620 State St.-2nd Floor
Schenectady, NY 12305
purchasing@schenectadycountyny.gov
518.388.4240

Schenectady County
Purchasing Department

ADDENDUM

RFP-2024-01
STRUCTURAL AND BUILDING SYSTEMS EVALUATION SERVICES

ADDENDUM #1

Issued Date: 05/17/2024

The purpose of this addendum is to provide detailed information to all Bidders. This addendum is hereby included in and made part of the Contract Documents, whether or not attached thereto. Receipt of this Addendum must be acknowledged on the bid form.

CONTENTS/RESPONSE TO QUESTIONS/REFERENCE TO ATTACHMENTS

General RFI's:

1. Please provide available existing as-built drawings for original construction and renovation projects at the building
    a. Response: Please see attached link to the Dropbox.
    b. Link to Dropbox: https://www.dropbox.com/scl/fo/8hioxw0qz8kfxm3go09c7/h?rlkey=p7yni933p598ujlm6oa5ntit1&st=y8tpdod2&dl=0
2. Please provide a copy of the mechanical assessment report referenced during the walk through
    a. Response: Please see attached (Attachment A).
3. The RFP scope of services includes examination and analysis of the existing mechanical systems including efficiency, life expectancy and compliance with relevant building codes. At the walkthrough it was noted that a mechanical assessment was completed, and that mechanical assessment was not included. Please confirm that all references to a mechanical scope for this project are removed and no mechanical analysis is required.
    a. Response: That is correct.
4. Is there a lift on-site that can be used by the consultant to access interior structural framing, and exterior wall systems?
    a. Response: No, there is not.
5. If no lift is available, should the lift be included in the scope of services?
    a. Response: Yes

620 State St.-2nd Floor
Schenectady, NY 12305
purchasing@schenectadycountyny.gov
518.388.4240

ADDENDUM

---

6. Please confirm that all assessments shall be visual assessments and that exploratory testing including geotechnical borings, test pits, groundwater monitoring wells, concrete testing, interior borings, etc. shall not be included.
    a. Response: Recommendations on what testing and its projected cost, should be included as a budget number. The actual cost for the testing will be borne by the Client and should not be included in the monetary cost of your work.

7. Can you clarify the MEP scope of services…what is included and what is not included in the assessment?
    a. Response: Electrical & Plumbing system evaluations should be included, HVAC study has been completed and made available.

8. Will the County do additional testing for moisture and/or to better understand water infiltration?
    a. Response: Any additional testing recommendations should be included in your proposal.

9. Will the topographic survey be provided in AutoCAD format for the consultant's use for the project?
    a. Response: Yes

10. Please confirm no HVAC study/evaluation is included in this RFP.
    a. Response: That is correct

11. Is mechanical evaluation of temperature controls and dehumidification systems to be included in this RFP?
    a. Response: No

12. During the site walkthrough, an expansion of the Challenger Learning Center was discussed. Is this expansion included in this RFP?
    a. Response: It is not, that would be Phase 2 of the redevelopment plan.

13. Is evaluation of the existing fire alarm system included in this RFP? If so, to what extent?
    a. Response: Yes, all life safety requirements should be reviewed.

14. Is evaluation of the existing lighting system included in this RFP?
    a. Response: Yes, upgrade to more energy efficient light fixtures (i.e. LED's).

15. Is the electrical power related to the concurrent HVAC study being done included in this scope?
    a. Response: Yes, it should be considered.

16. On-site, it was mentioned there is a Phase 1 and Phase 2 study. Can you elaborate on what scope is included in Phase 1 versus Phase 2?
    a. Response: Phase 1 is the undertaking of this RFP and then implementing the suggested modifications. Phase 2 will be the expansion of the building to move the Collections and Archives.

620 State St.-2nd Floor
Schenectady, NY 12305
purchasing@schenectadycountyny.gov
518.388.4240

ADDENDUM

17. Is an accessibility assessment of restrooms included in this RFP?
    a. Response: Yes, please review and advise as to what is deficient.
18. Is an overall life safety code assessment included in this RFP?
    a. Response: Yes, please review all life safety requirements and advise as to what is deficient.

19. Is a building envelope assessment included in this RFP?
    a. Response: Yes, review of building envelope, roof, electrical and plumbing systems.

20. Is an assessment of the "back" patio off of the lobby included in this RFP?
    a. Response: Only to the extent that it may be adding to the moisture problems in the lower level.

21. On-site, it was mentioned that the archives will be relocated. Are planning concepts for this included in the RFP? Are maximum load calculations included in this RFP?
    a. Response: That is deemed Phase 2 work and is not included in this RFP.

22. Is an evaluation of the roof included in this RFP?
    a. Response: Yes

23. Can the County provide the sign-in sheet from the site walkthrough?
    a. Response: Please see attached (Attachment B).

24. Would the firm awarded this project be precluded from pursuing any future renovation design projects?
    a. Response: No

25. Can the County provide additional information on current plans for future building renovations?
    a. Response: There are no plans at this point, TBD.

26. Are structural drawings of the buildings available? If so, can the County make them available to bidders?
    a. Response: The only drawings available are those found in the original documentation found on Bidnet or previously sent by the Purchasing Department.

27. Please clarify whether the desired cost estimate is for a Design estimate or Construction estimate.
    a. Response: We are looking for an "all inclusive number" that would include design and construction of any needed modifications.

28. Will equipment/items be removed and/or relocated as necessary to allow for the condition assessment?
    a. Response: Only those that are easily moved and those that need to be protected.

620 State St.-2nd Floor
Schenectady, NY 12305
purchasing@schenectadycountyny.gov
518.388.4240

Schenectady County
Purchasing Department

ADDENDUM

---

29. The RFP scope of services specifies the need for "c. Examination and analysis of the existing mechanical, electrical and plumbing systems including efficiency, life expectancy and compliance with relevant building codes and standards." However, at the walk through, it was indicated that HVAC assessment was not needed. Please clarify whether an assessment of HVAC systems is included in the scope of services for this project.
    a. Response: It is not.

30. Does the structural assessment scope include review of floor loading capabilities?
    a. Response: No, that is not necessary.

31. Can the County provide any geotechnical/soil information?
    a. Response: No, other than what is readily available from the USDA soil survey of Schenectady County.
    b. Link to Survey: https://www.simsgis.org/lite/

____
Company Name of Contract Document Holder

____ ______________________
Signature Acknowledgment of Contract Document Holder Date

RETURN WITH SIGNATURE ACKNOWLEDGEMENT WITH YOUR PROPOSAL

END OF ADDENDUM #1

Attachment A: M/E miSci Energy Audit Report

HVAC OPTION STUDY

MiSci Museum of Innovation and Science

Submitted to:
MiSci Museum of Innovation and Science
15 Nott Terrace Heights
Schenectady, NY 12019

Submitted from:
M/E Engineering, P.C.
60 Lakefront Boulevard, Suite 320
Buffalo, NY 14202

June 22, 2021
M/E Reference 203256-01

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

M/E ENGINEERING

BUFFALO · ROCHESTER · SYRACUSE · CAPITAL DISTRICT

www.meengineering.com

TABLE OF CONTENTS

NYSERDA Project Summary Sheet

PROJECT SUMMARY SHEET

FOR: [ENTER PROJECT IDENTIFER (NAME, ADDRESS, CLIENT, ETC.)]

