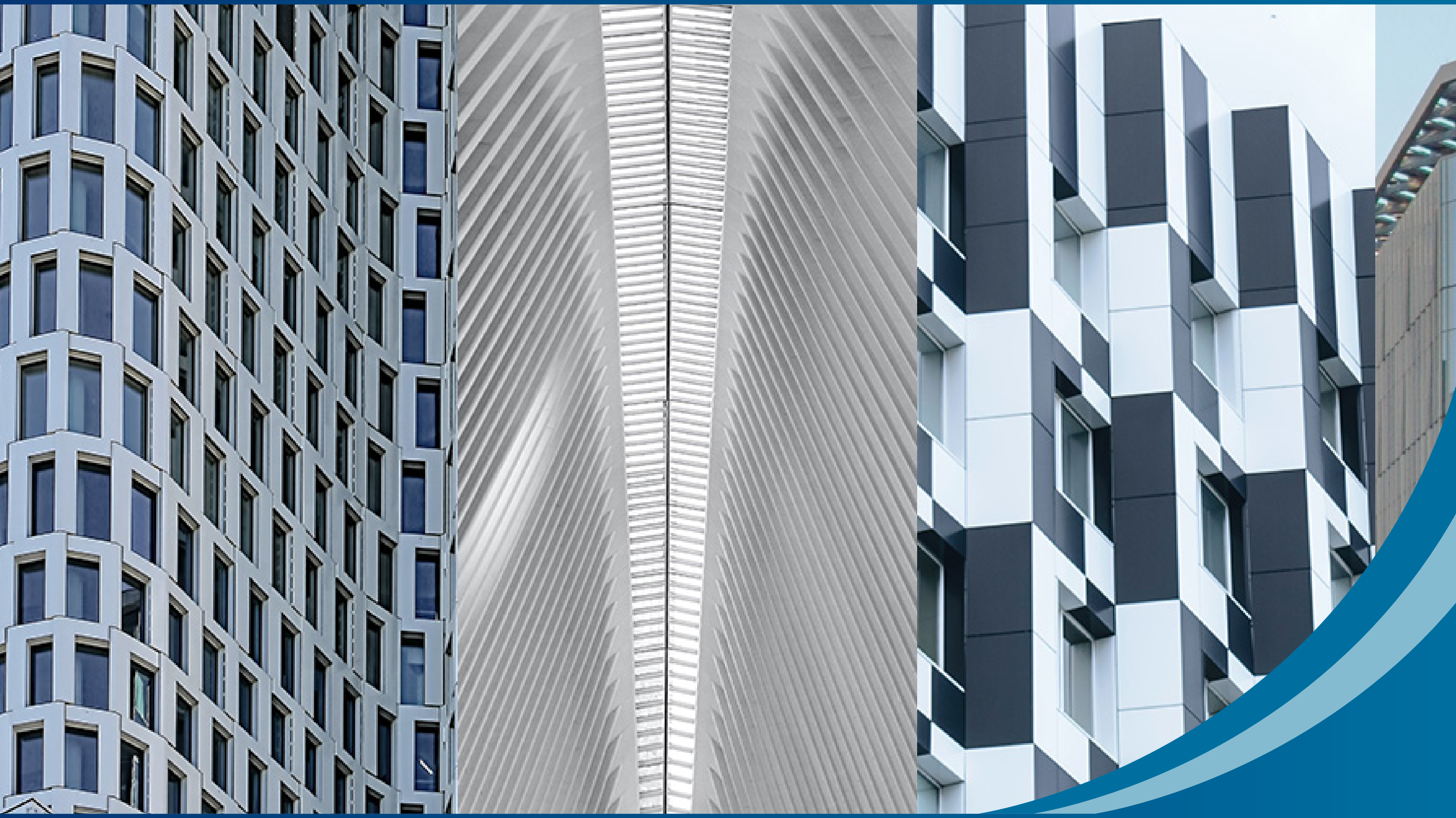
Geothermal Feasibility Report: The Peninsula



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Geothermal Feasibility Report: The Peninsula

Final Report

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Abstract

District thermal systems can offer greater efficiency and lower emissions than conventional heating, ventilation, and air conditioning (HVAC) systems. Initial challenges for installing district geothermal systems are often significant barriers to overcome. These include capital costs for design and installation, and uncertain regulatory pathways. Endurant explored the feasibility of a district thermal system at The Peninsula (New York, NY) to determine technical, regulatory, and lifecycle cost viability as compared to a business-as-usual approach. Various district configurations were explored for overall cost and carbon savings. Our results indicate that a district thermal system inclusive of water-source heat pumps tied to a ground loop heat exchanger and air-source heat pumps offers significant operational savings. District thermal installed costs were greater than conventional HVAC systems, but simple payback was reasonable (~10 years).

Keywords

building electrification, district thermal, district geothermal, geothermal, ground-source heat pump, life-cycle cost analysis

Acknowledgments

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Summary

The Peninsula Joint Venture, comprised of Gilbane Development Company, Hudson Companies, and the Mutual Housing Association of New York Management Inc, (collectively "the developer"), are developing a 5-acre site in Hunts Point, New York City. The building of the project is in three phases; at full build-out it will consist of 5 buildings and include 740 affordable housing units, light manufacturing, retail, and commercial facilities, and open space.

This study examines the opportunity for including a heat pump system in Phases 2 and 3 (see Figure 1. Peninsula Phasing Plan). The heat pumps will provide heating, cooling, and pre-heating for domestic hot water. Our team evaluated multiple system configurations and optimized the performance of the system within regulatory and technological parameters.

Figure S-1. The Peninsula: Artist's Rendering

S.1 Selecting a District over a Building-Scale Thermal Energy System

The study considers the benefits of developing three independent ground source heat pump (GSHP) systems versus developing a single community-scale solution. We found the community-scale option more beneficial to project performance, and while effective for navigating regulatory hurdles, it also allowed us to downsize the borefield, (reducing costs versus the independent systems by $140,000), while enabling more flexibility for future optimization.

Since the buildings considered in this study are all residential, we did not find a significant opportunity to exploit district level simultaneous heating and cooling load. Given the space constraints, the ground loop heat exchanger (GLHE) can deliver about 45% of the required space heating and cooling required, with the remaining load delivered using air source heat pumps (ASHPs), retaining the low-carbon approach.

S.2 A Variable Refrigerant Flow Distribution System Provides the Best Value Solution

The district-scale GLHE is to be shared and will be placed in plant rooms in Buildings 2A, 2B, and 3. We initially investigated a central plant paired with a 4-pipe hydronic distribution system. This is highly efficient and presents many operational benefits. However, during our economic analysis, we determined that comparison to the business-as-usual (BAU) costs makes the centralized hydronic system cost prohibitive.

We therefore propose a variable refrigerant flow (VRF) distribution system paired with both air and water-cooled condenser units located at each building. This solution will allow the developer to retain the existing distribution design and tenant billing capabilities, keeping design and installation costs down.

The Peninsula's existing design consists of air-cooled Mitsubishi condensers. Our solution will switch 45% of the air-cooled condensers for Mitsubishi water-cooled condensers, which will be linked to the GLHE. This solution will meet all of the buildings' space heating and cooling requirements. Since the buildings are cooling dominant, we will recycle excess heat from the GLHE into the domestic hot water (DHW) circuit, driving costs down and efficiencies up. We did investigate heating the DHW via a heat pump rather than the existing gas boiler; however, a tariff analysis based on an 8760 electric profile showed that doing so would eliminate the operational savings gained. Even so, we still manage to reduce the boiler gas consumption by 16–17% by preheating the DHW circuit from the GLHE system.

S.3 Analysis Shows Annual Operational Savings of 23 Percent against Business-as-Usual Baseline

We conducted a detailed economic analysis to determine capital costs, incentive values, and operational savings. After accounting for incentives, our proposed system results in a 16% cost premium compared to the baseline, which will then be recovered through reduced utility consumption and maintenance savings. We estimate annual operational savings of 23%, with a payback period of approximately 10 years and did not account for a cost of carbon in our analysis, because we expect the Peninsula to be exempt from

Local Law 97 due to the affordable housing units. However, if the development team places a cost on carbon emitted, the payback period would significantly decrease—we show a 19% reduction in annual CO_2 emissions.

S.4 Energy as a Service (EaaS) Would Be a Challenge in This Development

The Endurant team explored the opportunity to deploy an EaaS model; because the low-medium income housing regulations require the owner to provide heating at no cost to tenants (who pay for cooling), the project did not meet standard investment thresholds. Identifying a mechanism to recover costs via energy cost savings from heating, DHW, and cooling as well, would provide the potential for developing a financeable project.

From a regulatory perspective, the community solution presents no insurmountable barriers. The joint venture (JV) partnership across the Peninsula site eased concerns around district-level infrastructure; we expect that there are already common agreements under the JV partnership that could be expanded to include the GLHE. The primary regulatory challenge is the increased regulatory complexity when drilling over 500 feet (ft). Our cost benefit analysis showed that the added regulatory costs would prevent us from drilling beyond this depth, which limited the energy load we could serve with GSHPs.

This study demonstrates the regulatory, environmental, and economic feasibility of transitioning to a geothermal system, along with significant environmental, operational, and financial benefits to the project and local community. It would result in reduced on-site carbon emissions and almost $1 million life-cycle savings.

S.5 Regulatory Approval is Unclear but Reasonably Achievable

There is limited precedent and absence of a clear permitting and approval process for district thermal systems in New York State. This increases cost and uncertainty, and risks delaying the BAU development timeline. The challenges in obtaining necessary easements at this site is reduced by the fact that it is necessary to cross a public right of way. The building's metering configuration (specifically the submetering of tenants) may trigger compliance with NYS Public Service Commission regulation around billing and dispute resolution. While there are various regulatory considerations at play and a variety of authorities having jurisdiction (AHJs) and stakeholders that should be engaged, we believe that there is a viable pathway to regulatory approval.

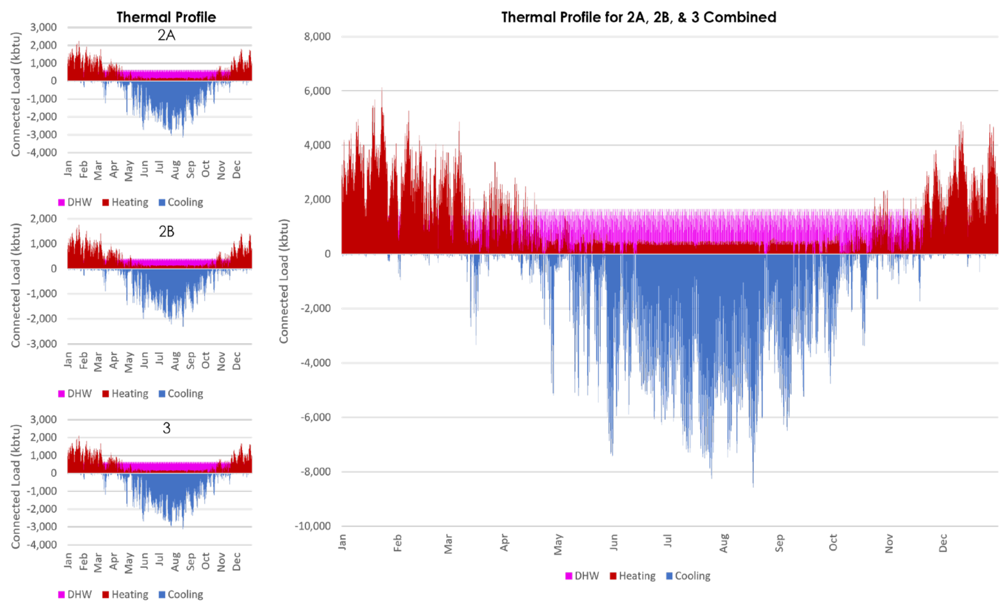
1 Characterization of the Proposed Community

The Peninsula Joint Venture (the developer) comprised of Gilbane Development Company, Hudson Companies and the Mutual Housing Association of New York Management Inc (MHANY) are developing a 5-acre site in Hunts Point in New York City. The project is located between Spofford Avenue and Tiffany Street near the mouth of the Bronx River. The project will be developed in 3 phases; at full build-out it will consist of 5 buildings with a variety of use-types including residential, light manufacturing, retail, and commercial, along with open space. It will include 740 affordable housing units, a day care center, facilities for Bronx-based businesses, higher education and career readiness resources, and a health and wellness center.

Figure 1. Peninsula Phasing Plan

Phase 1 construction was concluded in 2021. Phase 2 is expected to conclude in 2023 with Phase 3 following in 2024. This study examines the opportunity for including a ground source heat pump (GSHP) system in Phases 2 and 3.

Figure 2. Thermal Profile for Each Building and Combined Profile



We explored the feasibility of using a combination of GSHPs and air source heat pumps (ASHPs) to deliver heating, cooling, and domestic hot water (DHW). The resulting system would eliminate combustion of fossil fuels for space heating on site and achieve a significantly higher coefficient of performance (COP). There would still be gas use for domestic hot water (DHW). The annual thermal load to be served by this system is illustrated below. The study also considers incorporating heat recovery from wastewater, solar, and battery energy storage technologies. For these technologies to be deployed, they must be deemed feasible from a technical and regulatory perspective and produce an economic benefit that either generates revenue or savings to payback any incremental cost increase within a reasonable term.

The site presents unique opportunities and challenges for GSHP system design. Locating and arranging the boreholes, which will serve as the ground loop heat exchanger (GLHE), will be a challenge due to space constraints. The borehole arrangement requires 15 to 20 feet of spacing between boreholes to a depth of approximately 500 feet. We envision locating boreholes either under buildings in Phase 2 and Building 3, or in open areas between building footprints. This study explores the implications of each bore field design option.

The project will be designed to achieve LEED Gold, and to comply with Enterprise Green Communities.[1] All buildings will have rooftop solar photovoltaic (PV) panels and the development will be designed to achieve 20% better energy performance than New York City (NYC) building code.

2 Discussion of the Technologies Assessed

The team assessed a variety of technologies that could achieve greater efficiencies and improve the overall life-cycle value of the project. We explored GSHP, ASHP, and wastewater heat recovery to supply the thermal demands of the project and assessed the potential for solar PV and battery energy storage. This section will provide a brief description of each technology and intended benefit.

2.1 Ground Source Heat Pump

GSHPs are one of the most efficient heating and cooling technologies available. GSHP systems use water sourced heat pumps (WSHPs) containing a refrigeration loop that drives thermal exchange between a GLHE and working fluid. Ground temperatures are more stable than air temperatures making them warmer than air temperatures in the winter and cooler in the summer. This dynamic allows the GSHP to treat the ground as a heat source in the winter and a heat sink in the summer. While there are a variety of GLHE system types, Endurant will focus on a closed loop borehole solution for this project. Due to State regulations and the geological factors present at the site, our team will explore vertically drilled 500 feet deep boreholes.

The system's resilience and reliability will be improved via an N+1 design to allow for 1 heat pump unit to be serviced without impacting the system's ability to meet peak loads. The ground loop manifold design will incorporate additional resilience by allowing for the isolation of each ground loop; therefore, preventing a single point of failure for the system.

2.1.1 Simultaneous Load

A unique benefit of a GSHP solution is the ability to exploit simultaneous loads when there is both heating and cooling demands at the same time. An example is when a building is cooling and producing DHW at the same time. A water-to-water heat pump, unlike an ASHP, can reject the waste heat from the cooling process to supply the DHW demand.

2.1.2 Key Considerations

Table 1. Ground Source Heat Pumps: Pros and Cons

Pros	Cons
• Most efficient heating and cooling technology • Lowest operating costs • Lower maintenance costs • Ability to supply heating and cooling simultaneously • Low to zero carbon solution • Quieter operations	• Higher Capital Costs

2.1.3 Air Source Heat Pump

ASHPs provide a flexible solution for heating and can provide backup cooling capacity. In lieu of a GLHE, ASHPs rely on ambient air as a heat source or sink. A refrigeration loop allows for thermal exchange between the ambient air and working fluid. This solution performs best at moderate ambient conditions (i.e., fall and spring), while performance during extreme temperatures of the summer and winter dwindles significantly. ASHPs and GSHPs make an excellent hybrid solution, especially on sites with limited space, since ASHPs do not require GLHE capacity. Our team will explore using ASHP to supplement GSHP capacity in a hybrid design.

2.1.4 Key Considerations

Table 2. Air Source Heat Pumps: Pros and Cons

Pros	Cons
• Electrically powered • Good performance at moderate temperature (COP of 3-3.5 at 50 ºF) • Low- to zero-carbon solution	• Requires roof space • Reduced efficiency at extreme temperatures (<10°F). (COP of < 2.3 at 10 ºF)

2.2 Wastewater Heat Recovery

Wastewater that is normally discarded into sewer lines can be diverted, separated (liquids and solids), and passed through a heat exchanger to extract thermal energy. The average temperature of wastewater is 70 degrees Fahrenheit which provides excellent opportunity for thermal extraction if adequate flow rates are available. This solution is electrically powered, couples to the GLHE and its performance is not affected by ambient conditions. Due to variation in flow rates wastewater heat recovery cannot be relied upon for peak heating capacity. This analysis considers the ability of wastewater to contribute meaningful heat to supply building heat demands.

2.2.5 Key Considerations

Table 3. Wastewater Heat Recovery: Pros and Cons

Pros	Cons
• Electrically powered • Couples to the GLHE • Very efficient • Performance not directly dictated by ambient conditions • Low- to zero-carbon solution	• Dependent on location and flow through mains • Variable rates of heat production • Available thermal energy may not cover load • Production may not always be able to be used • Local municipality considerations if connecting into publicly owned sewer infrastructure

2.3 Solar Photovoltaic

Rooftop solar PV produces electricity from solar energy. It has been widely adopted across all building types due to its technical familiarity, relatively low costs, and ease of modular installation. In addition, utility programs allow for communities to access the value of solar PV via programs administered via their utility bill.

The benefits of solar PV are limited in two ways. First, it requires area to locate panels, either on rooftops, parking structures, or unused land. This requirement can be a significant limitation in urban areas where space (including rooftops) is at a premium. Second, solar PV is an intermittent resource that only generates electricity as solar energy is available. The system will not generate energy during nighttime hours and is limited when clouds obstruct sunlight.

Table 4. Solar PV: Pros and Cons

Pros	Cons
• Low capital cost • Able to deploy on otherwise unusable space (Rooftops, parking canopies, etc.) • Low maintenance	• Intermittent productions • Large space requirements

2.4 Battery Energy Storage

Battery storage is a versatile technology that can provide a variety of technical and commercial values to a project. Storage can be placed behind the utility meter on the customer's side to support demand management and reduce utility costs. It can also be placed in front of the meter, on the utility side, and be a commercial asset that pays the project owner a lease value for the ground area it sits on. It can also be used to store intermittent energy (particularly solar PV) for dispatch at peak times. Our team will investigate how storage can best integrate into our technology configuration and how it can produce the most value for all stakeholders.

Table 5. Battery Energy Storage: Pros and Cons

Pros	Cons
• Demand response capabilities • Ability to shift production to more valuable hours in the day • Value stacking revenue streams	• Cost is high and often requires incentives to make projects viable

2.5 Electric Vehicle (EV) Charging

As EVs become more widely adopted, charging infrastructure will become a critical component to support electric transportation. EV charging can be developed under a variety of commercial models; our team will look at two: commercial and merchant. The commercial structure would allow the project owner to own and operate the asset, the merchant option would remove the capital costs from the project owner and enable a specialist third-party to own and operate the charging infrastructure.

Table 6. Electric Vehicle Charging: Pros and Cons

Pros	Cons
• Enables EV vehicle growth • Reduce on-site emissions from cars • Multiple business models for development	• EV adoption varies across regions • Can be challenging to manage demand charges

3 Discussion of Analytical Methods

3.1 Overall Approach

This study will provide the developer with the information and data needed to proceed to a detailed design stage, should the results be beneficial to the project. At the feasibility stage we maintain ± 20% confidence interval in the data presented. We rely on the most detailed and up to date information available throughout the process, and use the information to inform thermal profiles, conceptual designs, and costs. Our team gathered the following information to perform the analysis:

- Site plans
- 90% construction drawings
- Universal Land-Use Review Process (ULURP) filings
- Geotechnical report
- CAD models

Following the data-gathering phase, our analytical approach was conducted in the following phases:

1. Generating energy models for each building in the development
2. Establishing BAU operational costs
3. Design optimal GSHP solution
4. Establish GSHP operational costs
5. Conduct extensive regulatory research on GSHP project requirements

3.1.1 Thermal Profile and Energy Model

In order to evaluate the impact of GSHP against the status quo, Endurant developed a business-as-usual scenario to serve as a benchmark for the GSHP alternatives. The first step in developing the BAU scenario was to generate an energy model for each building/phase. The energy model is an 8760 model of heating and cooling demand for each building.

