Geothermal Scoping Study for Wagner College

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Geothermal Scoping Study for Wagner College

Final Report

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Abstract

Wagner College operates a cogeneration system that provides electricity, space heating, and cooling to many campus buildings. The cogeneration system has reached the end of its useful life and requires replacement. An all-electric, district geothermal system can offer greater system efficiency, lower operator and maintenance costs, and eliminate emissions compared to fossil-fired cogeneration systems. Capital costs to replace the cogeneration system with geothermal are approximately twice those costs to replace the cogeneration system with a modern equivalent. Operating cost savings from reduced operations and maintenance costs and avoided Local Law 97 carbon liabilities generate a simple payback of 9 years.

Keywords

district geothermal system, cogeneration system replacement, Local Law 97, campus district thermal system, life-cycle cost analysis

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Executive Summary

Wagner College is a liberal arts college located on a campus in Staten Island, NY. The school has set a goal of achieving carbon neutrality by 2050. To do this, Wagner College recognizes the need to transition from carbon-based heating and cooling to clean, electrically driven heat pump technology. This study examines six of Wagner College's 24 buildings as candidates for replacing the existing natural gas fired district heating and cooling system with two, separate geothermal districts as illustrated below.

Figure ES-1. Campus Map Showing Proposed Geothermal Districts and Connected Buildings

The geothermal system delivers multiple benefits to Wagner College:

- The geothermal solution operates more efficiently, which will result in reduced CO_2 emissions and associated Local Law 97 fines.
- The geothermal solution requires less maintenance and fewer operators, which will greatly reduce Wagner College's operating costs over time.
- The all-electric system would make Wagner College carbon-neutral ready.

Our analysis demonstrates that the geothermal systems generate a net operating cost savings of approximately $2.4 million per year compared to the business-as-usual (BAU) scenario. A life-cycle cost analysis shows that the geothermal system requires significantly less cost to construct and operate over a 30-year period when compared to a replacement of the current fossil fired district system.

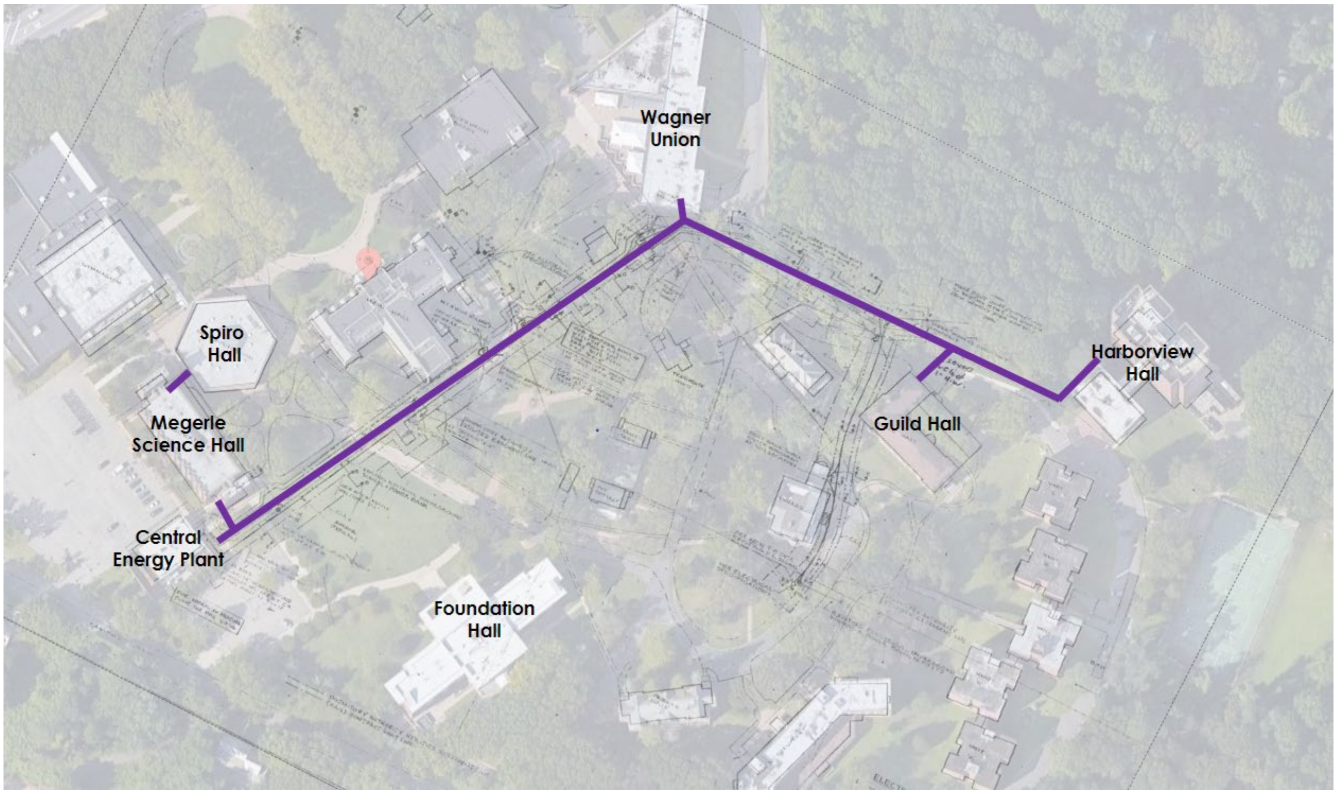
Table ES-1. Life-Cycle Cost Comparison

	Business-as-Usual	Geothermal
Central energy plant replacement cost	$10,554,300 (in year 2032)	
Geothermal capex (Phase 1 and Phase 2)		$22,487,262
Year 1 operations & maintenance cost	$1,868,500	$70,000
Year 1 utility cost	$618,052	$628,207
LL97 penalties	$520,000 begin 2024	No penalty through 2031
30-year life-cycle cost (present value)	$93,019,000	$52,654,000

1 Project Background

Wagner College has approximately 2,200 students, many of whom live on campus during the academic year. The campus contains 24 unique buildings used for administrative, housing, athletic, and classroom purposes. Several buildings receive thermal energy from a central energy plant (CEP) located on campus. The CEP and connected buildings are illustrated in Figure 1.

Figure 1. Campus Map Showing Existing District System and Connected Buildings



Much of Wagner College's existing energy infrastructure (including the CEP and distribution system) is nearing the end of its useful life and needs replacement. In 2020, Wagner College completed a campus energy audit and identified critical energy efficiency upgrades.[1] The college has commenced the design of some of these energy upgrades and intends to proceed with larger scale energy retrofits in the near-term.[2]

Table 1. District Geothermal Candidate Facilities

Building	Facility use	Energy services from CEP
Harborview Hall	Student residence hall.	Space heating & cooling, domestic hot water.
Guild Hall	Student residence hall.	Space heating, domestic hot water.
Wagner Union	Bookstore, multiple academic centers.	Space heating & cooling, domestic hot water.
Spiro Hall	Amphitheaters, classrooms, and planetarium.	Space heating & cooling, domestic hot water.
Megerle Science Hall	Academic building (science & math).	Space heating & cooling, domestic hot water.
Foundation Hall	Student residence hall.	Not connected to CEP.

The district thermal feasibility assessment for Wagner College focuses on six buildings with varying use-types and occupancy patterns. Of these six buildings, all except Foundation Hall are connected to a medium temperature hot water loop. The two-pipe distribution system delivers hot water generated year-round at the CEP. Hot water from the CEP is used for space heating in the winter months and drives absorption chillers in the summer months (May through October). Wagner College has two absorption chiller plants. The CEP houses an absorption chiller, which generates chilled water for space cooling at Megerle Hall and Spiro Hall. A second absorption chiller plant located in Harborview Hall generates chilled water for space cooling in Harborview Hall and the Wagner Union. Guild Hall receives space heating and domestic hot water only from the district loop (no cooling). The cogeneration plant, absorption chiller plants, and existing hot water distribution systems are nearing the end of their useful life. Some in-building systems that distribute heat, hot water, and chilled water also require replacement.

Wagner College's need for system upgrades presents an opportunity to transition to an efficient, all-electric district geothermal system. Although Foundation Hall is not served by the existing CEP, its proximity to the district loop and planned HVAC system replacement makes it a good contestant for a district geothermal system.

2 Energy Model

2.1 Methodology

It is critical to understand the campus's thermal loads (heating and cooling) to design geothermal systems that will appropriately supply these loads. Endurant bases our geothermal feasibility studies on an hourly, annual thermal profile for space heating, space cooling, and domestic hot water.

The existing district system is not equipped to meter hot water or chilled water use at the building level. Instead, most of the energy used to heat and cool the district enters the CEP as natural gas. Therefore, we relied on historic utility data[3] from the CEP and Foundation Hall to establish representative thermal load profiles. Despite the Covid-19 pandemic, facilities staff indicated that the campus buildings remained fully conditioned throughout 2020. Therefore, we included 2020 data in the overall data set as energy use appeared consistent with previous years. This nearly three-year sample provides a representative data set for thermal use across the five buildings in the district.

2.1.1 Central Energy Plant

To generate a representative 8760 hourly profile, we started with monthly gas use and assumed the percentage of gas directed for heating and cooling for each month. The monthly breakdown (Table 2) was informed by energy models and metered data from other college campuses in the northeast.