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

BASELINE ENERGY SUMMARY

	Electric (kWh)	Natural Gas (therms)	#2 Oil (gallons)	#4 Oil (gallons)	#6 Oil (gallons)	Steam (lbs.)	Propane (gallons)	Coal (tons)	Other (MMBtu)	Total Baseline Use (MMBtu)
Baseline Energy Use	333,937.0	9,140.0								2,053.4
Average Utility Rate	$0.086	$0.56								**Total Annual Cost ($)**
Baseline Annual Cost	$28,610	$5,110								$33,720

ENERGY SAVINGS SUMMARY

Measure Description	Measure Status [1]	Fuel Savings Type [2]	Electric		Fuel Savings (MMBtu)	Energy Savings to Total Baseline Use (%) [3]	Annual Cost Savings	Cost Savings to Total Annual Cost (%) [4]	Project Cost	Simple Payback (Years)
			Supply Savings (kWh)	Demand Savings (kW)						
Option 1: PVAV, HW Reheat	NR	Elec	115,003.0	-47.2	109.8	24.5%	$8,374	24.8%	$443,299	52.9
Option 2: VAV, HW/CHW	NR	Elec	95,987.0	-72.7	152.4	23.4%	$7,337	21.8%	$665,530	90.7
Option 3: VRF	R	NGas	-55,252.0	-171.2	725.4	26.1%	$382	1.1%	$571,425	1495.4
Option 4: WSHP	NR	NGas	-3,837.0	-95.6	78.7	3.2%	$256	0.8%	$602,331	2348.7
Option 5: GSHP	NR	NGas	-9,258.0	-94.9	882.4	41.4%	$4,322	12.8%	$2,442,681	565.2
		TOTAL (All):	142,643	-482	1,949	118.6%	$20,671	61.3%	$4,725,266	228.6
		TOTAL (Recommended Only):	**-55,252**	**-171**	**725**	**26.1%**	**$382**	**1.1%**	**$571,425**	**1495.4**

Measure Status[1]

I	Implemented
R	Recommended
RS	Further Study Recommended
NR	Not Recommended
RME	Recommeded Mutually Exclusive
ME	Mutually Exclusive to Recommended Option
RNE	Recommended Non-Energy

Fuel Saved

Elec	Electric
NGas	Natural Gas
Oil2	#2 Oil
Oil4	#4 Oil
Oil6	#6 Oil
Steam	District Steam
LPG	Propane
Coal	Coal
Other	Other

MMBtu Conversion Facto

Btu	1,000,000
kWh	0.003412
therms	0.1
#2 gallon	0.139
#4 gallon	0.1467
#6 gallon	0.15
Steam lbs.	0.0012
LPG gallon	0.0915
Coal tons	24

Notes:

[2] Fuel Savings Type: Indicate the reported MMBtu savings fuel type. Select the predominant fuel type if there are MMBtu savings from multiple fuel sources

[3] Energy Savings to Total Fuel Baseline Use is a comparison of the total electric & fuel savings to the total baseline energy use

[4] Cost Savings to Total Annual Cost is a comparison of the total annual cost savings to the total baseline annual energy cost

Instructions:

* Fill in the light blue cells, as appropriate. White cells will auto-calculate.
* Energy savings must be presented as savings at the customer's utility meter(s), not at the individual building or tenant space
* Update the baseline energy use conversion factors in the "References" tab, as necessary
* Unhide rows to enter more measures, as necessary

EXECUTIVE SUMMARY

The MiSci Museum of Innovation and Science, located in Schenectady, is a 42,000 gross square foot science museum and planetarium facility, originally built in 1968 and later expanded in 1991. The HVAC systems are of varying ages, and most are in poor condition or beyond their expected service life and in need of replacement. The goal of this study is to identify and compare options for upgrading / replacing the building HVAC systems with higher efficiency systems and modern controls. To achieve this goal, energy modeling was performed to compare several options identified by the design team. Other factors that were compared were estimated first cost, expected maintenance impact and basic overall feasibility for each option.

On 05/17/2021, M/E Engineering, P.C. performed a site walkthrough of the MiSci facility to collect information on the condition and operation of the existing equipment, as well as determine potential locations to install the proposed systems. Prior to the site visit, utility bills were provided for the 2019 and 2020 years, and after review and discussion with the building management staff, it was determined that the 2020 utility data did not provide an accurate picture of typical building energy use, due to the effects of the 2020 pandemic, which entailed a complete shutdown of the facility during the month of March, 2020. As a result, only the 2019 utility data has been used in for calculations in this report.

HVAC Design Concept Analysis:

A baseline and five HVAC options were modeled and a comparative analysis was performed. The baseline represents the existing building and existing energy consumption. The five HVAC options include a packaged variable air volume (PVAV) system with a natural gas boiler and DX cooling, a variable air volume (VAV) system with a chiller and natural gas boiler, a variable refrigerant flow (VRF) system, a water source heat pump (WSHP) system with gas boiler and cooling tower, and a ground source heat pump (GSHP) system. For implementation, the packaged variable air volume system resulted in the second lowest energy savings but the largest cost savings and therefore the shortest payback. However, if the main goal were energy savings, we would recommend the VRF system, since there is a significant energy savings and also some cost savings, and the initial cost premium with incentives will be lower than the PVAV system. This also sets the building up as electrified and provides the potential opportunity for a future net-zero setup with the addition of photovoltaic, community solar, or renewable energy certificates.

Below is a summary of the results of the energy analysis.

	Energy Model Results						Annual Utility Savings				Annual Utility Cost Savings			Est. Costs		Est. Incentives		Payback Analysis		
HVAC System	Est. Electricity (kWh/yr)	Est. Electricity Peak (kW/yr)	Est. Nat. Gas (therms/yr)	Est. Total Energy (MMBtu/yr)	EUI (kBtu/sf)	Est. Energy Cost ($/yr)	kWh Savings	kW Savings	Natural Gas Savings Therms	MMBtu Savings	Electricity Cost Savings $/yr	Nat. Gas Cost Savings $/yr	Total Cost Savings $/yr	Est. HVAC Equipment Cost	Est. Annual Maintenance Cost	Est. National Grid Clean Heat Incentive	Est. NYSERDA New Construction Incentive	Simple Payback (No Incentive) (yrs)	Simple Payback (Best Incentive) (yrs)	Recommended
Baseline-Existing	333,937	86.4	9,140	2,053	48.9	$32,429	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Option 1: PVAV	218,934	133.6	11,966	1,944	46.3	$25,347	115,003	-47.2	-2,826	109.8	$9,856	-$1,482	$8,374	$443,299	$3,452	N/A	N/A	52.9	N/A	Yes
Option 2: VAV	237,950	159.1	10,891	1,901	45.3	$26,383	95,987	-72.7	-1,751	152.4	$8,227	-$890	$7,337	$665,530	$6,048	N/A	N/A	90.7	N/A	No
Option 3: VRF	389,189	257.6	0	1,328	31.6	$33,338	-55,252	-171.2	9,140	725.5	-$4,728	$5,110	$382	$571,425	$5,759	$82,595	$84,000	1,495.4	1,275.6	Yes
Option 4: WSHP	337,774	182.0	8,222	1,975	47.0	$33,464	-3,837	-95.6	918	78.7	-$324	$580	$256	$602,331	$7,291	$30,853	N/A	2,348.7	2,228.4	No
Option 5: GSHP	343,195	181.3	0	1,171	27.9	$29,398	-9,258	-94.9	9,140	882.4	-$788	$5,110	$4,322	$2,442,681	$5,298	$95,150	$84,000	565.2	543.2	No

Note: Options 1, 2 and 4 are not eligible for NYSERDA NCP, which requires an all-electric building

CONTACT SHEET

MiSci Project Contacts:

Gina C. Gould, PhD
President
MiSci Museum of Innovation and Science
(518) 382-7890 x232
15 Nott Terrace Heights
Schenectady, NY 12019
president@misci.org

William R. Sweet
President
W.R. Sweet & Co., Inc.
2320 Nott Street E. #9027
Niskayuna, New York 12309
(518) 365-2868
wrsweet@aol.com

Engineering Consultants:

