GEOTHERMAL SYSTEM FEASIBILITY TOOL
USER GUIDE
(MARCH 21, 2023)

NYC SCHOOL CONSTRUCTION AUTHORITY

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1.0 Background

This user guide contains instructions for the design team to follow when completing the SCA Geothermal System Feasibility Tool. This tool was created for design teams to use to document geothermal feasibility assessment findings to determine if a project building site is feasible for a geothermal system (standing column, closed-loop, or open-loop) in order to meet the Geothermal Feasibility Law of LL06/2016.

The benefits of geothermal systems is highlighted in the *Geothermal Systems and their Applications in New York City* document by The City of New York dated February, 2015.

2.0 NYC Geothermal Pre-feasibility Tool

The NYC Mayor's Office of Sustainability and NYC DDC developed and made publicly available an online screening tool (referred to as *NYC Geothermal Pre-feasibility Tool* in this User Guide) that can be used to determine the geological, and to a basic extent technical feasibility of a geothermal system for a building site. This screening tool shall be utilized as the first stage of determining if a geothermal system is feasible for an SCA building site and will feed into the developed *SCA Geothermal System Feasibility Tool* if this *NYC Geothermal Pre-feasibility Tool* yields passing results. This *SCA Geothermal System Feasibility Tool* is a result of further development for technical and cost feasibility of geothermal system conducted by SCA and OLA for NYC schools. Depending on which type of geothermal system is recommended for a full system feasibility study in the *NYC Geothermal Pre-feasibility Tool*, this will narrow down which system options are reviewed within the *SCA Geothermal System Feasibility Tool*. This review process is illustrated in the below flow diagram (see Figure 1). See attached appendices for the full geothermal system feasibility process flow diagram.

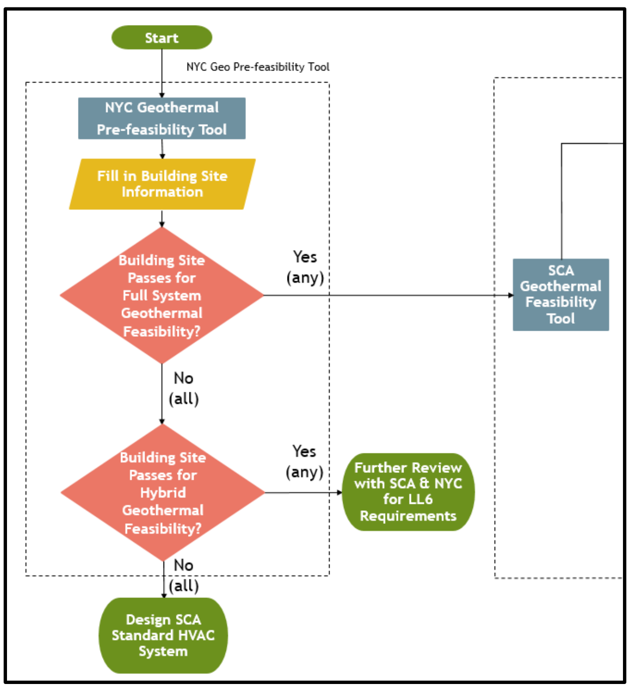

Figure 1. NYC Geo Pre-feasibility Tool Flow Diagram

The first step for this process would be to enter the building site information into the *NYC Geothermal Pre-feasibility Tool* (see Figure 2). The link to this tool can be found below and in the Instructions tab of the *SCA Geothermal System Feasibility Tool*.

Under the "Building" category, the user can modify the Lot Area, Building Area, Building Footprint, and the Building Type to the right-hand side of each of these default values in order to adjust the existing building information to account for the current design.

- For the gut renovation of an existing school, this building information will need to be verified and modified if necessary (for example, the DDC noted that this DOB building database does not include mechanical spaces and cellar/basement spaces).
- For the addition to an existing school building, the modification to the pre-feasibility tool will be required in order to appropriately represent lot area, building area, and available site area. One option is to enter just the building addition area (to accurately represent the capacity potential) and to modify the lot area by removing the existing building area to appropriately represent the available free site area.