A schematic level-building energy model was created for Buildings 2A, 2B, and 3 to estimate future energy consumption, energy cost, and hourly thermal load profiles associated with the residential and commercial spaces.

Buildings 2A and 2B were modelled using IES VE 2019 energy modelling software based on floorplan layouts in Revit, envelope thermal properties, use type, and lighting power density per space type. (Detailed model assumptions are presented in appendix A).

The geometry for Building 3 was assumed to be the same as Building 2A since schematic designs were not available at the time of this analysis. Space area and use were estimated based on the information in the ULURP filing date October 2017. Annual hourly thermal profiles for Building 3 were derived in Excel using thermal profiles calculated for Building 2A and scaled by area. Window to wall area ratio, thermal properties of the envelope and internal loads for Building 3 for commercial and residential spaces was assumed to be the same as in Building 2A.

The HVAC equipment for Buildings 2A, 2B, and 3 is assumed to match the existing equipment specified for Phase 1, which is already under construction. Baseline equipment for Phase 1 for residential apartments consists of air cooled variable refrigerant flow (VRF) systems for space heating and cooling, and gas fired boilers to serve domestic hot water demand. The common areas and commercial spaces also utilize VRF systems to provide space heating and cooling with outdoor air provided by a dedicated outdoor air system with an energy recovery ventilator. The parking garage, mechanical, and utility spaces utilize electric resistance heat.

3.1.2 Establishing Business-as-Usual Operating Costs

The team generated an electric profile using the heating and cooling loads profiles to estimate the electricity needed to drive the VRF system to provide heating and cooling to the buildings. The electric energy profile was run through Endurant Energy's proprietary tariff engines to simulate a Con Edison electric delivery and electric supply bill. We selected the appropriate rate/tariff from Con Edison's tariff leaves based on the electric consumption profile, particularly the maximum kilowatt (kW) demand registered on the meter.

Establishing a baseline BAU operating cost is highly dependent on the tariff/rate assumption. The total BAU operating cost will be different depending on how the units are metered. For example:

- Each unit may be individually metered. In this scenario, we would simulate a bill at each dwelling unit using Con Edison's residential rate while commercial units would be metered and billed according to Con Edison's commercial rates.
- Each building may be master-metered. In this scenario, each building would appear as a single, commercial account to Con Edison.
- The entire development may be master-metered. In this scenario, the entire development's energy profile would be metered at a single point and appear as one large commercial account to Con Edison.

Endurant studied the site drawings and consulted with the developer to determine that each building would be master-metered. Our electricity costs therefore assume each building is a Con Edison SC9 Rate 3 customer.

In addition to the electricity costs incurred to drive the VRF systems, the BAU operating costs also include on-going operations and maintenance (O&M) costs associated with VRF systems. Endurant worked with contractors to develop pricing for O&M services under the BAU scenario. BAU costs are quantified in section 7.

3.1.3 Design Optimal Ground Source Heat Pump Solution

The next step after establishing baseline BAU conditions was to begin designing the GSHP solution. This process involved the study of existing geotechnical reports and an assessment of the built environment to determine the optimal configuration. Due to space constraints imposed by the dense urban environment in the Bronx, several options had to be evaluated that considered spatial analysis, constructability, cost, and operational efficiency. These design considerations were balanced with the established energy profile so that the system is correctly sized for the site.

The initial assessment of available space and geotechnical reports suggested that the bore-field could either be sited in open areas between the project phases, or underneath the buildings. In collaboration with the development team, we concluded that the option of siting the bore-field adjacent to the buildings was preferred, and the GLHE would be shared between Building 2A and 2B.

The design team used GLD (Ground Loop Design), an industry-leading GLHE design software, to run various scenarios that tested for different bore-field designs, technology mixes, bore-hole lengths, etc. We identified four options that met the energy needs for the site, which were then run through a budgeting exercise to determine the most technically and economically feasible GSHP option.

The in-building distribution is also an important design factor when selecting equipment and conducting budgeting exercises. Since the Peninsula JV has a very developed design concept, our aim was to integrate with the existing distribution design. This required us to rule out a hydronic distribution system and opt for a VRF distribution system. Our team found this to be the most cost-effective way to approach the heat pump selection.

We considered the friction from pumping energy and the heat that would be added into the system. Any pumping heat added during the winter months would contribute heat during the winter months but would need to be rejected during the cooling season. We determined that heat gain from pumping energy is minimal when compared to the overall thermal loads. Heat gain into the fluid stream for chilled water, heating hot water, and geo (source) water are estimated below as a percentage of the annual thermal loads.

Table 7. Annual Heat Gain from Pumping Energy

	Chilled Water	Heating Hot Water	Geo Water
Heat gain from pumping as a percentage of annual thermal loads.	0.078%	0.055%	0.817%

Endurant did not perform a test bore in this feasibility study and prefers to conduct a conductivity analysis during the detailed design stage. Conductivity is more of a design consideration, rather than a feasibility determinant. Endurant has developed GSHP systems in a multitude of geological conditions and expects feasible subsurface conditions. As part of the detailed design phase Endurant would conduct a soil conductivity analysis.

3.1.4 Establishing Ground Source Heat Pump Operating Costs

The process of establishing GSHP operating costs follows that of the base case. A new energy model was developed to estimate hourly electric demands required to drive the GSHP system. The resulting electric profiles were analyzed to determine peak demand (kW), annual consumption (kWh), and the appropriate Con Edison electric delivery and supply rate.

Establishing the operating costs for the GSHP solution is dependent on whether the final solution is de-centralized (i.e., each unit receives its own dedicated heat pump that is individually metered) or centralized (i.e., a central pump system serves the entire building which is master-metered). Since each building would be master-metered, we have worked on the basis that a centralized solution wherein the GSHP solution would be master-metered under a single Con Edison SC9 Rate 3 electric account is most appropriate. The GSHP consumption profile was run through Endurant's proprietary tariff engines to simulate electric delivery and supply bills associated with the operations of the GSHP solution.

In addition to the electricity costs incurred to drive the GSHP solution, the GSHP operating costs also include on-going O&M costs associated with heat pumps. Endurant worked with contractors to develop pricing for O&M services under the GSHP scenario. These costs are presented in section 7.2.

3.1.5 Regulatory Research

In addition to the technical and economic analysis needed to determine the feasibility of deploying a GSHP solution, a detailed regulatory review of permitting, tax laws (particularly the exposure of such projects to real property taxes) and available incentives was conducted. This phase of the feasibility analysis focused on ascertaining whether there are any potential regulatory hurdles and associated costs that could delay or obstruct project development. Endurant worked with internal regulatory experts and external consultants to study the state of regulations around GSHP projects at the federal, State, and local level. A summary of anticipated regulatory challenges and recommendations to overcome is in section 4.1.5 and the complete regulatory analysis is in section 10, appendix B.

4 Results—System Design

Due to project phasing and build out sequence, the team focused more closely on the near-term, build-out of Buildings 2A and 2B. These two buildings are much more defined than Building 3 and will begin construction before Building 3. Given the shared infrastructure and parking garage under 2A and 2B, we treated these two buildings as a “mini district” of their own, to be connected to Building 3 later.

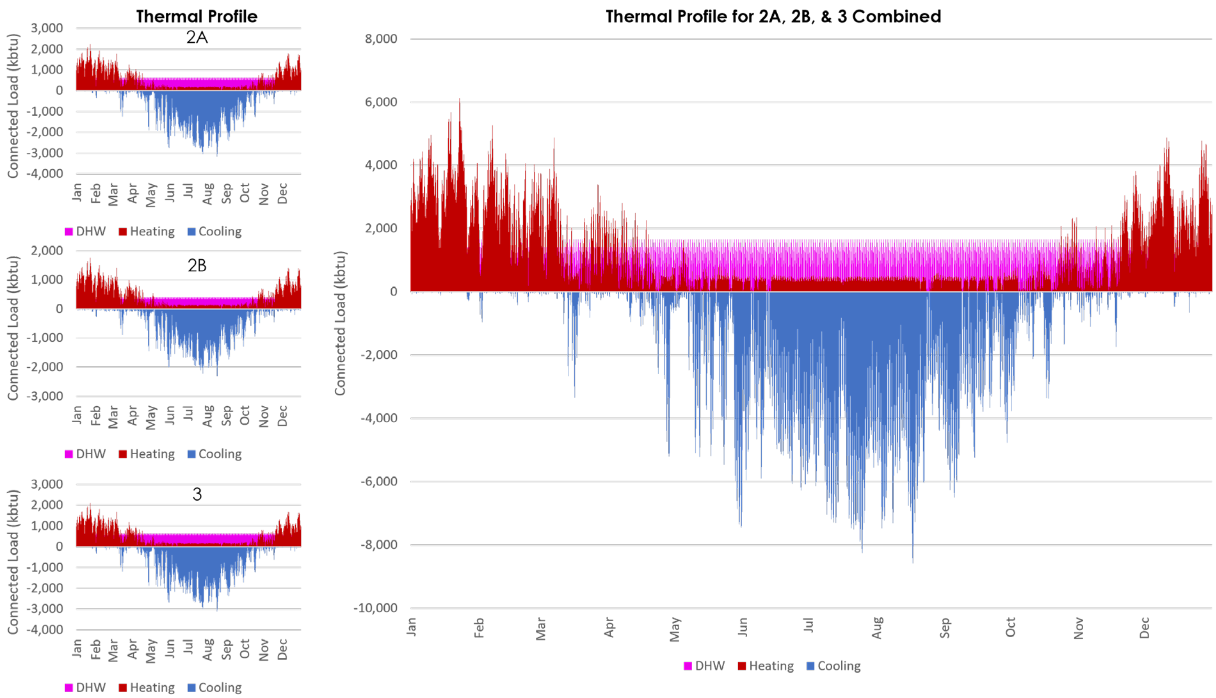
Figure 3. Illustration of Building Footprints and Site Layout

4.1 Energy Model Results

The thermal profile of each building is a critical design element. Use of space is a key driver in a building’s thermal profile because different occupancies and utilization patterns have different energy requirements over time. This in turn significantly impacts the capacity required from the GSHP system. These systems require annual balancing to prevent overheating or overcooling of the GLHE.

The projected thermal profile for Buildings 2A, 2B, and 3 is well balanced, both independently and combined. Annually, the building demands more heating (including domestic hot water) than cooling. This is preferred for geothermal systems because the added heat of compression[2] will thermally balance the load on the GLHE. A graphic representation of each building’s thermal profile can be seen below in Figure 4.

Figure 4. Thermal Profile for Building 2A, 2B, and 3



To properly balance the GLHE under an air and water-cooled VRF system, we will remove the DHW load and treat it as a standalone load and balance the GLHE on annual space heating and cooling. After removing the DHW load, a cooling dominant profile remains. We can use this to our benefit by bleeding excess heat into the DHW system as "pre-heat" if the GLHE temperatures rise beyond acceptable levels. This will reduce the operating costs and emissions on site.

Table 8. Thermal Demand by Building

Building	2A	2B	3
Modelled Square Footage	204,720	137,080	200,285
Peak Heating (kBtu/hr)	2,251	1,770	2,105
Peak Cooling (kBtu/hr)	3,165	2,314	3,113
Peak Domestic Hot Water (kBtu/hr)	619	402	641
Annual Heating Load (kBtu)	3,468,872	2,887,614	3,302,950
Annual Cooling Load (kBtu)	4,423,794	3,086,348	4,434,949
Annual DHW Load (kBtu)	2,861,441	1,865,328	2,951,240

4.2 Business-As-Usual Operating Costs

After developing the thermal profile, the team was able to estimate annual operating costs associated with each building by using standard equipment efficiencies and our proprietary tariff engine. We used equipment manufacturer efficiencies based on ambient air conditions to establish input energy required to meet each building's modelled thermal load.

Table 9. Equipment Efficiencies Used for Business-as-Usual Scenario

Space use-type	Heating	Cooling	Domestic Hot Water
Residential Units	VRF [COP 3.2 @ 100% Load]	VRF [COP 3.5 @ 100% Load]	GFB [COP .9 @ 100% load)
Residential ventilation	VRF [COP 3.2 @ 100% Load]	VRF [COP 3.5 @ 100% Load]	-
Commercial/Common space	VRF [COP 3.2 @ 100% Load]	VRF [COP 3.5 @ 100% Load]	GFB [COP .9 @ 100% load)
Commercial/Common ventilation	VRF [COP 3.2 @ 100% Load]	VRF [COP 3.5 @ 100% Load]	-

* Equipment efficiencies sourced from ASHRAE 90.1. (2016).

This electrical energy profile was used to determine the building-level Con Edison electric delivery and supply billing. Table 10 below summarizes the BAU utility costs for each building. Under the affordable housing requirements of this development, the building owner is required to offer heating and domestic hot water to the tenants at no additional cost to their rent. We therefore separated out heating and cooling costs to provide additional clarity.

Table 10. Heating and Cooling Costs by Building for Business-as-Usual Case

	Building 2A	Building 2B	Building 3
Space heating (kWh)	342,084	258,434	325,618
Cooling (kWh)	370,425	283,935	371,371
Domestic Hot Water (therms)	31,794	20,726	32,792
Electricity Cost	$161,879	$122,760	$156,784
Gas Cost	$36,679	$24,223	$37,802
Total Utility Cost	**$198,558**	**$146,983**	**$194,586**
Total District Utility Cost	**$540,127**		

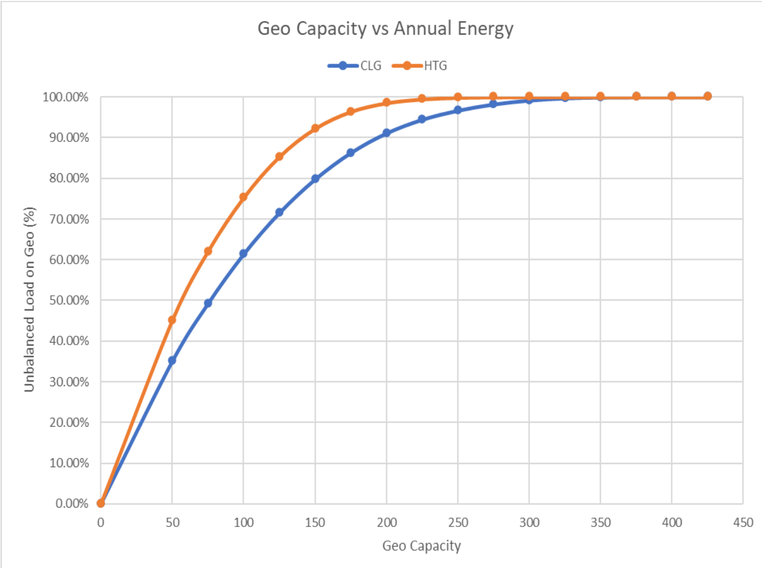
4.3 Preliminary Geothermal Design

Based on the thermal profiles for each building and the recommended VRF solution, there is opportunity to indirectly capture simultaneous load throughout the year from the GLHE. For example, if a building floor or group of spaces served by VRF requires cooling, waste heat can be transferred from the cooling process directly to another VRF system sharing a common source water loop or into the DHW circuit. The heat rejected from cooling does not interface with the GLHE. Figure 4 above illustrates this, as DHW (shown in pink) sits above the x-axis at the same time cooling requirements (blue) sit below the x-axis.

Since simultaneous load can be exchanged between thermal networks through a common source water loop, our approach is to remove simultaneous load and then size the system based on the unbalanced load. In geothermal systems WSHPs allow unbalanced loads to be rejected to the GLHE for future use. For example, the waste heat from cooling in summer can be used to warm the ground temperature, which can be used in the winter heating season.

The optimal GLHE and GSHP capacity is sized based on the principle of diminishing returns. Figure 5 illustrates how the unbalanced load benefit diminishes with increased geothermal capacity. For Phase 2, diminishing return accelerates substantially after about 150 tons of capacity. Figure 5 demonstrates that after 150 tons we need significantly more capacity to meet annual loads. Additional capacity requires a larger investment in the GLHE, which is the costliest component of a GSHP, therefore our team explored three system capacities that were adjacent to the 150-ton capacity optimization point to determine the space requirements associated with the GLHE.

Figure 5. Geothermal Capacity Required to Meet Annual Loads for Phase 2



The dense urban nature of the project site constrains available area for the ground loop design. With this under consideration we conducted an exercise to determine the amount of space required to support specific GLHE capacities.

Table 11. Ground Loop Heat Exchanger Space Requirements and Optimization Runs for Phase 2

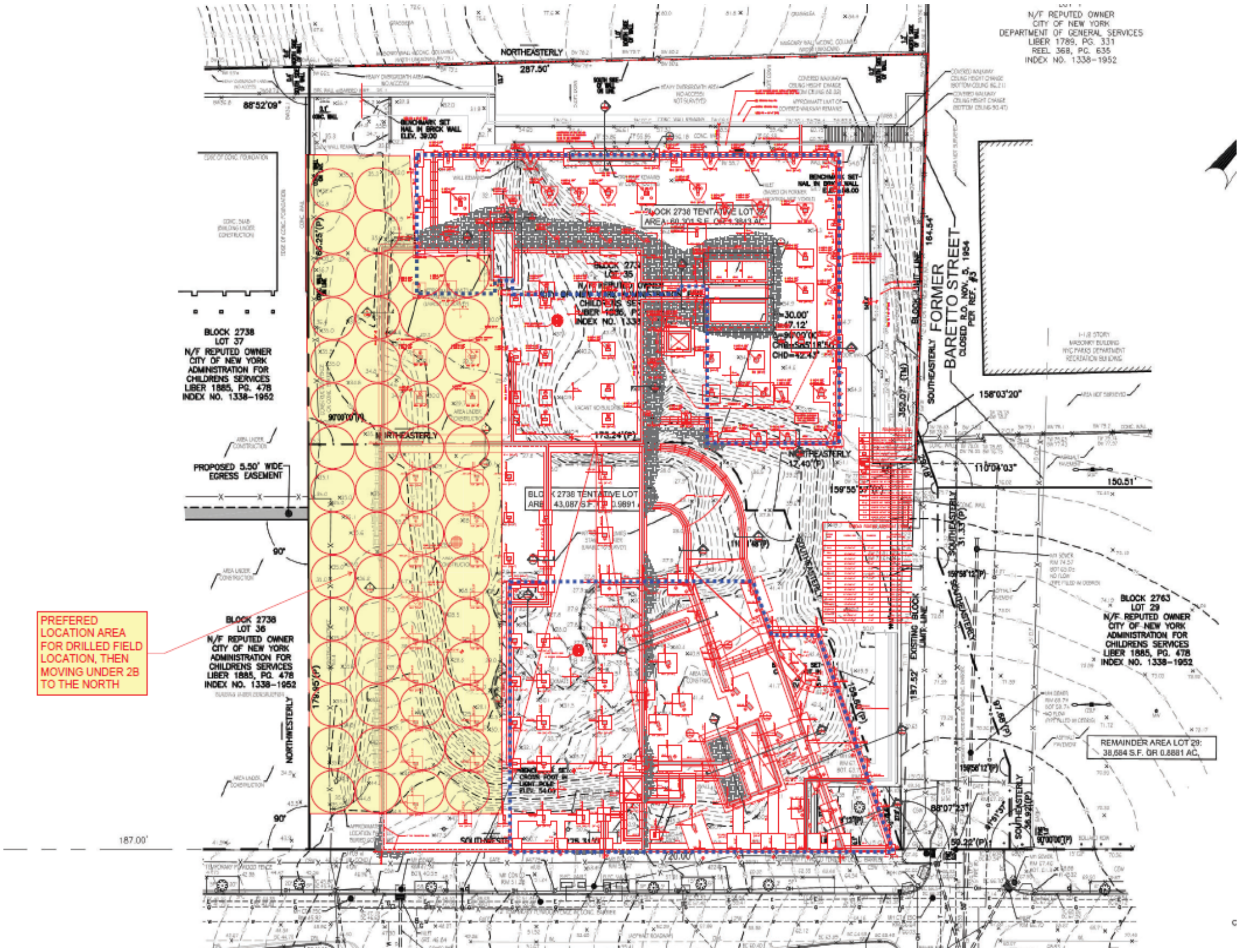
	150 Ton GSHP/GLHE	100 Ton GSHP/GLHE	75 Ton GSHP/GLHE
Space Requirements (sq. ft.)	32,000	22,000	16,800
Boreholes	80	55	42

Through conversations with the developer, we determined that there was roughly 25,000 square feet (sq. ft.) available for boreholes for Phase 2. Based on our simulations we opted for the 100-ton solution due to site space constraints. We applied the same methodology to Building 3 with the results represented in Table 12.