Beth Bilger
Project Manager
M/E Engineering, P.C.
433 State Street, Suite 410
Schenectady, NY 12305
(518) 533-2171 x1404
babilger@meengineering.com

Ted Sargent
HVAC Engineer
M/E Engineering, P.C.
433 State Street, Suite 410
Schenectady, NY 12305
(518) 533-2171 x1403
tesargent@meengineering.com

Primary Energy Consultants:

Melanie Stachowiak
Partner
M/E Engineering, P.C.
60 Lakefront Blvd, Suite 320
Buffalo, NY 14202
(716) 845-5092 x1207
mgstachowiak@meengineering.com

Thomas Gamer
Energy Engineer
M/E Engineering, P.C.
300 Trolley Boulevard
Rochester, NY 14606
(585) 820-1067
tggamer@meengineering.com

EXISTING CONDITIONS

SITE OVERVIEW

Built in 1968, and expanded in 1991, the 42,000 gross square foot MiSci Museum of Science and Innovation, located in Schenectady, NY, consists of gallery and exhibit spaces, a planetarium, classrooms, lobby with ticket counter, a gift shop, office and support spaces on the first floor. The second floor consists mainly of office space. The basement level consists of electrical/mechanical rooms, storage and archive spaces. The rooftop contains a variety of HVAC equipment, some currently in-operation and others abandoned in-place.

Typical operating hours are Tuesday-Saturday: 10:00 AM-5PM, Sunday: 12 PM 5 PM.

ARCHITECTURAL SYSTEMS

The building shell consists of reinforced concrete with a brick veneer and rigid insulation, and a white built-up roof. The building has double pane windows with aluminum frames.

LIGHTING SYSTEMS

The lighting consists of mainly fluorescent fixtures of various types with mostly manual controls. The gallery and planetarium area has some display and theatrical-type lighting as well.

MECHANICAL SYSTEMS

Air Handling Units 1-3

There are three main air-handling units, AHU-1 AHU-2 and AHU-3, which were originally constant volume systems, but have been converted to variable volume with VAV boxes. The original pneumatic controls have been disabled and the systems are manually controlled. Heating is provided by a hot water boiler serving each unit and cooling is provided by DX coils. The systems are in poor condition, show signs of repeated modification and repair, and are operating beyond their expected service life.

AHU-1 currently serves a portion of the second floor office area, basement classrooms 1-3, and the lobby. AHU-2 serves the lecture gallery, the eastern exhibit area, half of the object collection and part of the archive. AHU-3 serves the planetarium, the western exhibit area, and half of the object collection.


Boiler #1

Boiler #2


Boiler #3

Other HVAC Systems:

There is a DX unit serving the exhibit gallery in the new addition area. The Challenger Learning Center has five heat pump units, located above the ceiling, that serve the individual zones. The second floor auditorium is served by a small DX / furnace unit, located in a closet space, and there is an electric heater serving the administration suite.

HVAC Controls:

The HVAC controls are of mixed variety, with the newer addition using electronic controls, and older areas using a mixture of pneumatic and manual controls.



Typical HVAC Controls at MiSci

DOMESTIC WATER SYSTEMS

Service hot water is provided by two 50 gallon, 4.5 kW electric water heaters, one located in each mechanical room, which appear to be in good condition.



Domestic Water Heaters at MiSci

OTHER SYSTEMS

The planetarium has a star projector and theater-style lighting and sound system. The Challenger Learning Center has equipment to simulate space shuttle and mission control operation. In addition, typical office equipment is present throughout the building, such as computers, monitors, projectors, copiers and printers. There is a small workshop area with typical light fabrication and repair equipment.

MODELING APPROACH / METHODOLOGY

ENERGY MODELING PROGRAM

The facility, including each HVAC option, has been modeled utilizing the eQuest 3.65 simulation program. All six buildings are simulated for a period of one year, with New York City TMY2 Typical Meteorological Year weather data.

All parameters have been modeled as installed in the existing building, based upon field-gathered information and existing drawings, except as indicated as part of the alternate HVAC Option. Generally, the models follow the guidelines set forth in ASHRAE 90.1-2019 for modeling the proposed buildings in conjunction with the Energy Star Multifamily High Rise Program Simulation Guidelines.

COMMON MODELING PARAMETERS AND ASSUMPTIONS

A walk-through audit was performed on 5/17/2021, to document the existing building conditions and HVAC nameplate information. Design documents were provided containing information on the architectural systems in the original construction and renovation areas.

General Modeling Parameters:

- Energy Modeling performed using eQUEST software
- Unless otherwise indicated, the basic modeling parameters have been derived from the following sources:
  - Occupancy, Ventilation and Exhaust Air:
    - ASHRAE 62.1, 2019, average values
  - Lighting Power Densities and Mechanical Equipment Efficiencies:
    - ASHRAE 90.1, 2019

Building Exterior:

- Exterior Walls:
  - 12" concrete block, 1" R-5 rigid insulation, vapor barrier, 4" brick veneer
    - U-0.126
- Roofing:
  - 3" R-15 insulation entirely above deck
    - U-0.063

Vertical Fenestration:

- Double pane, air filled glazing, aluminum framed
  - ASHRAE 90.1, 2019, Zone 5A, 0%-10% of Wall
    - U-0.57 (assembly)
    - SHGC - 0.49
    - VLT - 0.54

Lighting:

- The existing interior and exterior lighting was has not been cataloged in detail for this project, and has been kept energy-neutral for the HVAC options being analyzed.
- Interior:
  - ASHRAE 90.1, 2019 Building Area Method
    - Weighted LPD: 0.57 W/sf, based on the following:
      - Museum: 0.55 W/sf, 80% of building area
      - Office: 0.64 W/sf, 15% of building area
      - School/University: 0.72 W/sf, 5% of building area

   - Lighting Controls: Manual
- Exterior:
   - Lighting Zone 1
   - 350W Base
   - Entrances: 14W/lf of entry
   - Controls: Time of day schedule

Typical Plug Loads:

- Expected plug loads include, but are not limited to hand dryers, automatic faucets / flush devices, computers, copiers/ printers, projectors, theater / planetarium sound / display equipment, aerospace classroom simulation equipment, cleaning / maintenance equipment.
- A value of 0.74 W/sf has been used in the model, which is in accordance with values provided by the COMNET Plug Loads Technical Support Document, September 28, 2015 for Entertainment / Culture facilities.

Exhaust Fans:

- Toilets, public: 60 cfm/unit

Service Water Heating:

- The existing electric service water heating equipment is in good operating condition and has been modeled using existing capacities and efficiencies for all options except for the full geothermal option (Option-5).

Space Temperature Setpoints:

- Heating:
   - Occupied: 70°F
   - Unoccupied: 65°F
- Cooling:
   - Occupied: 75°F
   - Unoccupied: 80°F

MODEL SETUP AND CALIBRATION

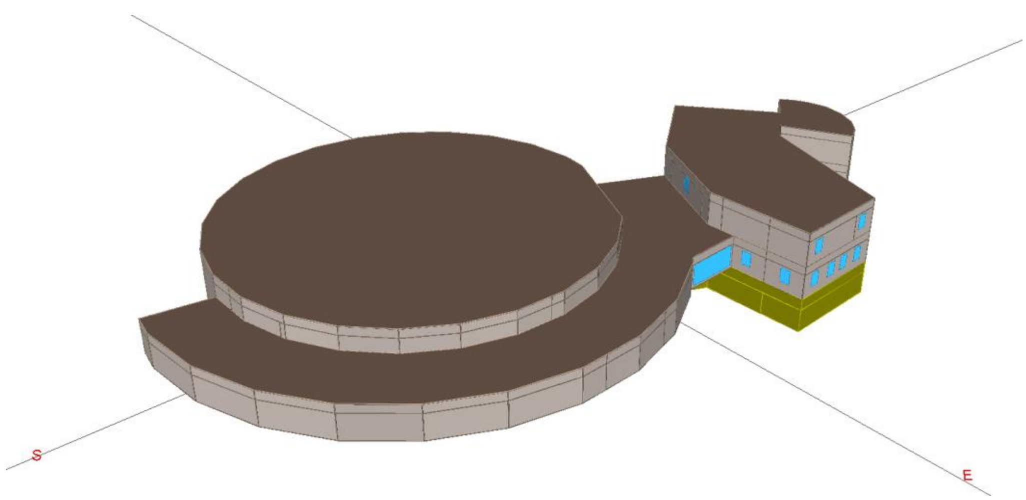
The initial model rendered an estimated electricity consumption of 318,298 kWh, which is 4.7% under the 2019-metered total of 333,937 kWh. The model also yielded a natural gas consumption of 9,372 therms, 2.5% over the 2019-metered total of 9,140 therms. This basic model has been used to develop the HVAC system options compared in this report.