Table 2. Estimated Percent of Monthly Natural Gas by End Use

Month	% Natural Gas to Heating	% Natural Gas to Cooling
Jan	100%	0%
Feb	100%	0%
Mar	100%	0%
Apr	100%	0%
May	47%	53%
Jun	27%	73%
Jul	23%	77%
Aug	16%	84%
Sep	18%	82%
Oct	41%	59%
Nov	100%	0%
Dec	100%	0%

We then made assumptions as to the efficiency of equipment within the CEP and at the Harborview Hall absorption chillers. In this way, we were able to estimate the amount of heating and cooling energy that was generated from the energy content of natural gas consumed at the CEP. We assume 60% as the overall heating plant efficiency (including distribution losses). We assumed a 0.64 COP for the cooling plant (assuming 80% heating plant efficiency and 0.80 COP for absorption chilling).

The team then generated hourly profiles using typical daily use profiles developed from energy models and normalized weather data. This resulted in a final heating and cooling profile for buildings served by the CEP. We then divided the central plant profile among the five connected buildings based on square feet (sq. ft.) of building area.

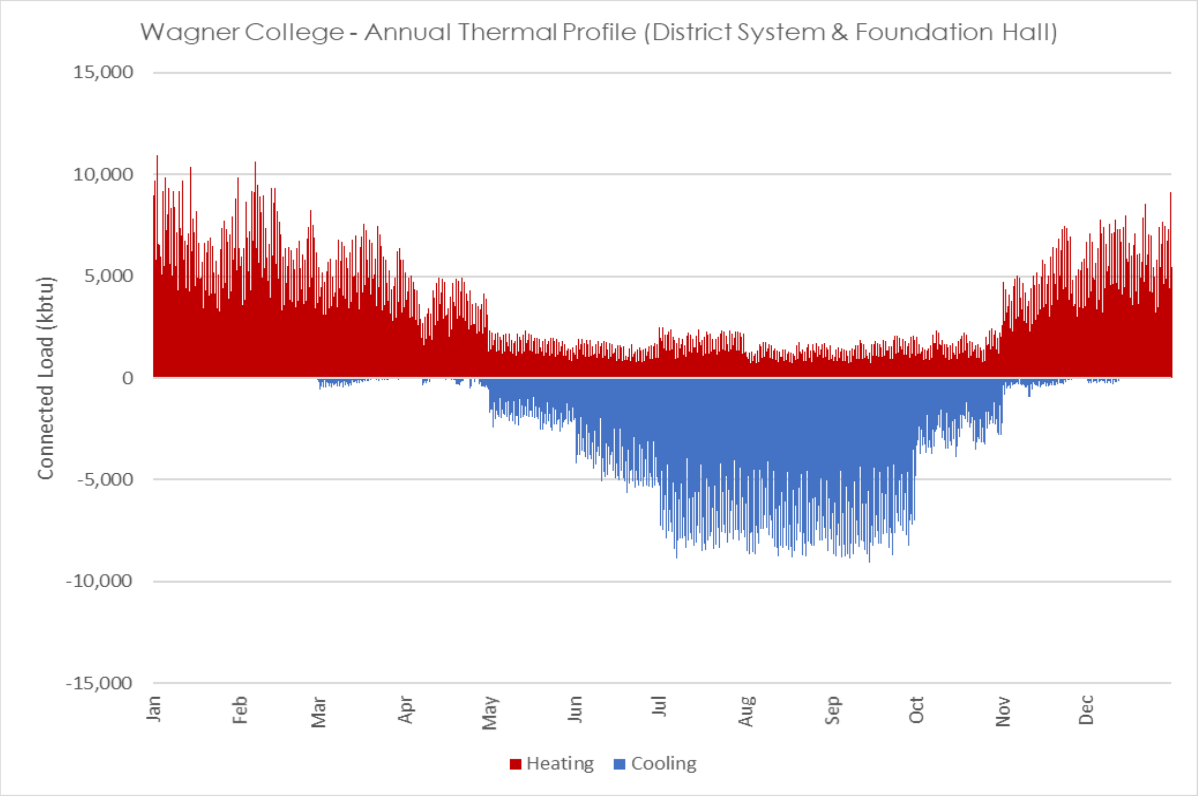
2.1.2 Foundation Hall

Foundation Hall currently relies on natural gas boilers for space heating and electric chillers for space cooling. The heating profile for Foundation Hall was estimated based on metered natural gas consumption. Cooling loads were estimated from electric interval data available from between March 2019 and December 2021. After removing estimated non-HVAC loads from the interval data, we created a cooling profile using the remaining electric hourly profile and a static electric chiller efficiency of 0.67 kilowatt per ton (kW/ton).

2.1.3 District Thermal Profile

Figure 2 illustrates the combined heating and cooling loads for all six buildings. The space heating and domestic hot water (DHW) loads are combined into a single heating profile (red).

Figure 2. Thermal Profile for the District System and Foundation Hall



2.1.4 Building-Level Summary

Energy use for each of the five buildings served by the CEP was apportioned by area (sq. ft.) and summarized in Table 3. Note that DHW loads are included in the peak and annual heating loads.

Table 3. Annual Heating and Cooling Loads by Building

Building Metric	Harborview	Guild	Union	Spiro	Megerle	Foundation	Total
Area (sq. ft.)	139,045	30,300	72,190	21,000	47,700	72,000	382,235
Peak Heating (kBtu/hr)	4,386	956	2,277	662	1,505	1,153	10,939
Peak Cooling (kBtu/hr)	3,562	776	1,849	538	1,222	1,773	9,720
Annual Heating (kBtu)	7,836,217	1,707,630	4,068,442	1,183,506	2,688,249	2,075,885	19,559,929
Annual Cooling (kBtu)	5,692,593	1,240,502	2,955,506	859,754	1,952,869	3,619,441	16,320,665

3 Technology Assessment

Endurant considered technical solutions that could serve thermal demands at the six campus buildings while achieving greater efficiency and life-cycle value as compared to the business-as-usual (BAU) system. We explored a combination of ground source heat pumps (GSHPs) and air source heat pumps (ASHPs) in a district arrangement that would replace the existing fossil-fired district system. Additionally, we assessed the potential for solar PV and battery energy storage systems (BESS). This section provides a brief description of each technology and the advantages and drawbacks of using each at Wagner College.

3.1 Ground Source Heat Pump

GSHPs are one of the most efficient heating and cooling technologies commercially available. GSHP systems require a water sourced heat pump (WSHP) containing a refrigeration loop that drives thermal exchange between a building and a ground loop heat exchanger (GLHE) via a working fluid[4] circulated between the GLHE and the WSHPs. Ground temperatures remain more stable than air temperatures throughout the year, which allows the GSHP system to treat the ground as a heat source in the winter and a heat sink in the summer.

GSHPs are unique in that they can deliver both heating and cooling simultaneously at a high coefficient of performance (COP).[5] An example of a simultaneous load occurs when occupants require space cooling and DHW at the same time. During these times, the water-based heat pump rejects waste heat from the cooling process into the DHW circuit thereby serving both a cooling and heating load simultaneously and efficiently.

Ground Source Heat Pumps — Key Considerations

Pros	Cons
• Most efficient heating and cooling technology (full load COP of between 5 and 6).	• Higher initial capital costs.
• Lowest operating costs compared to conventional equipment and other technologies assessed.	• Requires dedicated, permanent space to locate and install the GLHE.
• Lower maintenance costs than conventional HVAC equipment.	• Requires balanced heating and cooling loads to ensure acceptable GLHE temperature over time.
• Ability to supply heating and cooling simultaneously.	
• All-electric system can reduce or eliminate associated carbon emissions.	
• Quieter operations than rooftop condensers.	

3.2 Air Source Heat Pumps

ASHPs provide a flexible, electric solution for heating and cooling capacity. ASHPs function similarly to GSHPs, except that the ASHP relies on ambient air as the heat source or sink rather than the GLHE. COPs for ASHPs are highest at moderate ambient conditions (i.e., fall and spring), but fall during the extreme temperatures of summer and winter. As a result, the efficiency of ASHPs during peak heating and cooling conditions is lower than GSHPs. However, because ASHPs do not require a GLHE to operate, they are less costly to install. ASHPs may be used in conjunction with GSHPs to serve unbalanced thermal loads and peaks that exceed the design intent of the GSHP system. Endurant's geothermal system designs often include a mix of GSHPs and ASHPs. This hybrid approach reduces the number of boreholes required, and thus reduces capital costs.

Air Source Heat Pumps —Key Considerations

Pros	Cons
• Range of capacity and configurations support variety of installation requirements.	• Requires outdoor space to locate portions of the ASHP mechanical system (i.e., roof space).
• No requirement for GLHE.	• Requires refrigerant piping inside buildings, which may be more challenging than ducted or hydronic systems.
• Good performance at moderate temperatures (COP of 3 to 3.5 at 50°F).	• Reduced efficiency at extreme temperatures (COP of < 2.3 at 10°F).
• All-electric system can reduce or eliminate associated carbon emissions.	

3.3 Solar Photovoltaic and Battery Energy Storage

Rooftop solar photovoltaic (PV) systems produce electricity from solar energy and have been widely adopted across all building types due to the technical familiarity, relatively low costs, and ease of modular installation. In addition, utility programs in New York State allow communities to access the value of solar PV via subscription programs administered through the electricity bill.