Table 12. Building 3 Ground Loop Heat Exchanger Sizing and Space Requirements

75 Ton GSHP/GLHE	
Space Requirements (SQ. FT.)	16,400
Boreholes	41

Figure 6. Ground Loop Heat Exchanger Preferred Layout for Phase 2



4.4 Wastewater Heat Recovery

As discussed in section 3 our approach was not limited to GSHPs. We also considered the viability of wastewater heat recovery as a supplemental heat source. Our team generated a waste heat recovery profile for Building 2A and 2B by taking the DHW flow requirements and scaling the flow to include domestic cold water to obtain a total wastewater flow. The viability of using the wastewater as a heat source was analyzed by assuming a source-side ΔT and analyzing the potential heat flowing through a wastewater heat exchanger. Assumptions used in calculating the total wastewater heat recovery profile are the following:

- DHW accounts for 33% of total building water usage
- 67% of sewage is available for heat transfer through a wastewater HX
- 10ºF source-side ΔT for cooling mode
- 10ºF source-side ΔT for heating mode

The primary benefit of wastewater heat recovery is the potential to reduce the size of the GLHE. We conducted a simulation by running ground loop design (GLD) simulations to understand the change in loading and unloading of the GLHE that would result from using wastewater as a thermal resource. The results are side by side below in Table 13.

Table 13. Wastewater Heat Recovery Annual Load Impact

	Baseline 100 Ton System	100 Ton System + Wastewater Heat Recovery
GLHE Length	27,320	27,320
Annual Heating Load Simultaneous	23.5%	23.5%
Annual Heating Load Geothermal	50.0%	47.6%
Annual Heating Load ASHP	26.5%	21.7%
Annual Heating Load Wastewater		7.2%
Annual Cooling Load Simultaneous	26.6%	26.6%
Annual Cooling Load Geothermal	43.7%	41.6%
Annual Cooling Load ASHP	29.7%	25.3%
Annual Cooling Load Wastewater		6.5%

Results of our analysis demonstrated that there was not enough flow to reduce the GLHE. There is a small reduction in annual load on the GLHE and ASHP, but this is likely to occur at a variety of operational conditions. Therefore, some hours will have significant efficiency gain while others may have very little.

It is not recommended that this asset be integrated for Building 2A, 2B, and 3 due to the lack of flow available for thermal exchange.

4.5 Air Source Heat Pump

After ruling out the potential for a wastewater heat recovery system, we considered ASHP capacity to meet the remaining load. Building 2A and 2B have existing designs with air-cooled VRF condensers. We opted to preserve that design element and augment with water-cooled condensers linked to the GLHE. This approach presents the least disruptive and most cost-efficient solution given the existing project design.

One drawback to this approach is that the water-cooled and air-cooled units, must be on independent circuits.[3] This limits our ability to actively manage and temper the ground temperature as we can on ASHP/GSHP central plant with a hydronic distribution. For example, with a hydronic system when ambient air temperatures are moderate during shoulder seasons, the ASHP can be the priority dispatch equipment with GSHP standing by to supplement. In the peak seasons, we can exploit the stability of the ground temperature to operate the dispatch strategy in reverse, the GSHP becomes the priority dispatch equipment and ASHP is used to deliver peak heating and cooling. While this solution can achieve greater efficiencies, it would entail a mechanical redesign and cost premium, which is why we ruled it out for this project.

4.6 Optimized System Configuration

After taking a cost-conscious approach and accounting for site constraints our team developed the following solution to meet both the annual loads and the peak loads with an N+1 resiliency factor.

Table 14. Optimized Equipment Capacities

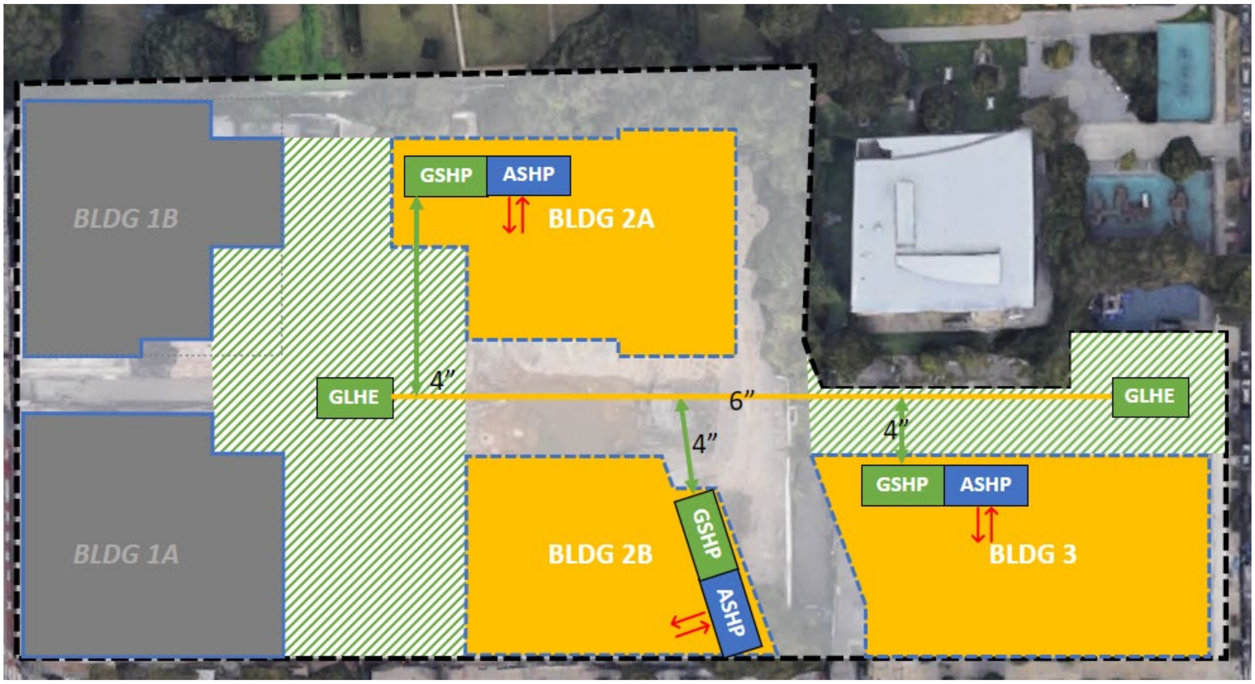
Load (Tons)	Building 2A	Building 2B	Building 3
Air-Cooled	130	95	128
Water-Cooled	106	78	105
Total	**236**	**173**	**233**

4.7 Plant Locations and Strategy

Our team explored a variety of configurations for equipment siting on the project. Based on design and site constraints we ruled out a single central plant to serve all three buildings. The equipment specified requires rooftop space to support the ASHP operations, and we would not be able to site enough capacity on a single rooftop to serve all three buildings. We also ruled out in-unit heat pumps, as the apartment floorplans did not contain any dedicated in-unit mechanical space. To accommodate in-unit heat pumps, the project architect would have to significantly redesign the floor plans. This left us to consider building-level plants and condenser farms, that share a common GLHE.

Our preferred approach would locate air-cooled condensers on the roof and water-cooled condensers in a dedicated indoor mechanical space. Each building would host a rooftop condenser farm and an indoor mechanical space that serves 100% of the load in each building. Our water-cooled equipment would serve the lower half of the building, with the air-cooled units serving the upper half of the building. This approach would also reduce the length of refrigerant pipe runs as it would reduce the need to run piping from the roof to the ground floor units.

Figure 7. Equipment Location in Relation to the Ground Loop Heat Exchanger



4.8 Additional Technology Assessments

4.8.1 Solar Photovoltaic (PV)

The development team previously conducted a solar PV assessment, and currently has plans to install a 185-kW system on Building 2A and a 109-kW system on Building 2B. Based on the Universal Land-Use Review Process (ULURP) filings, we estimate Building 3 to have enough roof space to host between 90–110 kW. Roof layouts are not yet available for Building 3 therefore we based our assumption for roof space on Building 2B. There are two primary approaches in developing solar technology: Behind the Meter (BTM) and Front of the Meter (FTM). This section will address the benefits and drawbacks of both approaches.

4.8.2 Battery Energy Storage

Our team assessed whether constructing a lithium-ion battery would be feasible on the Peninsula site. We began our approach by applying a few simple screenings to determine whether we could obtain a permit for a storage device in New York City. We assumed that we would develop a 1MW/4MWh storage asset. Though it varies between manufacturers we assumed that would be able to procure a storage asset with a maximum size of 30 ft long 6 ft tall and 9 ft wide. Based on this assumption we continued though following preliminary screenings:

- Zoning—Passed
- Fire Hydrant within 100 feet—Passed
- Minimum 6,000 sq. ft. of area—No Go

Figure 8. Rendering of the Peninsula Development

Upon reviewing the site, we determined that the zoning could include a storage device under the manufacturing zoning overlay, and there would be a fire hydrant in proximity to a potential storage device. The primary challenge is space constraints, as the development is a dense urban site with a heavily landscaped component. While the site did present 6,000 sq. ft. of space on its surface, the development team wants to prioritize open space as an amenity to the tenants without significant aesthetic disruption. This made it challenging to identify a ground level area to site a battery.

After determining that storage would not be viable as a ground mounted system, our team weighed the possibility of rooftop storage. While it is technically feasible from a permitting and regulatory perspective, the storage device would most likely require additional structural engineering and materials adding to initial costs. Energy storage devices of this size typically weigh a minimum of 50,000 pounds which equates to roughly 31 pounds per cubic ft. After discussing the implications of this approach with the developer we ruled out rooftop storage due to the added costs associated with structural engineering and increased material costs to support a storage device.

Ultimately, the team decided to make a non-feasible determination for battery energy storage at this site due to a combination of added costs and key development objectives that are not supported.

4.8.3 Electric Vehicle Charging

Phase 2 does include an underground parking facility, which presents an excellent opportunity to develop electric vehicle (EV) charging capability. Our team has determined that there are no site-specific impediments to EV Charging at this stage in the study. The primary objective is to minimize the cost of integration with the existing design, while providing adequate and convenient access to EV drivers.

There are currently 3 levels of EV chargers available on the market: Level 1, Level 2, and DCFC (Direct Current Fast Charge). Each one of these chargers has a slightly different application, use type, and commercial model. All three-support charging at different rates, the table below illustrates the differences across the three chargers.[4]

Figure 9. Subsurface Parking Garage Plan

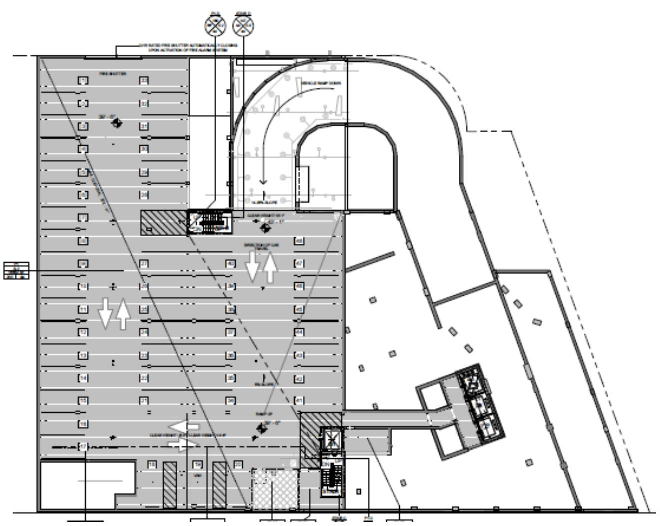


Table 15. EV Charging Infrastructure Summary

	Level-1	Level-2	DCFC
Voltage (V)	120	240	400+
Power (kW)	2.4	19	350
Charge Time (Miles/hr)	5	28	250-300
Application	Residential	Residential, Public, Workplace	Public

5 Results—Business Model

Endurant identified two potential commercial options for the proposed solution. First, we considered an Energy-as-a-Service (EaaS) model. Under this offering, Endurant would design, build, own, operate, and maintain all centrally located heat pump equipment and the GLHE serving the building's heating, cooling, and domestic hot water production. Secondly, we considered a more traditional engineering, procurement, and construction (EPC) service to develop the project. The building owner would own the equipment and subcontract the various project components, as they would in the baseline scenario with conventional HVAC equipment. These two business models are explored in greater detail in the following sections.

5.1 Energy-as-a-Service

EaaS is a comprehensive solution that Endurant offers clients for the development, construction, ownership, and maintenance of bespoke energy solutions for specific sites, delivered through a long-term energy management agreement. It may include a wide array of services and products and is tailored to meet the specific needs of each project.

Endurant has decades of experience navigating the rapidly changing distributed energy landscape. We are a unique partner in that we develop the entire suite of renewable technologies, which imparts a deep understanding of the value stream each technology offers and how it supports value creation at the site. Competitors typically only develop a single asset, such as solar, or fuel cells, but Endurant brings experience developing multiple complimentary technologies that enable enhanced energy and CO_2 savings. And since we also own the assets, we have an interest in designing and operating solutions that create tangible and long-term value for our customers.

Developing distributed on-site energy systems enhances reliability and energy flexibility and will position the development to better adapt to future changes in the energy landscape. Localized generation can produce revenue streams, electrified heating and cooling systems can be used in demand response programs, and energy storage can support resiliency. Endurant as the long-term EaaS partner will develop a solution that will serve as a platform for long-term value creation.

5.2 Endurant Offers Energy-as-a-Service

- Distributed Generation Asset DBOOOM (Design, Build, Own, Optimize, Operate, Maintain)
  - Ground Source and Air Source Heat Pumps
  - Solar PV/Solar Thermal
  - Storage
  - EV Charging
  - Fuel Cells
  - Combined Heat and Power
- Demand Management
- Energy supply contracts
- Efficiency upgrades

EaaS isn't just about a single technology or offering, it is about having a dedicated energy partner to support a customized energy solution, whether greenfield or brownfield, in a variety of ways including:

- Removing capital investment for bespoke energy solutions from client balance sheets
- Optimizing performance and reducing operating costs
- Monetizing underutilized space
- Providing clean, efficient energy solutions customized for the project and any expected growth, contributing to environmental, social, and governance (ESG) goals and objectives
- Managing commodities associated with energy solution

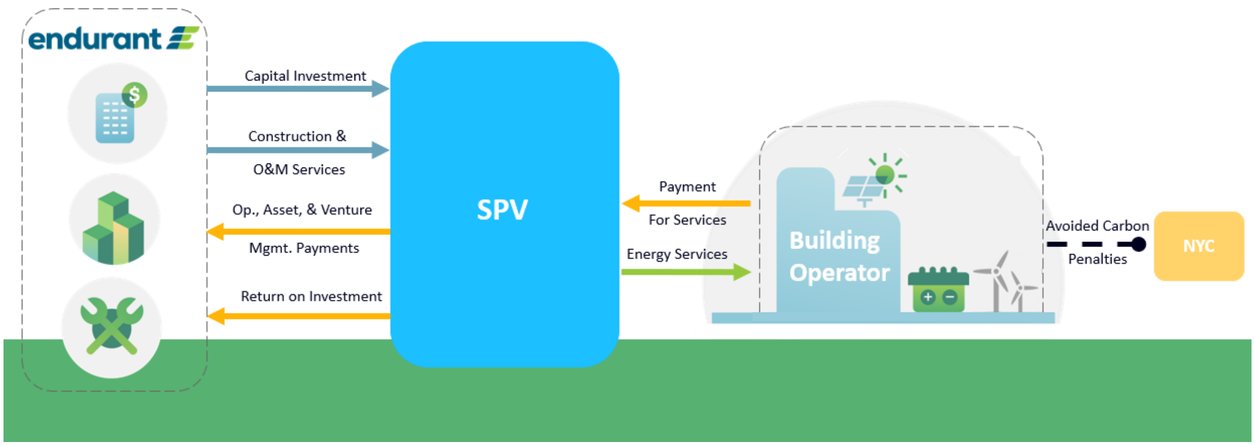
5.2.1 Energy-as-a-Service Scope

Endurant would own the GLHE and any centrally located thermal production equipment, while the landlord would own the decentralized equipment.

The EaaS scope would include the following elements:

- Detailed Design
- Installation
- Commissioning
- Operations/Optimization and Maintenance
- Decommissioning

Figure 10. Endurant Energy's Energy-as-a-Service Commercial Structure Diagram



All phases are presently owned by the same entity but will be subdivided into separate tax lots within separate special purpose vehicles upon commissioning. The landlord will be responsible for providing centralized heating at no additional cost to tenants. Cooling will be the tenants' responsibility. Intelligent metering methods connected to a site master meter will be utilized to support energy efficiency and financial arrangements between landlord and tenant.

The project utility metering must achieve pricing that complies with the affordable housing billing rules. For example, low-income tenants have utility/rent payment caps which must be considered in the financial model. These arrangements may lead to a model support cooperative arrangement with the local utility, constituting an intermediary step toward utility geothermal. Figure 10 illustrates the overarching relationships and responsibilities in the EaaS business model:

Endurant will set up a Special Purpose Vehicle (SPV) that will develop, finance, build, own, and operate the GSHP system. A core component of the EaaS model is to simplify counter-party relationships. In our proposed structure, the SPV will contract directly with the building owner/operator for Energy Services, namely heating and cooling energy from the GSHP system. From the building owner's perspective, this relationship would be similar to their relationship with Con Edison in the BAU case, i.e., a payment in exchange for the heating energy (either gas or electricity). However, in this construct the building owner is also paying Endurant for the cooling energy, which in BAU would be the responsibility of the tenant. For the building owner to recover the costs associated with cooling energy, a third-party billing provider will be responsible for metering and billing the tenants for the cooling energy they utilize. The revenues collected from the tenant will be passed on to the building owner.

The annual capacity fee includes a "turnkey" service to the building, including provision of energy as well as timely maintenance. There are unique advantages to the EaaS business model proposed here:

- The building owner receives the benefit of installing GSHP without the risk of financing and owning the asset
- We are able to wrap several value-added benefits into the EaaS, such as:
  - Hedged electric supply pricing, if determined to be necessary for the project.
  - Monetization of tax-based benefits such as the ITC and depreciation, which serves to improve project economics for all stakeholders involved.
  - Electric supply can be sourced from fully renewable sources, which will help position the project as 100% green and renewable.

The EaaS business model's fundamental tenet is to maximize value to all stakeholders, as summarized in Table 16.

Table 16. Energy-as-a-Service Benefits Summary

Stakeholder	Benefits due to EaaS business model
Developer	• Lower utility/operational costs incurred to provide heating and cooling to tenants • Low risk since the developer is not responsible for financing and owning a complex DER project on their balance sheet • Improves the brand value and marketability of future development projects
Tenants	• Lower utility costs
Endurant	• Directly in-line with our mandate to deploy capital and own DER projects • Builds on our expertise in GSHP design, construction, and financing
Community	• More efficient thermal energy means increased carbon emission reductions • Eliminate on-site emissions completely • Serves as a proof-of-concept for the scalability of this model to other parts of the community

5.3 Engineering, Procurement, and Construction (EPC)

The EPC model represents the business-as-usual approach. Under this model the developer would design, build, own, operate, and maintain the heat pump and ground loop equipment through multiple subcontracts. Value for tenants is realized via operational savings produced by the efficiencies of the GSHP system, but the developer takes on more project risk. The risk can be managed through quality contracting partners. Compared to the EaaS model, the developer would increase their exposure to risk elements associated with GSHP development. Three key risks are:

1. Execution Risk—throughout the development process, schedules, quality, and delivery must be carefully managed to avoid costly delays.
2. Economic Risk—developer must secure financing and service debt or equity associated with the equipment capital costs.

3. Operational Risk—energy assets require on-going preventative maintenance and occasional repairs.

Risks are common in the development process, and none pose an insurmountable hurdle to the project. Our team has engaged on over 400 GSHP projects since the founding of our company. Through this experience we have developed a deep understanding of project risk and mitigating strategies.

One common misstep we have encountered in GSHP risk management is the subcontracting of various project components to multiple vendors, including the energy modelling, ground loop design, mechanical design, controls strategy, and installation. Each one of these project components interacts with one other to create an optimal GSHP system and it is critical that each iteration in the design process is closely coordinated. Under the EPC approach, Endurant would strongly recommend the developer to pursue an EPC contract that places all of the GSHP design elements under one subcontractor. This approach is more likely to produce a reliable outcome while placing accountability with one subcontractor. In Endurant's view, this is the best hedge against the risks outlined.

5.4 Incentives and Depreciation Schedules

Each ownership model requires different financial structuring associated with various incentives available for GSHP systems. This study identified the following incentives.

