,790 kWh baseline less 2,125,178 kWh proposed), or 25,330,183 kBtu compared to the baseline (see Appendix E and D for baseline and proposed operation energy values)

3.1.6 Integrate baseline system and desired mechanical system alternatives for comparison.

A submitted parcel data worksheet recorded baseline heating type and whether or not each building has central air. Specific equipment type was then estimated from this worksheet, field walkthroughs, and satellite imaging. It was assumed that any building listed as hot air contains a furnace and any building listed as either hot water or steam contains a boiler. The determination of either a furnace or boiler was also based on the building type when required. Cooling equipment was estimated from the observation of outdoor condensing units or window AC units.

The existing heating equipment consists of oil and liquid propane gas (LPG) fired equipment since natural gas is not available in the area. System alternatives to the baseline are therefore a fully electrified heating system. In order to fully electrify buildings' heating systems, air source heat pumps (ASHPs) are a potential solution but will lose both capacity and efficiency near the design heating temperature in Woodstock of 0°F. Buildings are assumed to replace the LPG and oil equipment in-kind with electric boilers, electric furnaces, or air source heat pumps (for buildings with RTUs or currently equipped with central air) for the standalone electrification alternative. Approximately 97% of the buildings would be electrified via an electric boiler or furnace. The alternative equipment models can be found in Appendix C.

3.1.7 Determine energy impact for each system alternative.

A primary energy impact of the system alternatives to the existing system is that delivered fuel consumption will be eliminated. A total of 11 buildings already utilize electric resistance, ground source heat pumps, or air source heat pumps and are therefore not included in determining the demand increase of an electrified baseline alternative. These baseline stand-alone systems represent alternative electrified customer systems to the preferred borefield, distribution system, and customer system of ground-source heat pumps.

The first alternative is to replace the existing heating equipment with electric boilers and furnaces. Total demand of the standalone electrification model utilizing electric boilers and furnaces would be approximately 4.2 MW. This approach's peak demand increase would have a significant impact on grid infrastructure, even more than the preferred community system's peak demand of approximately 1.4 MW.

The individualized air-source heat pump alternative must take into consideration the impact of outdoor air temperature on heating efficiency (COP). It was assumed that the efficiency of the individual units would be approximately the same for each building and thus the energy impact was determined from the aggregated hourly load profile over the course of a full year. Air-source heat pumps provide improved efficiency over electric boilers and furnaces (COP=1), resulting in a total peak demand of approximately 2.9 MW. Efficiency degradation with colder air temperatures causes this demand to still exceed the preferred community heat pump system's peak demand of approximately 1.4 MW.

3.2 DEVELOP CONCEPTUAL DESIGN OF COMMUNITY HEAT PUMP SYSTEM

Conceptual design of the district heat pump system is discussed in the executive summary and in Section 4.2. Details on the thermal balance of the ground source over years of operation (no change in ground temperature), design considerations in meeting peak loading, and overall bore hole quantity and bore field layout is previously discussed.

The distribution system is a one-pipe system distributing the system water from the borefields to each customer system and back to the borefields. The borefields and each customer connection are isolated from the main loop. Each customer is connected indirectly to the one-pipe distribution loop through a heat exchanger that is packaged with a small distribution pump to circulate the isolated individual customer loop water to the customer heat pumps. The customer's equipment system includes both the heat pump equipment, heat exchanger, customer pump, and this individual customer loop between the heat exchanger and customer building. The customer system loop will need to consider glycol for freeze protection even though the main distribution loop is designed to operate with fresh water. Borefield design results in operating temperatures above freezing and distribution piping is deep enough in the ground to prevent freezing.

3.3 HEAT TRANSFER MEDIUM OPTIONS

The proposed borefield is sized at approximately 200 linear feet of borefield per ton of capacity. Attempts to reduce this metric to a more aggressive value such as 190 ft/ton or 175 ft/ton caused the distribution loop temperatures to drop below freezing during the winter months. The schematic design of the borefield utilizes distilled water, or water without any antifreezing agents, as the fluid mediums without any anti-freeze or chemical agents. Antifreeze adds capital and operating costs and, while low, environmental risk. The terms distilled water and fresh water are commonly used interchangeably. However, the water to be used in the ambient loop is to be chemically neutral in order to not react with any chemicals or materials in the systems.

This design strategy lowers pumping power and improves heat transfer. Adding customers should be possible based on the modeled district distribution fluid temperatures. See Appendix A for modeled loop temperatures on a monthly basis over a 15-year period using GLD software. If, as load is added, the district distribution fluid approaches the freezing point (32°F), the district maintenance entity can add freeze protection.

The ability to run the district distribution loop colder in the winter/heating season will allow for a best “spring swing” into cooling season as the ground temperatures will be colder as summer begins. This phenomenon will benefit the commercial entities on the district loop more so than the residential; commercial heat pump equipment due to their nominal capacities are required to have economizer accessories which permit free cooling when conditions can support. Commercial

buildings require cooling throughout the year, and therefore will have free cooling during the heating months and early cooling months.

The trade-off to the benefits of using glycol for freeze protection is higher viscosity and density than fresh water. Pressure drops will increase the required pumping energy. Pumping energy will still remain low relative to the energy used in the entire district system.

4.0 PERFORM ECONOMIC AND FINANCIAL ANALYSIS

The focus of this section is to perform the detailed economic and financial analysis of the preferred conceptual design produced in Task 3. Following the business model of municipal operation of the borefields and distribution system, and customer operation of the customer systems (customer-owned heat pumps), the financial analysis looks at the perspective of both the municipal and customer. The goal is that the system is beneficial for both parties.

4.1 ESTIMATED ANNUAL UTILITY COSTS FOR THE SYSTEM

The goal of the financial analysis is to compare the continued operation of baseline equipment to the operation of the district heat pump system to determine the financial viability of switching to the new system. Utility costs of the overall system are comprised of the total electrical consumption of both the customer heat pump systems (170) and distribution pumping as part of the borefield system. The baseline thermal energy from propane or fuel oil is removed through electrification via the heat pumps. Electrical consumption therefore increases in the proposed scenario to serve both the cooling and heating loads.

Year 1 energy costs are based on a blended electrical rate of \$0.274 per kWh based on the sample of utility bills provided. With the shift of energy to fully electric energy consumption, the total system (borefield and customer systems) energy consumption is estimated to be 2,125,178 kWh at a cost of \$582,299. Additionally, operations and maintenance of the borefield and distribution system equipment is given an allowance of \$100,000 annually for a part-time operator/staff member.