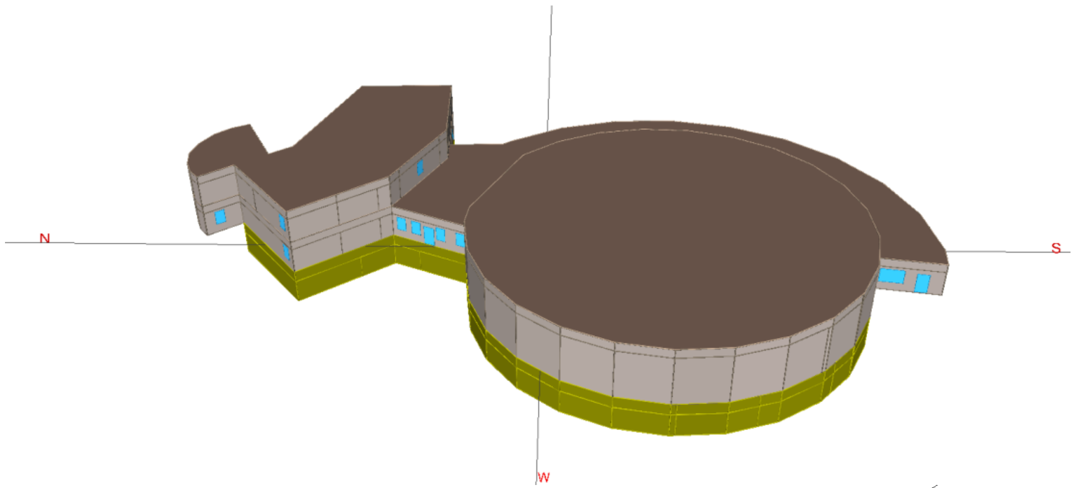
Zoning and Layout:

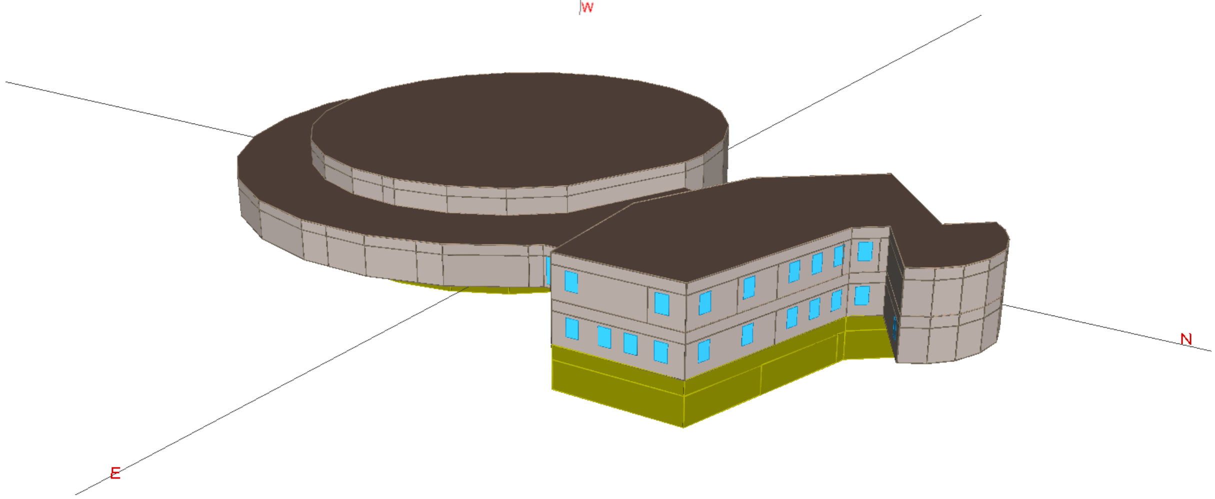
The system zoning was based on the following configuration:

- Basement:
  - Individual classrooms zoned separately
  - Museum storage under main exhibit
  - Museum archive
  - Hallway and mechanical rooms
- First Floor:
  - Challenger Learning Center rooms zoned separately
  - Front lobby
  - Front gallery
  - Each half of main exhibit hall zoned separately
  - Planetarium
  - Shop / loading dock
- Second Floor:
  - Office area divided into two zones
  - Each classroom zoned separately
  - Hallway and support spaces

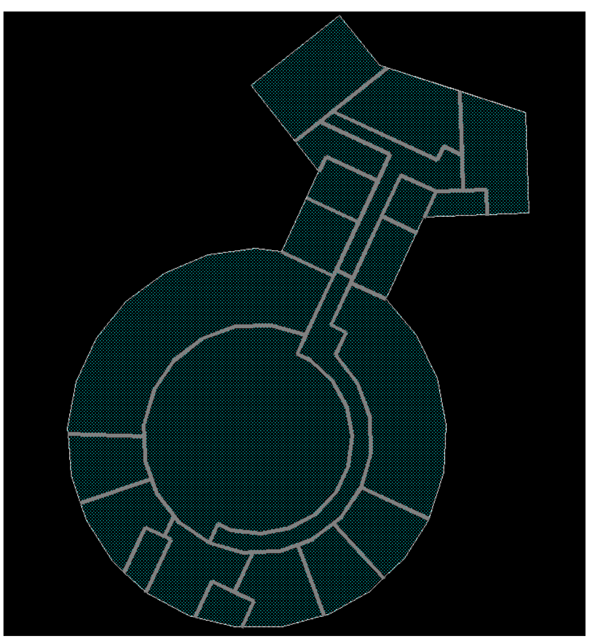
3-D Views of Model



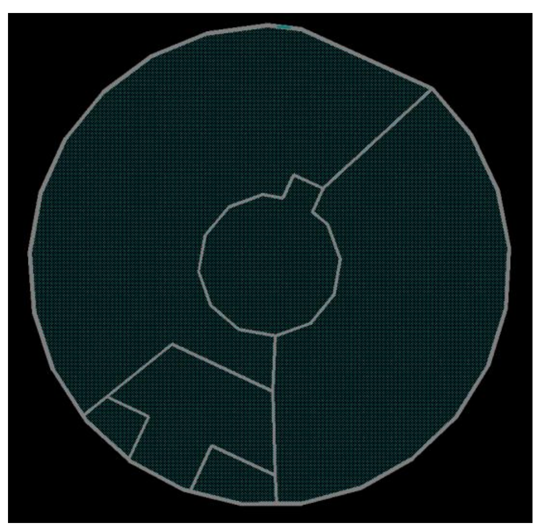




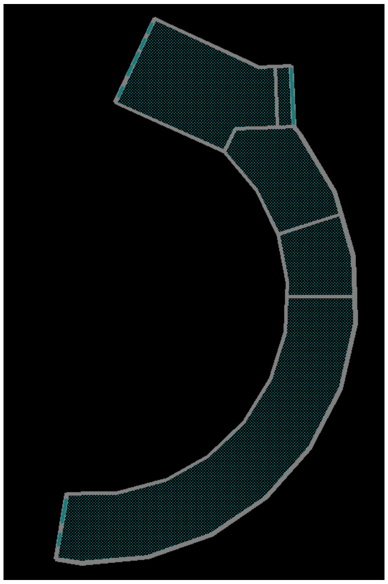
2-D Layouts of Model Showing Zone Breakdown