1. New York State Clean Heat Incentive (NYSCHI)—Administered through Con Edison
2. Federal Accelerated depreciation schedules
3. Federal Business Energy Investment Tax Credit
4. NYSERDA PON 4337

The following section will describe available incentives and the payout mechanism in relation to the two ownership structures. Each incentive value is fully calculated and quantified in section 7.1.

5.4.1 New York State Clean Heat Incentive

The NYSCHI[5] is a statewide incentive program administered through the NYS Joint Utilities.[6] The program has a variety of incentive categories that encompass small- to large-scale energy projects and numerous heat pump-based technologies. These incentives would apply under the EaaS model or the

EPC model. This project qualifies for the Category 4—Custom Incentive—since GSHP does not meet the building's full heating load. This is a performance-based meaning that the amount of energy savings impacts the incentive value. The following formula is for determining the incentive value, and the incentive values are determined in section 7.1.

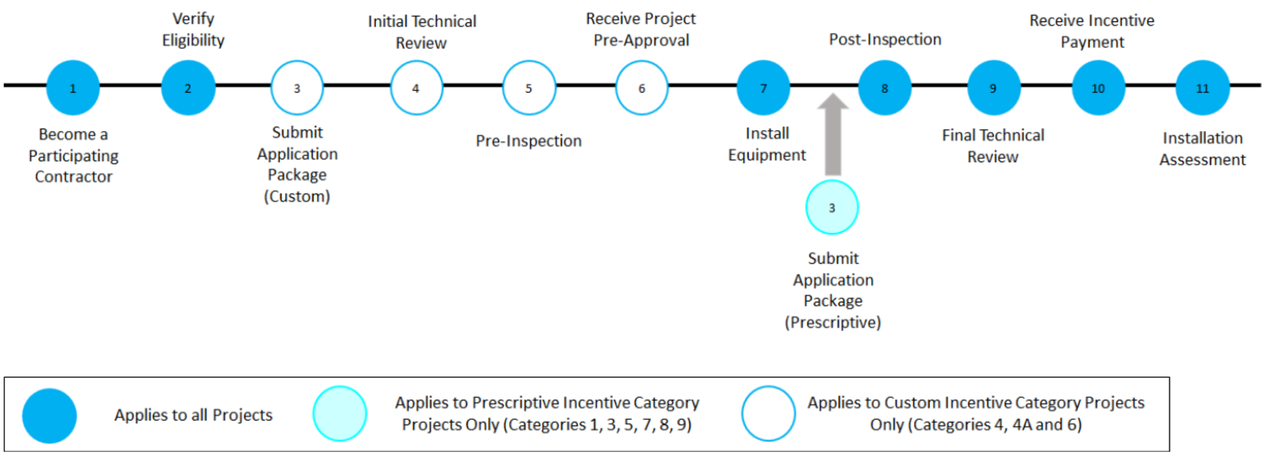
{Modeled Code Compliant Heating &Cooling (MMBtu)-(Modeled GSHX Energy Heating &Cooling (MMBtu)} x $Incentive Value=Cat 4-Custom Incentive

Within category 4 there is an additional category, category 4A – Heat Pump + Envelope. This category allows for additional incentives if the dominant load is reduced by 5% from eligible measures, including: Window Replacements, Window Film, Wall Insulation, Continuous Insulation, Window Walls, Curtain Walls, Exterior Façade, Air Leakage Sealing, Air Barrier Continuity, Roof Insulation. The Peninsula is cooling dominant therefore must achieve a 5% reduction in Building Cooling Load (BCL) to qualify. Based on our team's analysis the Peninsula achieves a 4.5% BCL reduction, nearly qualifying the project for category 4A yielding an incentive value of $400 per MMBtu saved per year, doubling the category 4 incentive. A slight improvement to window glazing or any of the eligible measures could make the project eligible for this incentive.

These incentives must be applied for prior to the installation of the equipment. Con Edison will review the application package and provide incentive approval prior to the installation. The application requires the following elements:

- Completed Program Application
- Cutsheets for Proposed Equipment
- Cost Estimate for Proposed Work
- Load Calculations
- Detailed Scope of Work
  - Description of baseline
  - Describe the extent of the work
  - Specify type of heat pump technology
  - Provide design capacity
  - Specify what percentage of the design heating/cooling load heat pumps will meet
  - Specify whether supplemental heating is required
    - Why additional electrification is non-feasible
    - Document a controls strategy that prioritizes heat pump dispatch
- Approved Department of Buildings Permit Submission
- Savings Analysis

Figure 11. Application and Approvals Timeline for New York State Clean Heat Incentive



5.4.2 NYSERDA Program Opportunity Notice (PON) 4337

NYSERDA PON 4337—New Construction Housing Program provides support for highly efficient new construction multifamily buildings. The Peninsula would qualify based on energy efficiencies associated with GSHPs. If the Peninsula were to fully electrify it would be considered carbon-neutral ready and eligible for the highest incentive amount.

Under PON 4337 there are four incentive Tiers and two categories: Market Rate and Low-Moderate Income (LMI.) Tier 1 is the lowest incentive value, and incentives increase for LMI project. Our analysis indicates the Peninsula would qualify at a minimum as a Tier 2 LMI building. If the project pursued an all-electric approach including electric DHW and electric stovetop ranges, the project would be eligible for Tier 4 incentives, the highest incentive category. Incentives are paid out in three milestones as defined in Table 18.

Table 17. Program Opportunity Notice 4337 Tier 2 and Tier 4 Incentive Comparison

	Incentive per Dwelling Unit	Incentive per sq. ft. of Non-dwelling Unit Occupied Residential Space	Incentive Cap
Tier 2	$1,000	$1.00	$200,000
Tier 4	$4,000	$4.00	$550,000

Table 18. Program Opportunity Notice 4337 Incentive Milestone Payment Schedule

Milestone 1 Proposed Design	Milestone 2 Open Wall	Milestone 3 As Built
30%	30%	40%
• Proposed design meeting eligibility thresholds. • Deliverable: Contracts between engineer and project, LMI Qualifications, Energy Models, Design Documents, Workbooks.	• 30% completion of various measures: exterior insulation, insulated concrete form, exterior insulation and finishing systems, interior insulation only, exterior insulation with interior insulation, prefabricated exterior wall assembly and modular construction. • Deliverable: Multifamily Workbook, checklists, multifamily high-rise measurement & verifications, photo documentation.	• Project Completion • Deliverables: Multifamily workbook or equivalent, photo documentation as required, as-built energy modeling files, ASHRAE path calculator or approved equivalent, proof of review by Multifamily Review Organization, HVAC functional testing checklist, testing, and verification worksheets.

This program also contains an incentive for commercial space paid out at a rate up to $2/sq. ft. with a cap of $250,000. This incentive can be layered on top of the residential incentives.

5.4.3 Federal Accelerated Depreciation Schedules

Geothermal assets are eligible for accelerated methods of depreciation such as Bonus Depreciation and Modified Accelerated Cost-Recovery System (MACRS), which allow geothermal systems to achieve the return on investment sooner.

One hundred percent Bonus Depreciation is available for qualified property placed in service before January 1, 2023. Under the current law, Bonus Depreciation rate begins to phase out in calendar years 2023 through 2027.

When MACRS is elected, one of the two types of systems apply: the General Depreciation System (GDS) or the Alternative Depreciation Systems (ADS) which determine the depreciation method and recovery periods used. GDS is generally used unless ADS is required by law. Under GDS, property is depreciated over 3, 5, 7, 10, 15, 20, 25, 27.5, and 39 years depending on the property class as defined by the IRS.

5.4.4 Federal Business Energy Investment Tax Credit

The Business Energy Investment Tax Credit, commonly referred to as ITC, is currently set at 10%[7], with a sunset at the end of 2023. To receive the tax credit construction must begin before 2024. The value of the ITC credit is monetized via a reduction in federal tax liability. For developers that have an effective tax rate of 0% or near 0% they will not be able to monetize this benefit. Alternatively, there are tax equity investors who can monetize this tax credit. Under Endurant's EaaS we can utilize tax equity investors to help drive down EaaS payments for customers who are unable to monetize tax equity.

This incentive applies only to GSHP equipment, and downstream distribution equipment that receives 75% of the annual load from the GSHP system. For example, a fan coil unit delivering heating at least 75% derived from the GSHP on an annual basis would be eligible to receive the ITC. The ITC must be monetized within one year of when the system becomes operational and cannot be monetized before the equipment becomes operational.

5.4.5 Summary of Available Incentives

The table below summarizes the estimated incentive value for available to the project based on a geothermal solution. A detailed analysis of the incentive impact is in section 7/Results/Impact.

Table 19. Incentive Values Associated with the Proposed Ground Source Heat Pump Solution at the Peninsula

	Building 2A	Building 2B	Building 3
PON 4337[a]	$200,000	$141,387	$200,000
NYS Clean Heat	$885,000	$707,600	$854,600
ITC	$250,561	$183,556	$247,376
TOTAL	**$1,335,561**	**$1,032,543**	**$1,301,976**

[a] If commercial space is present in any of the buildings then commercial spaces are eligible for a Tier 4 incentive of $2/sq. ft. with a cap at $250,000. The commercial incentive is available in addition to the incentive values represented in Table 14 associated with PON 4337.

5.5 Regulatory Review

The team's regulatory review identified approximately 20 different entities that the project would have to interface for various permitting and regulatory approvals. The various regulatory requirements for executing a GSHP project can primarily be grouped into the following buckets:

- **Environmental permits**: Permits related to water quality standards (NYSDEC), environmental impact clearances for State-funded projects (SEQRA, CEQR), Office of Renewable Energy Siting (ORES) approval, groundwater discharge.
- **Construction permits**: Permits related to drilling (different requirements for <500' and >500'), building codes, clearance for proximity of wells to Water tunnels (NYCDEP), revocable consent agreement/permits related to streets and sidewalks (New York City Department of Transportation (NYCDOT) Office of Construction Mitigation and Coordination).

- **Land-use permits**: Clearances and permits related to landmark preservation, historic resource preservation (SHPO).
- **Energy service regulations**: Uniform heat standards for multi-unit residential buildings, sub-metering regulations for electrical heat, affordable housing requirements, right-of-way easements.

Of the permits required some permits may have already been obtained as part of the overall development process, and it is likely that some Authorities Having Jurisdiction (AHJs) have already been engaged. The following sections summarize anticipated hurdles and mitigating strategies to reduce regulatory risk to the project. This section is abridged; the full regulatory report can be seen in section 9.

5.5.1 Lack of Municipal Regulatory Regime for Geothermal Systems

Few municipalities in NYS have developed permitting guidelines for geothermal systems, and no municipality has developed guidelines for multi-property district systems, without a permitting regime and standards for equipment, developers, and municipal officials are left to navigate the various zoning, building, mechanical, environmental, and other regulations that may apply to geothermal systems but were not designed specifically for these systems.

This ad hoc approach in the absence of a dedicated geothermal permitting regime increases costs, uncertainty, and risks, and delays the approval process.

To address this challenge, project developers should start educating municipal permitting authorities and elected officials about the benefits of the geothermal features early in the development process and highlight the mitigating measures taken to reduce risks to the environment or other subsurface infrastructure as early as possible. This educational effort should commence as soon as the developer decides to proceed with a geothermal design. The project developer should also be prepared to engage with environmental and community groups interested in the project.

5.5.2 Rights-of-Way and Approvals

Developers must obtain either fee simple ownership or easements to drill and install a shared ground loop across multiple properties. Crossing property lines, streets, railroad tracks, or existing utility infrastructure will require the grant of an easement and approval by the owner or authority responsible for their operation. Granting an easement limits the property owner’s ability to use his/her own property, and can adversely affect private property rights, or diminish private property values. The Joint Venture ownership across project phases should significantly reduce challenges in obtaining easements.

5.5.3 Drilling Regulatory Restrictions

NYS imposes different requirements for geothermal wells drilled less than 500 feet and wells over 500 feet. Permitting requirements for wells over 500 feet in depth are considerably more rigorous and costly. New York City imposes additional restrictions at more shallow depths and within the vicinity of a water tunnel shaft, without obtaining permits. Due to the additional permitting requirements imposed by NYS, our team elected to limit drilling to 500 feet to avoid the significant costs of compliance with additional regulation.

5.5.4 Submetering and Tenant Billing

If submetering is installed, the Public Service Commission requires compliance with metering, billing, dispute resolution, and other regulations. Obtaining submetering approval for a new development is far less complex a process than submetering a building with existing tenants.

Presently, New York State's submetering regulations apply to electricity and electric heating services. No regulatory arrangement exists for the billing of heating services measured in thermal units. Accordingly, to simplify submetering arrangements, the project should introduce submetering prior to entering into agreements with any prospective tenants and, preferably, prior to advertising rental units.

5.5.5 Summary of Recommendations to Overcome

Several of these challenges can be addressed through contractual arrangements between the developer and other stakeholders. Recommended contractual arrangements include:

- **Common Agreement Among Phases**. The project is presently owned and developed by a single entity, but over time will be separately incorporated and equity interests may be sold to disparate groups of investors. Anticipating this, the developer should adopt a common agreement to govern various aspects of the project's maintenance, access, and financial responsibility.

  The common agreement should specifically address the ownership, operation, and maintenance of the geothermal system as the geothermal system will cross internal property boundaries and require cooperation across separated properties and ownership structures. A common agreement would govern maintenance, management, pricing, financial contributions, and other responsibilities for operating the system. A common management body, such as an owner's association or similar entity, should be established for this purpose and supported by association charges.

- **Third-Party Energy Services**. The common agreement would facilitate the project entering into a third-party energy services agreement with a geothermal system operator. The third party could provide a turnkey solution or perform discrete tasks on behalf of the project's common management association. Any arrangements with a third-party energy services provider should require performance and compliance consistent with developer obligations to tenants and requirements that may be imposed by the New York Public Service Commission or other government agencies in relation to provision of heat to tenants.
- **Submeter Billing.** The developer or a third-party energy service provider operating the system will be required to use an approved billing form and maintain billing service and dispute mechanisms as required by New York State's submetering regulations. The developer or third-party energy service provider may desire to contract with a third-party billing provider to comply with these requirements. Such arrangements must provide compliance with any applicable landlord-tenant laws.
- **Tax Optimization.** The geothermal system is a depreciable asset that provides opportunities for tax-advantaged financing. The form of ownership for those assets can be separated from the project and its phases to monetize tax benefits. A separate geothermal financing structure potentially improves the financial return of the overall project; however, this must be weighed against the additional complexity and legal risk in the event of a failure to meet obligations for any reason or from legal dispute.

5.5.6 Regulatory Conclusion

While there are various regulatory considerations at play and a variety of AHJs and stakeholders that should be engaged, we did not discover any "no-go" signals in our analysis. The objective of this regulatory analysis is to account for risks and identify mitigating strategies. While there may not be prescriptive geothermal regulations, there are several geothermal precedents located in NYC some of which Endurant Energy has developed. While district energy systems are less common in the multifamily space, there are many examples of district thermal systems operating on campuses in NYS and NYC.

The unabridged regulatory analysis is in section 10, Appendix B–Regulatory Roadmap.

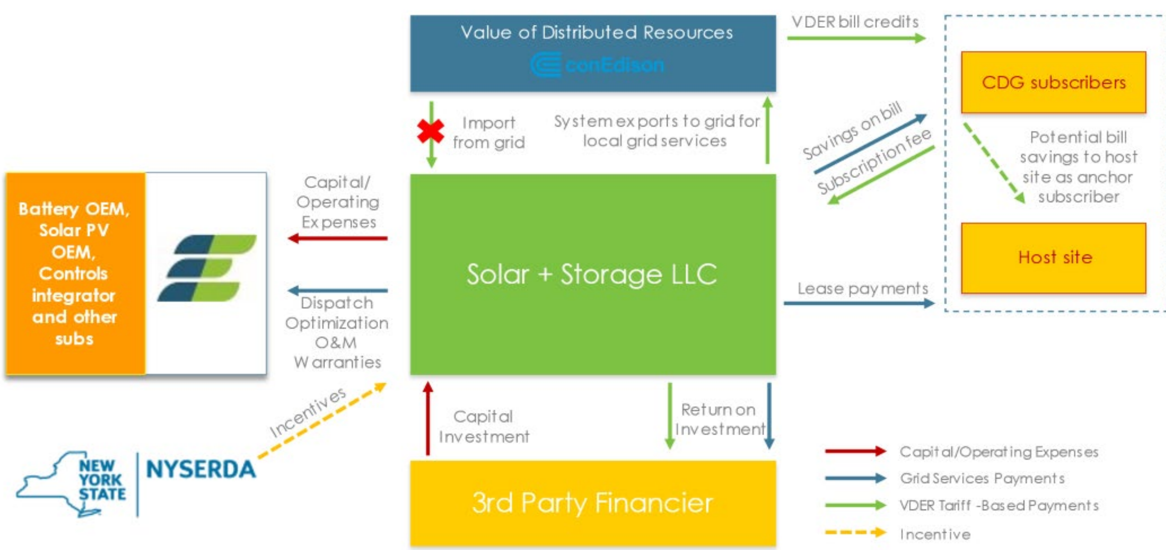
5.6 Additional Technology Business Models

5.6.1 Front-of-the-Meter Solar Photovoltaic

New York State has an established program called Value of Distributed Energy Resources (VDER) that allows solar PV (optionally paired with battery energy storage) systems to connect directly to the distribution grid in front of the customer meter (FTM). An asset enrolled in the VDER program generates a monetary credit for each kilowatt-hour (kWh) of electricity injected into the grid. The VDER program has several sub-options that dictate how that monetary credit can be applied to a variety of customer bills.

Community Distributed Generation (CDG) is one such version of the VDER program, which allows commercial and residential customers to "subscribe" to the output of an FTM VDER asset and see a portion of those monetary credits as savings on their bill. FTM assets deployed under the CDG VDER program offer landowners the opportunity to generate stable lease payments for use of their land (or rooftops) by third party asset developers, as well as the opportunity for Con Edison customers to subscribe to the renewable energy generated by the asset. As per the rules of the CDG VDER program, up to 40% of the total monetary credit may be allocated to a large commercial account, with the remaining 60% reserved for mass-market (residential and small business) customers. Figure 12 summarizes the third-party funded business model for the FTM CDG VDER asset.

Figure 12. Third-Party Funded Front of the Customer Meter Community Distributed Generation Value of Distributed Energy Resources Commercial Structure



Under this business model, all credits appear as savings (or bill reductions) on each allocated subscribers' bill. The project then recovers 90%–95% of this credit as a fee (this is the primary revenue to the solar PV asset owner), leaving the remainder as savings on subscribers' bills.

The Peninsula JV would receive a lease payment from the third-party asset owner for use of their rooftop. Furthermore, the proposed geo-exchange solution's primary Con Edison account can be designated as a subscriber to the solar PV project, thereby seeing approximately 5%–.10% reduction in electricity bills.

- Works seamlessly with geo-exchange solutions as it is independent of any metering configurations.
- Offers stable and predictable cash flows in the form of lease payments which can serve to further reduce the operating expenses.

5.6.2 Behind-the-Meter Solar Photovoltaic

BTM solar PV projects are structured as Power Purchase Agreements (PPAs) where the off taker pays a fixed $/kWh price for the output of the system.[8] PPA prices are calculated based on third-party costs of development and expected rate of return. A successful BTM PPA results in an overall discounted $/kWh price when compared to the prevailing rates of purchasing electricity from the grid.

Under this business model, the solar PV would be connected behind the geo-exchange solution's meter, thereby directly supplying energy to the geo-exchange heat pumps, which reduces the amount of energy imported from the grid. This solution has one inherent disadvantage when compared to the FTM solution, as it cannot be connected behind multiple meters; only a centralized geo-exchange solution integrates with a BTM solar PV solution.

A BTM PPA solar PV solution does offer one advantage over an FTM solution: Since solar energy is directly feeding the geo-exchange meter, the geo-exchange is effectively providing clean and carbon-free electricity directly to the geo-exchange system.

From a purely technical perspective this project presents a viable opportunity to deploy a modest, yet meaningful, amount of solar PV arrays.

5.6.3 Electric Vehicle Charging

Our team proposes two options for commercial structures and EV Charging.

1. Commercial Model: EV charging installed by the developer as an amenity to the residents. This would be installed and owned by the developer and the developer would be responsible for setting rates and any cost recovery.
2. Merchant Option: An EV charging developer would design, build, own, operate, and maintain the charger. This option would allow the developer to avoid the initial capital expenses while still offering charging as an amenity. Since this model relies on consistent usage for cost recovery the building would have to allow access to a portion of the garage for non-residents. This can be done in a secure manner; some EV charging companies provide their customers with key cards that can be used in garage facilities that require card access.