Table 14. Annual Utility and Operation Costs (Year 1)

	Energy Consumption (kWh)	Cost
Customer (Customer Systems)	2,082,818	\$570,692
Municipal (Borefield/Distribution Systems)	42,360	\$11,607
Operation & Maintenance (Borefield/Distribution Systems)	N/A	\$100,000
Total		\$682,299

4.2 25-YEAR LIFE CYCLE COST MODEL

- Construction cost estimates

High-level project construction costs are shown in Appendix F and include the following:

- Borefield System:
 - Borefield drilling and restoration of the land above the bore holes after drilling, and one pump station per borefield including pumps, controls, valve station, and commissioning.
 - Distribution loops include one pump station per street (3 total) and associated pumps, controls, electrical service, and various piping and equipment such as strainers, air separators, and expansion tanks.
- Distribution System:
 - Underground distribution piping along each of the three main streets would reach each of the potential customers in the community in the full project buildout scenario.
- Customer Systems:
 - Construction costs also include the requirements for customer connections including underground piping to the building with associated fittings, trench fill, and small distribution pumps, and water-source equipment installation and existing equipment removal if required or requested. These customer system costs were first estimated for a sample building with the determination of a \$/ton value which was then extrapolated across the remaining buildings. Costs include a 20% design contingency and 10% overhead and profit. The 10% represents typical contractor markup on equipment and labor, and overhead costs such as employee benefits, liability coverage, insurance, and transportation costs.

Table 15. Opinion of Probable Cost

<u>Item</u>	<u>Opinion of Cost</u>
Municipal	
Thermal Source (Borefield)	\$14,500,000
Distribution System	\$11,000,000
<u>TOTAL MUNICIPAL</u>	<u>\$25,500,000</u>
Customer	
<u>Customer Systems</u>	<u>\$4,500,000</u>
Total Project Cost	\$30,000,000

- Estimated equipment service life, associated maintenance costs, and replacement costs

Borefield and distribution system piping, and associated equipment is expected to have a service life exceeding the duration of the NPV analysis and therefore replacement costs were not included in the analysis. Water source heat pump equipment in the customer buildings, however, are expected to require replacement starting in year 25 per the NYS Technical Manual. The analysis assumes that 25% of the equipment requires replacement starting in this final year of the analysis and the remaining replacements over the next 3 years (25% per year) fall outside of the analysis. Maintenance costs are also associated with the customer system equipment and are estimated as

\$200 per heat pump unit in the sample building, equivalent to \$38 per ton. It is assumed that each home requires two heat pumps. These costs are included in the NPV costs in Table 16 below.

- Financial metrics, including payback, return on investment, and life cycle cost

Comparing the total probable cost of Table 15 to the Year 1 net energy savings results in the simple payback. The net energy savings in the first year are approximately \$730,000 which results in an approximately 41-year payback. This is a simplistic approach to a financial analysis and the full 25-year life cycle cost described and analyzed in this section provides a more comprehensive financial analysis.

Financial feasibility from both the municipal and customer perspective is important for developing a strong business case. However, implementation will have significant clean energy impacts on the greater community, which is a benefit that cannot be directly monetized by the developer under current state policy. The financials have been separated into the municipal's perspective and the customer perspective to capture the financial benefits for all project stakeholders.

The median municipal rate over 20 years is 3.75%⁶. The Town of Woodstock interest bond rate of 4.0% was used in the analysis to be slightly conservative.

Discount rate describes the rate of return available on alternative investments of comparable risk. Municipal, state, and federal government projects are generally analyzed at a 3% discount rate. Customer financials were analyzed at a 7% discount rate, which is often used for commercial projects.

The 25-year NPV analysis uses the following assumptions:

- Utility inflation of 5.0% per NIST handbook
- General inflation of 3.0%
- Municipal discount rate of 3.0%
- Customer discount rate of 7.0%
- Municipal financing rate of 4.0% for 20 years for installation investment
- Customer financing rate of 6.0% for 20 years for installation investment
- Thermal Utility Rate of \$0.15/ft²/month paid by the customer to the municipality with an escalation rate of 3.0%
- Equipment is assumed to be installed in the same year
 - In reality there will be phasing of an unknown schedule.
- Customer systems (water source heat pumps) will be replaced starting in year 25.
- Customer System efficiency degradation of 0.25% per year

⁶ <https://fixedincome.fidelity.com/ftgw/fi/FILanding?bar=p#tbcurrenyields|median-yield>

- Inflation Reduction Act (IRA) tax credit applied at 40% of project cost (the municipality should consult a tax professional to determine if the tax credit is applicable to this project, which may depend on the final ownership model)
- NYSERDA cost-sharing for system design

The tables below show the project costs, direct benefits, and indirect benefits. Indirect benefits are a result of the carbon reduction social benefit. The New York State Department of Environmental Conservation has issued a social cost of carbon guide for policy decisions. In 2020, the value was calculated to be \$126 per metric ton of CO₂ for 2023⁷. This value increases in subsequent years. The analysis also considers the impact of a cleaner grid. A benefit cost ratio (BCR) greater than 1.0 indicates that the project has a positive NPV. The project is viable if both the customer and municipal perspectives have a positive NPV.

The table below shows the project costs from the perspective of all the potential customers. It is broken down into costs (cash outflows) and benefits (cash inflows) to determine the NPV and BCR. Avoided customer O&M and equipment reconditioning benefits represent the operation and maintenance and equipment replacements if the customers were to stay on their current baseline heating and cooling systems over the 25-year analysis. At the thermal energy cost stated in the assumptions above, the customer still maintains a BCR greater than 1.0 and a positive NPV.

Considering the potential for no federal tax credit, the analysis was performed with the tax credit removed. This increases the financing costs and thermal energy rate was adjusted to attempt to create a positive NPV and a BCR greater than or equal to 1.0 for both the customer and municipality. Increasing the rate between \$0.18/ft²/month and \$0.19/ft²/month maintains these characteristics for the customer despite not maintaining them for the municipality as described later.

The thermal energy charge is the charge that the customers pay the municipality providing the thermal energy from the district loop. This provides a benefit to the municipality to offset installation and operational costs of the borefields and distribution system. As can be seen in the Net Present Value tables, the 25-year NPV for the thermal charge received by the municipality exceeds the 25-year NPV of the thermal charge paid by the customers due to the higher discount rate that can be achieved by a municipality over individual customers. The carbon reduction social benefit establishes a monetary value of carbon demonstrating the societal value of carbon reduction including public health, economic opportunities, and environmental justice.

⁷ The \$126 per metric ton figure assumes a discount rate of 2% and is based on an average of modeled results. Estimating the Value of Carbon: Two Approaches, NYSERDA & Resources for the Future 6 (Jan. 2021).