The benefits of solar PV may be limited in two ways. First, solar PV requires an unobstructed area to locate panels. Common areas available for PV installation include building rooftops, over parking spaces, or mounted at ground level on unused land. Wagner College has identified unobstructed rooftop and ground-mount opportunities for solar PV installation.

Figure 3: Potential Location for Solar PV and Battery Energy Storage Systems

Second, solar PV is an intermittent resource that only generates electricity as solar energy is available. Therefore, the system will not generate electricity during nighttime hours or times of heavy cloud cover. Because energy production is intermittent, a solar PV system by itself cannot be relied upon to supply electricity continuously or consistently. Solar PV is often paired with battery storage to increase dispatchability while operating in parallel with the grid.

Solar PV—Key Considerations

Pros	Cons
• Low capital cost. • Ability to deploy on otherwise unusable space (i.e., rooftops, parking canopies, marginal land). • Fully renewable electricity production. • Established utility tariffs that allow for net metering or "community solar" programs. • Low maintenance.	• Intermittent production. • Relatively large space requirements when compared to other distributed electricity generation technologies.

In addition to solar PV, the Endurant team conducted a comprehensive evaluation of Wagner College's potential to host a battery energy storage system (BESS). BESS technologies are versatile assets that can store and discharge electricity on demand. They vary across chemistry used, although lithium ion (Li-ion) is currently the most common chemistry deployed in large, stationary applications.

BESS—Key Considerations

Pros	Cons
• Dynamic use cases for FTM and BTM applications.	• High initial capital cost.
• Demand response capabilities.	• Capacity/energy are limited by state of charge.
• Ability to shift solar PV generation to more valuable hours in the day.	
• Established utility tariffs that allow for community distributed generation offtake.	
• Value stacking revenue streams.	

3.3.1 Front-of-the-Meter versus Behind-the-Meter Interconnection

There are two main use cases for solar PV and batteries in New York State, each distinguished by how they are interconnected. The first takes advantage of the State's Value of Distributed Energy Resources (VDER) tariff that allows solar PV systems (optionally paired with BESS) to connect directly to the distribution grid in a front-of-the-meter (FTM) interconnection. 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 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 owners, 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 residential and small business customers. Under the FTM CDG VDER solar PV and BESS model, Wager College could receive a simple lease payment as compensation for hosting a solar PV and BESS installation on their property in addition to the opportunity to subscribe for up to 40% of the solar PV energy output.

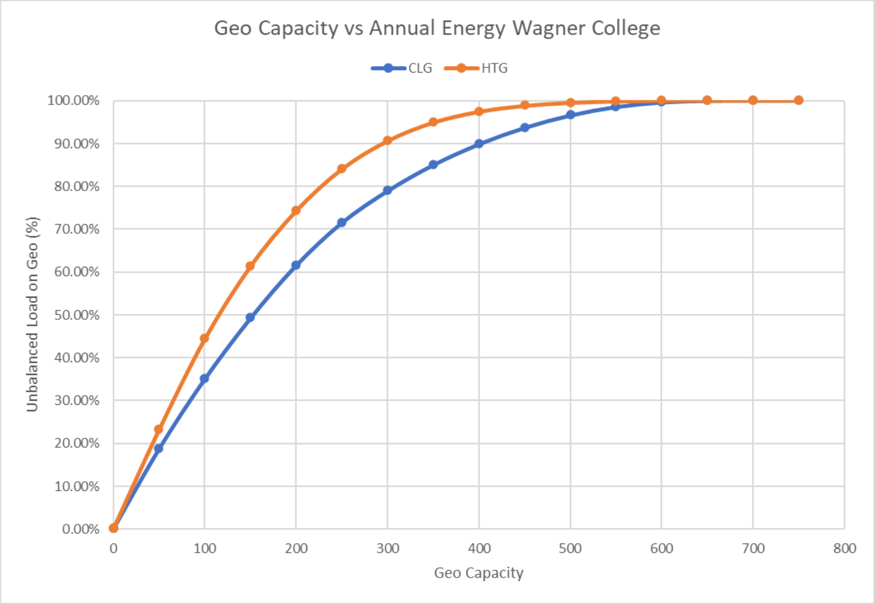
The second use case is a behind-the-meter (BTM) model whereby the solar PV and/or BESS connects to Wagner College's electric distribution system on the customer side of the Con Edison meter. The solar PV array would offset electricity from the grid or may be used to charge the BESS. During peak demand hours, one or more buildings would draw power from the battery to reduce grid demand at the utility meter and therefore reduce Con Edison's demand charges or participate in demand response programs. In some BTM applications, the battery may also be used for temporary backup power during a grid failure.

Wager College is a strong candidate for a battery storage project due to the lucrative VDER[6] tariff incentives on Staten Island, excellent proximity to Con Edison's distribution service, ample space to locate PV and BESS assets, and a large electric account which may be used as an anchor subscriber. A complete and detailed explanation of the use cases and recommendations may be found in appendix A.

4 Geothermal Ground Loop Design

The ground loop heat exchanger (GLHE) and ground source heat pump (GSHP) capacities are sized based on the principle of diminishing returns. Figure 4 illustrates how the marginal increase in geothermal system satisfies diminishing unbalanced loads as the geo capacity increases. For example, a 150-ton system can cover ~50% of the unbalanced annual cooling load and ~65% of the unbalanced annual heating load. Doubling the system size to 300 tons, however, does not double the amount of load that can be served. Instead, a 300-ton system serves 80% of the unbalanced cooling load and 90% of the unbalanced heating load.

Figure 4. Portion of Unbalanced Load Served by Geo System Capacity



A GLHE sized for annually balanced thermal loads runs the risk of evaporator temperatures falling below operationally permissible limits during the peak heating season. This is particularly prevalent in northern climates where undisturbed ground temperatures are low (~50°F) and seasonal heating demands are high. In these cases, extracting heat from the ground to provide space heating could result in the ground temperature falling below 40°F, which will cause the water flowing through the evaporator to freeze. To avoid this, a larger GLHE is needed to increase the surface area for heat exchange to meet the peak heating loads. The drilling and installation of boreholes is the costliest aspect of a geothermal system. Therefore, the design should seek opportunities to reduce the size of the borefield, rather than add additional boreholes to increase capacity.

This issue is alleviated by adding propylene glycol to the solution. The glycol-water GLHE solution has a lower freezing point, which allows for much lower evaporator temperatures. As a result, the same sized GLHE can now serve a larger peak heating load, since more heat can be extracted from the ground without causing the evaporator fluid to freeze. Glycol therefore serves to lower the overall size of GLHE needed to serve peak heating loads and is a preferred approach in northern climates and projects where space is scarce and drilling costs are high. Our analysis suggests that a ~20% propylene glycol solution can reduce the GLHE size by up to, and in some cases more than, 50%.

Conversely, the addition of glycol results in a decrease in the specific heat of the GLHE fluid. This means that for the same amount of heat transfer to/from the fluid, flow must increase (increasing pumping energy). Additionally, since the glycol solution's temperature can fall lower than pure water, the system must work to supply the same condenser temperature to satisfy heating loads by extracting heat from a GLHE with a cooler working fluid temperature. The compressor must work harder to accomplish this. The addition of glycol therefore negatively impacts the overall operational performance of the system.

The ultimate benefit of adding glycol is dependent on the interplay between lower capital costs and increased inefficiencies in operating performance. Our team tested each sizing run assuming a 17.7% glycol GLHE solution. Since the efficacy of adding glycol to the evaporator solution is highly dependent on project site conditions and location, our team recommends testing the runs without glycol as well to determine the overall benefits (or additional costs) imposed by the addition of glycol.

In order to minimize disruption, construction and cutover to the new geothermal system would occur during the summer season when programming is not in session. Construction of the GLHE and GSHP would occur initially. Buildings would remain connected to the existing system. Switch over would be scheduled to minimize disruption to heating/cooling during the late summer/early spring when ambient temperatures are less severe.

It is important to ensure that debris and air pockets are removed from the GHLE. To do this, every section of piping will be flushed and purged prior to commissioning the completed system. Flushing removes debris within the piping network and is done by pumping potable water through the piping system at a minimum pipe velocity of 2 feet per second in all sections of pipe. Following flushing, purging is done by removing air from the system by pumping potable water through the piping system at a minimum velocity of 4 feet per second, sometimes higher. During purging, air-release valves are installed at several points throughout the piping system, making sure there are several located at the high points of the system, where air tends to collect. Usually two temporary, in-line filters are utilized during purging with a fabric filter size of 5 micron, to ensure all fine debris have been captured. The pumping for both flushing and purging is completed with a temporary, contractor-supplied flush pump. Under no circumstances would the new, permanent pump(s) be utilized for the flushing and purging processes. Upon successful completion of flushing and purging, propylene glycol may be added to the system (depending on the project design) and then the entire completed system is properly commissioned with all relevant parties—typically the equipment manufacturer(s), mechanical contractor, mechanical engineering teams, and an owner's representative.