Our team will also conduct a cost benefit analysis of "Make-ready" upgrades to the developer's parking facilities. Make ready upgrades are intended to install the requisite infrastructure for the long-term phased implementation of EV charging. Make ready upgrades support the long-term integration of renewable technologies, while not incurring prohibitive capital costs prior to widespread adoption.

6 Results: Impact

This study analyzed two potential configurations: a district solution of one or more buildings, and a solution where each building was independent of the other. We assessed these two systems based on cost, constructability, efficiency, and regulatory compliance. As a result of this analysis, we determined the best approach would be to link the ground loop across the entire site with heat pump equipment located at each building. We found this increased the opportunity to optimize system performance, while reducing capital costs associated with additional bore field requirements, without significant regulatory hurdles.

6.1 business-as-usual Capital Cost Summary and Comparison

Based on our preferred configuration our team worked with NYC-based drilling and mechanical contractors and equipment providers to produce cost estimates for the proposed solution. We used this information to develop the business-as-usual costs and our preferred alternative costs. We took a holistic approach and included heat pump equipment, GLHE, and the buildings distribution system. This approach ensures the developer can be confident in the accuracy of the costs proposed.

The table below breaks out cost elements and provides budgetary pricing dated November 2021 for the preferred configuration on Phase 2 and 3. The cost estimates represent installed costs, and do not include design costs. Building 3 costs are scaled based on per unit costs from Phase 2.

Table 20. Capital Costs for Business-as-Usual and Ground Source Heat Pump System

		Building 2A	Building 2B	Building 3
GSHP Solution	GLHE System	$1,564,799	$1,146,341	$1,544,908
	VRF Condensers	$1,766,225	$1,244,721	$1,743,773
	Distribution	$1,446,000	$1,056,000	$1,427,619
	Controls	$150,000	$100,000	$148,093
TOTAL		**$4,927,025**	**$3,547,062**	**$4,864,393**
BAU Solution	VRF Condensers	$1,500,750	$1,010,000	$1,481,673
	Distribution	$1,446,000	$1,056,000	$1,427,619
	Controls	$150,000	$100,000	$148,093
TOTAL		**$3,096,750**	**$2,166,000**	**$3,057,385**
Incremental Cost		**$1,830,275**	**$1,381,062**	**$1,807,009**

Prior to incentives this solution represents a premium to the project compared to the baseline. To determine real costs, we must account for the incentives outlined in the table below. The incentive values are calculated based on existing building design and Endurant's preferred GSHP approach. There are additional incentives available for increased envelope efficiency and electrifying DHW production; however, those incentives are not represented in the table below.

Table 21. Incentive Summary for Phase 2 Buildings and Building 3

		Building 2A	Building 2B	Building 3
GSHP Solution	PON 4337[a]	$200,000	$141,387	$200,000
	NYS Clean Heat	$885,000	$707,600	$854,600
	ITC	$250,561	$183,556	$247,376
	TOTAL	$1,335,561	$1,032,543	$1,301,976
Incremental Costs after Incentives		**$494,714**	**$348,519**	**$505,033**

[a] If commercial space is present in any of the buildings than commercial spaces are eligible for a Tier 4 incentive of $2/sq. ft. with a cap at $250,000. The commercial incentive is available in addition to the incentive values represented
in Table 19 associated with PON 4337.

Based on these capital cost estimates the GSHP solution introduces an incremental cost to the project. This incremental project cost can be recovered via operational savings created by GSHP efficiencies.

6.2 Ground Source Heat Pump Operating Cost Summary and Comparison

GSHP systems are far more efficient than standard boilers and chillers, and even significantly more efficient than air-cooled VRF systems. In our analysis we are demonstrating a 21% input energy reduction by replacing 45% of Building 2A's capacity with a water-cooled VRF unit linked to the GLHE. We did consider placing the DHW production onto a CO_2 heat pump; however, we found operating costs increased when switching from natural gas as a fuel source to electricity despite significant efficiency gains. There is a more detailed discussion of this in section 8 Lessons Learned. Our team prioritized preserving the operational savings, which leaves DHW production on gas, this approach will support the payback of the incremental costs incurred over the BAU scenario. We did increase the DHW efficiency by preheating the water to balance the GLHE on an annual basis. Since each building is cooling dominant, we can exchange excess heat from the GLHE to preheat the DHW circuit. This resulted in a 16–17% reduction in the input energy required for DHW production annually.

Since the Peninsula is an affordable housing project, the developer is responsible for providing space heating and domestic hot water free of cost to tenants; the tenants continue to be responsible for space cooling expenses.[9] The overall electrical energy needed to run the GSHP solution can be broken out into input required for heating versus cooling loads, which in turn allows us to break out these costs separately. In practice, the GSHP solution will be on one commercial Con Edison account that will charge the developer for all the input energy required (i.e., the bills are not separate for heating and cooling input electrical energy). The tables below summarize the electricity costs incurred to operate the GSHP solution.

Table 22. Annual Operating Costs Broken Out by Cooling and Heating

Building 2A		
	BAU	Geo
Space Heating (kWh)	342,084	247,245
Space Cooling (kWh)	370,425	314,654
DHW Gas (therms)	31,794	26,489
Cooling Utility Costs	$77,720	$69,926
Heating & DHW Utility Costs	$120,838	$85,787
Operations & Maintenance	$8,000	$3,600
Heating, DHW, O&M Cost	$120,838	$89,387
	-	$31,451
Building 2B		
	BAU	Geo
Space Heating (kWh)	258,434	204,286
Space Cooling (kWh)	283,935	219,412
DHW Gas (therms)	20,726	17,268
Cooling Utility Costs	$64,266	$48,685
Heating & DHW Utility Costs	$82,717	$65,746
Operations & Maintenance	$5,864	$2,639
Heating, DHW, O&M Cost	$88,581	$68,385
Heating, DHW, O&M Cost Savings	-	$20,196
Building 3		
	BAU	Geo
Space Heating (kWh)	325,618	235,828
Space Cooling (kWh)	371,359	315,465
DHW Gas (therms)	32,792	27,320
Cooling Utility Costs	$83,537	$69,462
Heating & DHW Utility Costs	$111,049	$83,708
Operations & Maintenance	$7,898	$3,554
Heating, DHW, O&M Cost	$118,947	$87,262
Heating, DHW, O&M Cost Savings	-	$31,685

6.3 Carbon Savings Summary

We achieved carbon savings by reducing energy (kWh) consumed by 21–22% for space heating and cooling, and 16–17% reduction in gas consumption for DHW. By increasing efficiencies, we achieved a carbon savings of 19–20% as represented below. If we moved the DHW production to electricity, we would expect over a 30% carbon savings, and an all-electric, carbon-neutral ready building.

Table 23. Estimated Annual Carbon Emission Reductions When Compared to Business-as-Usual

	Building 2A	Building 2B	Building 3
Annual CO_2 Reductions	19.1%	19.9%	19.9%

6.4 Life-Cycle Cost Analysis

Endurant conducted a 30-year life-cycle cost analysis for the district including Phases 2 and 3 as outlined in Table 24. The life cycle cost analysis (LCCA) summarizes the operational and capital costs to construct a business-as-usual scenario. The LCCA considers capital costs, annual utility, and maintenance costs for the district scenario, a 2.5% inflation rate, a 3.0% escalation on utility costs, and a 4.0% discount rate. Major equipment replacement is scheduled in year 15 and year 30 for the heating and cooling equipment.

Table 24. 30-Year Life-Cycle Cost Analysis

	Building 2A	Building 2B	Building 3	Total Phases
GSHP + Gas Fired DHW LCCA (Communal Bore Field)	$10,276,755	$7,001,487	$10,148,112	$27,426,354
GSHP + Gas Fired DHW LCCA (Independent Bore Fields)	$10,147,299	$6,857,022	$9,928,266	$26,932,587
BAU LCCA	$10,613,534	$ 7,582,452	$10,441,065	$28,637,051

Results indicate a reduced 30-year life cycle cost for each of the geothermal scenarios as compared to the BAU case. While initial installation capital costs remain higher for each of the geothermal scenarios, the reduced operational costs generate enough savings to bring the present value of the 30-year total cost below the BAU. This indicates that over the long term, the geothermal options represent the least cost HVAC option even though the initial installation costs are higher.

6.5 Energy-as-a-Service

Endurant explored offering this solution as a third-party funded Energy-as-a-Service (EaaS) solution. Under our modelled EaaS scenario, Endurant would own the GLHE and the GSHPs. The developer would own the in-building distribution, the ASHPs, and the DHW system. The concept behind EaaS is to allow the developer to opt for a more efficient and low-carbon solution while avoiding up-front capital costs. Endurant would design, build, own, operate, and maintain the GLHE and the GSHP system for a fixed term. At the expiration of the term, the developer could renew the EaaS agreement or pay a terminal value fee to acquire the assets.

Endurant’s objective when developing an EaaS is to reduce capital costs to the customer to the greatest extent possible, while not exceeding BAU operating costs paid for by the tenants and meeting a reasonable rate of return to project investors. Our team modelled this offering to determine the value to each stakeholder. One of the unique aspects of affordable housing in NYC is the requirement for building owners to pay for heating and DHW, but not cooling. Space cooling is a cost paid for by tenants via their electric bill. Since the owner does not pay for cooling, we assumed that we could only capture savings associated with heating and DHW. Savings from efficiency gains on cooling equipment would accrue to the tenant directly. Therefore, revenues paid to the EaaS provider by the building owner via energy cost savings is limited by roughly 50%. If the EaaS model is limited to only recovering costs from heating and DHW, the project does not meet standard investment thresholds. If we could identify a mechanism to recover costs via energy cost savings from heating, DHW, and cooling as well, we see potential for developing a financeable project. However, limitations on low-income rents prevent our ability to recover energy cost savings from cooling efficiency gains.

This presents a unique challenge for EaaS offerings in the NYC affordable housing sector. In this example, the EaaS solution delivers a 19% carbon reduction, offers the developer an avoided capex cost, and offers the tenants a net savings on their utility bills compared to the BAU operating costs. However, the misalignment between the heating utility costs and cooling utility costs prevents the EaaS structure from recovering revenues required to justify third-party investment.

In our view there are two potential solutions to this challenge. The first is to allow the developer to charge a sustainability fee via tenant rent that would pay a portion of the EaaS fee. Alternatively, a regulatory shift that would bring all utility costs under the building owner would create an incentive for the owner to pursue energy savings from all uses. This would also enable the building owner to contract with Endurant under an EaaS and realize all energy cost savings. Under both solutions, the tenants (end-users) would still experience a net utility cost savings against the BAU costs.

6.6 Building versus District Configuration

Our team evaluated the district versus building-level configuration from a variety of standpoints. We assessed project cost, regulatory and commercial viability, and technical performance. This section will discuss potential benefits and drawbacks to developing three independent GSHP systems. As discussed in the prior section we concluded the drawbacks outweighed the benefits. Among the drawbacks, were reduced efficiency, increased capital expense, and reduced ability to optimize system performance. These attributes will be explored in greater detail in the following sections.

6.6.1 Thermal Profile and Ground Loop Heat Exchanger Sizing

From a thermal load perspective, Phase 2 and 3 buildings did not present significant load diversity. Phase 2 and 3 buildings are primarily residential buildings, therefore have similar load profiles, if not coincident. Due to the coincident peaks, there is not significant opportunity to exploit simultaneous load across this district. The community configuration did not significantly benefit from simultaneous load demonstrated in the table below.

Table 25. Bore Count by Building and District

<table>
<tr><th></th><th>2A</th><th>2B</th><th>3</th><th>Total</th></tr>
<tr><td rowspan="3">Bore Count</td><td>34</td><td>23</td><td>42</td><td>99</td></tr>
<tr><td colspan="2">55</td><td>42</td><td>97</td></tr>
<tr><td colspan="3">96</td><td>96</td></tr>
</table>

While the reduction in bores is relatively small, from a technical perspective there is no benefit to drilling three independent bore fields to serve each building. The only benefit of this approach our team discerned was to preserve independence for future building sales and reduce the need for a common agreement across the property. However, given the JV partnership developing this project and the large common open space, and subsurface parking area, our team opted to select a single contiguous bore field shared across Phase 2 and 3 as the highest performing option. This will provide additional flexibility around future optimizations. Removing three boreholes reduces the bore field cost by $140,000.

6.6.2 Mechanical Equipment and Distribution

By centrally locating the equipment to the greatest extent possible we minimize costs. We developed 2 plants across the three buildings. One plant located on Building 2A to serve Buildings 2A and 2B, and one plant to serve Building 3. This strategy reduced the mechanical equipment costs by 18%, by reducing the pump sets, number of crane lifts, and piping. This approach also benefits the project, in that it gives the developer increased flexibility to use the roof for amenity programming, green roof space, or other beneficial uses. We were unable to consider a single plant to serve the three buildings due to rooftop space constraints. The distribution costs were not impacted by district or building-level GSHP systems.

6.6.3 Operational and Carbon Savings

Due to the coincident loads, both operational savings and carbon savings were relatively static between a district-level system and individual building-level systems. We only saw a 3% difference in CO_2 emissions per square feet and a 4% difference in operational savings. Neither of these differences made a significant impact on the project results.

6.6.4 Key Findings

After concluding the environmental, economic, and regulatory analysis. This project demonstrated significant economic and environmental benefits without any insurmountable regulatory hurdles.

Based on the costing exercises completed, we estimate the payback period to be between 8.5- and 12.5-years accounting for an operational savings of 23% per year. If accounting for a cost of carbon, the payback period would decrease further. The proposed solution reduces annual emissions by 19–20%, producing a local and global benefit. If we placed the Social Cost of Carbon at $51, a relatively low figure, the payback period would decrease to between 7.5 and 11.5 years. [10] Furthermore, the project demonstrates a 30-year life cycle cost savings of $805,000. Overall, the project demonstrates strong economic viability. In addition, Endurant can develop this project as an EaaS offering, first-year avoided costs, and long-term savings.

While we conducted a cost-conscious analysis that aimed to preserve operational savings, it’s worth noting that there are opportunities to dramatically increase incentive availability by modifying design decisions. If the developer considers modifying the building envelope to achieve the 5% reduction in

BCL and electrifying the DHW production, the incentives would more than double. For example, for Building 2A, incentives would increase from $1.3 million to $2.5 million. While the change in the envelope may have a cost impact, it would eliminate any incremental cost of a GSHP solution.

From a regulatory perspective after considering site conditions and existing regulations, our view is that this project does not pose any no-go signals. We aimed to avoid triggering certain regulations, such as drilling deeper than 500 feet, and in doing so have eased the regulatory process to the greatest extent possible from a technical perspective. The primary consideration will be the treatment of the GLHE as common resource to be shared between three buildings. Our view is that the technical benefits of connecting the GLHE between Phases 2 and 3 outweigh the regulatory hurdles. If for instance Building 2A and 2B are completed and operational, and we discover that the GLHE is slightly oversize, we can place more of Building 3's units on the GLHE resulting in either capital cost reductions or operational savings.

7 Lessons Learned

A variety of lessons were learned during this study. Some are representative of project specific nuances; others have sweeping market implications.

The most important learning in our team's view on this project is the penalty for moving from gas DHW production to electric. The choice to move to a system that reduced source energy by 46% and achieved a 32–34% carbon savings was penalized by an additional 10% utility cost. This is particularly germane in the affordable housing sector, where the building owner is responsible for all heating and DHW production costs, and therefore particularly sensitive to increased operating costs on those line items. This is an area that should receive closer regulatory scrutiny and should be considered in utility rate making. NYS should consider a beneficial electrification tariff that recognizes the public value of electrification from an environmental perspective. Any beneficial electrification tariff should be thoughtfully designed to ensure real benefits accrue to customers switching to all-electric HVAC systems. As of the writing of this report, NYC's Housing Preservation and Development (HPD) is aware of the "split incentive" issue as it relates to space cooling for LMI tenants. While the geo system benefits from having balanced heating and cooling demands, the building owner is incentivized to provide only space heating and DHW to tenants. Endurant looks forward to working on the issue with HPD in a way that grows renewable heating/cooling for LMI tenants in a way that promotes equity.

From a technology perspective, one challenge we faced was that heat pump technologies commercially available in European or global markets were not available in the United States. The United States heat pump market is years behind its European counterpart, limiting options. This was of particular importance on this project which utilizes VRF as the baseline system. Our initial intent was to develop a GSHP/ASHP hybrid system rather than place a GSHPs and ASHPs on separate circuits. Upon discussion with equipment providers, we concluded that technology to support our solution is only available in the European market although it is intended to be available in the U.S. market in the coming years. The U.S. market does contain VRF GSHP modules, however they are intended to support full-load geothermal projects, and not hybrid solutions. Based on discussions with equipment providers, we understand that heat pump manufacturers are seeing a growing market opportunity in the United States, which should resolve the more limited offerings in the next few years. That said, the team is aware of tightening restrictions regarding refrigerant regulations. The EPA has issued regulations to implement certain provisions of the American Innovation and Manufacturing Act (AIM Act). The national law proposes a phase down of consumption and production of HFC's by 85% from 2020 levels by 2035. What this means long term for a VRF type solution remains unclear, other than increase in install costs. For this reason, the Endurant team would prefer to see a hydronic distribution system, which is also more compatible to a GLHE solution.

Appendix A. Energy Model Assumptions

A.1 Energy Model Assumptions Building 2A

Envelope	• Roof assembly U- 0.030 • External Wall Steel Assembly U- 0.057 • Residential Window Assembly U-0.280; SHGC=0.400 • Commercial Window Assembly U-0.280; SHGC=0.400 • Glazed Door Assembly U-0.680; SHGC=0.360 • Opaque Door U-0.500 • Ground floor unheated U= F (0.52) • Window to wall area ratio 28.9%
Occupancy	• ASHRAE 90.1 space-by-space method
Interior Lighting Power Density	• Living Units 0.62 W/sq. ft. • Conference/Meeting/Multipurpose 0.49 W/sq. ft. • Corridor/Transition 0.23 W/sq. ft. • Electrical/Mechanical 0.56 W/sq. ft. • Gym-Exercise Area 0.23 W/sq. ft. • Laundry 0.41 W/sq. ft. • Lobby 0.67 W/sq. ft. • Locker Room 0.75 W/sq. ft. • Lounge/Breakroom 0.73 W/sq. ft. • Office Enclosed 0.48 W/sq. ft. • Parking 0.19 W/sq. ft. • Retail-Sales Area 1.44 W/sq. ft. • Stairs 0.20 W/sq. ft. • Storage 0.63 W/sq. ft. • Workshop 1.59 W/sq. ft.
Exterior Lighting	• Estimated exterior lighting 0.02 W/sq. ft. of buildings area ~ 4,494 Watts
Miscellaneous Loads	• Receptacles plug load per ASHRAE 90.1 space-by-space method • Living Units 0.5 W/sq. ft. • Overall building 0.45 W/sq. ft. • Four Elevators 20kW each
HVAC Systems	• Residential Spaces • VRF system with heat recovery for heating [COP 3.2] and cooling [COP 3.5] • VRF DOAS Unit cooling [COP 3.5], heating [COP 3.2], ERV 50% sensible, 50% latent effectiveness • Commercial/Common Spaces • VRF system with heat recovery for heating [COP 3.2] and cooling [COP 3.5] • VRF DOAS Unit cooling [COP 3.5], heating [COP 3.2], ERV 50% sensible, 50% latent effectiveness • Back of house spaces heating only with electrical resistance [100% Eff.] • Unconditioned parking garage

A.2 Energy Model Assumptions Building 2B

Envelope	• Roof assembly U- 0.032 • External Wall Steel Assembly U- 0.057 • Residential Window Assembly U-0.270; SHGC=0.280 • Commercial Window Assembly U-0.350; SHGC=0.330 • Glazed Door Assembly U-0.680; SHGC=0.360 • Opaque Door U-0.500 • Ground floor unheated U= F (0.52) • Window to wall area ratio 25.6%
Occupancy	• ASHRAE 90.1 space-by-space method
Interior Lighting Power Density	• Living Units 0.70 W/sq. ft. • Conference/Meeting/Multipurpose 1.23 W/sq. ft. • Corridor/Transition 0.36 W/sq. ft. • Electrical/Mechanical 0.25 W/sq. ft. • Gym-Exercise Area 0.62 W/sq. ft. • Laundry 0.48 W/sq. ft. • Lobby 0.41 W/sq. ft. • Locker Room 0.75 W/sq. ft. • Office Enclosed 0.48 W/sq. ft. • Parking 0.19 W/sq. ft. • Restroom 0.25 W/sq. ft. • Stairs 0.26 W/sq. ft. • Storage 0.63 W/sq. ft. • Workshop 1.59 W/sq. ft.
Exterior Lighting	• Estimated exterior lighting 0.02 W/sq. ft. of buildings area ~ 3,609 Watts
Miscellaneous Loads	• Receptacles plug load per ASHRAE 90.1 space-by-space method • Living Units 0.5 W/sq. ft. • Overall Building 0.45 W/sq. ft. • Four Elevators 20kW each
HVAC Systems	• Residential Spaces • VRF system with heat recovery for heating [COP 3.2] and cooling [COP 3.5] • VRF DOAS Unit cooling [COP 3.5], heating [COP 3.2], ERV 50% sensible, 50% latent effectiveness • Commercial/Common Spaces • VRF system with heat recovery for heating [COP 3.2] and cooling [COP 3.5] • VRF DOAS Unit cooling [COP 3.5], heating [COP 3.2], ERV 50% sensible, 50% latent effectiveness • Back of house spaces heating only with electrical resistance [100% Eff.] • Unconditioned parking garage

A.3 Energy Model Assumptions Building 3

Building 3 was modelled based on Building 2A assumptions.