Table 16. Net Present Value – Combined Customers’ Perspective

NPV (25 Year)	With Tax Credit	Without Tax Credit
Costs		
Customer Systems/Connections (Initial Install)	\$2,600,000	\$4,400,000
Equipment Replacements (End-of-Life within 25 yrs.)	\$200,000	\$200,000
Customer System O&M (Operation and Maintenance)	\$1,100,000	\$1,100,000
Thermal Energy Charge	\$14,900,000	\$13,900,000
Total Costs	\$18,800,000	\$19,600,000
Direct Benefits		
Avoided Customer O&M (Baseline)	\$1,100,000	\$1,100,000
Avoided Customer Equipment Recondition (Baseline)	\$1,100,000	\$1,100,000
Customer Energy Savings (Baseline-Proposed)	\$17,500,000	\$17,500,000
Total Direct Benefits	\$19,700,000	\$19,700,000
Indirect Benefits		
Carbon Reduction Social Benefit	\$2,000,000	\$2,000,000
Net Direct Benefits (Direct Benefits Minus Costs)	\$900,000	\$100,000
BCR	1.0	1.0
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	\$2,900,000	\$2,100,000
BCR	1.2	1.1

Given the business model of a municipal owned thermal system and customer end users, the analysis is split between the total customer and municipal’s perspective. Combining all costs and benefits into a single analysis with no thermal energy charged by the municipal to the customers would otherwise provide the customers with all of the benefits. Adding the thermal energy charge listed in the assumptions allows the project to be financially viable for both parties. The selected charge is such that BCR just reaches a value greater than 1.0 for both the customers and municipality for the given conditions.

Removing the tax credit due to the uncertainty in qualifying, the analysis was adjusted with increasing the thermal utility rate to attempt to maintain a BCR greater than or equal to 1.0 for both the municipal and customer. At a thermal utility rate for the customer to maintain these requirements, the municipality is unable to maintain the BCR and NPV requirements. As shown in the sensitivity analysis of Section 4.4, there are discount, finance, and inflation rates that result in positive NPV and a BCR of 1.0 or more.

Table 17. Net Present Value – Municipal’s Perspective

NPV (25 Year)	With Tax Credit	Without Tax Credit
Costs		
Thermal Source (Borefield)/Distribution (Initial Install)	\$17,100,000	\$28,800,000
Equipment Replacements (Pumps – Pumps Stations)	\$100,000	\$100,000
Borefield System O&M (Operation and Maintenance)	\$2,500,000	\$2,500,000
Borefield Distribution Energy Costs	\$400,000	\$400,000
Total Costs	\$20,100,000	\$31,800,000
Direct Benefits		
Thermal Energy Revenue from Customers	\$22,600,000	\$21,100,000
Total Direct Benefits	\$22,600,000	\$21,100,000
Indirect Benefits		
Carbon Reduction Social Benefit	\$0	\$0
Net Direct Benefits (Direct Benefits Minus Costs)	\$2,500,000	-\$10,700,000
BCR	1.2	0.7
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	2,500,000	-\$10,700,000
BCR	1.2	0.7

For comparison, a similar 25-year analysis was performed for the electrification alternative of individual air source heat pumps. There is only the customer perspective in this analysis and the same assumptions were made as the community option. The estimated costs for ASHPs are lower than a community system, and the benefits of energy savings are less due to the decreased efficiency of ASHP compared to ground source heat pumps. Overall, the BCR is greater for the ASHP alternative if the customers have adequate electrical capacity. Similar to the ground source heat pump analysis, the air source heat pump analysis also had the tax credit removed.

Table 18. Net Present Value – ASHP Alternative

NPV (25 Year)	<u>With Tax Credit</u>	<u>Without Tax Credit</u>
Costs		
Customer Systems/Connections (Initial Install)	\$5,400,000	\$9,100,000
Equipment Replacements (End-of-Life within 25 yrs.)	\$2,500,000	\$2,500,000
Customer System O&M (Operation and Maintenance)	\$1,500,000	\$1,500,000
Total Costs	\$9,400,000	\$13,100,000
Direct Benefits		
Avoided Customer O&M (Baseline)	\$1,100,000	\$1,100,000
Avoided Customer Equipment Recondition (Baseline)	\$1,100,000	\$1,100,000
Customer Energy Savings (Baseline-Proposed)	\$12,600,000	\$12,600,000
Total Direct Benefits	\$14,800,000	\$14,800,000
Indirect Benefits		
Carbon Reduction Social Benefit	\$1,800,000	\$1,800,000
Net Direct Benefits (Direct Benefits Minus Costs)	\$5,400,000	\$1,700,000
BCR	1.6	1.1
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	\$7,200,000	\$3,400,000
BCR	1.8	1.3

The two total net present value analyses for the customer and municipal perspectives were also broken out by phase to remain consistent with a potential phased approach. Inputs into the analysis such as replacement costs, operation and maintenance costs, square footage, energy consumption, and equipment costs are phase specific. The thermal utility rate for Phase A was increased compared to the total analysis to attempt to make both the customer and municipality realize a positive NPV and a BCR of at least 1.0. This change is due to the assumption that Phase A carries all of the O&M costs for the municipality since staff will need to be hired for this phase and the same staff will be used for the other two phases. Due to this cost in Phase A, the municipality does not realize benefit initially in Phase A and does not realize a benefit until the other Phases are completed. The analysis was performed considering a potential tax credit. Tables 19-24 detail the results of each phase. The change in thermal utility rate just described results in a difference between the values of the full project analysis and the summation of the individual phases. Please also note that rounding in each phase creates differences between the full project analysis and the summation of the individual phases.