NYC Geothermal Pre-feasibility Tool: https://www.nyc.gov/assets/ddc/geothermal/geothermalTool.html

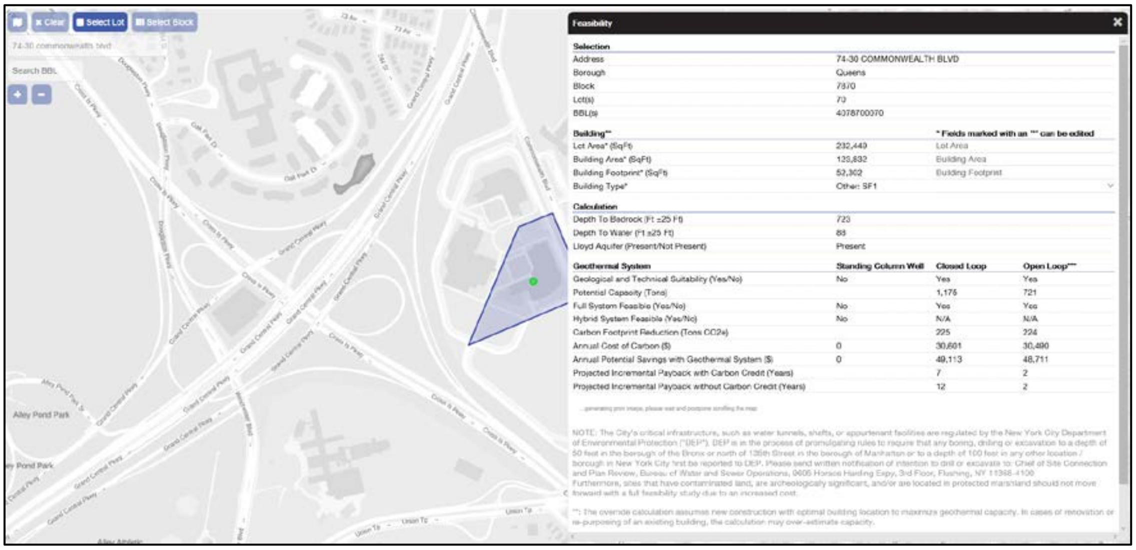

Figure 2. NYC Geo Pre-Feasibility Tool Map

Once the building site information is entered, the *NYC Geothermal Pre-feasibility Tool* will automatically determine if a building site has Geological and Technical Suitability. In addition, this tool will automatically determine if the project site is recommended for a Full System Feasibility study or not. If "Yes" for any indicated geothermal system type, these results will be entered into the *SCA Geothermal System Feasibility Tool*. If "No" for all indicated geothermal system types, the *SCA Geothermal System Feasibility Tool* is not required and the design team can proceed with the design of SCA standard HVAC systems (the path for hybrid geothermal feasibility is still being reviewed by SCA).

3.0 SCA Geothermal System Feasibility Tool – Summary

As noted above, if the *NYC Geothermal Pre-feasibility Tool* indicates "Yes" for any geothermal system type Full System Feasibility, these results will be entered into the *SCA Geothermal System Feasibility Tool*. This process is illustrated in the below flow diagram (see Figure 3). See attached appendices for the full geothermal system feasibility process flow diagram.