Appendix B. Regulatory Roadmap

B.1 Applicable Laws and Regulations

Laws and regulations are organized in federal, State, and local law sections; however, administration of laws is often shared at multiple levels of government and primary responsibility delegated to lower levels of government. Accordingly, laws appear in this section based on the primary level of administration.

B.1.1 Federal

Based on the information provided, this project does not trigger federal jurisdiction over permitting and approvals. Any federal laws applicable to the project would be administered by delegation through New York State agencies and are described in the State law section.

B.1.2 State

B.1.2.1 State Pollutant Discharge Elimination System Permit

The federal Clean Water Act establishes a permitting scheme that regulates the discharge of pollutants into the United States waters and quality standards for surface waters, known as the National Pollution Discharge Elimination System (NPDES) permit program.[11] NPDES requires all facilities that discharge pollutants, which includes heat, into surface water from a point source to obtain a permit before discharging.[12] A NPDES permit incorporates both water quality standards and technology-based effluent limitations to protect water quality.

The Clean Water Act authorizes the approval of State programs in lieu of federal administration and specifies the underlying authorities that states possess in regulating water pollution under the Clean Water Act. These include the authority to issue pollution discharge permits in conformance with or stricter than federal requirements.[13] Accordingly, New York State's water quality requirements contain additional requirements, including defining pollutant to include all thermal discharges—encompassing both heating and cooling discharges.

Pursuant to the Clean Water Act, water quality standards and water quality criteria for covered navigable waters regulate based on use.[14] Additionally, EPA regulations implementing the Clean Water Act's requirements to "maintain" the chemical, physical, and biological integrity of the nation's waters requires States to include in their water quality standards an antidegradation policy.[15] Accordingly, all

NPDES/ State Pollutant Discharge Elimination System (SPDES) permits must include effluent limitations that restrict the quantity, quality, rates, and concentration of chemical, physical, biological, and other constituents of effluents which are discharged.[16] These effluent limitations are based either upon available technology, as prescribed by the EPA, or State water quality standards, whichever is stricter.[17]

The New York Department of Environmental Conservation (NYSDEC), which administers the State's environmental laws, is responsible for promulgating water quality standards and issuing SPDES permits in New York State. Notably, the State law is stricter than the federal NPDES program and requires a SPDES Permit for point source discharges of pollutants into all waters of the State.[18] Generally, SPDES permitting requirements are triggered by a "discharge" of "pollutants" from a "point source" into receiving waters of the State, encompassing both surface waters and ground water.

New York State's water quality standards establish classifications and designated uses for all waters in the State including groundwater and surface water.[19] The State's classification differentiates between surface and ground water and between fresh and saline waters. NYSDEC regulations also contain general conditions applying to all water classifications including criteria governing thermal discharges. Thermal discharges are defined as "a discharge that results or would result in a temperature change of the receiving water."[20]

The requirement of a SPDES permit will depend on whether the geothermal system discharges to groundwater or surface water, the classification of the receiving water body and whether the system discharges heat or some type of water or heat treatment chemicals.[21] However, all systems are subject to best use criterion established for every water body in the State,[22] and as such, a review by NYSDEC is required to determine whether a particular system requires a SPDES permit.

Generally, geothermal systems that discharge heat, cooling, or any water treatment chemicals into surface or ground waters of the State must obtain a SPDES permit. While this is typically more applicable to open-loop systems, all systems, including the closed-loop, are subject to New York State's water quality standards and best use criterion set forth at 6 NYCRR Parts 649-758, including criteria for thermal discharges.[23] Accordingly, a review by NYSDEC is required to determine whether a particular system requires a SPDES permit.

SPDES Permits require temperature monitoring and reporting and may limit how much heat may be discharged from the system depending on the receiving waterbody's classification.

Additionally, NYSDEC's Division of Fish and Wildlife requires that the location, design, construction, and capacity of cooling and water intake structures that result in thermal discharges be equipped with best technology available (BTA) to minimize adverse environmental impacts, such as harming fish on the intake screen and the entrainment of eggs through the cooling system.

At the time of application, the division may impose additional conditions appropriate to the system, which may require the applicant to provide biological information on the water body and an analysis of available technology or operational measures that can be employed to minimize any potential impingement and entrainment. The BTA required for compliance will vary depending on the system and the water body classification. The division will consider applicable costs when making this determination.

There are presently no surface waters on site. However, pursuant NYSDEC regulations, there is a presumption that discharges to the ground will result in discharges to groundwater.[24] Accordingly, because groundwater is present on-site, review by NYSDEC is required to ensure that the system will not violate applicable State water quality standards for groundwater and NYSDEC's thermal discharge criteria.

Additionally, section 402 of the CWA requires permits for stormwater discharges from construction activities, which would include geothermal drilling operations, that disturb one or more acres of land. In New York State, a SPDES General Permit for Stormwater Discharges from Construction activity is required for construction activities involving soil disturbances of one or more acres based on a common plan, and soil disturbances of less than one acre that could potentially contribute to a violation of a water quality standard or pollutants to surface.[25] To qualify for the permit, permit applicants are required to develop a Stormwater Pollution Prevent Plan (SWPPP) in accordance with the requirements in the General Permit to prevent discharges of construction-related pollutants to surface waters. [26]

B.1.2.2 State Environmental Quality Review Act

New York's State Environmental Quality Review Act (SEQRA) requires State and local agencies to consider environmental factors in the planning, review, and decision-making processes regarding permits, zoning changes, or government funding. SEQRA review is triggered by State projects that require some form of discretionary State or local government approval.[27]

The SEQRA review process requires agencies to determine whether actions they directly undertake, fund, or approve may have a "significant impact" on the environment ("a determination of significance"), and if so, to prepare, or require to be prepared, an Environmental Impact Statement (EIS) that assesses the potential impacts of the proposed actions, as well as ways to avoid or mitigate those impacts.[28] The lead agency responsible for authorizing the project issues a "negative declaration" if it determines that the proposed action will not result in a significant environmental impact. This ends the SEQRA review process and can result in subsequent litigation brought by project opponents.[29] A positive declaration triggers the procedural mandates that lead to the preparation of a Final Environmental Impact Statement (EIS), which will be the basis of the final decision to fund or approve the project.[30]

An action is subject to review under SEQRA if any State or local agency has authority to issue a discretionary permit, license, or other type of approval for that action, as well as if an agency funds or directly undertakes a project. Consequently, any State or local approvals such as issuing a permit, will trigger the provisions of SEQRA. Additionally, any funding by NYSERDA for subsequent phases of the project would likely constitute an agency action subject to SEQRA.

Once there is an "agency action" the agency must determine whether the action is subject to SEQRA. Type II actions, which are actions for which it has been determined not to have a significant effect on the environment, are not subject to the SEQRA review process.[31] However, if the action does not fall within one of these exclusionary categories, then it is subject to SEQRA and the agency will need to determine whether it is a Type I action or an unlisted action, which will trigger different procedural requirements.

To reach a determination of significance, the agency must prepare an Environmental Assessment Form (EAF) (either a short EAF or full EAF, depending on the action).

The short form EAF, which is used for unlisted actions deemed to have a significant effect, requires the lead agency to consider whether the proposed action would cause "an increase in the use of energy" and whether it "fails to incorporate reasonably available energy conservation or renewable energy opportunities."[32] The Full EAF also requires applicants for commercial and industrial projects to provide information about the proposed action's new or additional demand for energy, including information about the anticipated sources of energy.[33]

If the agency issues a positive declaration, the preparation of an EIS is required, which involves the preparation of a Draft Environmental Impact Statement (DEIS) that is then circulated for public review and comment.[34] In addition to "analyzing the significant adverse impacts and evaluating all reasonable alternatives," the DEIS should include an "assessment of impacts only where relevant and significant" including "impacts of the proposed action on the use and conservation of energy" and "measures to avoid or reduce both an action's impacts on climate change and associated impacts due to the effects of climate change…"[35]

B.1.2.3 Office of Renewable Energy Siting Approval

Geothermal systems equal to or greater than 25-MWth planned capacity are subject to the permitting requirements of the Office of Renewable Energy Siting (ORES).[36] A 25-MWth equivalent geothermal system would support a small community of approximately 2,000 homes.[37] ORES regulations provide for an application process similar to Article 10 of the Public Service Law for siting major electric generating facilities, as well as uniform standards and conditions for all proposed projects. Applicants are required to work with municipal authorities in which the proposed facility is to be located, obtain several environmental approvals from ORES prior to applying, and file an application including exhibits addressing areas of impacts on land use, public health, safety and security, noise and vibration, cultural resources, endangered and threatened species, visual impacts, water quality, and wetlands. Applications are also subject to a comment period and public hearing procedures.

Under Section 94-C governing ORES decisions, the siting agency has 60 days to review an application and determine whether it complies with applicable requirements.

To determine that an application is complete, the record must contain proof the applicant consulted with the host municipalities and communities. Applicants are required to work with host municipalities in which the proposed facility is to be located, obtain several environmental approvals from ORES prior to applying, and file an application including exhibits addressing areas of impacts on land use, public health, safety and security, noise and vibration, cultural resources, endangered and threatened species, visual impacts, water quality, and wetlands.

During the Section 94-C comment period, the host municipality is to file a statement "indicating whether the proposed facility is designed to be sited, constructed and operated in compliance with applicable local laws and regulations, if any, concerning the environment, or public health and safety."[38] Following the public comment period, the agency may set the matter for an adjudicatory hearing to hear arguments or to rule on the application.

Under Section 94-C, ORES is required to issue a permit within 12 months of the application deemed complete. ORES may issue a permit only if it finds that any significant adverse environmental impacts have been avoided or minimized, that a review of applicable local zoning laws has been completed, and that the application complies with applicable laws and regulations. Under Section 94-C, in making its determination of compliance, ORES may elect to not apply local law and ordinances in favor of a uniform set of standards and conditions set out in the Regulations Implementing Section 94-C. However, the present regulations do not provide specific guidelines for geothermal energy systems.

B.1.2.4 Drilling Permits

New York State imposes different requirements for geothermal wells drilled less than 500 feet and wells over 500 feet, based on permitting regimes that were designed for non-geothermal systems, but adapted for these purposes.

Wells that are less than 500 feet deep are regulated by the NYSDEC Division of Water. The Division of Water requires the submission of driller and pump installer registration and certification, and preliminary notice and well completion reports for open loop or standing column systems.[39] Completion reports are waived for closed loop geothermal systems with boreholes drilled up to 500 feet deep.[40]

The NYSDEC Division of Mineral Resources regulates the drilling, construction, operation, and plugging of geothermal wells deeper than 500 feet.[41] Wells deeper than 500 feet impose additional requirements, which are set out in the table below. Among these requirements, detailed information regarding well locations, depth, use, casing material, cementing procedures, drilling fluid, and cutting disposal methods, as well as completion of an Environmental Assessment Form, which will be used by the NYSDEC to evaluate the environmental impacts of the well, and to decide whether any "special permit conditions, a Supplemental Environmental Impact State, or any additional NYSDEC permits are required."[42] NYSDEC also imposes reporting requirements throughout the permitting and drilling process, and a separate permit must be obtained before a well may be permanently plugged and abandoned by the well owner.[43]

Importantly, prior to obtaining a well drilling permit for a well that may produce brine, saltwater, or other polluting fluids in sufficient quantities to harm the surrounding environment, the well owner must obtain a permit for the safe and proper disposal of such produced fluids.[44] Depending on the applicable method of disposal, NYSDEC may require the well owner to obtain additional permits for discharge and/or disposal.

NYSDEC also mandates minimum standards for all wells pursuant to the division's Casing and Cementing Practices to protect groundwater by preventing the migration of fluids.[45] However, NYSDEC imposes stricter permitting conditions for wells that will be drilled through primary and principal aquifers, as well as for wells where subsurface conditions are unknown or where high pressures are expected.[46]

The Division of Mineral Resources will also consult with the New York State's State Historic Preservation Office (SHPO) within the New York State Office of Parks, Recreation, and Historic Preservation to determine whether the proposed location of a well is within a State-listed historic area, which would require additional permissions.[47] If applicable, SHPO will review the project and ensure the well will not negatively impact cultural resources.[48] The permit application process takes approximately six to eight weeks, but may take longer depending on the project. Additionally, filing fees for the application materials vary depending on the depth of the well.[49] Drilling permit requirements and restrictions under both regimes are summarized in the table below.

B.1.2.5 Requirements for Closed Ground Source Loops

Table B-1. Permitting Summary for Borehole Drilling

Under 500 Feet	500+ Feet
Driller and pump installer certification and registration.	Organizational Report (Form 85-15-12).
Municipalities may impose additional requirements.	Application for permit to drill well (Form 85-12-5).
	Environmental Assessment (Form 85-16-5).
	Financial Security Worksheet and deposit of required financial security starting at $2,500 per well over 500 feet.
	Certified site plan.
	Casing and cementing plan.
	Drilling progress reports.
	Periodic drilling drift correction.
	Well drilling and completion report (Form 85-15-7).
	Annual reports of status and use of well.
	Incident reports of leakage or condition posing risk to environment or the health, safety, welfare, or property of any person.
	Permit to plug and abandon.

* Well Owner and Applicants Information Center, NYSDEC, available at https://www.dec.ny.gov/energy/1522.html (accessed March 6, 2021); Well Operator Responsibility, NYSDEC, available at https://www.dec.ny.gov/energy/1639.html (accessed March 6, 2021); Ground Source Heat Pump Drilling Regulations Discussion, Presentation by NY-GEO (November 12, 2020).

B.1.2.6 New York State Historic Preservation Act

New York's State Historic Preservation Office (SHPO) within the New York State Office of Parks, Recreation and Historic Preservation helps communities identify, evaluate, preserve, and revitalize their historic, archeological, and cultural resources. SHPO administers programs authorized by both the National Historic Preservation Act of 1966 and the New York State Historic Preservation Act of 1980. These programs, including the Statewide Historic Resources Survey, the New York State and National Registers of Historic Places, the federal historic rehabilitation tax credit, the Certified Local Government program, the State historic preservation grants program, State and federal environmental review, and a wide range of technical assistance, are provided through a network of teams assigned to territories across the State.

In carrying out these responsibilities, SHPO conducts project review, specifies conditions for modification of sites subject to their jurisdiction, and approves or assists other agencies in approving plans for modifications to historic sites. Project sponsors are required, to the fullest extent practicable consistent with other provisions of the law, avoid or mitigate adverse impacts to such properties, to fully explore all feasible and prudent alternatives, and give due consideration to feasible and prudent plans that will avoid or mitigate adverse impacts.[50] Accordingly, geothermal elements be designed and constructed, including drilling, to avoid impacting historic features.

The Peninsula site is adjacent to the "Corpus Christi Monastery" which is eligible for listing on the National Register of Historic Places. Additionally, according to the OPRHP's Cultural Resource Information System, portions of the site are located in "archeologically sensitive areas," which are buffer areas that are a specified distance around archaeological sites that SHPO has inventories. Consequently, consultation with OPRHP may be required.

B.1.2.7 Uniform Heat Standards for Multi-Unit Residential Buildings

New York State establishes statewide standards for the provision of heat in multi-unit buildings. Heating facilities must be capable of maintaining a temperature of 68 degrees F.

Heat must be supplied from October 1 through May 31 to tenants in multiple dwellings. If the outdoor temperature falls below 55°F between the hours of 6:00 a.m. to 10:00 p.m., each apartment must be heated to a temperature of at least 68°F. If the outdoor temperature falls below 40°F between the hours of 6:00 a.m. to 10:00 p.m., each apartment must be heated to a temperature of at least 55°F.[51]

B.1.2.8 Utilities Regulation

New York State's Public Service Law governs utilities and delegates the regulation of utilities to the New York Public Service Commission. The scope of the Public Service Law covers electricity, natural gas, water, and telecommunications, but does not cover geothermal or the provision of heat generally.[52] As a result, utilities are presently not permitted to own or operate geothermal assets. Also, because geothermal falls outside the scope of the law, private providers of heat services are not presently regulated under the Public Service Law.

Beyond the omission of geothermal from the Public Service Law, common law principles suggest that geothermal heat services provided on a competitive basis by a company that does not possess a monopoly or otherwise exert market power would not be deemed a utility or regulated as a utility. The historical genesis of utility regulation is rooted in concerns over market power during the early 1900s as a variant of anti-trust legislation. The modern approach to defining a utility for purposes of determining whether an energy provider is deemed and regulated as a utility has been refined by the courts deciding whether third party power providers entering into power purchase agreements with energy users, a situation analogous to the provision of geothermal services. Multiple factors are considered in determining whether the activity constitutes provision of utility services:

- The nature of the transaction and relationship between the parties, in particular whether it is an arm's length transaction between willing buyer and willing seller.
- Whether the services are for the public or private use, determined in part by whether the provision of energy is in front or behind the meter.
- Whether the service provided is an indispensable service that generally requires public regulation; if the service is structured so that the end user has alternative grid-supplied options in addition to the service, it may be deemed non-essential or not requiring regulation.
- The presence of market power or monopoly.
- Ability to serve all members of the public.
- Ability to discriminate against members of the public.
- Actual or potential competition with other entities that are regulated in the public interest.[53]

Although no single factor is determinative, if a geothermal provider contracts on a one-to-one basis with a building or commercial user, and the building retains backup utility service for heating as an alternative option, it is unlikely that such an arrangement would be deemed as requiring regulation as a utility under common law principles.

B.1.2.9 Home Energy Fair Practices Act and Submetering Regulations for Electric Heat

Notwithstanding providing geothermal services may not be regulated as a utility, a building or service provider that provides electricity and/or electric heat to residents on a submeter basis must comply with the Home Energy Fair Practices Act (HEFPA) part of the Public Service Law §§30-53, and the Department of Public Service Residential Electrical Submetering regulations,[54] pursuant to the New York Public Service Law.[55] Importantly, for purposes of submetering, electric heat services include heat services provided by electric heat pumps.[56]

HEFPA and its regulations subject covered parties to the same standards as utilities for consumer initiation and termination of service, billing and deposits, disputes over service and charges, and standards for quality of service. The submetering regulations further require that buildings apply to the New York Public Service Commission for permission to submeter, which approval may be conditioned upon requirements set by the Commission. These conditions include rate caps, and violation of Commission conditions or failure to adhere to regulations can result in reductions in rate caps,[57] sanctions and termination of authority to submeter. [58]

For existing buildings that seek to convert from a master meter to a submeter, in order to approve the application, the Commission must make a positive determination that the proposed submetering is in the public interest and consistent with the provision of safe and adequate electric service to residents.[59] This requirement applies to rental buildings, condominiums, and cooperative buildings.

For conversion of rental buildings, the application requires notice to all residents, publication for public comment, and the Commission may consider all supplemental information submitted, including public comments.[60] Conversion of an existing building is therefore a far more cumbersome process involving actual tenants with pre-existing contractual and statutory rights that must be adjusted if submetering is to be permitted.

For buildings that are mixed rental and condominium, such as where sponsors retain ownership of certain units that are rentals, the regulations do not specify which regime is followed. The answer should follow whether the sponsor remains obligated to pay the submeter bill under the lease, or whether that can be passed to tenants. Contract, landlord-tenant, rent control, and other laws would be relevant to what would be permissible.

Applications for submetering must include a plan for complying with HEFPA, demonstration that submetering will comply with equipment, energy efficiency, income-based housing assistance, rate cap, and other requirements.[61]

The process is complex, requires months to complete, and the public interest finding is a relatively high standard to meet. However, submetering that supports meeting State and local climate targets by enabling geothermal technologies could be deemed to be in the public interest, provided all other requirements are also satisfied.