Table 19. Net Present Value – Combined Customers’ Perspective – Phase A

<u>NPV (25 Year)</u>	<u>With Tax Credit</u>
Costs	
Customer Systems/Connections (Initial Install)	\$700,000
Equipment Replacements (End-of-Life within 25 yrs.)	\$0
Customer System O&M (Operation and Maintenance)	\$300,000
Thermal Energy Charge	\$3,600,000
Total Costs	\$4,600,000
Direct Benefits	
Avoided Customer O&M (Baseline)	\$300,000
Avoided Customer Equipment Recondition (Baseline)	\$200,000
Customer Energy Savings (Baseline-Proposed)	\$4,600,000
Total Direct Benefits	\$5,100,000
Indirect Benefits	
Carbon Reduction Social Benefit	\$500,000
Net Direct Benefits (Direct Benefits Minus Costs)	\$500,000
BCR	1.1
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	\$1,000,000
BCR	1.2

Table 20. Net Present Value – Municipal’s Perspective – Phase A

<u>NPV (25 Year)</u>	<u>With Tax Credit</u>
Costs	
Thermal Source (Borefield)/Distribution (Initial Install)	\$7,500,000
Equipment Replacements (Pumps – Pumps Stations)	\$0
Borefield System O&M (Operation and Maintenance)	\$2,500,000
Borefield Distribution Energy Costs	\$100,000
Total Costs	\$10,100,000
Direct Benefits	
Thermal Energy Revenue from Customers	\$5,400,000
Total Direct Benefits	\$5,400,000
Indirect Benefits	
Carbon Reduction Social Benefit	\$0
Net Direct Benefits (Direct Benefits Minus Costs)	-\$4,700,000
BCR	0.5
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	-\$4,700,000
BCR	0.5

Table 21. Net Present Value – Combined Customers’ Perspective – Phase B

<u>NPV (25 Year)</u>	<u>With Tax Credit</u>
Costs	
Customer Systems/Connections (Initial Install)	\$900,000
Equipment Replacements (End-of-Life within 25 yrs.)	\$100,000
Customer System O&M (Operation and Maintenance)	\$400,000
Thermal Energy Charge	\$5,900,000
Total Costs	\$7,300,000
Direct Benefits	
Avoided Customer O&M (Baseline)	\$500,000
Avoided Customer Equipment Recondition (Baseline)	\$600,000
Customer Energy Savings (Baseline-Proposed)	\$6,200,000
Total Direct Benefits	\$7,300,000
Indirect Benefits	
Carbon Reduction Social Benefit	\$700,000
Net Direct Benefits (Direct Benefits Minus Costs)	\$0
BCR	1.0
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	\$700,000
BCR	1.1

Table 22. Net Present Value – Municipal’s Perspective – Phase B

<u>NPV (25 Year)</u>	<u>With Tax Credit</u>
Costs	
Thermal Source (Borefield)/Distribution (Initial Install)	\$5,800,000
Equipment Replacements (Pumps – Pumps Stations)	\$0
Borefield System O&M (Operation and Maintenance)	\$0
Borefield Distribution Energy Costs	\$200,000
Total Costs	\$6,000,000
Direct Benefits	
Thermal Energy Revenue from Customers	\$9,000,000
Total Direct Benefits	\$9,000,000
Indirect Benefits	
Carbon Reduction Social Benefit	\$0
Net Direct Benefits (Direct Benefits Minus Costs)	\$3,000,000
BCR	1.5
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	\$3,000,000
BCR	1.5

Table 23. Net Present Value – Combined Customers’ Perspective – Phase C

<u>NPV (25 Year)</u>	<u>With Tax Credit</u>
Costs	
Customer Systems/Connections (Initial Install)	\$1,000,000
Equipment Replacements (End-of-Life within 25 yrs.)	\$100,000
Customer System O&M (Operation and Maintenance)	\$400,000
Thermal Energy Charge	\$5,800,000
Total Costs	\$7,300,000
Direct Benefits	
Avoided Customer O&M (Baseline)	\$1,100,000
Avoided Customer Equipment Recondition (Baseline)	\$1,100,000
Customer Energy Savings (Baseline-Proposed)	\$6,600,000
Total Direct Benefits	\$8,800,000
Indirect Benefits	
Carbon Reduction Social Benefit	\$800,000
Net Direct Benefits (Direct Benefits Minus Costs)	\$1,500,000
BCR	1.2
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	\$2,300,000
BCR	1.3

Table 24. Net Present Value – Municipal’s Perspective – Phase C

NPV (25 Year)	With Tax Credit
Costs	
Thermal Source (Borefield)/Distribution (Initial Install)	\$2,700,000
Equipment Replacements (Pumps – Pumps Stations)	\$0
Borefield System O&M (Operation and Maintenance)	\$0
Borefield Distribution Energy Costs	\$200,000
Total Costs	\$2,900,000
Direct Benefits	
Thermal Energy Revenue from Customers	\$8,800,000
Total Direct Benefits	\$8,800,000
Indirect Benefits	
Carbon Reduction Social Benefit	\$0
Net Direct Benefits (Direct Benefits Minus Costs)	\$5,900,000
BCR	3.0
Net Direct + Indirect Benefits (Total Benefits Minus Cost)	\$5,900,000
BCR	3.0

- Carbon reduction calculations based on the baseline and proposed low-carbon solution

Carbon emission calculations were performed for both the baseline and proposed low-carbon solution, demonstrating the carbon reduction of the proposed solution. The analysis starts with the current-year CO₂ equivalency for electricity of 0.3 kg per kWh and as the grid becomes cleaner it will reduce to 0 kg per kWh by the year 2040. The 25-year life cycle cost analysis assumes a linear decrease from the current value down to zero. As previously described, the indirect social cost of carbon was applied to this reduction in carbon emission to develop the indirect benefit of the proposed solution. The resulting NPV of the social cost of carbon for the total project and phases are shown in the summary tables above. The carbon saving values throughout the life cycle of the scenarios can be found in the analysis.

4.3 BUSINESS MODEL OPTIONS

This section analyzes the business model options for owning and operating the district heat pump system, specifying a preferred business model and determining the annual costs to the site owner over the term of the arrangement.

The selection of a business model for large infrastructure projects including district energy systems (DES) should mitigate several types of risk including objectives risk (governance and ownership

structure), design risk (selection of technologies and equipment), construction risk (procurement, scheduling), operational risk (commissioning, maintenance), demand/market risk (customer acquisition, rate structure), and financial risk (ROI). A preferred business model will not only mitigate these various forms of risk but also establish mechanisms of control and impact the financing structure for the project.

A range of business models are available ranging from completely public-owned (i.e., public utility or municipal department-run) to completely privately-owned with a range of hybrid forms in between including concession, joint venture and special purpose vehicles. A review of the literature suggests that the most common business models for district energy systems include public sector ownership and operation, public sector ownership with operation by a private energy company or utility, cooperative ownership, and private sector ownership and operation through either an existing energy utility or a new energy services firm. The choice of business model will affect the cost of capital as well as the overall financing structure. It is also important to note that district energy systems are not only large and complex engineering projects but also dynamic businesses that are subject to change, innovation, and operating/market risk. Once established, the Woodstock DES business may evolve relative to the initial business case as new opportunities and circumstances arise.