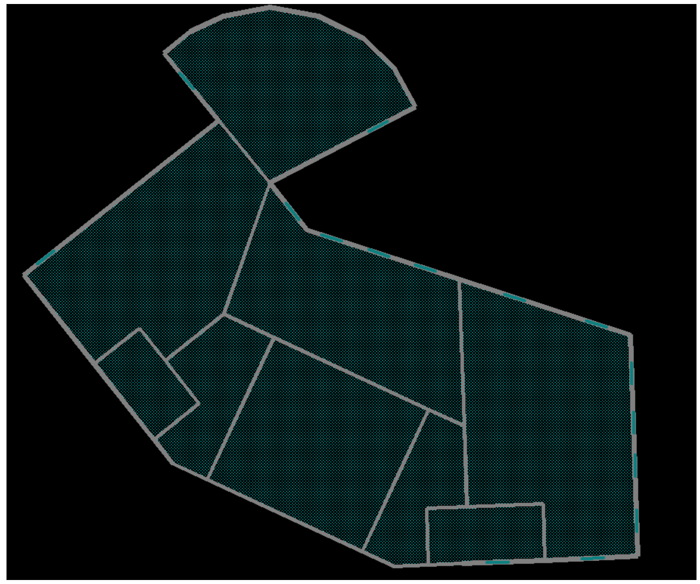


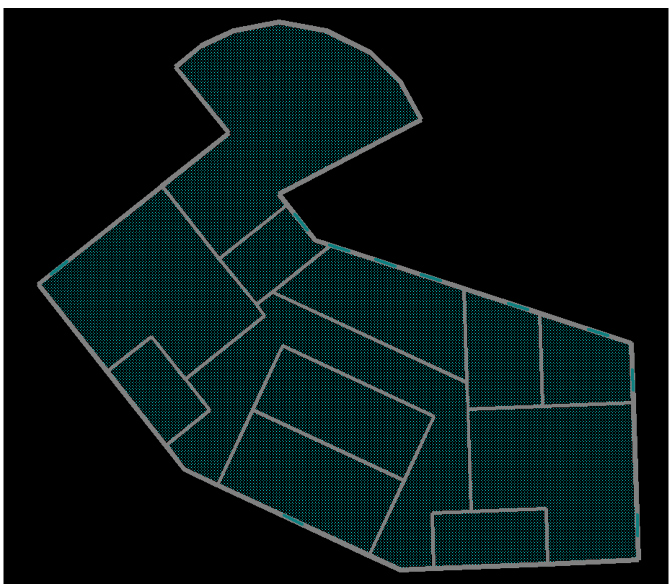
Basement Level



First Floor Planetarium and Gallery Area


First Floor Addition


First Floor Challenger Learning Center Area


Second Floor

UTILITY ANALYSIS

UTILITY CONSUMPTION AND COST

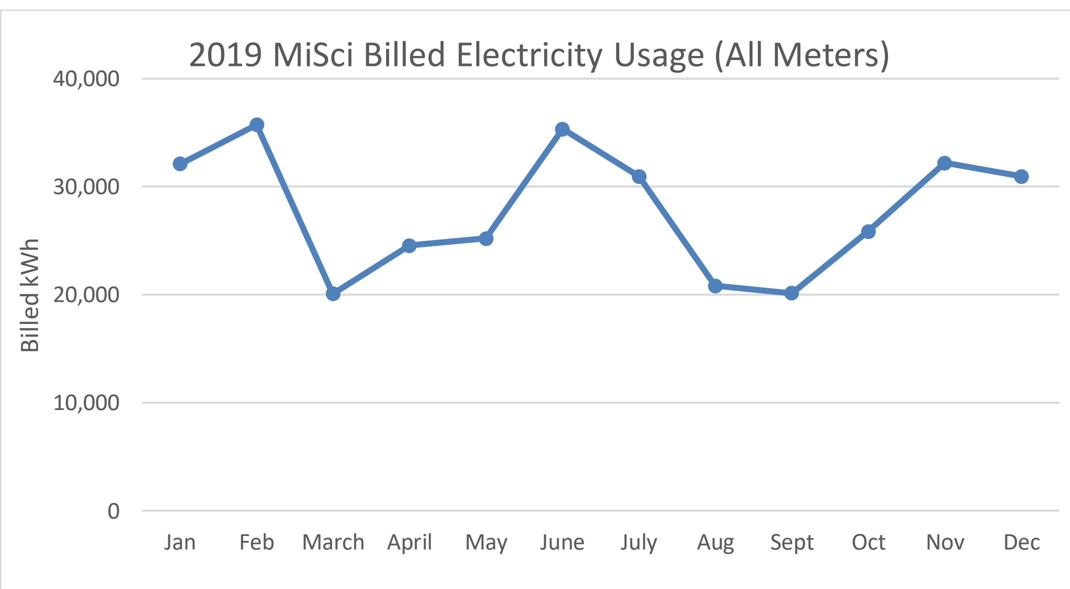
Utility bills for the 2019 and 2020 years were provided by the MiSci staff, and due to the effects of the 2020 pandemic, which entailed a complete shutdown of the facility, the 2020 utility data was deemed non-typical of the building's annual usage, and as a result, only the 2019 utility data has been used in this analysis.

ELECTRICITY

Electricity is supplied and delivered by National Grid under the SC2 rate classification. The average blended rate for electricity for MiSci is $0.086/kWh and has been used for all subsequent electricity savings calculations.

Summary of Electricity Usage for 2019-2020

	2019			
	kW	kWh	Cost	Cost/kWh
Jan	79.2	32,117	$2,822.15	$0.088
Feb	86.4	35,729	$3,140.58	$0.088
March	50.4	20,072	$1,545.34	$0.077
April	57.6	24,542	$2,052.52	$0.084
May	79.2	25,199	$2,125.64	$0.084
June	86.4	35,342	$3,227.45	$0.091
July	86.4	30,953	$2,948.91	$0.095
Aug	64.8	20,819	$2,017.84	$0.097
Sept	57.6	20,137	$1,489.76	$0.074
Oct	72	25,856	$2,151.18	$0.083
Nov	64.8	32,208	$2,578.74	$0.080
Dec	72	30,963	$2,509.74	$0.081
Total		**333,937**	**$28,609.85**	**$0.086**