B.1.2.10 Non-Electric Heat and Cooling

While HEFPA regulates electric heat submeters, non-electric heat and cooling fall outside of HEFPA and the submetering regulations. The absence of a specific regulatory regime means other non-energy regimes at the State and local level may set default rules without providing a clear path toward submetering residential units for these services. As described in the following section, these include municipal landlord-tenant laws.

Non-electric heating is allocated as a responsibility of the landlord in State and municipal law and leases, whereas cooling generally is omitted from both. This may enable bifurcated business models that more easily support cooling as a service to be offered, the provision of electric heat under HEFPA, but non-electric heat facing barriers under local law.

Proposals to submeter geothermal will likely require the submetering regulations for electricity and electric heat be adapted to incorporate geothermal or new regulations developed for geothermal.

B.1.2.11 Other Consumer/Tenant Protection Laws

Regardless of whether heat services are billed as electric heat or therms, contract law, consumer protection laws, tort laws, and other laws and regulation governing the marketing of heat services would apply.

In the context of building contracting geothermal heat services and on-selling them to tenants, local landlord-tenant laws would apply to protect tenant-consumers, which would necessarily expand the range of regulatory stakeholders to include municipal regulatory authorities regulating buildings and protecting tenants. Thus, New York State's Division of Homes and Community Renewal, as well as municipal tenant advocates could become actively involved, including the NYC Department of Housing Preservation and Development and NYCHA. Other non-government tenancy advocacy groups will also likely become active to influence government decision making processes.

The New York State construction code requires buildings to provide a means to heat residential units, but does not allocate in the specific responsibility for the cost of operation of those units or fuel:

> §27-740 Heating requirements. All habitable or occupiable rooms or spaces, and all other rooms or spaces … shall be provided with means of heating in accordance with the requirements of this subchapter and reference standard RS 12-1….[62]

As noted in the prior section, in the absence of a regulatory regime like HEFPA for non-electric heating, municipal landlord tenant laws may allocate the responsibility for heating to landlords. Similarly, for existing buildings, incumbent leases will allocate the responsibility to landlords.

Assuming a building provider is permitted to separately provide and bill for heat, failure to provide adequate heat according to standards set in municipal regulations protecting tenants could result in violations and penalties under these laws. In turn, this could trigger contractual violations between the building owner and a third-party heat provider.

B.1.2.12 Affordable Housing

If a multi-unit residential building is deemed affordable housing, New York State and local municipal regulations set maximum amounts that can be charged to residential tenants. In determining housing affordability, all housing costs must be included in the calculation. In rental units, housing costs include rent and any tenant paid utilities. In ownership units, costs include the mortgage payment (principal and interest), property taxes and homeowner insurance, and any common charges or homeowners association fees for condominiums or cooperatives.

The U.S. Department of Housing and Urban Development (HUD) sets income limits annually for a variety of housing programs known as the Area Median Income (AMI) for each Metropolitan Statistical Area (MSA). MSAs are typically large cities or counties. NYC Department of Housing Preservation and Development and NYCHA, which finance housing and administer their own affordability programs, uses the AMI standard to set eligibility requirements for its funding programs for both rental and ownership housing. Affordability is broadly defined as a household paying no more than 30% of their monthly gross income towards their housing costs. The number of persons in the household determines the specific amount that may be charged for housing costs to stay within the affordability thresholds.

In addition, HUD annually publishes HOME Program Rent Limits for each MSA based on affordability for households with incomes at or below 50% AMI or up to 60% AMI.

For rental units, because both rent and utilities are included in the calculation, an arrangement between a building owner and third-party heat providers must be governed by contractual arrangements to ensure that affordability compliance thresholds are met.

B.1.3 Local

New York City has not developed permitting guidelines for geothermal systems, however various local laws and regulations could apply to the geothermal aspects of the project.

B.1.3.1 Building Code and Permitting

The building permitting process reviews mechanical and construction approvals. Although no specific requirements for geothermal systems are provided by regulation, the geothermal elements will be reviewed for mechanical, structural, and other standard requirements.

B.1.3.2 City Environmental Quality Review

As authorized by New York State's SEQRA, New York City formulated a separate "City Environmental Quality Review" (CEQR) process by which city agencies may disclose and review the potential environmental effects of discretionary actions which impact the urban environment in particular.[63] CEQR adapts the SEQRA review process to the urban setting and is required when a proposed discretionary action will be approved, funded, or undertaken by a city agency and will take place in New York City.[64] Similarly to SEQRA, CEQR requires agencies to study the environmental consequences of their actions and to take all feasible measures to avoid, minimize, and mitigate damage to the environment.[65] Some of the primary practical differences between CEQR and SEQRA are that CEQR provides guidance on selection of a lead agency, adds public scoping requirements, uses City-created forms for assessments, and promotes the use of the City's detailed CEQR Technical Manual in conducting environmental reviews.[66]

B.1.3.3 New York City Department of Environmental Protection—Proximity to Water Tunnels

Prior to drilling geothermal boreholes, NYC Department of Environmental Protection requires a letter addressed to the Bureau of Water and Sewer Operations stating their depth and use, and a map showing their locations. NYC Department of Environmental Protection will issue a letter stating if wells are located within 500 feet of a city water tunnel or associated structure and, if drift monitoring and reporting are required.

The locations of subsurface water infrastructure should be checked for all boroughs with the Bureau of Water and Sewer Operations.[67]

This process should require approximately four weeks to complete in most cases.

B.1.3.4 Landmark Preservation Commission

The New York City Landmarks Law establishes Landmark Preservation Commission (LPC) and grants it the authority to designate City Landmarks, Interior Landmarks, Scenic Landmarks, and Historic Districts and to regulate any construction, reconstruction, alteration or demolition of such landmarks and Districts.[68] In addition, LPC maintains records of known archaeological sites and areas that are considered likely to contain archaeological resources. Under the Landmarks Law, no new construction, alteration, reconstruction, or demolition can take place on Landmarks, Landmark sites, or within designated
New York City Historic Districts until the LPC has issued a Certificate of no Effect on protected architectural features, Certificate of Appropriateness, or Permit of Minor work.[69]

If a project is within a known archaeological site or sensitive area, it is an indication that the site itself may also contain such resources.[70] According to New York State's Cultural Resource Information System, portions of the Peninsula are within an archeologically sensitive area. Accordingly, the NYC Planning Commission should be consulted to determine whether further investigation is required to ascertain whether there are archaeological resources on site, and whether subsequent evaluation of potential impacts and mitigation measures are required.[71]

B.1.3.5 New York City Department of Transportation—Streets/Sidewalks

If any part of the geothermal system is installed under a City street or sidewalk, the building owner must enter into a revocable consent agreement with the New York City Department of Transportation Bureau of Franchises.[72] A revocable consent is the grant of right to an individual or organization to construct and maintain certain structures on, over, or under the inalienable property (streets and sidewalks) of the City.[73] Generally revocable consents are granted for a term of ten years but may be renewed. However, the City retains the right to revoke consent at any time.[74]

Obtaining a revocable consent agreement can take up to 6 months, 75 and can cost $100–$750 in filing fees and additional costs as high as $1,200 for NYCDOT to publish notice of public hearing as part of the consideration process.[76]

Additionally, if construction of the geothermal system requires use of adjoining sidewalks or streets as a work area for equipment and material storage, a permit may be required from the NYCDOT Office of Construction Mitigation and Coordination.[77] Three categories of construction-related permits for work on a sidewalk/street may be potentially relevant:

- Street opening permits apply to openings/excavations or other work in a street that may cause damage to the street surface.[78]
- Building operations/construction activity permits apply to construction related activity that takes place within and adjacent to the street, such as placement of materials, equipment and temporary structures on the street or sidewalk, or movement of construction equipment across roadways and sidewalks.[79]
- Sidewalk construction permit applies to any repairs, replacements, or new sidewalk installations.[80]

There is one permit application form for all three permits. Permit applications can be submitted through the NYC Streets Permit Management System and require about four weeks.[81]

All permits that are required by other state and federal agencies must be in place before the NYCDOT issues a permit.[82]

B.1.3.6 New York City Office of Parks and Recreation

NYC Department of Parks and Recreation (NYC Parks) requires a permit for any construction work that affects assets under the jurisdiction or control of NYC parks, which may include natural areas, adjacent sidewalks and roadways, monuments, and concessions.[83] Project proponents must first submit the scope and design of the project for approval, and a subsequent construction permit upon approval from NYC Parks.[84]

The permit can only be issued for a limited amount of time (usually for the duration of construction), which in most cases cannot exceed two years, and the area must be restored to NYC Parks' satisfaction at the conclusion of the construction period.[85] Additionally, if construction may affect any tree under Parks jurisdiction, a tree work permit must be obtained by NYC Parks before issuing a construction permit.[86]

Generally, it takes NYC Parks up to six weeks upon receipt of a complete permit application to review a permit.[87]

B.1.3.7 Metropolitan Transportation Authority Approvals

The Metropolitan Transportation Authority, which includes the New York City Transit Authority, the Long Island Rail Road and Metro North, and the Port Authority of New York and New Jersey, must be informed of planned drilling/excavation located within 200 feet from their transportation structures, including tunnels, substations, ventilation buildings and stations.[88] If approval is required, the owner and drilling firm may also have to procure additional insurance coverage and vibration monitoring may be required depending on the proximity to the site.[89]

Applications are submitted to MTA, and require:

- Site plan showing the proposed drilling locations in relation to transportation structures.
- Review to verify the transportation structures' location.

Plan review and approval, or finding of no impact, is conducted through the MTA's External Partner Program. The program will coordinate with developers and engineers if necessary to modify design to protect MTA infrastructure.[90]

New York City Noise Code - Construction Noise Mitigation Plan

NYC Department of Environmental Protection regulates construction noise that may be triggered by drilling activities that create noise, vibrations, or dust. A construction noise mitigation plan may be required as part of the application to the NYC Department of Buildings for a construction permit. Operation outside the hours of 7:00 a.m. to 6:00 p.m. requires a variance. Copies of the plans must also be available on site for inspection.[91]

B.1.3.8 Groundwater Discharge Permits

The NYC Department of Environmental Protection issues permits for the temporary disposal of drilling fluids and ground water to the City sewers generated during drilling/construction.[92]

For discharges of 10,000 gallons of groundwater per day or less, a Self-Certification form must be submitted to the Bureau of Customer Services.[93] If the discharge exceeds 10,000 gallons of groundwater per day into a public sewer, a groundwater discharge permit from the Department's Bureau of Customer Services is required. Prior approvals from the Bureau of Water and Sewer Operations and Bureau of

Wastewater Treatment are also required.[94] Bureau of Wastewater Treatment will review the water quality of the proposed discharge to determine if pre-treatment is necessary and Bureau of Water and Sewer Operations reviews the proposed water quantity discharge to ensure that the local sewer mains have the capacity to handle the discharge.[95]

Discharges to storm sewers must be approved by NYSDEC prior to applying for a discharge permit from the Bureau of Customer Services.[96]

Average approval time from the Bureau of Wastewater Treatment is two to four weeks, although approval from the Bureau of Water and Sewer Operations may take longer.

B.1.3.10 Drilling and Excavation Permit

No person may drill or excavate in a corridor within the City of New York, to a depth greater than 50 feet below ground surface in the borough of the Bronx or on or north of 135th Street in the borough of Manhattan; or greater than 100 feet in the borough of Brooklyn, Queens or Staten Island or south of 135th Street in the borough of Manhattan or to any depth within 200 feet horizontal distance of a water tunnel shaft, without obtaining a permit from the department.[97]

Drilling beyond these depths require submission of a pre-application for proposed drilling and/or excavation to NYC Department of Environmental Protection Bureau of Water and Sewer Operations.[98] Within 10 days from receipt of a pre-application assessment submission, the Department will notify the applicant as to whether the proposed drilling and/or excavation requires a permit or is located in a No Drilling/Excavation Zone.[99] If the proposed drilling and/or excavation is located in a corridor, defined as "a block that has any part of its boundary falling within five hundred feet horizontal distance from any centerline of any water tunnel or shaft as measure at or near the surface," a permit from the NYC Department of Environmental Protection Bureau of Water and Sewer Operations permitting office is required.[100]

For drilling/excavation located in a corridor, NYC Department of Environmental Protection will issue a permit within 30 days from receipt of an application and processing fee if it determines that the drilling and/or excavation will not impair the stability of a water tunnel or shaft and complies with all other applicable standards and requirements.[101] NYC Department of Environmental Protection will not issue a permit for drilling/ excavation in a No Drilling and/or Excavation zone, Permits are not required if the drilling/excavation will not take place in a corridor.[102]

B.1.3.11 Use of Sewer System as Thermal Source/Sink

A variation of the geothermal system design proposes to exploit the project's sewage stream as a source and sink for heat. The proposed system would divert sewage through a bypass pipe that is coupled with a heat exchange unit. Sewage would return to the main line and travel outward to the edge of the property where it passes to the municipal sewage lines.

NYC Department of Environmental Protection administers the sewer regulations.

Based on the proposed system, we assume the following:

- The system would be entirely closed without possible discharge into the environment.
- The sewage stream would not be changed by addition or removal of any of its original components, including changes in bio-chemical oxygen demand (BOD), total suspended solids (TSS), pH, fecal or total coliform bacteria, phosphate and phosphorus compounds, fats, oils, and greases of animal or vegetable origin, and the sewage stream would conform to these requirements.
- The only change in the diverted and return sewage stream would be changes in temperature.
- System cleaning and maintenance uses ordinary water and mild degreasing agents and would not introduce any substances that would be prohibited.
- System operation would not involve any significant additional water use.
- System operation would not change the concentration of viscosity of waste streams.
- System design and connections to the sewer system will confirm with all applicable codes, include NYSDEC regulations, for materials and system design of sewage systems.

Regulations for sewers are primarily municipal law governing sewer use, building and construction codes, which, where appropriate draw upon or be supplemented by county, NYSDEC, New York State Plumbing Codes, and US Environmental Protection Agency requirements.

B.1.3.12 Right of Way

If the sewage thermal exchange unit is entirely located on the project premises and serviced without going beyond the project premises, no easements or other property rights of way would be required for the thermal exchange unit, beyond those required for the conventional sewer system. By confining the thermal exchange system in this manner, the project confines the approval required to meet ordinary design and right of way requirements.

B.1.3.13 Sewer Connection Permit

New York City will require a sewer connection permit for the development to connect to the City sewer system, issued by the Bureau of Water and Sewer Operations. Additionally, a sewer certification is required for any new connection to a city sewer, a private sewer, a private drain, a septic system, or an approves outlet sewer certification may also be required for an alteration or renovation that increases the sanitary and/or storm flow generated on the site.[103] The purpose of a sewer availability certification is to verify the adequacy of the existing abutting sewer to receive site storm and sanity discharge from a development.[104]

Although the proposed geothermal system will not change flows to the city sewer, the installation of this equipment will require disclosure and may raise requests for further information that may delay the issuance of the sewer connection permit.

B.1.3.14 Temperature of Discharge

Municipal regulations specify a default range for the temperatures of outflow in the public sewer system, which can be varied by the sewer authority if such temperatures could harm the sewer system, treatment process, or otherwise have an adverse effect. Temperatures are regulated at the point of entering the municipal system pipes and at the sewage treatment plant.

According to New York City regulations:

- Sewage streams may not exceed 150 degrees Fahrenheit (150° F) (65° C).
- Sewage streams should be above freezing so as not to be ice.[105]
- New York City does not specify default temperatures for the temperature of streams at the point of reaching the treatment plant.

Together these requirements would confine the use of sewage streams as a heat source and sink to outflow that enters the public sewer within the range of above 0° C (32° F) and below (150° F) (65° C). The sewer authority may specify a narrower range of temperature as part of the review process.

B.1.3.15 System Construction

The construction of sewage systems must be built to contain waste and prevent it from polluting the environment. Accordingly, connections between the diversion and main line connected to the sewer must conform to regular NYSDEC requirements for sewer construction and be made watertight so that no leakage into or out of such connections will occur. New York City sewer construction requirements would apply to the heat exchange component of the project's proposed sewer system.[106]

The system design and materials will be reviewed as part of the ordinary permitting process. Although there are no specific geothermal requirements, lack of familiarity with these systems will potentially require additional time for review.

B.1.3.16 New York City Building Decarbonization Requirements

New York City's Local Law 97 of 2019 requires buildings over 25,000 square feet in ten categories of building classes to reduce greenhouse gas emissions by 40% by 2030, and 80% average reduction by 2050.

For multifamily housing, including cooperatives, condominiums, and rental buildings, the law sets some of the most stringent reduction requirements effective in 2024 with further reductions required in 2029, calculated on an emissions per square foot basis.

As a simple rule of thumb, residential buildings of 25–30 units or more will very likely trigger the 25,000 square feet threshold requirements. Group R-2 multifamily housing is subject to emissions caps of 0.00675 tCO2e per square foot from 2024–2029, and 0.00407 tCO2e per square foot from 2029–2034.[107]

Buildings failing to comply face penalties, unless they qualify for exception, and may be required to purchase carbon offsets in a yet to be established market at an uncertain price. Almost 26 thousand buildings in NYC are subject to the law.

Local Law 97 builds on prior New York City laws that require buildings to insulate pipes and install energy efficient lighting, and phase out dirtier forms of fuel oil, eventually eliminating all heavy fuel oils by 2030, requiring all new boiler or burner installations utilize natural gas, ultra-low sulfur 2 oil, biodiesel, or steam. Local Law 97's separate requirements effectively further require the phase out of natural gas or, at very least, penalizes its continued use.

The proposed geothermal system will help avoid or reduce penalties under Local Law 97.

B.1.4 Relevant Precedents

Saint Patrick's Cathedral in New York City installed a closed-loop geothermal system with boreholes deeper than 500 feet. This project has different characteristics than this project, however it is useful precedent for New York City that can be drawn upon with City officials and permitting authority.

B.2 Description of Regulatory Approach to Decentralized Building-Level Ground Source Heat Pump Systems with Isolated Loads

An alternative configuration of several smaller individual systems could simplify the common management of a shared loop system among separately owned buildings following development. Individual systems would obviate the need for shared operation and maintenance of a common system. However, provided the entire development has homogenous physical conditions, separate development, operation, and maintenance will necessarily involve duplication of effort and likely lower technology and institutional efficiencies, and thus higher costs.

Because common ownership at the time of development enables a common system management agreement to be adopted, common management can be achieved cost effectively. Under these circumstances, the next-best alternative of separate systems will likely achieve sub-optimal results compared to a district system.

The small footprint of the development relative to the heating/cooling load will constrain the number of boreholes. Exceeding 500 feet depth of boreholes would enhance the energy performance of the geothermal system but would impose significant regulatory costs to drill beyond the 500-foot regulatory threshold. Given the small project footprint, the regulatory burden might be worthwhile.

B.3 Authorities Having Jurisdiction

AHJ	Permit or Approval Required	Description	Estimated Time of Approval	Risks
Federal				
Housing and Urban Development	Regulation and potential enforcement	Compliance with affordable housing rules.	Follows State process unless complications.	Public complaint or lawsuit.
State				
NYSDEC Environmental Conservation	Permits and approvals	SPDES Permit for construction/drilling activities, potential drinking water pollution. Division of Water Approval or Division of Mineral Resource approves wells less than 500 feet or over 500 feet. NYSDEC requirements for sewer construction.	45 days for minor projects. 90 days for major projects. 150 days for major projects if public hearing required.	No significant risks.
State Historic Preservation Office	Approval	Protected historical or cultural resources.	Concurrent with SEQRA.	Design decisions.
NYSDOT Transportation	Road closure, Easement.	Approval to encroach upon or work in road or railroad track.	Weeks	No significant risks.
Office of Renewable Energy Siting	Approval for projects over 25 MWth.	ORES approval if geothermal system is greater or equal to 25 MWth.	Up to 12 months.	No significant risks provided consultation with City government and compliance with laws.
Public Service Commission	Home Energy Fair Practices Act (HEFPA) and submetering approvals.	Approval of submetering applications.	6 months to 1 year.	Pricing and ability to comply with submetering service requirements. Submetering regulations not designed for non-electric services.
Department of Public Service	Submetering and notices.	Approval of submetering under Residential Electrical Submetering Regulations, notice of historical artefacts on project site.	6 months to 1 year.	Pricing and ability to comply with submetering service requirements. Submetering regulations not designed for non-electric services.