The preferred business model will involve the Town of Woodstock carrying responsibility for operations and maintenance of the thermal production and all related components of the distribution system. Financial cost and benefit would have the same types of assumptions as the NPV analysis, but adjustments to actual values may be made based on market conditions, final risk determinations, customer size, or based on customer building retrofit costs necessary for connection. The cost per square foot per month for the thermal energy charge would be calculated such that the annual customer energy spend and system use charges would not exceed current utility costs.

Funding from the NYSERDA and from the Inflation Reduction Act (IRA) tax credit is expected to decrease the total design and capital expenditure for the Town of Woodstock. Public funds could be used to defray any costs to facilitate customer acquisition since connection will require system retrofit for most buildings. Public debt may be used to establish a reserve account to cover the “under recovery” of revenue from reduced rates in the early years to be repaid in future years, along with a return on investment for this revenue gap. For example, the City of Vancouver created a Rate Stabilization Reserve for the Southeast False Creek Project. This pool of funds provided a “revolving line of credit” used to fund system development in early years and ensure stable rates and covered cumulative financial losses in the system’s early years which were repaid from revenues in later years. Public sector loans thus allow for the recovery on initial capital investments as district energy rates increase over time, especially if the customer base or future energy prices grow at rates higher than initially forecast and thus generate increased revenue from district energy services.

The literature suggests that flexible public debt tools should be used, as opposed to providing direct grants and local tax subsidies. Public debt has several advantages over grants and tax incentives as

it provides the potential to recapture and recycle funds and thus can be used to finance expansion of the system or development of new DES projects. It also creates the potential to access and leverage a larger range of funding sources.

Additional planning and research will be needed to determine the details of the business model and financing structure to address the capital needs of the Woodstock DES. However, it is clear that any strategy will require a pool of flexible and patient capital to finance long-term system capital investment.

4.4 SENSITIVITY ANALYSIS

The following tables provide a sensitivity analysis for the preferred system and business model for both the customer and municipal perspectives with the tax credit and without the tax credit. The analysis represents the changes in NPV (in thousands) for varying combinations of discount rate and inflation rate, and discount rate and finance rate. As expected, as inflation increases, costs increase and the NPV decreases, eventually becoming negative for the customer. For the municipality, increased inflation improves the revenue generated from the thermal energy charge. Also as expected, as the finance rate reduces, the overall project cost is less and the NPV also improves for both perspectives. A sensitivity analysis was also performed using the same variables for the ASHP alternative. The NPV across all values is positive, with a reduction in NPV as the inflation rate, finance rate, and/or discount rate increases.

Table 25. NPV (in thousands) – Inflation Rate Sensitivity (Customer Perspective)

With Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Inflation Rate	1%	\$8,600	\$7,000	\$5,700	\$4,700	\$3,800	\$3,000	\$2,300	\$1,900
	2%	\$6,200	\$4,900	\$4,000	\$3,100	\$2,500	\$1,800	\$1,300	\$1,000
	3%	\$3,500	\$2,700	\$1,900	\$1,400	\$900	\$500	\$300	-\$100
	4%	\$400	\$0	-\$300	-\$700	-\$700	-\$1,000	-\$1,000	-\$1,100
	5%	-\$3,400	-\$3,100	-\$3,000	-\$2,800	-\$2,800	-\$2,700	-\$2,600	-\$2,400
	6%	-\$7,700	-\$6,800	-\$6,100	-\$5,500	-\$4,900	-\$4,700	-\$4,200	-\$3,900
	7%	-\$12,800	-\$11,100	-\$9,700	-\$8,600	-\$7,600	-\$7,000	-\$6,300	-\$5,500
	8%	-\$18,700	-\$16,100	-\$13,900	-\$12,100	-\$10,700	-\$9,500	-\$8,500	-\$7,600

No Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Inflation Rate	1%	\$7,600	\$5,900	\$4,600	\$3,700	\$2,800	\$2,100	\$1,500	\$1,100
	2%	\$5,400	\$3,900	\$3,100	\$2,200	\$1,600	\$1,100	\$600	\$300
	3%	\$2,800	\$1,900	\$1,100	\$600	\$100	-\$200	-\$400	-\$700
	4%	-\$100	-\$700	-\$900	-\$1,300	-\$1,400	-\$1,600	-\$1,600	-\$1,700
	5%	-\$3,700	-\$3,600	-\$3,500	-\$3,400	-\$3,400	-\$3,200	-\$3,100	-\$2,900
	6%	-\$7,700	-\$7,100	-\$6,400	-\$5,900	-\$5,400	-\$5,100	-\$4,600	-\$4,300
	7%	-\$12,500	-\$11,100	-\$9,800	-\$8,800	-\$7,900	-\$7,200	-\$6,500	-\$5,800
	8%	-\$18,100	-\$15,800	-\$13,800	-\$12,100	-\$10,800	-\$9,600	-\$8,600	-\$7,800

Table 26. NPV (in thousands) – Finance Rate Sensitivity (Customer Perspective)

With Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Finance Rate	2.0%	\$4,600	\$3,700	\$2,800	\$2,200	\$1,600	\$1,300	\$1,000	\$600
	3.0%	\$4,300	\$3,500	\$2,500	\$2,000	\$1,500	\$1,100	\$800	\$400
	4.0%	\$4,100	\$3,200	\$2,300	\$1,800	\$1,300	\$900	\$600	\$300
	5.0%	\$3,800	\$3,000	\$2,100	\$1,600	\$1,100	\$700	\$500	\$100
	6.0%	\$3,500	\$2,700	\$1,900	\$1,400	\$900	\$500	\$300	-\$100
	7.0%	\$3,300	\$2,400	\$1,600	\$1,100	\$700	\$300	\$100	-\$300
	8.0%	\$2,900	\$2,200	\$1,400	\$900	\$400	\$100	-\$100	-\$400

No Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Finance Rate	2.0%	\$4,500	\$3,500	\$2,600	\$2,000	\$1,400	\$1,000	\$700	\$300
	3.0%	\$4,100	\$3,200	\$2,300	\$1,700	\$1,100	\$700	\$400	\$100
	4.0%	\$3,700	\$2,800	\$1,900	\$1,300	\$800	\$400	\$100	-\$200
	5.0%	\$3,200	\$2,400	\$1,500	\$1,000	\$500	\$100	-\$100	-\$400
	6.0%	\$2,800	\$1,900	\$1,100	\$600	\$100	-\$200	-\$400	-\$700
	7.0%	\$2,300	\$1,500	\$700	\$200	-\$200	-\$500	-\$800	-\$1,000
	8.0%	\$1,800	\$1,000	\$300	-\$200	-\$600	-\$900	-\$1,100	-\$1,300