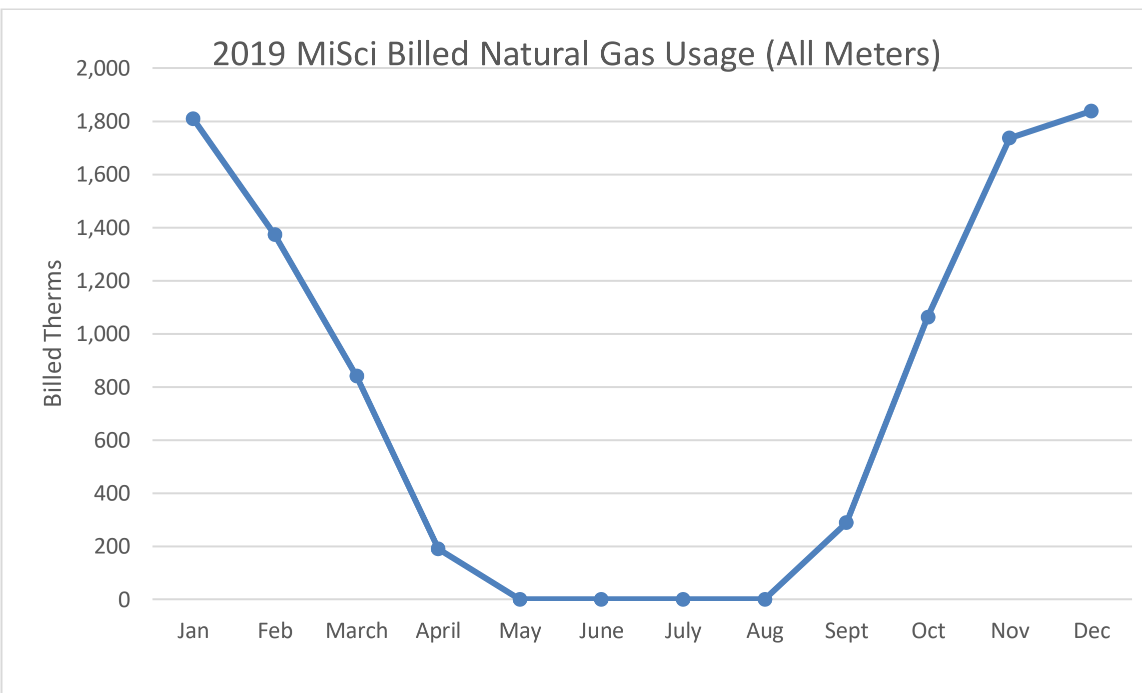


NATURAL GAS

Natural Gas is supplied and delivered by National Grid, under the SC2 rate classification. The average rate for natural gas for MiSci is $0.56/therm and has been used for all subsequent natural gas savings calculations.

Summary of Natural Gas Usage from January-December 2019

	2019		
	Therms	Cost	Cost/Therm
Jan	1,809	$967.11	$0.53
Feb	1,373	$739.60	$0.54
March	841	$499.46	$0.59
April	190	$130.90	$0.69
May	0	$24.52	
June	0	$24.52	
July	0	$24.52	
Aug	0	$24.52	
Sept	289	$178.25	$0.62
Oct	1,063	$594.28	$0.56
Nov	1,737	$863.72	$0.50
Dec	1,838	$1,038.96	$0.57
Total	**9,140**	**$5,110.36**	$0.56



SITE ENERGY UTILIZATION INDEX (EUI)

Based on an analysis of the provided utility bills, the following summary table of site energy usage and overall site Energy Utilization Indices was tabulated:

	MiSci
Annual kWh	280,035
Annual Therms	7,799
Annual Site MMBtu	1,735
Calc Site EUI (kBtu/sf)	41.3
EnergyStar Museum EUI	56.2

The national median EUI for a museum facility, according to Energy Star Portfolio Manager, is 56.2 kBtu/sf. From the EUI comparison above, the facility is performing better than the median EUI for this facility type, though there is a definite potential for energy savings throughout the building.

SYSTEM OPTION ANALYSIS

OPTION-1: PACKAGED VARIABLE AIR VOLUME WITH BOILER AND DX COOLING

Option Overview

The proposed HVAC system would consist of Packaged Variable Air Volume (PVAV) air handlers equipped with hot water reheat. Hot water would be provided by high efficiency condensing boilers, and cooling would be provided by DX coils.

Analysis Methodology:

A calibrated eQUEST whole-building model was used to calculate the expected energy usage of this HVAC system configuration. The building shell, fenestration, interior and exterior lighting, internal process and plug loads, occupancy conditions, and thermostat settings and controls schedules were kept constant and as noted in the *Common Modeling Parameters and Assumptions* section of this report.

Option-Specific Modeling Parameters and Assumptions:

- Water Side Systems:
  - Hot Water Condensing Boilers:
    - Quantity: 2, Equally Sized
    - Capacity: 993 kBtu/hr, each
    - Efficiency: 96% E_t
  - Hot Water Temperature Setpoints:
    - Reset based on outdoor air temperature
      - OAT ≤ 20°F, HWT = 180°F
      - OAT ≥ 50°F, HWT = 150°F
      - HWT varies linearly between 150°F and 180°F when OAT is between 20°F and 50°F
    - Hot Water Pumps:
      - Power: 19 W/gpm
      - Controls: Riding the pump curve
- Air Side Systems:
  - Rooftop Air Handling Units:
    - Type: Packaged Variable Air Volume (VAV) with Hot Water Reheat and DX Cooling
    - Quantity: 3
    - Capacities:
      - AHU-1:
        - Heating: 402.1 kBtu/hr
        - Cooling: 277.9 kBtu/hr
        - Cooling Efficiency: 9.8 EER
        - Fan: 5,848 cfm
        - Energy Recovery:
          - Type: Enthalpy Wheel
          - Effectiveness: 70% Enthalpy Effectiveness
      - AHU-2:
        - Heating: 1,993.5 kBtu/hr
        - Cooling: 914,238 kBtu/hr
        - Cooling Efficiency: 9.5 EER
        - Fan: 19,241 cfm

  - Energy Recovery:
    - Type: Enthalpy Wheel
    - Effectiveness: 70% Enthalpy Effectiveness
- AHU-3:
  - Heating: 156.6 kBtu/hr
  - Cooling: 128.4 kBtu/hr
  - Cooling Efficiency: 11 EER
  - Fan: 2,757 cfm
  - Energy Recovery:
    - Type: Enthalpy Wheel
    - Effectiveness: 70% Enthalpy Effectiveness

<u>Modeling Results:</u>

Measure Summary									
	Electricity		Natural Gas		Total			Savings over Existing	
	Consumption (kWh)	Cost ($)	Consumption (therms)	Cost ($)	Consumption (MmBtu)	Cost ($)	EUI (kBtu/sf)	Consumption (%)	Cost (%)
Option 1	218,934	$18,754	11,966	$6,593	1,944	$25,347	46.3	5.3%	24.8%

<u>Potential Equipment Locations:</u>

There is ample space on the building roof for the installation of the Air Handling Units. The individual VAV boxes could be installed above the suspended ceiling. The boilers could be installed in the existing mechanical rooms. The chiller could be mounted on the rooftop if the structure will hold, or outside the building in an adjacent area.

OPTION-2: VARIABLE AIR VOLUME WITH BOILER AND CHILLER

Option Overview:

The proposed HVAC system would consist of Variable Air Volume air handlers equipped with hot water reheat. Hot water would be provided by high efficiency condensing boilers, and chilled water would be provided by a remote air-cooled chiller system.

Analysis Methodology:

A calibrated eQUEST whole-building model was used to calculate the expected energy usage of this HVAC system configuration. The building shell, fenestration, interior and exterior lighting, internal process and plug loads, occupancy conditions, and thermostat settings and controls schedules were kept constant and as noted in the *Common Modeling Parameters and Assumptions* section of this report.