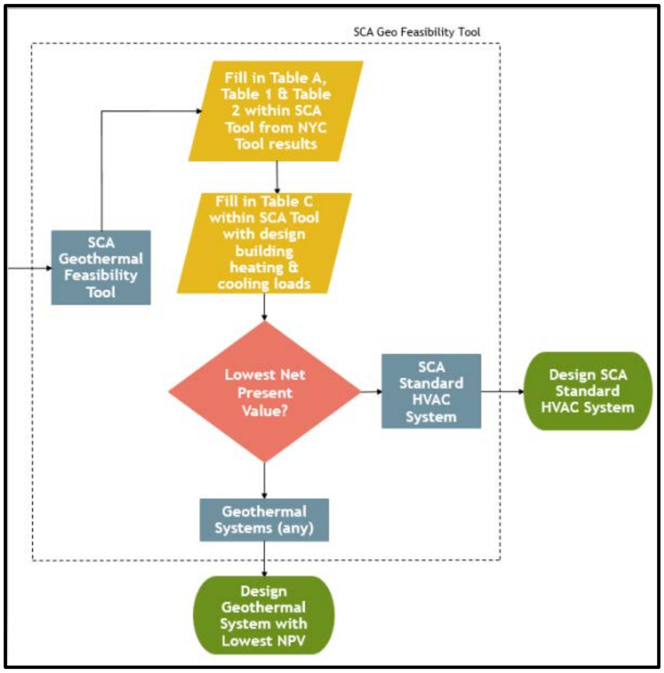

Figure 3. SCA Geo Feasibility Tool Flow Diagram

The first step for the SCA design team when using this tool would be to fill in the Table A Building Site Information shaded in orange (i.e. project name, project address, building area, number of floors, and lot area) at the top left side under the Summary tab (see Figure 4).

Table A: Building Site Information

Building Site Information	
Project Name	
Project Address	
Building Area (ft^2)	
No. of Floors	
Lot Area (ft^2)	
Depth to Bedrock (ft)	

Figure 4. SCA Tool Building Site Information

Depending on which geothermal systems pass for full feasibility, the user will use the drop down menu to fill in Table 1 in the Summary tab of the *SCA Geothermal Feasibility Tool* (see Figure 5 below).

Table 1: SCA Geothermal Feasibility Tool Results

	Geothermal System	Standing Column Well	Closed Loop	Open Loop
1	Geological and Technical Suitability (Yes/No)			

Is a Geothermal Feasibility Study Required	

Figure 5. SCA Tool Table 1 – NYC Geo Pre-feasibility Tool Results

Relevant information from the *NYC Geothermal Pre-feasibility Tool* can then be entered into Table 2 in the Summary tab of the *SCA Geothermal Feasibility Tool* (see Figure 6 below).

Table 2: SCA Geothermal Feasibility Tool Results Continued

	Geothermal System	Standing Column Well	Closed Loop	Open Loop
1	Potential Capacity (Tons)			
2	Full System Feasibility (Yes/No)			
3	Carbon Footprint Reduction (Tons CO2e)			
4	Annual Cost of Carbon ($)			

Figure 6. SCA Tool Table 2 – NYC Geo Pre-feasibility Tool Results

The non-demand electricity ($/kWh) and demand ($/kW) rates are “fixed” in Table B at the top right of the Summary tab (see Figure 7). SCA will review these rates and change based on DCAS’ changes. The 2023 DCAS energy rates are provided below for reference (see Figure 7 for electricity). SCA projects are currently based on the ‘All-Elec’ Schools rate.

Table B: Utility Rates	
Utility Rates	
Electricity (non-demand) Usage $/kWh	$0.0720
Electricity Demand $/kW	$34.73

ELECTRICITY RATES (NEW YORK POWER AUTHORITY):

	Production *		Delivery			
Service Classification	Energy (¢/kWh) Summer [Pk/Off-Pk] *Winter [Pk/Off-Pk]*	Demand ($/kw)	Energy (¢/kWh)	Demand Low Ten., ($/kW) Summer *Winter*	Demand High Ten., ($/kW) Summer *Winter*	Facility Points ($/Point)
General Small (062)	8.029 7.686	na	23.34	na	na	na
General Large, Conventional (069)	6.675 *6.332*	6.14	na	31.45	21.85	na
General Large, TOD (069)	7.430/5.659 *6.627/5.676*	7.35	na	56.25 *20.47*	33.31 *15.07*	na
Street Lighting	7.275	3.65	na	31.45	21.85	13.07
Pub. Buildings, Conventional (091)	6.500 *6.156*	5.91	na	31.45	21.85	na
Pub. Buildings, TOD (091)	7.148/5.355 *6.335/5.372*	9.73	na	56.25 *20.47*	31.74 *33.31*	na
All-Elec Schools, Conventional (093)	7.432 *7.091*	3.28	na	31.45	21.85	na
WPCP, Conventional (098)	6.523 6.179	4.67	na	31.45	21.85	na
WPCP, TOD (098)	8.058/6.287 *7.255/6.304*	6.87	na	56.25 *20.47*	33.31 *15.07*	na