While there are a variety of GLHE systems, Endurant focused on a closed loop borehole solution to circumvent any regulatory concerns typically associated with open loop systems (such as aquifer contamination). The team explored vertically drilled boreholes to a depth of 500 feet, which is appropriate for both New York State drilling regulations and the geological factors present at the site. The team identified various campus locations as potential borefield sites; however, it is best to minimize the distance between plant rooms and borefields. We estimate that the shaded areas (Figure 5) would allow for up to 255 vertical bores, which is sufficient borehole capacity based on thermal load profiles.

Figure 5. Space Available for Boreholes at Preferred Locations

5 Geothermal System Configuration

Wagner College is considering a two-phase approach to replacing the existing system with a geothermal district system. A multibuilding district system offers many advantages over a single-building geo design. Table 4 below lists the advantages and disadvantages offered by a district system.

Table 4. Advantages and Disadvantages of District Geo System with Centralized Heat Pumps

Pros	Cons
• Economies of scale on equipment procurement.	• 4-pipe distribution (optional).
• More efficient dispatch of plant assets.	○ Increased investment cost for site trenching and lateral piping.
• Reduced maintenance (fewer compressors to service).	○ Increased investment cost at building level.
• Greatest opportunity for simultaneous load.	• Potential for greater thermal losses from distribution.
• Eliminates or reduces space required for distributed HVAC equipment.	

Wagner College's status as a single-owner campus, available space, and familiarity with district thermal systems make a district geothermal system a natural fit. Phase 1 focuses on HVAC replacement for Harborview, Guild, and Union buildings. Phase 2 would complete HVAC replacement for Spiro, Megerle, and Foundation Hall. Each phase would operate independently with its own borefield, central plant for mechanical equipment, and hot/chilled water distribution. Each mechanical space would house the GSHPs, circulating pumps, controls, and other mechanical equipment such as ASHPs or heat recovery chillers. The conceptual design includes both GSHPs and ASHPs. This hybrid approach allows use to reduce the size (and cost) of the GLHE, but also provides the ability to use the ASHPs to temper the ground loop temperature. This allows the system to operate with more flexibility and resiliency than a geothermal system entirely dependent on the GLHE for thermal exchange. If, over time, the ground loop temperature exceeds design conditions, the ASHPs may be used to bring the ground loop back to design temperature.

Figure 6. Two-Phase District Geothermal Concept

The team performed an exercise to determine the equipment needed to supplement various GSHP system sizes. Table 5 summarizes the thermal capacity of conventional equipment required to complement the geo system size.

Table 5. Geo and Conventional Capacity Requirements

	Geo size (tons)	Simultaneous[7] (tons)	Geo cooling (tons)	Conventional cooling (tons)	Geo heating (MMBtu/hr)	Conventional heating (MMBtu/hr)
Harborview, Guild, Union	200	90	200	285	3,120	4,499
	300	90	300	185	4,680	2,939
	400	90	400	85	6,240	1,379
Spiro, Megerle, Foundation	150	30	150	112	2,340	980
		200	30	200	62	3,120

Final equipment capacities for Phase 1 and Phase 2 are summarized in the following tables. Phase 1 would require approximately 93 boreholes at a depth of 500 feet. Phase 2 would require approximately 46 boreholes drilled to the same depth.

Table 6. Proposed Geothermal Mechanical Capacities

Wagner College - Phase 1							
	Simultaneous		Geothermal		ASHP		Electric Boiler
Thermal Demand	CLG	HTG	CLG	HTG	CLG	HTG	HTG
Capacity	90 tons		200 tons		285 tons	2,280 MBH	2,219 MBH
Annual load *(kbtu)*	2,330,254	3,029,331	6,080,368	9,430,041	1,477,978	1,043,795	109,123
% Annual load	24%	22%	61%	69%	15%	8%	0.8%
Wagner College – Phase 2							
	Simultaneous		Geothermal		ASHP		Electric Boiler
Thermal Demand	CLG	HTG	CLG	HTG	CLG	HTG	HTG
Capacity	30 tons		100 tons		162 tons	1,306 MBH	500 MBH
Annual load *(kBtu)*	1,103,257	1,434,235	3,848,055	4,214,191	1,480,752	296,881	2,333
% Annual load	17%	24%	60%	71%	23%	5%	0.0%

Each phase would require a central geothermal plant to be constructed in locations identified in Figure 6. The central plant to house mechanical systems for Phase 1 would be constructed at grade level adjacent to Harborview Hall. All heat pump equipment, the electric boiler, and circulating pumps would be housed in the plant room. Horizontal piping would connect the GSHPs to the adjacent borefield. A 2-pipe distribution system would connect the Harborview geo plant to each of the three buildings (Harborview Hall, Guild Hall, and the Wagner Union) and supply heating hot water during the winter and chilled water during the summer.

Phase 2 would follow Phase 1. The borefield could be located in open space adjacent to Foundation Hall or the existing central energy plant (CEP). The CEP could be repurposed as the plant room to house heat pumps, an electric boiler, and circulating pumps for the district serving Foundation Hall, Megerle Science Hall, and Spiro Hall.

5.1 Unitary Geothermal System Configuration

Wagner College's existing district system lends itself to a replacement with a district geothermal system for several reasons. First, the geothermal district system may leverage opportunities to reuse rather than abandon existing district infrastructure. Secondly, existing buildings do not have dedicated HVAC mechanical spaces. This presents a challenge when designing a replacement system that requires finding or creating a new mechanical space in each building. Third, Wagner College has an experienced facility staff who operate a district system. While it is not imperative that Wagner College continue district system operations, the College's institutional familiarity with district systems is suitable to support geothermal district system operation in the future. However, NYSERDA does have an interest in understanding the impacts of a unitary geothermal system configuration.[8] As noted in Milestone 2, Endurant developed the estimated thermal profiles for each building based on historic data from Wagner College's existing CEP. This methodology does not lend itself to identifying non-coincident peak thermal demands for each building, which would be required to estimate efficiency losses from six unitary geothermal systems.

It is estimated that aggregate mechanical capacity would increase significantly if the historic thermal loads were disaggregated between buildings under a unitary system design. Wagner College, as most college campuses, enjoys a diversity of building use type and therefore thermal profiles. This is especially true between dormitories, academic buildings, and athletic facilities. We estimate that the buildings considered in this study would experience an increase in electricity and mechanical capacity of at least 5-10% under a unitary system design. Overall capital expense would also increase for six unitary systems as each individual system design would need to account for redundancy in equipment.

6 Capital Costs

Estimated capital costs for each phase are summarized in Table 7.

Table 7. Estimated Geothermal Capital Costs

	Phase 1 (Harborview, Guild, Union)	Phase 2 (Spiro, Mergerle, Foundation)	Total
Installed Costs	$13,890,463	$8,596,799	**$22,487,262**

These costs include installation of the hybrid GSHP/ASHP central mechanical plants, borefields, and horizontal distribution to each of the three buildings connected for each phase.

7 Operating Costs

As noted above, Wagner College continues to operate a fossil fuel fired CEP and district system for five of the six buildings considered in this analysis. Utility costs were estimated using hourly energy profiles and electric and natural gas tariff engines. Other operating costs were provided by Wagner College facility staff.

The BAU scenario assumes continued operation of Wagner College's existing district system. Medium temperature hot water originates from the CEP. The two-pipe distribution system delivers hot water all year to Harborview, Union, Guild, Spiro, and Megerle. The hot water is used for space heating in the winter months and drives absorption chillers in the summer months (May through October). Wagner College has two absorption chiller plants. The CEP houses an absorption chiller, which generates chilled water for space cooling at Megerle Hall and Spiro Hall. A second absorption chiller plant in Harborview Hall serves Harborview and the Wagner Union. Guild Hall receives space heating and domestic hot water only from the district loop (no cooling). Most of the buildings' heating and cooling needs are fueled by natural gas.

To determine utility costs, we simulated utility electricity and gas accounts at Foundation Hall and a single gas account for the CEP. We estimate that Foundation Hall would be billed under Con Edison's Service Class (SC) 9 Rate 1 Large Commercial rate for electricity and SC 2 Rate 1 for natural gas. We estimate that the CEP natural gas account would also be billed under SC 2 Rate 1. We took hourly electricity and gas demand profiles and calculated utility delivery and supply costs using tariff engines that simulate how the utility calculates customer bills. The tables below summarize estimated electricity and gas use by building. Note that there is a single natural gas cost for all buildings currently supplied by the CEP.

Table 8. BAU Utility Use and Cost

Building Metric	Harborview	Guild	Union	Spiro	Megerle	Foundation	Total
Electricity (kWh)	n/a	n/a	n/a	n/a	n/a	202,085	202,085
Electricity Cost						$44,055	$44,055
Natural Gas (therms)	219,550	47,843	113,987	33,159	75,318	25,949	515,806
Natural Gas Cost	$539,797					$34,200	$573,997
Annual Utility Cost	$539,797					$62,492	$618,052
CO2 Emissions	1,166	254	605	176	400	196	2,797

In addition to utility costs, Wagner College incurs additional costs for operations and maintenance. A summary of operations and maintenance costs are included in the following table. This information was supplied by Wagner College facility staff.