Table 27. NPV (in thousands) – Inflation Rate Sensitivity (Municipal Perspective)

With Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Inflation Rate	1%	-\$1,600	-\$1,800	-\$1,900	-\$2,000	-\$2,000	-\$2,000	-\$2,000	-\$2,000
	2%	\$300	-\$200	-\$500	-\$800	-\$1,000	-\$1,100	-\$1,200	-\$1,300
	3%	\$2,400	\$1,700	\$1,100	\$600	\$200	-\$100	-\$300	-\$500
	4%	\$5,000	\$3,800	\$2,900	\$2,200	\$1,600	\$1,100	\$700	\$400
	5%	\$7,900	\$6,300	\$5,000	\$4,000	\$3,200	\$2,500	\$1,900	\$1,400
	6%	\$11,300	\$9,200	\$7,500	\$6,100	\$5,000	\$4,000	\$3,300	\$2,600
	7%	\$15,200	\$12,500	\$10,300	\$8,500	\$7,100	\$5,800	\$4,800	\$4,000
	8%	\$19,800	\$16,400	\$13,600	\$11,300	\$9,500	\$7,900	\$6,600	\$5,500

No Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Inflation Rate	1%	-\$14,600	-\$13,700	-\$12,800	-\$12,300	-\$11,600	-\$10,900	-\$10,300	-\$9,800
	2%	-\$12,800	-\$12,200	-\$11,600	-\$11,100	-\$10,600	-\$10,200	-\$9,600	-\$9,200
	3%	-\$10,800	-\$10,500	-\$10,100	-\$9,800	-\$9,400	-\$9,100	-\$8,800	-\$8,400
	4%	-\$8,500	-\$8,500	-\$8,400	-\$8,400	-\$8,200	-\$8,000	-\$7,800	-\$7,600
	5%	-\$5,900	-\$6,200	-\$6,400	-\$6,600	-\$6,700	-\$6,700	-\$6,700	-\$6,600
	6%	-\$2,700	-\$3,600	-\$4,100	-\$4,700	-\$5,000	-\$5,300	-\$5,400	-\$5,600
	7%	\$1,000	-\$500	-\$1,600	-\$2,400	-\$3,100	-\$3,600	-\$4,000	-\$4,300
	8%	\$5,200	\$3,100	\$1,500	\$0	-\$900	-\$1,700	-\$2,300	-\$2,800

Table 28. NPV (in thousands) – Finance Rate Sensitivity (Municipal Perspective)

With Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Finance Rate	2.0%	\$5,300	\$4,300	\$3,500	\$2,800	\$2,300	\$1,900	\$1,500	\$1,200
	3.0%	\$3,900	\$3,000	\$2,300	\$1,700	\$1,300	\$900	\$600	\$400
	4.0%	\$2,400	\$1,700	\$1,100	\$600	\$200	-\$100	-\$300	-\$500
	5.0%	\$900	\$300	-\$200	-\$600	-\$900	-\$1,100	-\$1,300	-\$1,400
	6.0%	-\$700	-\$1,200	-\$1,600	-\$1,900	-\$2,100	-\$2,200	-\$2,300	-\$2,400
	7.0%	-\$2,300	-\$2,700	-\$3,000	-\$3,200	-\$3,300	-\$3,400	-\$3,400	-\$3,400
	8.0%	-\$4,100	-\$4,300	-\$4,500	-\$4,600	-\$4,600	-\$4,600	-\$4,500	-\$4,500

No Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Finance Rate	2.0%	-\$6,000	-\$6,100	-\$6,100	-\$6,000	-\$5,900	-\$5,800	-\$5,700	-\$5,500
	3.0%	-\$8,300	-\$8,300	-\$8,100	-\$7,900	-\$7,600	-\$7,400	-\$7,300	-\$6,900
	4.0%	-\$10,800	-\$10,500	-\$10,100	-\$9,800	-\$9,400	-\$9,100	-\$8,800	-\$8,400
	5.0%	-\$13,300	-\$12,900	-\$12,300	-\$11,800	-\$11,400	-\$10,800	-\$10,500	-\$10,000
	6.0%	-\$16,000	-\$15,400	-\$14,600	-\$14,000	-\$13,300	-\$12,700	-\$12,300	-\$11,700
	7.0%	-\$18,800	-\$18,000	-\$17,000	-\$16,200	-\$15,400	-\$14,700	-\$14,100	-\$13,400
	8.0%	-\$21,700	-\$20,600	-\$19,500	-\$18,500	-\$17,600	-\$16,700	-\$16,000	-\$15,100

Table 29. NPV (in thousands) – Inflation Rate Sensitivity (ASHP Alternative)

With Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Inflation Rate	1%	\$11,200	\$9,700	\$8,400	\$7,300	\$6,500	\$5,600	\$5,000	\$4,400
	2%	\$10,200	\$8,800	\$7,700	\$6,800	\$6,000	\$5,200	\$4,600	\$4,100
	3%	\$9,100	\$7,900	\$6,900	\$6,100	\$5,400	\$4,800	\$4,200	\$3,800
	4%	\$7,800	\$6,800	\$5,900	\$5,200	\$4,700	\$4,100	\$3,700	\$3,400
	5%	\$6,200	\$5,400	\$4,800	\$4,300	\$3,900	\$3,500	\$3,100	\$2,900
	6%	\$4,300	\$3,900	\$3,500	\$3,200	\$2,900	\$2,600	\$2,400	\$2,200
	7%	\$2,100	\$1,900	\$1,900	\$1,800	\$1,800	\$1,700	\$1,600	\$1,600
	8%	-\$600	-\$300	\$0	\$300	\$500	\$600	\$600	\$800

No Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Inflation Rate	1%	\$6,300	\$5,200	\$4,200	\$3,400	\$2,800	\$2,200	\$1,800	\$1,400
	2%	\$5,300	\$4,300	\$3,500	\$2,900	\$2,300	\$1,800	\$1,400	\$1,100
	3%	\$4,200	\$3,400	\$2,700	\$2,200	\$1,700	\$1,400	\$1,000	\$800
	4%	\$2,900	\$2,300	\$1,700	\$1,300	\$1,000	\$700	\$500	\$400
	5%	\$1,300	\$900	\$600	\$400	\$200	\$100	-\$100	-\$100
	6%	-\$600	-\$600	-\$700	-\$700	-\$800	-\$800	-\$800	-\$800
	7%	-\$2,800	-\$2,600	-\$2,300	-\$2,100	-\$1,900	-\$1,700	-\$1,600	-\$1,400
	8%	-\$5,500	-\$4,800	-\$4,200	-\$3,600	-\$3,200	-\$2,800	-\$2,600	-\$2,200