* Add an additional 1.50 cents per kwh ($0.015) to calculate full rate charged; do not include when calculating savings from energy efficiency projects (this covers certain fixed charges and statewide Clean Energy Standard ‘ZEC’ (zero emissions) surcharges that do not vary with usage; identified here as a kwh rate to capture full costs)

- Power factor charge of $2.14/kvar for billable reactive power, based on facility size, for facilities with power factor < 95%.
- Production energy rates are subject to a monthly Energy Charge Adjustment to cover unexpected fluctuations
- TOD: Energy On-Peak, 8:00am to 10:00pm Monday to Friday; Demand On-Peak, 8:00am - 6:00pm Monday to Friday; other times are Off-Peak.
- Summer: June through September; Winter: October through May.

Figure 7. SCA Tool Table B - Current Electricity Rates

Next, still within the tool’s Summary tab, the design team should fill in Table C: SCA Standard HVAC Baseline System (see Figure 8). Enter in the Cooling Load (ft^2/ton) and the Heating Load (Btu/ft^2) of the system. Peak cooling loads and heating loads shall be input as loads prior to any equipment safety factors or redundancy requirements. For long term efficiency, the proposed systems will provide a balance between heating and cooling loads and system capacity.

Table C: SCA Standard HVAC Baseline System					
Baseline Cooling System Chiller Type	Cooling Load (ft²/ton)	Cooling Load (tons)	Baseline Heating System Type	Heating Load (Btuh/ft²)	Heating Load (MBH)
SCA Standard HVAC System (Air-Source Heat Pump RTUs)	400	303	SCA Standard HVAC System (Air-Source Heat Pump RTUs)	25	3,025

Figure 8. SCA Standard HVAC Baseline System Table

Once this information is entered, the *SCA Geothermal System Feasibility Tool* will automatically determine if a geothermal system is required for this project under both low cost and high cost assumptions (see Figure 9). If a geothermal system is required, the design team shall proceed with the design of the geothermal system type chosen as the lowest net present value. If a geothermal system in not required, the design team can proceed with the design of the SCA standard HVAC systems.

Table 3: SCA Geothermal Feasibility Study Results

Type of Systems Studied	Capital Cost Estimate (Plant)		Yearly Maintenance Cost		Electric Cost (Yearly)	Cost of Carbon (Year)	Cost of Carbon (Site Cost)	System Life Expectancy			Net Present Value		Lowest Net Present Value?	
	Low	High	Low	High							Low	High	Low	High
SCA Standard HVAC System (Air-Source Heat Pump RTUs)	$3,680,820	$7,381,000	$3,000	$5,000	$122,841	2023	$17,789	15	To	19	$5,981,411	$9,925,969	Yes	Yes
Geothermal Closed Loop	$5,127,155	$11,953,052	$1,220	$1,830	$110,301	2023	$16,571	15	To	19	$7,147,425	$14,167,957	No	No
Geothermal Standing Column	$4,377,914	$9,656,741	$24,400	$48,800	$92,474	2023	$13,648	15	To	19	$6,441,330	$12,333,115	No	No
Geothermal Open Loop	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	To	N/A	N/A	N/A	N/A	N/A
Is a Geothermal System Required	No	No												
	(Low)	*(High)*												

Figure 9. Geothermal System Feasibility Results Table

The design team can review the other tabs within the tool for reference to see how each component in the table above was calculated. Section 4.0 provides further information on the calculations/assumptions for each of these tabs in the tool.