Table 9. BAU Operations and Maintenance Costs

Operations and Maintenance Item	Annual Cost
Hot water distribution loop repairs	$100,000
Operating engineers	$1,666,000
CEP boiler and abs. chiller maintenance	$70,000
Harborview abs. chiller maintenance	$13,000
Cooling tower water treatment	$19,500
Cooling tower water use	$87,000
Total CEP Operations and Maintenance	**$1,955,500**
Utility Costs	**$618,052**
Local Law 97 Penalty (est. for 2024)	**$520,000**
Total Annual Operating Cost	**$3,093,552**

To compare BAU operating costs to the geothermal alternative, the team estimated the electricity that would be required to supply the heating and cooling needs of the six buildings using two district geothermal systems. The geothermal systems eliminate the need for natural gas completely, while increasing electricity associated with heating and cooling. The geothermal systems require less maintenance and fewer operators than the existing CEP.

Overall, the geothermal systems generate a net operating cost savings compared to the BAU. Table 10 presents the utility, maintenance, and operator costs estimated for the geothermal district systems by phase. The result is a net annual savings of approximately $2.4 million compared to the BAU scenario.

Table 10: Geothermal Operations and Maintenance Costs

	Phase 1 (Harborview, Guild, Union)	Phase 2 (Spiro, Mergerle, Foundation)	Total
Electricity (kWh)	1,916,142	971,632	2,887,774
Electricity Cost	$431,203	$197,004	$628,207
Operations & Maintenance	$50,000	$20,000	$70,000
Total Annual Operating Cost	$481,203	$217,004	**$698,207**

Note: Per recommendation by Wagner College, operator labor costs are eliminated for the geothermal operations budget.

7.1 Carbon Savings

In addition to operating costs savings, Wagner College will significantly reduce future costs associated with New York City's Local Law 97 (LL97) carbon emissions penalty. LL97 regulates greenhouse gas emissions from buildings in New York City larger than 25,000 sq. ft. The law sets emissions limits for buildings and imposes fines for buildings that exceed emissions limits. Annual fines begin in 2025 and limits are reduced in 2030. Bright Power's report estimates Wagner College's current emissions to be 7,229 tons of carbon dioxide (CO_2) per year and their 2025 limit is expected to be 5,285 tons of CO_2 per year. Carbon emissions reductions from the geothermal system are in Table 11.[9]

Table 11: Estimated Carbon Emissions

	BAU	District Geo
Electricity (kWh)	202,000	2,888,000
Natural Gas (therms)	516,000	0
Annual CO_2 emissions (tons)	2,797	834
Annual CO_2 reduction (tons)	-	1,963

While the geothermal system increases electricity use associated with heating and cooling the six target buildings, it also eliminates the need for natural gas. This results in a net decrease of carbon emissions by 1,963 tons per year. The team estimates that the impact of avoided CO_2 emissions from the geothermal system will reduce Wagner College's baseline emissions to 5,266 tons (which is below the 2025 LL97 limit of 5,285 tons) and eliminate associated LL97 fines. Bright Power estimates the cost of LL97 fines to be $268 per ton of CO_2. The avoided penalty in 2025 would be approximately $520,000 per year.

7.2 Incentive Analysis

There are two incentive programs applicable for the proposed geo solutions for Wagner College. See the following for a description of each program.

Potential incentives may vary depending on a variety of factors. Each incentive program outlined in this section does require certain qualifying criteria that may apply to either the applicant or project. Once qualifying criteria are met, most incentive programs require a technical, third-party review to verify the methodology and assumptions behind an incentive application. Additionally, incentive funds can be exhausted or closed.

7.3 New York State Clean Heat Incentive

The New York State Clean Heat Incentive (NYSCHI)[10] is a statewide incentive program administered through the New York State Joint Utilities. The program has a variety of incentive categories that encompass small to large-scale energy projects and numerous heat pump-based technologies. This is a performance-based incentive that compensates the project based on energy savings generated against a standard New York State code compliant energy baseline for HVAC. The formula for determining the incentive value is based on the units of energy reduced by an electric GSHP system as compared to a code compliant building.

Wagner College will qualify for Category 4: Custom Incentives. This category pays $200 per million British thermal unit (MMBtu) of annual HVAC energy avoided. Within Category 4, the Category 4A–Heat Pump + Envelope allows for additional incentives if the dominant load is reduced by 5% though implementing 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

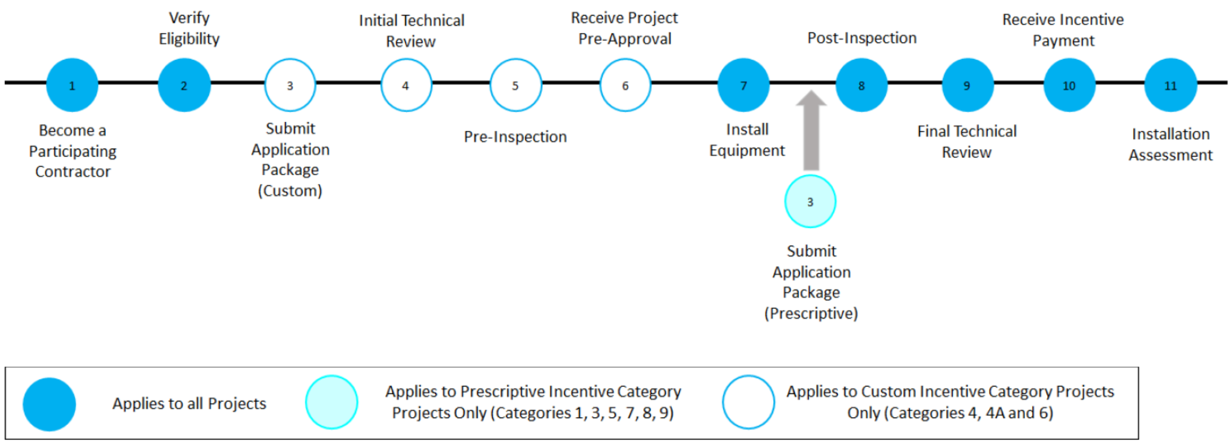
The applicability of any additional incentives from Category 4A to Wagner College will depend on envelope improvements to the existing buildings.

The application for these incentives, followed by Con Edison's review and incentive approval, must be completed prior to project construction. The completed program application requires the following:

- 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 not feasible
        - document a controls strategy that prioritizes heat pump dispatch
- Approved Department of Buildings Permit submission

Figure 7. Application and Approvals Timeline for NYS Clean Heat Incentive



7.4 NYSERDA PON 4614—Community Heat Pump Systems

PON 4614 is a competitive solicitation designed to support the development of district scale heat pump systems. A qualifying district contains at least two buildings with a total area of greater than 40,000 square feet (sq. ft.) or at least 10 buildings of any size. The program contains four categories that support different stages of the heat pump design and development.

- **Category A**—Offers up to a $100,000 contribution to study a district heat pump system with no cost share required.
- **Category B**—Offers up to a $500,000 contribution to support the design of a district scale heat pump system with a 50% cost share required.
- **Category C**—Offers up to a $4 million contribution toward the construction of a district scale heat pump system.
- **Category D**—Offers up to $250,000 to support the development of best practices guidebooks for district scale heat pump projects.

Wagner College is a non-profit institution. As such, Wagner College would not be able to claim federal tax benefits, such as depreciation or investment tax credits. GSHPs qualify for these benefits and could be monetized through a tax equity partnership. Both tax advantages are described below. However, neither are included in the basic incentive calculation as tax equity partnerships can be difficult and costly to arrange.

7.4.1 Federal Accelerated Depreciation Schedules

Geothermal assets are eligible for accelerated methods of depreciation such as Bonus Depreciation and Modified Accelerated Cost-Recovery System (MACRS). Under the federal MACRS program, companies may recover investments in qualified property (including geothermal ground source heat pumps) via depreciation deductions on an accelerated schedule. 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. Bonus depreciation of 100% in the first year is available for qualified property placed in service between September 27, 2017 and January 1, 2023.

7.4.2 Federal Business Energy Investment Tax Credit

The Federal Business Energy Investment Tax Credit (ITC) is a tax credit that may be claimed for qualifying investments in renewable technologies. The ITC has been extended on numerous occasions. Currently, the ITC rate for qualifying geothermal heat pumps is set at 10%. It is due to expire at the end of 2023.

The value of the ITC may be monetized via a reduction in federal taxes owed by the project owner. Project owners that have an effective tax rate of 0% or near 0% will not be able to monetize this benefit. Alternatively, there are tax equity investors who may be able monetize this tax credit via an equity partnership role in the project. Under Endurant's Energy as a Service approach the team can partner with tax equity investors to monetize the ITC benefit on behalf of the project.

This incentive applies only to GSHP equipment and downstream distribution equipment receiving at least 75% of the annual thermal energy from the GHSP system. For example, a fan coil unit delivering heat that is at least 75% derived from the GSHP on an annual basis would be eligible for the ITC. The ITC must be monetized within one year of initial operations and cannot be monetized before the equipment becomes operational.

It should be noted that any federal tax incentives monetized through a tax equity partner are complicated to structure, not guaranteed, and require transaction costs that erode the net value of the ITC and/or accelerated depreciation.

7.4.3 Estimated Incentive Values

The total estimated incentive value applicable to Wagner College's geothermal project from each of the programs identified above is summarized in Table 12.