Table 30. NPV (in thousands) – Finance Rate Sensitivity (ASHP Alternative)

With Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Finance Rate	2.0%	\$11,300	\$9,900	\$8,800	\$7,800	\$7,000	\$6,300	\$5,600	\$5,100
	3.0%	\$10,800	\$9,400	\$8,300	\$7,400	\$6,600	\$6,000	\$5,300	\$4,800
	4.0%	\$10,300	\$9,000	\$7,900	\$7,000	\$6,200	\$5,600	\$5,000	\$4,500
	5.0%	\$9,700	\$8,400	\$7,400	\$6,500	\$5,800	\$5,200	\$4,600	\$4,200
	6.0%	\$9,100	\$7,900	\$6,900	\$6,100	\$5,400	\$4,800	\$4,200	\$3,800
	7.0%	\$8,500	\$7,400	\$6,400	\$5,600	\$4,900	\$4,400	\$3,800	\$3,400
	8.0%	\$7,900	\$6,800	\$5,900	\$5,100	\$4,400	\$4,000	\$3,400	\$3,100

No Tax Credit		Discount Rate							
		3%	4%	5%	6%	7%	8%	9%	10%
Finance Rate	2.0%	\$7,800	\$6,700	\$5,800	\$5,000	\$4,400	\$3,900	\$3,400	\$3,000
	3.0%	\$7,000	\$5,900	\$5,100	\$4,400	\$3,800	\$3,300	\$2,800	\$2,500
	4.0%	\$6,100	\$5,100	\$4,300	\$3,700	\$3,100	\$2,700	\$2,300	\$2,000
	5.0%	\$5,200	\$4,300	\$3,600	\$2,900	\$2,400	\$2,100	\$1,700	\$1,400
	6.0%	\$4,200	\$3,400	\$2,700	\$2,200	\$1,700	\$1,400	\$1,000	\$800
	7.0%	\$3,200	\$2,500	\$1,900	\$1,400	\$1,000	\$700	\$400	\$200
	8.0%	\$2,200	\$1,500	\$1,000	\$500	\$200	\$0	-\$300	-\$400

5.0 CONDUCT PERMITTING & REGULATORY REVIEW

5.1 IDENTIFY AUTHORITIES HAVING JURISDICTION

A project of this type may require permits and approvals from federal, state, and local government agencies and departments. This section discusses permit requirements and government agencies responsible for issuing them.

State

The Project will require a series of state permits and approvals, the exact number and type of which will depend upon the Project's final design and its chosen route.

If the borefield is in parkland, there are parkland abandonment requirements by the state to allow the borefield to be placed underneath. This allows for potential negotiation of subsurface leasing. The final location of the borefield has not been determined. Only a portion of the public parks or public sporting fields are needed to 100% drive the system and the community center greenspace and soccer fields are the viable plots to be considered without the use of private parcels. No park or green space will be rendered useless during the construction or post-construction periods. A small space will be required for each borefield pump station and loop branch pump station.

The State Environmental Quality Review Act (SEQRA) requires all New York State and local government entities approving, funding or undertaking a discretionary action to conduct an assessment of the environmental impacts of that action. All potential impacts are evaluated to identify which may be significant, then a further evaluation determines whether such impacts are unavoidable or can be mitigated to the point of non-significance. Projects of considerable size or extensive scope will generally require preparation of an Environmental Impact Statement (EIS), which is intended to assist agencies' decision making by detailing potential impacts and mitigation methods. In situations involving multiple permitting jurisdictions and agencies, SEQRA provides for the selection and establishment of a single "Lead Agency" that coordinates comments from all agencies and drives the review process toward issuance of a set of findings that must be considered during the remaining permit processes. No permits or approvals may be issued for a project until the SEQRA review process has been completed. It is not known at this time which government entities would be involved in SEQRA review or declare themselves Lead Agency, although it is reasonable to expect that the Town of Woodstock would be involved to some degree.

New York State, through authorization from the United States Environmental Protection Agency, manages the State Pollutant Discharge Elimination System (SPDES) program for all point source discharges to surface and groundwater within the State. Two phases of the project have SPDES implications – construction and operations. It is expected that the project sponsor/developer will be the party responsible for securing the required SPDES permits.

Local

The Town of Woodstock falls within Ulster County.

Zone Change: Depending on the location of the project infrastructure, the DES project may require a zone change by the local legislature to accommodate a commercial/industrial facility.

Building Permit: The construction of a structure within a municipality may trigger a building permit. Such permits are ministerial (non-discretionary), but typically require an inspection upon completion by the local codes office. Municipalities may offer expedited review of building permits as a non-financial incentive for existing building owners to connect to the district system. Installing the DES project's distribution infrastructure (underground piping) may require construction permits and coordination with the state, county, Town of Woodstock, and utility.

Site Plan Approval: The infrastructure required for the project will typically require site plan approval by the local planning board to ensure compliance with the local zoning requirements and the aesthetic concerns of the neighborhood. Depending on the final design and routing of the thermal and distribution systems, additional land procurement, right of ways, or easements may be required to utilize land for borefields or distribution piping while keeping this equipment municipally-owned. However, as it currently stands, the project is staying in the right-of-way and not crossing onto private property.

Excavation Work: Any excavation or pipeline installation along or within the street right-of-way will require proper permitting from the Town of Woodstock.

5.2 ESTIMATED PERMITTING APPROVAL TIMELINE

The timeframe for permitting approval will be dependent on actual permits required and the time it takes for the Authority Having Jurisdiction (AHJ) to review, which often do not have set timeframes. Permitting requirements will become more apparent during the detailed design stage of the project, and AHJs should be engaged as early in the process as possible to avoid potential critical path delays.

5.3 IDENTIFY POTENTIAL RISK FOR RESTRICTIONS/DELAYS

The financial analysis for the DES project was conducted using assumptions such as cost of energy, value of emission reduction, incentives, finance rates, inflation rates, and scoping-level cost estimates. These variables were developed with the intent of predicting future conditions. However, the economic climate has seen a spike in real inflation, interest rates, energy costs, and material lead times. Supply chain disruptions for construction materials have extended construction timelines. Homeowner and commercial building enrollment and participation will be critical for the project viability.