Upon completion of the *SCA Geothermal Feasibility Tool*, the design team will need to fill out the SCA Geothermal Feasibility Report (with tables from the Tool, as indicated in the user notes within the Report), fill out the Geothermal Credit Form, and attach the form and report to the GSG DD submission.

Please note that due to the cost, maintenance, and performance issues experienced with open loop ground source heat pumps, if this geothermal system type yields the most feasible results, the design team will need to defend this option further to SCA with the above submission.

4.0 SCA Geothermal Feasibility Tool – References

4.01 Assumptions

The Assumptions tab within the *SCA Geothermal Feasibility Tool* lists the cooling and heating systems performance data consisting of calculations derived from operating data entered in the Baseline Systems tab which are based on NYC SCA requirements, ASHRAE 90.1, or industry standards.

4.02 Baseline Systems

The baseline systems utilized in this tool are based on 2020 NYC SCA eQuest Input Summary, NYC Green Schools Guide 2016, SCA Design Requirements Document, and ASHRAE 90.1 – /2016.

The cooling system type under the Baseline Systems tab is based on ASHRAE 90.1-2016 for air-cooled heat pumps systems greater than 240,000 Btu/h (EER = 9.3, IEER = 10.4) (Figure 10).

Cooling Systems			
Cooling Type	**Size Category (Btu/h)**	**EER**	**IEER**
Air-Source Heat Pump	≥240,000	9.3	10.4
Data for air-cooled heat pump based on ASHRAE 90.1-2016, Table 6.8.1-2.			

Figure 10. Cooling System Specifications

The heating system type under the Baseline Systems tab is based on a combination of ASHRAE 90.1-2016 for air-cooled heat pump systems greater than 135,000 Btu/h (COP = 3.2), (Figure 11).

Heating Systems		
Heating Type	**Size Category (Btu/h)**	**Heating COP**
Air-Source Heat Pump	≥135,000	2.9
Data for air-cooled heat pumps based on ASHRAE 90.1-2016, Table 6.8.1-2. *Effective Heating COP is an estimated value based on equipment performance data rated at approximate average NYC winter temperature.*		

Figure 11. Heating System Specifications

The geothermal systems data performance indicated in the Geothermal Systems table under the Baseline Systems tab is based on ASHRAE 90.1-2016 for closed loop and open loop / standing column well systems (Figure 12).

Geothermal Systems					
System Type	Equipment Type	Rating Condition	Minimum Efficiency	Efficiency Unit	Well Water Delta T
Closed Loop	Ground Source brine to air (cooling mode)	77°F entering water	14.1	EER	10
	Ground Source brine to air (heating mode)	32°F entering water	3.2	COP	10
	Ground Source brine to water (cooling mode)	77°F entering water	12.1	EER	10
	Ground Source brine to water (heating mode)	32°F entering water	2.5	COP	10
Open Loop/ Standing Column	Groundwater Source water to air (cooling mode)	59°F entering water	18	EER	10
	Groundwater Source water to air (heating mode)	50°F entering water	3.7	COP	10
	Groundwater Source water to water (cooling mode)	59°F entering water	16.3	EER	10
	Groundwater Source water to water (heating mode)	50°F entering water	3.1	COP	10
Data based ASHRAE 90.1-2016 Table 6.8.1-2. All equipment types assumed to be less than 135,000 Btu/h.					

Figure 12. Geothermal Systems Specifications

4.03 Energy Consumption

The Energy Consumption tab within the *SCA Geothermal Feasibility Tool* displays the Bin analysis calculations performed based on Central Park, NY weather data from the BinMaker software tool to calculate the total energy consumption of each system type studied. Bin hours were separated into average school occupied hours and average school unoccupied hours, based on an occupied schedule of an average of 4.5 days per week, 7am-6pm on full days. From this, heating and cooling load profiles were developed for both occupied and unoccupied periods.

Annual electric energy usage (kWh) are calculated for each system type based on load, hours, and equipment efficiencies. Energy usage for the heat pumps, water pumps, and heat rejection systems were evaluated. The geothermal system types were calculated with the assumption that these are variable flow well water systems.