Table 12. Summary of Incentives

Program	Phase 1	Phase 2	Total Project
NYSCHI	$6,320,000	$2,163,000	$8,483,000

7.5 Life-Cycle Cost Analysis

Endurant conducted a 30-year life-cycle cost analysis (LCCA) for the district as outlined in Table 13. Since Wagner College operates an aging cogeneration plant, we assume that the system would operate for the next 10 years. In year 11, we assume that the campus would convert to an all-electric VRF system. Capital cost estimates for the VRF conversion were taken from the Bright Power report. For the BAU case LL97 penalties of $520,000 are assumed beginning in year 2025 and increasing to $1,194,000 in year 2031. For the geothermal scenario, LL97 penalties of $668,000 begin in year 2031. The LCCA assumes a 2.5% inflation rate, 3.0% escalation on utility costs, and 4.0% discount rate.

Table 13. BAU Life-Cycle Cost Analysis

LCCA Metric	Value
CEP Replacement Cost	$10,554,300 (in year 2032)
Year 1 Operations and Maintenance Cost	$1,868,500
Year 1 Utility Cost	$618,052
30-year Life-Cycle Cost (Present Value)	$93,019,000

Table 14. Geothermal Life-Cycle Cost Analysis

LCCA Metric	Value
Geo capex (Phase 1 and Phase 2)	$22,487,262
Year 1 Operations and Maintenance Cost	$70,000
Year 1 Utility Cost	$628,207
30-year Life-Cycle Cost (Present Value)	$52,654,000

The simple payback for the entire geothermal solution is estimated to be 9 years. Simple payback considers annual cost savings from reduced operations and maintenance costs and avoided LL97 carbon liabilities.

8 Regulatory Discussion

The design as proposed does not pose any significant regulatory hurdles. The proposed system sits entirely within Wagner College's property boundary and does not traverse any public rights-of-way. The proposed geothermal district system replaces an existing district heating and cooling system. For these two reasons, we do not expect the geothermal system would introduce any novel regulatory issues.

Furthermore, there is no adjacent subway infrastructure, or subgrade utilities that would trigger engagement with New York City Transit Authority or investor-owned utilities. Staten Island does have a water tunnel that extends to the northern portion of the island; however, its location is not expected to impact the project.

Figure 8: Water Tunnel Location (left) and Wagner College Location (right)

Permitting for the project is expected to flow through two key agencies:

1. New York State Department of Environmental Conservation (DEC)—DEC will be the Authority Having Jurisdiction (AHJ) over the geothermal drilling scope and supply the associated permits.
2. New York City Department of Buildings (DOB)—DOB will be the AHJ issuing permits for the mechanical scope including the heat pumps, district distribution, and associated equipment.

9 Endurant Energy's Commercial Offering

The proposed district geothermal system at Wagner College is an ideal candidate for Endurant's Energy-as-a-Service (EaaS) offering.

Developing distributed energy resource systems enhances reliability and energy flexibility and will position the development to better adapt to future changes in the energy landscape. As Wagner College's EaaS partner, Endurant will develop a solution that will deliver value to Wagner College's operations over the long term.

9.1 Energy-as-a-Service

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

Developing distributed on-site energy systems enhances reliability and energy flexibility. It will position the college 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. As Wagner College's EaaS partner, Endurant will develop a solution that will serve as a platform for long term value creation.

Endurant's EaaS offering includes DBOOM (Design, Build, Own, Operate, Maintain) services for the following technologies and energy services:

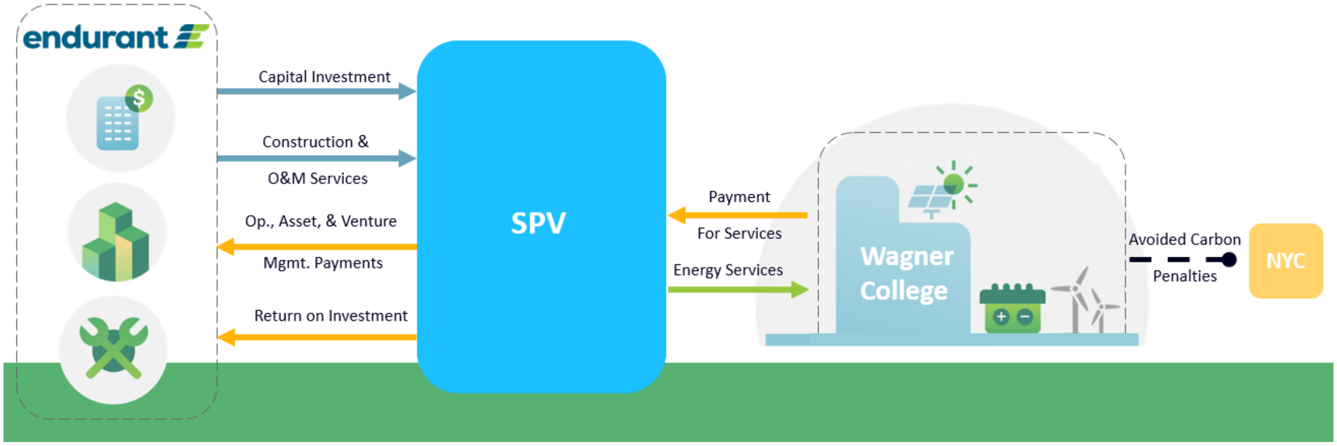
- Ground source and air source heat pumps.
- Solar photovoltaic (PV) and solar thermal.
- Battery energy storage systems (BESS).
- Electric vehicle (EV) charging.
- Fuel cells.
- Combined heat and power (CHP).
- Demand management.
- Energy supply contracts.

For the district geothermal solution proposed here, Endurant's EaaS will include the following services:

- Detailed design.
- GLHE and GHSP installation.
- Commissioning.
- Operations/optimization and maintenance.
- Project financing.

Figure 9 below illustrates the overarching relationships between key stakeholders in the EaaS commercial arrangement.

Figure 9. Energy-as-a-Service Commercial Structure



Under the EaaS arrangement, Endurant will create a special purpose vehicle (SPV) that will serve as the contracting vehicle for the project. Through the SPV, Endurant will design, finance, build, own, optimize and operate the geothermal system for Wagner College. A core component of the EaaS model is to simplify counter-party relationships. From Wagner College's perspective, Endurant would act much like the utility in the BAU scenario (i.e., a payment in exchange for thermal energy services).

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.

- Endurant can 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 15.

Table 15. EaaS Benefits Summary

Stakeholder	Benefits of EaaS business model
Wagner College	• Lower utility/operational costs incurred to provide heating and cooling to campus. • Low risk since the college is not responsible for financing and owning a complex DER project on their balance sheet. • Improves the brand value and marketability to prospective students.
Students	• Reduced operating costs helps contain tuition costs. • On-site renewables closely align with student's desire to reduce emissions.
Community	• More efficient thermal energy means more 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.

9.2 Engineering, Procurement, and Construction

The engineering, procurement, and construction (EPC) model represents the "business-as-usual" approach. Under this model Wagner College would contract with one or multiple firms to provide design and construction services. Operations and maintenance services might be provided by Wagner College's facilities staff, or via contracts with third-party service providers. The value from energy cost savings and carbon reduction would accrue entirely to Wagner College. However, the college would be exposed to more project risk than when compared to the EaaS model. 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**—Wagner College would be responsible for capitalizing the entire project from debt, other financing sources, or from Wagner College's capital budget.
3. **Operational Risk**—Energy assets require ongoing 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 the company has 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 of these project components interacts with one another and affects operations. It is therefore critical that each iteration in the design process is closely coordinated. Under the EPC approach, Endurant strongly recommends that Wagner College pursue an EPC contract that places all the GSHP design and elements under one subcontractor. This approach is more likely to produce a reliable outcome while placing accountability with one subcontractor.

10 Conclusion

Endurant Energy recommends that Wagner College pursue a district geothermal solution to replace the CEP and district system that has reached the end of its useful life. This study illustrates the following benefits that the geothermal system would deliver to Wagner College.

- The geothermal solution operates more efficiently, which will result in reduced CO_2 emissions and associated Local Law 97 fines.
- The geothermal solution requires less maintenance and fewer operators, which will greatly reduce Wagner College's operating costs over time.
- The all-electric system would make Wagner College carbon-neutral ready.

The conversion from natural gas to an all-electric geothermal system should be conducted in two phases, resulting in two, separate geothermal districts. Phase 1 represents the larger geothermal opportunity. By continuing to proceed with Phase 1 now, Wagner College will be more likely to secure available Clean Heat and other NYSERDA incentives, schedule the geothermal installation to coincide with planned HVAC renovations at Harborview Hall, and ensure real CO_2 reductions prior to 2025 when LL97 penalties are expected to materialize. In addition, Wagner College can begin to decommission the portions of the existing district system and avoid continued repair and maintenance costs.

The results of this study provide directional confirmation that a district geothermal system is a viable replacement for Wagner College's existing district system. Additional analysis and design are required to advance the conceptual designs proposed and explored here.

Actionable next steps include:

1. Conduct energy model to finalize equipment selection.
2. Develop a schematic design and equipment layout.
3. Apply for New York State Clean Heat Incentives.

10.1 Lessons Learned

The proposed system offers value beyond efficiency gains and reduced utility and operating costs. This study focused on the buildings that currently connect to Wagner's district system. However, additional buildings exist that could be interconnected to the proposed geothermal system, or the college could undertake subsequent phases that would install additional GLHE capacity in other areas of the campus. While not assessed in this study, there is future geothermal potential if these initial phases achieve the efficiency gains and cost reductions expected.