5.4 IDENTIFY UNIQUE REGULATORY OBSTACLES

This section identifies potential regulatory obstacles to the project as they relate to the distribution of non-utility-generated electricity and thermal energy. These are related to the following:

- Ratepayers – who is paying for the energy as well as the operation and maintenance of the utility?
- Rate structure – who pays for waste heat versus who pays for needed heat?
- Stakeholders – who stands to make a profit?
- Utility franchise rights – potential private property owners who will allow their greenspace land to be used for development of additional GHX fields.
- Issues attributable to the preferred business model (Town of Woodstock-owned thermal & distribution)
 - Easements/permissions to cross property lines
 - Can easements be granted by the Town of Woodstock in general and is the process difficult and drawn-out?
 - Does final system design require crossing onto private property?
 - Financing capabilities
 - The ability of the Town of Woodstock to bond and the customers to finance at the assumed rates.
- Project phasing – borefield development coinciding with buried pipe networks, electrical upgrades.
- Regulatory proceedings – community programs and committees whose purpose is environmental conservation.
- The definition of “small-scale” by the Public Service Commission for exemption of regulation.

Related to easements and previously mentioned in Section 3.1.4, there is an easement on the Comeau property for well water that could prevent putting anything on the land other than new wells for the Town of Woodstock water. Borefield placement would require a negotiation to change the easement. It would also need to be demonstrated that aquifer water would not be contaminated and borefield design needs to ensure that aquifer water would not be eliminated.

Creating a municipal utility is a time-consuming process that requires commitment from both the community and elected officials. The process includes, but is not limited to the following key aspects:

- Identifying a campaign leader
 - An individual or group to lead and build the effort
- Feasibility studies/economic feasibility
 - This study is the first step to determine feasibility
- Legal analysis
 - Potential franchise agreements with the Town of Woodstock’s utility providers
 - Citizen referendums or petition requirements
- Valuation to determine the value of the distribution system
 - This study performs a high-level valuation and life-cycle cost analysis
- Community education of citizens and business community

- Success of the municipality requires customers (off-takers) of the distribution system
- Referendum
 - May be required by law to authorize its establishment
- Securing municipal bond financing

Potential barriers with creating a municipal utility in addition to the long implementation process include:

- Potential utility lawsuits and political challenges
- Litigation, campaigning, and ballots
- Asset acquisition, staffing, and maintenance

With a project of this size, there will many stakeholders that need to be made aware of the potential project and some may have concerns. Woodstock places an emphasis on environmentally friendly systems and conservation efforts, protecting open lands, forests, water resources, and scenic and historic sites. Potential stakeholders in the project include, but are not limited to:

- Woodstock Land Conservancy
- Comeau Stewardship Advisory Committee
- Private owners and potential customer system users
- Taxpayers
- Utilities

Regulatory obstacles will be dependent on the final business model and implementation partner responsible for construction. The preferred model can likely be broken into three project phases (one phase for each street). There is also potential for the installation of smaller borefields located in privately-owned lots and fields which could allow for additional phasing if the system is ultimately designed this way. This, however, adds to the complexity of installation, operations, and rate structures. As with any community or district heat pump project, the sponsor/developer of the Woodstock DES project will be required to obtain easements in order to install underground distribution piping as crossing property lines, streets, and existing utility infrastructure. All will require approval from the responsible parties. The Woodstock DES may require approvals for drilling since the system will require bore holes for its operation.

Legislation enacted in New York in 2022 amends the state's Public Service Law to authorize investor-owned utilities to own and operate thermal energy networks. This has addressed one of the potential regulatory obstacles to the development of a Woodstock DES project. The Utility Thermal Energy Network and Jobs Act, signed by Governor Hochul in July 2022, also charges the Public Service Commission (PSC) with initiating proceedings to support and regulate thermal energy network development. Specifically, the PSC is required to:

- Direct utilities to commence thermal energy network pilot programs in every utility territory in the State.
- Develop a regulatory structure to scale up thermal energy network deployment, coordinate the activities of utilities and other market and public actors, and protect consumers.
- Formulate labor policies that ensure the development and maintenance of a highly-skilled, well-paid thermal energy network workforce, including by applying or incorporating existing state labor policies and programs.
- Exempt small-scale, non-utility-owned thermal energy networks from PSC regulation; and
- Create fair market access rules for utility-owned thermal energy networks to accept low-emissions thermal energy produced by third parties, and otherwise facilitate market competition that benefits consumers and supports State emissions-reduction goals.

Pursuant to compliance with the Utility Thermal Energy and Jobs Act, the associated Public Service Commission initiated Rate Case 22-M-0429.

Currently there are other projects that are proposed by the relevant utility, Central Hudson, which are focused on disadvantaged communities. However, the utility-owned model could be a viable option if there was interest from the utility in proposing additional projects to the PSC. The utility owned model, however, could have more obstacles involved since Woodstock owns the land proposed for the borefields.

Another noteworthy regulatory obstacle for the Woodstock DES is the creation of a policy mechanism to require users to pay the social cost of carbon for their emissions through a tax, penalty, or carbon trading scheme. While this issue is not unique to the Woodstock DES, as noted above this project is sensitive to such policy and any associated incentives that may be available to the sponsor/developer of low-carbon DES projects. While the New York State Department of Environmental Conservation has adopted a social cost of carbon to guide policy decisions, with a 2023 central value of \$126 per metric ton of CO₂,⁸ it is not known at this time what action the State's Climate Action Council may take to implement such policy on a broader level to affect private market investments.

⁸ https://www.dec.ny.gov/docs/administration_pdf/vocguidrev.pdf

CONCLUSIONS

Full implementation of the district system is a large undertaking with not only a significant cost and potential disruption to the Town of Woodstock but also brings potential regulatory obstacles and risks for project delay. Breaking the project down into phases helps to alleviate some of these implementation barriers and risks. This project was broken into three phases, with one phase for each main street.

- Phase A: Rock City Road
- Phase B: Tinker Street
- Phase C: Mill Hill

The analysis is performed from the perspective of both the customer and the municipality for the project as a whole and for each phase, including scenarios where a tax credit is obtained and where there is no tax credit. Of the three phases, Phase C (Mill Hill) is the most economically attractive for both the customers and the municipality. Each phase has relatively the same 25-year life cycle cost results with Phase C slightly outperforming the other two phases. Phase C for the municipality, however, has approximately twice the benefit of Phase B, with Phase A being not financially viable from the municipality perspective.

APPENDIX A
Load Profiles and Borefield Design

APPENDIX B

Utility

APPENDIX C
Equipment Costs

APPENDIX D
Life Cycle Cost Analysis

APPENDIX E
District Energy Calculator

APPENDIX F
Central Plant Sizing

APPENDIX G

Central Plant Calculator and Heat Pumps vs Chiller Assessment

APPENDIX H
Cost Estimate

APPENDIX I

Attachment A-2

Category A: Site-Specific Scoping Study

CHIA