Table B.3 continued

AHJ	Permit or Approval Required	Description	Estimated Time of Approval	Risks
New York State Homes and Community Renewal	Regulation	Provision and cost of heat, compliance with affordable housing rules.	None unless complaint.	Pricing and public opposition.
		Local		
NYC Department of Buildings	Building Permit	Geothermal reviewed in building or mechanical permit application.	Months	Design, communications.
NYC Department of Environmental Protection	Permits and approvals. Verification of underground water tunnels.	Must be notified of drilling (depth and use of the wells, and a map). Groundwater discharge permit for drilling fluids. Drilling and excavation permit for depths exceeding 50 ft. Connect to water or sewer systems–temperature control and impact on system operation. Verify location of underground water tunnels and other infrastructure with Bureau of Water and Sewer Operations in all boroughs.	Subsumed within local project permitting.	Design
NYC Department of Health	Approval	Impact on water and sewer system. Provision of heating services.	Subsumed within project permitting. None unless complaints.	Design Reliability of heating services.
NYC Department of Transportation	Revocable Consent/Permits. Road and sidewalk closures.	Revocable consent agreements for installations under sidewalks. Street/sidewalk permits for construction-related activity. Road closure, right of way to encroach or temporary work.	4 weeks	Design
NYC Department of Parks and Recreation	Permits	Construction permit for drilling in public park. Tree work permit for city-owned trees.	6 weeks	Design

Table B.3 continued

AHJ	Permit or Approval Required	Description	Estimated Time of Approval	Risks
NYC Landmark Preservation Commission	Consultation/potential investigation.	Possible presence of archaeological resources. Archaeological field testing/permits may be required.	10 days	Design
Metropolitan Transportation Authority	Notification/approval	Must approve drilling within 200 feet of a transportation structure.		Design
NYC Department of Housing Preservation and Development and NYCHA	Rent regulation and tenant rights enforcement.	Provision and cost of heat, compliance with affordable housing rules.	None unless opposition	Public opposition, compliance with regulations.
Courts	Adjudication	Landlord-tenant disputes over provision of heat and cost.	None unless opposition, then months to years.	Public opposition, force change of business model.

B.4 Non-Governmental Stakeholder Approvals or Consents

Stakeholder	Approval or Consent Required	Description	Estimated Time of Approval	Risks
Project Development Investors	Agreement by all investors to commonly managed elements of project.	Development is presently controlled by a single developer. Once subdivided, a common management agreement for the geothermal and other elements of the development among uniquely owned buildings would be necessary or desirable.	Months. Agreement should be developed once geothermal system and other infrastructure is finalized and prior to subdivision and accepting third party investors.	Acceptance of investors prior to resolution of common agreement presents several risks, including: Failure to disclose material terms resulting in investor liability. Incomplete agreement or delay in agreement could result in delay, cost and/or deadlock.
Electric and Gas Utility	Submetering	Coordinate submetering for electric heat under HEFPA	6 months to year	See NY Public Service Commission.
All Utilities Electricity Gas Water Sewer Cable Telephone	Right of Way Franchise.	Encroachment or access across utility infrastructure. Confirm no interference with utility franchise agreements. Agreement on compensation, maintenance, decommissioning, and liability.	Weeks to months.	Negotiations in absence of default regulations could require time to negotiation consent and agreement on liability and compensation.
Electrical Utility	Electric load.	Electrical approval and expansion to accommodate equipment like heat pumps and exchangers.	Weeks	No significant risks.
NGO/Community	Participation in public hearings and consultation.		Not quantifiable.	Public opposition.

B.5 Anticipated Challenges and Risks

B.5.1 Lack of Municipal Regulatory Regime for District Geothermal Systems

In New York State, few municipalities have developed permitting guidelines for geothermal systems, and no municipality has developed guidelines for multi-property district systems,

Without a permitting regime and standards for equipment, developers and municipal officials are left to navigate the various zoning, building, mechanical, environmental, and other regulations that may apply to geothermal systems but were not designed specifically for these systems.

This ad hoc approach in the absence of a dedicated geothermal permitting regime increases costs, uncertainty, and risks, and delays the approval process. For project designs in which multiple stakeholders—property owners, utilities, and government agencies—must consent or grant approval, lack of a permitting regime and standards risks the inability of stakeholders to reach decisions or consensus, resulting in deadlock and bureaucratic paralysis. Application of zoning and other regulations not designed for geothermal systems, such as setback requirements, may even block geothermal projects altogether in dense urban and peri-urban areas where small lot sizes are common.

To address this challenge, project developers should start educating municipal permitting authorities and elected officials about the benefits of the geothermal features of the project and the measures to mitigate any potential risks to the environment or other subsurface infrastructure as early as possible. This educational effort should commence as soon as the developer has approved a proposed geothermal design and the assessment of mitigation measures is completed. The project developer should also be prepared to engage with environmental and community groups interested in the project.

B.5.2 Rights-of-Way and Approvals

Developers must obtain either fee simple ownership or easements in order to drill and install a shared ground loop across multiple properties. Crossing property lines, streets, railroad tracks, existing utility infrastructure all will require the grant of an easement and approval by the owner or authority responsible for their operation.

The costs of acquiring rights of way can be expensive and time-consuming. Each utility that has installed infrastructure in the subsurface should be consulted as part of the approval process to ensure that proposed designs and implementation will not disturb their operations. To safely install geothermal piping in the subsurface without interfering with other utilities will likely require site visits to individual properties by these other utilities. The costs and risk of damage incurred by these utilities will likely generate resistance to granting their approval.

Granting easements over a property limits the property owner's ability to use its own property, and can adversely affect private property rights, or diminish private property values. Compensating the grant of an easement and its impact on the servient property can be difficult to value,[108] potentially resulting in deadlock in negotiations.

Without government intervention, geothermal developers must negotiate with property owners and affected utilities to grant approval, which may be conditioned upon agreement on compensation, maintenance, decommissioning, and indemnification for liability.

The costs of obtaining rights of way have been well documented for roads, pipelines,[109] telecommunications, railroads, subways and intracity surface rail, and other types of infrastructure that necessarily crosses property lines. These costs may include a one-time acquisition fee, annual fees, excessive or escalating fees,[110] and the time and cost of organizational staff and legal professionals to procure rights.

In New York State investor-owned electric and gas utilities resolve rights of way issues by entering into franchise agreements with municipalities.

B.5.3 Drilling Regulatory Restrictions

New York State imposes different requirements for geothermal wells drilled less than 500 feet and wells over 500 feet. Permitting requirements for wells over 500 feet in depth are considerably more rigorous and costly.

New York City further imposes additional restrictions at more shallow depths and within the vicinity of a water tunnel shaft, without obtaining permits.

The different permitting regimes effectively limit geothermal system design to shallower depths for many developers of residential and individual building systems. Consequently, more wells must be drilled than would be required if deeper wells were employed to support the same system capacity. The greater number of wells increases overall costs due to greater drilling time, materials requirements, particularly costly well casing, expanded site restoration area, and increased production of cuttings and water.

The decision whether to drill beyond the State's 500-foot depth threshold requires a benefit-cost analysis of the potential additional thermal capacity and more efficient use of limited land weighed against the costs of compliance with the regulatory regime.

The project developer has elected to limit drilling to 500 feet in order to avoid the significant costs of compliance with additional regulation, foregoing a more energy efficient design.

B.5.4 Business Model

Geothermal development can follow one or more of several business models that exhibit differing technical economies relative to transactional diseconomies. Utilizing the continuum of business models set out in the NYSERDA-sponsored Pace Energy and Climate Center Overcoming Legal and Regulatory Barriers to District Geothermal in New York State (2021), the present project is classified being developed based on a "Multiple Properties—Multiple Owners Under a Common Agreement" business model.

In this model, each building sits or will sit on its own individual property for tax purposes, each building is its own entity and operates independent of the others, but all buildings are roughly identical in nature (and energy use) and share common management bringing the geothermal system and other aspects of the development under common management.

Geothermal development following this model involves more complex property rights arrangements as a system will cross property boundaries and require cooperation across properties and organizations. A common agreement for maintenance, management, pricing, and financial and other responsibilities of the system, and a common management body such as an owner's association or similar entity would be needed to be established for this purpose and supported by association charges. However, because the developer is common to all phases of the development and controls all phases, these arrangements can be adopted prior to the subdivision and sale of equity in the separate phases.

B.5.5 Submetering and Tenant Billing

If the project plans to submeter heating services so that individual tenants control their usage and pay for their heat services on an individual basis, the developer or a third-party energy services provider must apply with the Public Service Commission for approval of submetering tenant units. Public Service Commission submetering regulations require compliance with metering, billing, dispute resolution and other requirements.

Obtaining submetering approval for a new development is far less complex a process than submetering a building with existing tenants. If submetering is introduced to an existing tenant relationship, this will require additional public hearing and amendment of leases.

Presently, New York State's submetering regulations apply to electricity and electric heating services. No regulatory arrangement exists for billing heating services in measured in thermal units.

Accordingly, to simplify submetering arrangements, the project should introduce submetering prior to entering into agreements with any prospective tenants and, preferably prior to advertising rental units. Further, the project should measure and bill heat services as electric heat following established guidelines to conform to the current regulations as closely as possible. If the project proposes to measure and bill services on a submeter basis, it should at the earliest possible time consult the New York Public Service Commission and the New York Department of Public Service for guidance as this request will raise novel issues likely requiring adaptation of existing rules.

B.6 Summary of Recommendations to Overcome

Certain challenges can be addressed through contractual arrangements between the developer and other stakeholders. Recommended contractual arrangements include:

- **Common Agreement Among Phases**. As the project is presently owned and developed by a single entity, but over time will be separately incorporated and equity interests sold to disparate groups of investors, the developer should adopt a common agreement to govern various aspects of the project's maintenance, access, and financial responsibility.

The common agreement should specifically address the ownership, operation, and maintenance of the geothermal system as the geothermal system will cross project internal property boundaries and require cooperation across separated properties and ownership structures. A common agreement for maintenance, management, pricing, and financial contributions and other responsibilities to operating the system, and a common management body such as an owner's association or similar entity would be needed to be established for this purpose and supported by association charges.

- **Third-Party Energy Services**. The common agreement would facilitate the project entering into a third-party energy services agreement with a geothermal system operator. The third party could provide a turnkey solution or perform discrete tasks on behalf of the project's common management association. Any arrangements with a third-party energy services provider should require performance and compliance consistent with developer obligations to tenants and requirements that may be imposed by the New York Public Service Commission or other government agencies in relation to provision of heat to tenants.
- **Submetering and Tenant Leases**. If the project plans to submeter heating services so that individual tenants control their usage and pay for their heat services on an individual basis, submetering arrangements should be approved by the Public Service Commission prior to entering into leases with any tenants. Leases should then be drafted with language clearly allocating financial responsibility for billed to the tenant.
- **Submeter Billing**. The developer or a third-party energy service provider operating the system will be required to use an approved form of bill and maintain billing service and dispute mechanisms as required by the State's submetering regulations. The developer or third-party energy service provider may desire to contract with a third-party billing provider in order to comply with these requirements. Such arrangements must provide compliance with any applicable landlord-tenant laws.
- **Tax Optimization.** The geothermal system is a depreciable asset that provides opportunities for tax-advantaged financing. The form of ownership for those assets can be separated from the project and its phases in order to exploit tax advantages. A separate geothermal financing structure potentially improves the financial return of the overall project; however, this must be weighed against the additional complexity and legal risk in the event of a failure to meet obligations for any reasons or a legal dispute.

Endnotes

[1] Enterprise Green Communities is a national green building program designed to promote and support the adoption of green building practices within the affordable housing sector.

[2] Heat of compression refers to the portion of input electrical energy to the compressor that gets released as thermal energy due to mechanical inefficiency. With hermetically sealed compressors, this thermal energy is absorbed on the condenser side and can be used as thermal input for spaces that require heating. In cooling mode, thermal energy is being removed from conditioned spaces and rejected to the GLHE. The amount of thermal energy rejected to the GLHE is actually 20-30% more than is removed from conditioned spaces due to the heat of compression factor. The same happens in heating mode. Due to the heat of compression factor from the heat pump, only 70-80% of the thermal energy required by the conditioned spaces is extracted from the GLHE.

[3] Mitsubishi did inform us that there is a VRF product capable of sharing the same circuit between an air cooled and water-cooled unit. However, that unit is currently unavailable to the US market and is expected to be available in the US market within 3 years.

[4] Freewire "*What's the Difference Between EV Charging Levels?"* https://freewiretech.com/difference-between-ev-charging-levels/

[5] New York State Clean Heat State-wide Heat Pump Program Manual - Version 5, October 2021 NYS-Clean-Heat-Program-Manual.pdf

[6] The Joint Utilities of New York is a regulatory framework developed to suppport coordination amongst utilities in response to NYS's Climate leadership and Community Protection Act. https://jointutilitiesofny.org/

[7] 26 U.S. Code § 48 - Energy credit

[8] This solution could also be capitalized directly by the developer if the system's capital expense is not an impediment to project deployment.

[9] New York City is investigating policies that require cooling to be included in rent for affordable housing projects. As the urban heat island effect intensifies in New York City with climate change the city is viewing a requirement to provide cooling at no additional cost as a public health measure.

[10] Scientific American; E&E News: Climate Change "*Cost of Carbon Pollution Pegged at $51 a Ton*:" https://www.scientificamerican.com/article/cost-of-carbon-pollution-pegged-at-51-a-ton/

[11] 33 U.S.C. 1342.

[12] Ken Krich et al., Biomethane from Dairy Waste: A Sourcebook for the Production and Utilization of Renewable Natural Gas in California, USDA Rural Devel., at 135 (July 2005).

[13] Colburn T. Cherney & Karen M. Wardzinski, *State and federal Roles Under the Clean Water Act*, NAT. RESOURCES & ENV. 19 (1986).

[14] 33 U.S.C. § 1313(c)(2)(A); NYS Dep't of Envtl. Conservation, Division of Environmental Planning and Protection, Clean Water Act Section 401 Certification for Commercial Vessel and Large Recreation Vessel General Permit (November 3, 2008, https://www.nwf.org/Regional-Centers/~/media/PDFs/Regional/Great-Lakes/DEC_VGP_401_Certification_final.ashx

[15] NYS Dep't of Envtl. Conservation, Division of Environmental Planning and Protection, Clean Water Act Section 401 Certification for Commercial Vessel and Large Recreation Vessel General Permit (November 3, 2008, https://www.nwf.org/Regional-Centers/~/media/PDFs/Regional/Great-Lakes/DEC_VGP_401_Certification_final.ashx

[16] Knauf Shaw LLP, Clean Water Regulation at 8, https://www.nyenvlaw.com/wp-content/uploads/2015/05/Chapter-4-Clean-Water-Regulation.pdf (accessed September 27, 2021).

[17] Knauf Shaw LLP, Clean Water Regulation at 8, https://www.nyenvlaw.com/wp-content/uploads/2015/05/Chapter-4-Clean-Water-Regulation.pdf (accessed September 27, 2021).

[18] https://www.nyenvlaw.com/wp-content/uploads/2015/05/Chapter-4-Clean-Water-Regulation.pdf

[19] Regulatory Overview and Legal Responsibilities Chapter 4: https://efc.syr.edu/wp-content/uploads/2015/03/Chapter4-web.pdf

[20] 6 NYCRR 700.1

21 Heat is considered a pollutant pursuant to 6 N.Y.C.R.R. Part 704.

22 N.Y. Env't Conserv. Law § 13-0103; 6 N.Y.C.R.R. Part 701.

23 6 N.Y.C.R.R. Parts 649-758.

24 6 N.Y.C.R.R. § 703.6.

25 NYSDEC, Permit No. GP-0-20-001, SPDES General Permit for Stormwater Discharges from Construction Activity (January 28, 2020), https://www.dec.ny.gov/docs/water_pdf/constgp020001.pdf

26 Stormwater Permit for Construction Activity, NYSDEC, https://www.dec.ny.gov/chemical/43133.html (Accessed September 28, 2021).

27 Matthew Ahrens, et al., *Climate Change Considerations Under SEQRA: DEC's New Policy*, 29 THE N.Y. ENVT'L LAWYER 34, 34 (Fall 2009), https://www.lw.com/thoughtLeadership/climate-change-considerations-under-seqra-new-york-policy

28 Matthew Ahrens, et al., *Climate Change Considerations Under SEQRA: DEC's New Policy*, 29 THE N.Y. ENVT'L LAWYER 34, 35 (Fall 2009), https://www.lw.com/thoughtLeadership/climate-change-considerations-under-seqra-new-york-policy

29 Matthew Ahrens, et al., *Climate Change Considerations Under SEQRA: DEC's New Policy*, 29 THE N.Y. ENVT'L LAWYER 34, 35 (Fall 2009), https://www.lw.com/thoughtLeadership/climate-change-considerations-under-seqra-new-york-policy

30 6 N.Y.C.R.R. § 617.9 (b)(5)(iii)(e)

31 1 Environmental Impact Review in New York § 3.01 (2021).

32 2 Environmental Impact Review in New York § 5.12 (2019).

33 2 Environmental Impact Review in New York § 5.12 (2019).

34 Mark A Chertok et. al, Environmental Law: Developments in the Law of SEQRA, 96 Syracuse L. Rev. 773, 778 (2019).

35 6 N.Y.C.R.R. § 617.9(b)(1).

36 Pursuant to the Accelerated Renewable Energy Growth & Community Benefit Act, S. 7508-B, A. 9508, 2020-21 Reg. Sess. (N.Y. 2020), the Office of Renewable Energy Siting is responsible for siting and permitting new major renewable energy facilities in New York State, which are defined as "any renewable energy system, as such term is defined in section sixty-six-p of the public service law… with a nameplate generating capacity of twenty-five thousand kilowatts or more". Section 66-p of the Public Service Law defines renewable energy systems as "systems that generate electricity or thermal energy through use of the following technologies: solar thermal, photovoltaics, on land and offshore wind, hydroelectric, geothermal electric, geothermal ground source heat, tidal energy, wave energy, ocean thermal, and fuel cells which do not utilize a fossil fuel resource in the process of generating electricity."

37 A 25 MW_{th} system based on 2.93 kW_{th} per heating ton (3.517/(12,000 BTU/10,000 BTU)) would support 1,700 homes using 5-ton systems and 2,130 homes using 4-ton systems. See *Kilowatts to Refrigeration Tons Conversion*, RapidTables, available at https://www.rapidtables.com/convert/power/kw-to-ton.html (accessed April 14, 2021).

38 New York Consolidated Executive Laws, Executive Law Section 94-C(5)(c)(ii).

39 *Geothermal Wells*, NYSDEC, available at https://www.dec.ny.gov/lands/61176.html (accessed March 10, 2021).

40 *Geothermal Wells*, NYSDEC, available at https://www.dec.ny.gov/lands/61176.html (accessed March 10, 2021).

41 N.Y. Env't Conserv. Law § 23-0305(14).

42 *Geothermal Systems & Their Application in New York City,* NYC Office of Sustainability at 36 (February 2015), http://www.nyc.gov/html/planyc/downloads/pdf/publications/2015_Geothermal.pdf; *Well Permitting Requirements*, NYSDEC, available at https://www.dec.ny.gov/energy/1783.html (accessed March 10, 2021).

43 *Well Permitting Requirements*, NYSDEC, available at https://www.dec.ny.gov/energy/1783.html (accessed March 10, 2021).

44 6 NYCRR § 554.1(c).

45 *Designing & Drilling Your Well Permit*, NYSDEC available at https://www.dec.ny.gov/energy/1628.html (accessed March 10, 2021).

46 6 NYCRR § 554.1(c).

46 *Designing & Drilling Your Well Permit*, NYSDEC available at https://www.dec.ny.gov/energy/1628.html (accessed March 10, 2021).

47 *Geothermal Systems & Their Application in New York City,* NYC Office of Sustainability at 37 (February 2015), http://www.nyc.gov/html/planyc/downloads/pdf/publications/2015_Geothermal.pdf

48 *Geothermal Systems & Their Application in New York City,* NYC Office of Sustainability at 37 (February 2015), http://www.nyc.gov/html/planyc/downloads/pdf/publications/2015_Geothermal.pdf

49 *Well Permit Fee Calculator*, NYSDEC (accessed March 10, 2021) https://www.dec.ny.gov/energy/1779.html

50 9 N.Y.C.R.R. § 428.1.

51 New York State Multiple Dwelling Law § 79; New York State Multiple Residence Law § 173. See also, New York City Administrative Code § 27-2029.

52 Section 5(1)(b)-(c) of the Public Service Law.

53 See, e.g., SZ Enterprises, LLC D/B/A Eagle Point Solar v. Iowa Utilities Board, 850 N.W.2d 441 (Iowa 2014).

54 Title 16 Department of Public Service, Chapter II Electric Utilities, Part 96.

55 Public Service Law, §4, 53, 65 and 66.

56 Title 16 Department of Public Service, Chapter II Electric Utilities, Part 96.1.

57 Title 16 Department of Public Service, Chapter II Electric Utilities, Part 96.2(b)(2).

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