There is also opportunity for a district geothermal system at Wagner College to support the development of district geothermal systems in downstate New York. Endurant's experience has shown that the market suffers from a lack of successful, diverse, district geothermal systems. Many potential customers considering a geothermal system seek reassurance from owners of other local geothermal systems that are representative of the buildings offered as hosts. Should Wagner College proceed with this proposed geothermal system, successful operations will serve to reassure future building and campus owners of the real value that geothermal offers. A successful outcome here would not only provide value to Wagner College, but also bolster confidence in the technology and support wider adoption across the State.

Appendix A: Solar PV and Battery Energy Storage System Discussion

Many factors are considered when exploring opportunities for solar PV and/or battery energy storage systems (BESS). Either asset might be deployed independently, or solar PV and BESS might be paired as a single installation. Utility programs and incentives change depending on the size, configuration, location, and pairing (or not) of solar PV and BESS. Finally, the value proposition to the host site may be different depending on whether the assets are interconnected in front-of-the-meter (FTM) or behind-the-meter (BTM).

A.1 Solar PV

Endurant Energy assessed the benefits that solar PV and BESS offers to Wagner College under various configurations. We initially explored the opportunity to install solar PV at Wagner College on the Spiro Hall rooftop, over the main parking lot (off Campus Road) and the Hameline Field parking lot, and an area adjacent to Hameline Field.

Figure A-1. Potential Areas to Locate Solar PV

Through review of Wagner College’s 2020 solar feasibility study and discussions with Wagner College, the team estimates solar PV capacity to be 2,000 kW direct current (DC) across the areas available. If connected to the Wagner College distribution system, electricity generated by the solar PV arrays would offset electricity from the grid. Annual electricity production would be approximately 2.277 megawatt-hours (MWh) per year. If these solar PV arrays could be interconnected behind the main Con Edison electricity meter, then this electricity would offset grid imported electricity and approximately 658 tons of associated CO_2 emissions.[11] There is little opportunity to enhance the economics of a BTM solar PV array with BESS since we expect that solar PV electricity would be consumed on campus at the time of production. However, we would need to verify this assumption using historic electricity loads from all campus electricity accounts.

A.2 Battery Energy Storage

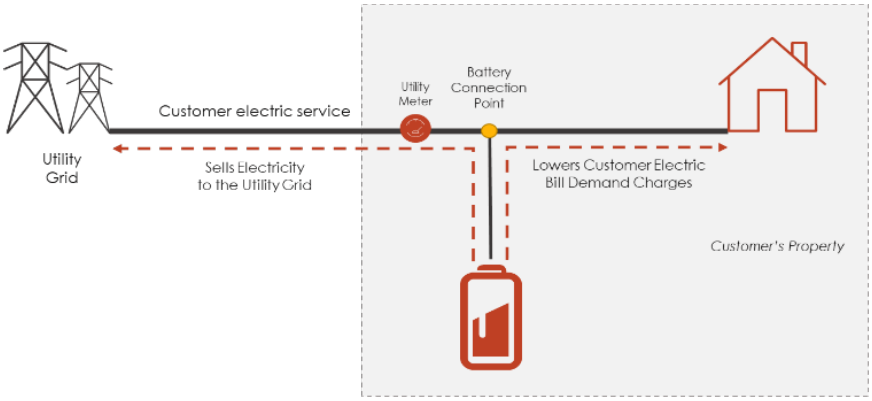
The Endurant team conducted a comprehensive analysis of Wagner College’s existing and planned infrastructure, evaluating the campus’s Battery Energy Storage (BESS) potential.

Battery storage is a versatile technology that can provide a variety of technical and commercial values. Batteries can function as a flexible asset to grid operators by supplying additional energy at times of peak demand, when the grid needs it most, or by delivering grid services that help balance and stabilize the network. In addition, batteries may provide demand reduction or temporary resiliency to utility customers.

There are two main use cases for batteries in New York State. The first is a “front-of-the-meter” (FTM) application where the battery would not connect to Wagner College’s facilities but would instead connect directly to Con Edison’s distribution network and sell energy services to the grid. In this instance, the College would receive a simple lease payment as compensation for hosting the battery on its campus.

In the second use case, the “behind-the-meter” (BTM) model, the battery connects to Wagner College’s facilities. During the peak demand hours, Wagner College would draw power from the battery instead of the grid, minimizing demand and associated electricity demand charges. In some behind-the-meter applications, the battery can also backfeed into the grid to supply electricity and services to grid operators.

Figure A-2. Behind-the-Meter Battery Energy Storage Interconnection



From a technical perspective, Wagner College's legacy infrastructure, campus layout, and proximity to Con Edison distribution network connection points make the campus an excellent prospect for battery storage.

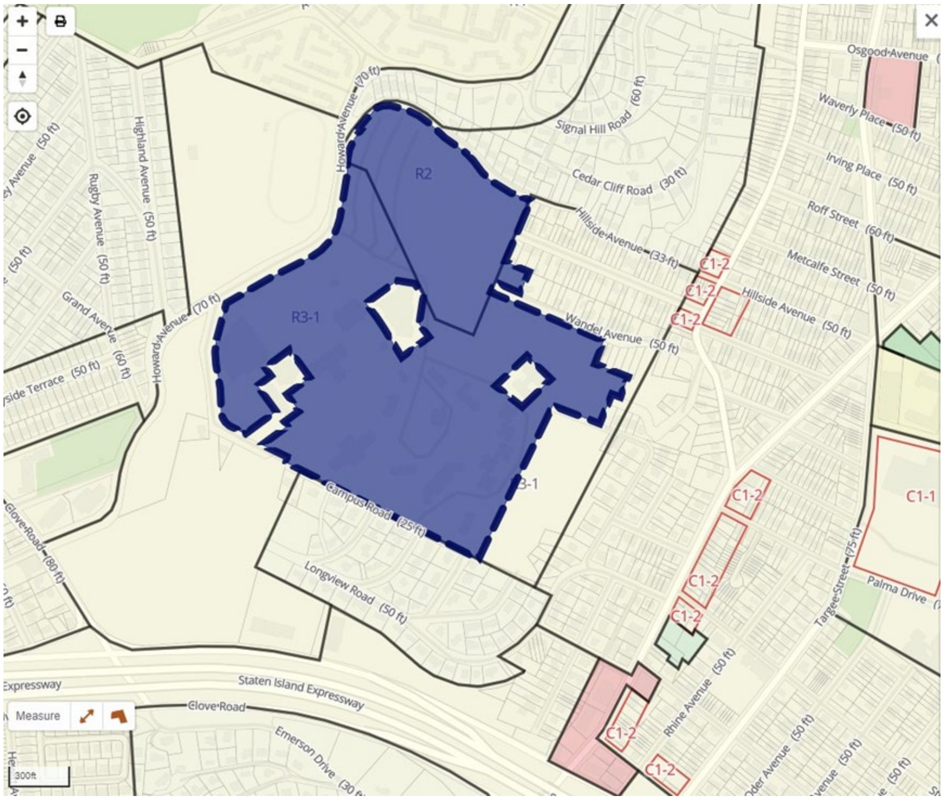
To start, the mixed-use energy profile on the campus makes for a diverse, complementary load profile. This mix provides the energy value of BESS in different ways at different times of the day or year. Specifically, with the residential Harborview, Guild, Towers and Foundation Halls, paired with the academic, administrative, and student life buildings, the campus' mix of peak demand times rounds the energy demand curves. Further, the location's energy in the early morning hours will likely be lower, therefore, making it a more opportune time to charge at night and discharge during the day, as is typical for these systems.

For both front-of-the-meter (FTM) and behind-the-meter (BTM) use cases, the shift from daytime academic and administrative peaks in the mid-to-late afternoons (1:00 p.m.–4:00 p.m.) to evening peaks corresponding to residential demand (peaking from 4:00 p.m.–8:00 p.m.) would make the battery valuable across a broad demand window.

This logic applies seasonally as well (winter and summer peaks versus shoulder seasons). For example, the BESS could power geothermal heat pumps during the winter and summer peak times to reduce grid demand. Lastly, the battery could be used to provide up to four hours of resilient backup power during grid outages.

From a zoning perspective, Wagner College' lots are predominantly zoned as Residential (R3-1, R2). For the battery's siting, Wagner College would need to split part of these lots (~5,000 sq. ft.) and rezone them to be industrial, commercial, or manufacturing.[12] While adding another step, this process is not prohibitive to a project. The map in Figure A-3 shows the historic zoning map for the development site.

Figure A-3. Wagner College Zoning Map



Endurant's floodplain analysis yielded positive results as well. Some properties throughout the city situated closer to the water face challenges where flooding is a concern, especially during storm events. However, Wagner College's inland, high-elevation location keeps it outside of the Federal Emergency Management Agency (FEMA) flood zones and within a safe area to build a battery system. The map below shows the floodplain layout of the site. The lack of "blue" and "orange" highlights (as seen to Wagner College's neighbors to the east and south) indicates that the campus is outside of the flood zone area.