Option-Specific Modeling Parameters and Assumptions:

- Water Side Systems:
  - Hot Water Condensing Boilers:
    - Quantity: 2, Equally Sized
    - Capacity: 637 kBtu/hr, each
    - Efficiency: 96% E_t
  - Hot Water Temperature Setpoints:
    - Reset based on outdoor air temperature
      - OAT ≤ 20°F, HWT = 180°F
      - OAT ≥ 50°F, HWT = 150°F
      - HWT varies linearly between 150°F and 180°F when OAT is between 20°F and 50°F
    - Hot Water Pumps:
      - Power: 19 W/gpm
      - Controls: Riding the pump curve
  - Remote Air Cooled Chiller:
    - Type: Electric Screw
    - Quantity: 1
    - Capacity: 1,249 kBtu/hr (104-ton)
    - Efficiency:
      - Full Load: 10.1 EER
      - Part Load: 13.7 IPLV
  - Chilled Water Temperature Setpoints:
    - Reset based on outdoor air temperature
      - OAT ≤ 60°F, CWT = 54°F
      - OAT ≥ 80°F, CWT = 44°F
      - CWT varies linearly between 44°F and 54°F when OAT is between 60°F and 80°F
    - Chilled Water Pumps:
      - Power: 22 W/gpm
      - Controls: Primary / Secondary, riding the pump curve

- Air Side Systems:
  - Rooftop Air Handling Units:
    - Type: Variable Air Volume (VAV) with Hot Water Reheat
    - Quantity: 3
    - Capacities:
      - AHU-1:
        - Heating: 389.5 kBtu/hr
        - Cooling: 349.3 kBtu/hr
        - Fan: 5,665 cfm
        - Energy Recovery:
          - Type: Enthalpy Wheel
          - Effectiveness: 70% Enthalpy Effectiveness
      - AHU-2:
        - Heating: 1,277.8 kBtu/hr
        - Cooling:701.6 kBtu/hr
        - Fan: 12,327 cfm
        - Energy Recovery:
          - Type: Enthalpy Wheel
          - Effectiveness: 70% Enthalpy Effectiveness
      - AHU-3:
        - Heating: 156.9
        - Cooling: 122.2
        - Fan: 2,757 cfm
        - Energy Recovery:
          - Type: Enthalpy Wheel
          - Effectiveness: 70% Enthalpy Effectiveness

<u>Modeling Results:</u>

Measure Summary									
	Electricity		Natural Gas		Total			Savings over Existing	
	Consumption (kWh)	Cost ($)	Consumption (therms)	Cost ($)	Consumption (MmBtu)	Cost ($)	EUI (kBtu/sf)	Consumption (%)	Cost (%)
Option 2	237,950	$20,383	10,891	$6,000	1,901	$26,383	45.3	7.4%	21.8%

<u>Potential Equipment Locations:</u>

There is ample space on the building roof for the installation of the Rooftop Air Handling Units. The individual zone VAV boxes could be installed above the suspended ceiling. The boilers could be installed in the existing mechanical spaces.

OPTION-3: VARIABLE REFRIGERANT FLOW (VRF) HVAC SYSTEM

<u>Option Overview</u>

The proposed HVAC system would consist of Variable Refrigerant Flow Heat Pumps, with ventilation air provided by a Dedicated Outdoor Air System (DOAS).

VRF systems utilize an array of air-cooled heat pumps located outside to condition a refrigerant loop, using electricity as the input fuel for both heating and cooling. This loop transfers energy to small indoor fan coil units, equipped with refrigerant coils to provide conditioned air to the space. VRF units with heat recovery allow spaces to share energy along the loop. This system type is typically very efficient, with high part-load ratings. Some units de-rate and sacrifice efficiency and capacity at lower outdoor air temperatures, so when used for heating, equipment must be carefully selected for colder climates.

<u>Analysis Methodology:</u>

A calibrated eQUEST whole-building model was used to calculate the expected energy usage of this HVAC system configuration. The building shell, fenestration, interior and exterior lighting, internal process and plug loads, occupancy conditions, and thermostat settings and controls schedules were kept constant and as noted in the *Common Modeling Parameters and Assumptions* section of this report.

<u>Option-Specific Modeling Parameters and Assumptions:</u>

- Dedicated Outdoor Air System:
  - VRF-Based
  - 11,904 cfm
  - For VRF capacities, see Appendix B
  - Enthalpy Wheel Energy Recovery:
    - 70% Enthalpy effectiveness
- Zone-Level VRF Units:
  - For VRF capacities, see Appendix B
  - VRF Efficiency Rating:
    - From ASHRAE 90.1 2019
      - VRF Systems up to 65 kBtu/hr:
        - Cooling Efficiency: 12 SEER
        - Heating Efficiency: 7.7 HSPF
      - VRF Systems between 65 and 135 kBtu/hr:
        - Cooling Efficiency: 10.8 EER
        - Heating Efficiency: 3.3 COP
      - VRF Systems between 135 and 240 kBtu/hr:
        - Cooling Efficiency: 10.4 EER
        - Heating Efficiency: 2.25 COP
      - VRF Systems 240 kBtu/hr and above:
        - Cooling Efficiency: 9.3 EER
        - Heating Efficiency: 2.05 COP

Modeling Results:

Measure Summary									
	Electricity		Natural Gas		Total			Savings over Existing	
	Consumption (kWh)	Cost ($)	Consumption (therms)	Cost ($)	Consumption (MmBtu)	Cost ($)	EUI (kBtu/sf)	Consumption (%)	Cost (%)
Option 3	389,189	$33,338	0	$0	1,328	$33,338	31.6	35.3%	1.1%

Potential Equipment Locations:

There is ample space on the building roof for the installation of the Dedicated Outdoor Air system. The individual zone VRF units could be installed above the suspended ceiling for most zones, or in the existing mechanical rooms in the basement. There is also ample room on the roof to mount equipment.

OPTION-4: WATER-SOURCE HEAT PUMP SYSTEM WITH BOILER AND COOLING TOWER

Option Overview

The proposed HVAC system would consist of Water-Source Heat Pumps (WSHP) served by high-efficiency condensing boilers and a cooling tower. Ventilation air would be provided by a Dedicated Outdoor Air System (DOAS).

Analysis Methodology:

A calibrated eQUEST whole-building model was used to calculate the expected energy usage of this HVAC system configuration. The building shell, fenestration, interior and exterior lighting, internal process and plug loads, occupancy conditions, and thermostat settings and controls schedules were kept constant and as noted in the *Common Modeling Parameters and Assumptions* section of this report.

Option-Specific Modeling Parameters and Assumptions:

- Water Side Systems:
    - Hot Water Condensing Boilers:
        - Quantity: 2, Equally Sized
        - Capacity: 585 kBtu/hr, each
        - Efficiency: 96% E_t
    - Hot Water Pumps:
        - Power: 19 W/gpm
        - Controls: Riding the pump curve
    - Fluid Coolers::
        - Quantity: 2
        - Capacity: 1,146 kBtu/hr, ea
        - Efficiency:
            - 0.0540 Electric Input Ratio
    - WLHP Loop Pumps:
        - Power: 20.5 W/gpm
- Air Side Systems:
    - Dedicated Outdoor Air System:
        - WSHP-Based
        - 11,904 cfm
        - For WSHP capacities, see Appendix B
        - Enthalpy Wheel Energy Recovery:
            - 70% Enthalpy effectiveness
    - Zone-Level WSHP Units:
        - For WSHP capacities, see Appendix B
        - WSHP Efficiency Ratings:
            - From ASHRAE 90.1 2019
                - WSHP Systems up to 17 kBtu/hr:
                    - Cooling Efficiency: 12.2 EER
                    - Heating Efficiency: 3.2 COP
                - WSHP Systems 17 kBtu/hr and above:
                    - Cooling Efficiency: 13 EER
                    - Heating Efficiency: 3.2 COP
                - WSHP Systems between 135 and 240 kBtu/hr:
                    - Cooling Efficiency: 10.4 EER
                    - Heating Efficiency: 2.25 COP
                - Systems 240 kBtu/hr and above:
                    - Cooling Efficiency: 9.3 EER
                    - Heating Efficiency: 2.05 COP

Modeling Results:

Measure Summary									
	Electricity		Natural Gas		Total			Savings over Existing	
	Consumption (kWh)	Cost ($)	Consumption (therms)	Cost ($)	Consumption (MmBtu)	Cost ($)	EUI (kBtu/sf)	Consumption (%)	Cost (%)
Option 4	337,774	$28,934	8,222	$4,530	1,975	$33,464	47.0	3.8%	0.8%

Potential Equipment Locations:

There is ample space on the building roof for the installation of the Dedicated Outdoor Air system. The individual zone heat pumps could be installed above the suspended ceiling for most zones, or in the existing mechanical rooms in the basement. The boilers could be installed in the existing mechanical rooms, and the fluid cooler could be installed on the roof, if the structure will support it; otherwise, it could be mounted outside the building in an adjacent location.