4.04 Energy Demand

The Energy Demand tab within the *SCA Geothermal Feasibility Tool* displays the monthly and annual cooling electric demand, monthly and annual heating electric demand and total plant monthly and annual electric demand calculated for each system studied based on the values inputted in the Summary tab and the Baseline Systems tab. As the current SCA standard HVAC system is all electric, the peak demand is expected to be higher than the geothermal systems.

4.05 Energy Cost

The Energy Cost tab within the *SCA Geothermal Feasibility Tool* calculates the total energy cost of each system studied based on the total energy consumption calculated in the Energy Consumption tab and the total demand calculated in the Energy Demand tab along with the utility rates entered in the Summary tab.

4.06 Capital Cost

The capital cost for each heating and cooling plant system type is variable depending on the particular system design and project bidding conditions. With the proposed design for geothermal equipment within the building being variable and assuming institutional level equipment being used, the majority of the cost difference between the geothermal options and baseline systems is in the well field or well water systems. The construction cost ranges for the various geothermal options are impacted by parameters such as the amount of well casing required for the particular site specific drilling conditions along with heat exchangers and pumping systems for standing column/ open loop systems. Well field construction costs were developed with the help of well field contractors familiar with installing various well field systems within the 5 boroughs.

An assumption was made that air handling systems within the building would meet SCA standards and have load reducing strategies such as energy recovery and demand control ventilation which is critical for reducing plant equipment and well field capacities.

The tool also assumes that SCA requirements for a perimeter radiation heating system is included in all system types in order to reduce off hours fan energy usage. Building fan energy usage is assumed to be similar for each system type and will be based on actual design.

4.07 Annual Maintenance Cost

The Annual Maintenance Cost tab indicates the incremental low and high maintenance costs for each system studied per year. The SCA standard HVAC system maintenance costs were primarily based on annual cleaning of the air-cooled condensers for each rooftop unit. The geothermal closed loop maintenance costs were based on minor water treatment required annually. The geothermal standing column system maintenance costs were based on heat exchanger and well pump maintenance costs. The geothermal open loop system maintenance costs were based on heat exchanger, water filtration, and well pump maintenance costs. The tool indicates a significant variance in maintenance costs for both standing column and open loop systems due to site specific water quality and actual system installation.

4.08 Carbon Impact

The Carbon tab within the spreadsheet tool indicates the annual carbon dioxide emissions cost per system type studied. This is determined by using Energy Star's CO_2 emission rates for electricity. In addition, LL6 dollar value per metric ton of carbon dioxide equivalent per year was used to determine this cost estimate.

4.09 System Life Expectancy

The System Life Expectancy tab within the spreadsheet tool indicates the estimated low and high life expectancies of each system type studied. These values were taken from ASHRAE's Life Expectancy Chart while the life expectancy on the geothermal heat pump systems were based on industry standards. NPV analysis for all systems are currently based on 20 years in the tool per LL6, so this specific system information is not yet factored into analysis. Factoring this in would further disadvantage geothermal systems.

4.10 Net Present Value (Low)

The NPV (Low) tab within the SCA Geothermal Feasibility Tool spreadsheet indicates the low net present value analysis on each system type studied. The net present value calculations are based on the initial costs (capital costs) of each system type, the total annual costs (utility cost, maintenance cost, and carbon cost) of each system type, along with an assumed discount/interest rate of 5%.

4.11 Net Present Value (High)

The NPV (High) tab within the *SCA Geothermal Feasibility Tool* spreadsheet indicates the high net present value analysis on each system type studied. The net present value calculations are based on the initial costs (capital costs) of each system type, the total annual costs (utility cost, maintenance cost, and carbon cost) of each system type, along with an assumed discount/interest rate of 5%. The high NPV calculations were developed using risk or lack of risk between the systems studied.

5.0 Appendices

Appendices documents are available separately on the SCA website.