Figure A-4. Wagner College Flood Zone Map

Finally, Endurant reviewed Con Edison’s existing distribution infrastructure at the site to determine the grid’s ability to accommodate new energy storage on the network. Wagner College is in an excellent location from this perspective, predominantly fed by the Fox Hills Substation network. This part of the network has a high amount of hosting capacity. The hosting capacity map indicates up to 9.58 megawatts (MW) of hosting capacity on distribution feeder S2-1 to the east of the campus, which would be an ideal interconnection location. Additionally, due to the campus’ sprawling coverage across Con Edison’s network, energy storage could be sited at several locations, especially where two separate feeders conjoin. The map below shows Con Edison’s existing distribution infrastructure at the site.

Figure A-5. Con Edison Hosting Capacity Map for Area Surrounding Wagner College

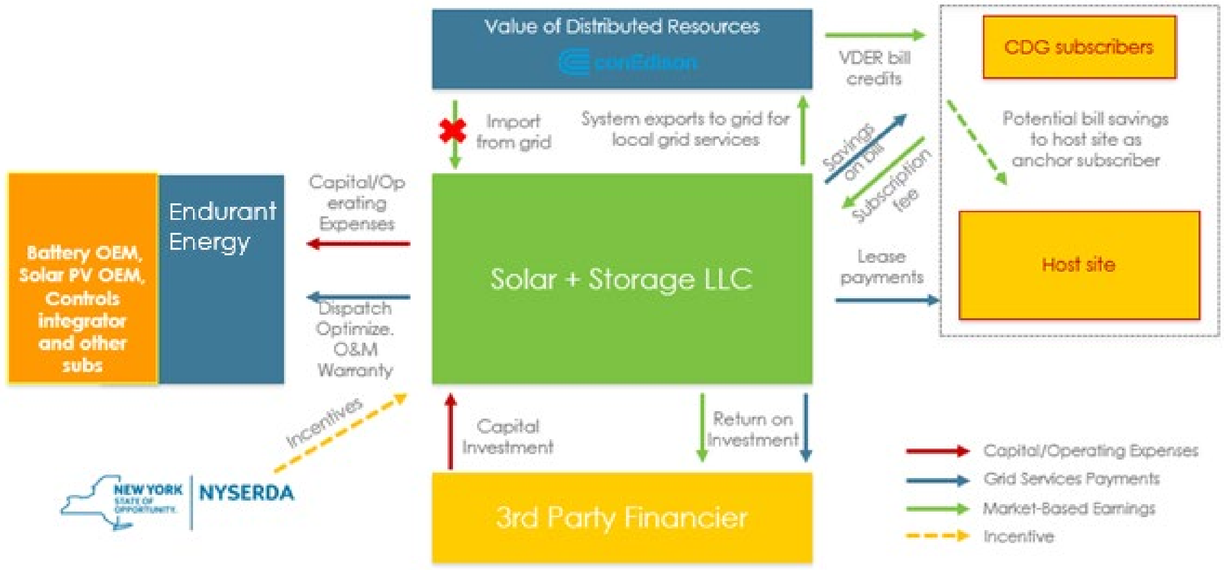
A BTM use case that manages Wagner College's peak demand charges and time-of-use energy charges is possible here. However, a BTM BESS used for demand management would ideally need to be located adjacent to facilities with the highest loads during Con Edison peak hours. Instead, the simplicity of a FTM configuration may make the most financial sense for Wagner College. FTM systems can be sited more flexibly, which is a critical consideration in the New York City environment.

A.3 Community Distributed Generation with Solar PV and Battery Energy Storage Systems

New York State has an established program called Value of Distributed Energy Resources (VDER) that allows solar PV (optionally paired with BESS) systems to connect directly to the distribution grid in front of the customer meter. An asset enrolled in the VDER program generates a monetary credit for each kilowatt-hour 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 owners, 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 9 below summarizes the third-party funded business model for the FTM CDG VDER asset.

Figure A-6. Third-Party Funded FTM CDG VDER Commercial Structure



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

Wagner College would receive a lease payment from the third-party asset owner for use of their rooftops and ground space. In addition, Wagner College's main electric account can be designated as a subscriber to the solar PV and BESS project, thereby seeing approximately 5%–.10% reduction in electricity bills. The FTM VDER projects would be physically independent of the proposed geothermal solution and can therefore be pursued in parallel and independently of the geothermal project. The solar PV and BESS project would create financial benefits and enhance overall value to Wagner College by:

1. Offering stable and predictable lease payments to Wagner College which will offset the college's operating expenses.
2. Provide an opportunity for electricity bill savings to the Wagner College community without any out-of-pocket costs.
3. Enhance on-campus renewable energy attributes and overall marketability of Wagner College.

A.4 Economic Potential

From an economic perspective, energy storage is highly valuable in Staten Island for several reasons. First, New York State's most lucrative energy storage opportunities are under the new VDER tariff. These markets pay batteries (and solar + storage systems) for the locational marginal value of flexibility and demand relief that they provide to the electric utility.

The Demand Relief Value (DRV) market, for instance, incentivizes assets that provide additional demand relief in areas of greatest need, which are often within the most densely populated networks (like New York City). The Locational System Relief Value (LSRV) market pays batteries (and solar + storage) for the demand relief it provides for that specific node on the grid. Nodes that are more congested receive LSRV Zone status, making them eligible for payments in that special program. Endurant Energy analyzed the local market prices and VDER rates which can be shown below.

Table A-1. Value of Distributed Energy Resources Rates Available for the Value Stack

Wagner College VDER Value Stack Available Rates	
Market	Rate Price
Capacity (Alternative 3)	$4.22 ($/kW)
Environmental Component	$0.03103 ($/kWh)
Demand Reduction Value (DRV)	$0.85360 ($/kWh)
LSRV	Does not Qualify

The VDER tariff has established a statewide market for community distributed assets and is the gold standard for solar PV and BESS deployment in New York City. Electricity and capacity prices are relatively high in Staten Island compared to other areas of New York State which support economics for distributed generation assets in the VDER program. However, for solar PV projects, the economics are highly dependent on location. This is because the DRV component of the VDER tariff is based on the asset's production during defined time-windows that align with the peak demand of the local network. Wagner College is in a 4:00 p.m.–8:00 p.m. network, which does not align with the peak hours of solar production (typically, 12:00 p.m.–6:00 p.m.). As such, a solar PV VDER project located at Wagner College will miss out on the full DRV value. Until recently, the Community Credit (CC) component of the VDER tariff offered a lucrative $0.12/kWh value to VDER projects that involve renewable technologies such as solar PV. The CC component has now been discontinued. In lieu of the CC, a new upfront incentive program has been rolled out. However, the overall economics of the project are diminished due to loss of 20–25 years' worth of CC payments valued at $0.12/kWh.

For these reasons, the economics of a standalone solar PV project located at Wagner College are challenging compared to other locations. While the issue of lost community credit is seen throughout the city, the 4:00 p.m.–8:00 p.m. zone remains a challenge specific to Wagner College. Our conclusion is that solar developers are likely able to finance community solar PV across Wagner's campus but offer lease payments lower than those quantified in the Bright Power feasibility report.

BESS is dispatchable and hence not impacted by the grid peak time window. As such, a BESS project under the VDER tariff will be able to maximize revenue and offer improved economics for financiers and Wagner. BESS also occupies significantly lower footprint. Our conclusion is that Wagner College is a strong BESS host candidate due to the excellent proximity to Con Edison's distribution service, ample space to locate BESS assets, and a large electric account to use as an anchor subscriber. Current zoning may need to be changed to install a BESS. Flood risks remains very low here and is highly unlikely to be a barrier for adding batteries at the site. A BESS project will be able to generate attractive lease offers, particularly when viewed in the context of the amount of footprint occupied.

Endnotes

[1] "Wagner College, Phase 1: Energy Audit and Retro-Commissioning Report." Prepared by Bright Power. June 2020.

[2] Both Harborview and Guild Hall will receive façade improvements and significant HVAC upgrades. Completion expected Fall of 2022.

[3] We received monthly natural gas use at the CEP from utility bills between November 2017 and August 2020.

[4] The working fluid is typically water, although some geo system designs can benefit by a mixture of glycol and water.

[5] Coefficient of performance (COP) is the ratio of useful thermal energy out compared to the input energy powering a heat pump. Higher COPs signal higher energy efficiency as compared to lower COP heat pumps.

[6] Value of Distributed Energy Resources (VDER) is a mechanism established by the New York State Public Service Commission to compensate distributed energy resources (DERs) for the local value they provide to the electric grid.

[7] The GSHP solution allows for simultaneous heating and cooling of the building. Water-to-water heat pumps can reject the waste heat from the cooling process to supply heating at the same time. Simultaneous heating and cooling demands may occur in the cooling season when DHW loads remain consistent. There may also be times during the year when interior spaces require heating while others require cooling.

[8] We define a unitary system as a single, isolated geothermal system designed for a single building. All mechanical heat pumps and the ground heat exchanger are solely dedicated to serving the individual building under a unitary system design.

[9] Annual carbon emissions assume the same carbon intensity factor used in LL97 (0.000288962 tons CO_2 per kWh, 0.0000531 tons CO_2 per therm).

[10] https://cleanheat.ny.gov/

[11] Annual carbon emissions assume the same carbon intensity factor used in LL97 (0.000288962 tons CO_2 per kWh).

[12] Endurant Energy is currently in discussion with the Mayor's Office to explore alternative pathways to installing solar PV and BESS given current zoning status.

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