OPTION-5: GROUND-SOURCE HEAT PUMP HVAC SYSTEM

Overview

The proposed HVAC system consists of Ground-Source Heat Pumps (GSHP) with ventilation air provided by a Dedicated Outdoor Air System (DOAS). A GSHP-based DHW system has been modeled for this option.

Analysis Methodology:

A calibrated eQUEST whole-building model was used to calculate the expected energy usage of this HVAC system configuration. The building shell, fenestration, interior and exterior lighting, internal process and plug loads, occupancy conditions, and thermostat settings and controls schedules were kept constant and as noted in the *Common Modeling Parameters and Assumptions* section of this report.

Option-Specific Modeling Parameters and Assumptions:

- Dedicated Outdoor Air System:
  - 11,904 cfm
  - GSHP Efficiency Rating:
    - From ASHRAE 90.1 2019
      - GSHP Systems up to 135 kBtu/hr:
        - Cooling Efficiency: 18 EER
        - Heating Efficiency: 3.2 COP
      - For GSHP capacities, see Appendix B
  - Enthalpy Wheel Energy Recovery:
    - 70% Enthalpy effectiveness
- Zone-Level Ground Source Heat Pumps:
  - GSHP Efficiency Rating:
    - From ASHRAE 90.1 2019
      - GSHP Systems up to 135 kBtu/hr:
        - Cooling Efficiency: 18 EER
        - Heating Efficiency: 3.2 COP
      - For GSHP capacities, see Appendix B
- Vertical bore wells
  - Number of Bores: 108
  - Borehole Depth: 400ft
  - Borehole Diameter: 6in
  - Spacing: 20ft
  - U-Tube Leg Separation: 4in

Modeling Results:

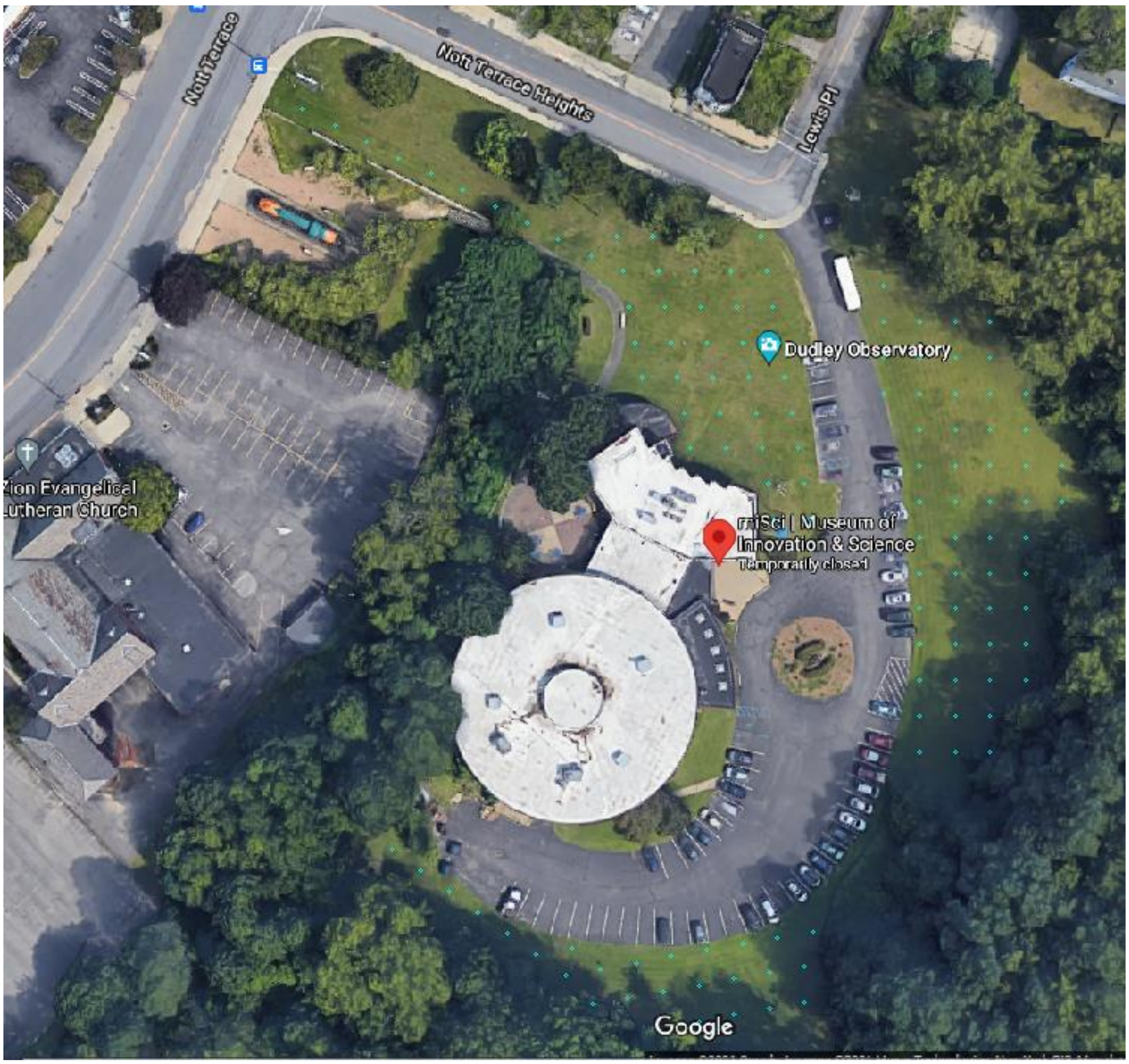
Measure Summary									
	Electricity		Natural Gas		Total			Savings over Existing	
	Consumption (kWh)	Cost ($)	Consumption (therms)	Cost ($)	Consumption (MmBtu)	Cost ($)	EUI (kBtu/sf)	Consumption (%)	Cost (%)
Option 5	343,195	$29,398	0	$0	1,171	$29,398	27.9	43.0%	12.8%

Potential Equipment Locations:

There is ample space on the building roof for the installation of the Dedicated Outdoor Air system. The individual zone heat pumps could be installed above the suspended ceiling for most zones, or in the existing mechanical rooms in the basement. There is also ample room on the roof to mount equipment.

Geothermal Well Field:

Based on the results of the model, approximately 108 wells are required. The overhead view shown below shows a possible configuration that would allow for the necessary wellfield, while minimizing damage to the existing parking lot, access roads and landscape. However, the gradient of the hill may present difficulties in drilling the wells, making the parking lot a better option. Further investigation is recommended.



Overhead View of Site, Showing Possible Wellfield Locations in Blue

ADDITIONAL CONSIDERATIONS

Although the main considerations in selecting an HVAC system are typically energy and cost implications, there are several other factors at play.

Existing Useful Life of Equipment

A full life cycle cost analysis has not been performed as part of this study. However, each system has a different lifespan. For example, an electric chiller has a relatively short expected useful life of 15 years before replacement becomes necessary, while a geothermal heat pump can be expected to last 25 years.

Expected Useful Lifespan			
Equipment Description	Years	Equipment Description	Years
Air-cooled chiller	15	Electric resistance boiler	15
Water-cooled chiller	20	Natural gas DWH	15
Cooling tower	15	Electric DWH	13
Geothermal heat pump	25	Geothermal HP DHW	20
Natural gas boiler	25	Pumps	15

In order to fully capture the replacement and the true cost of each system type, a full life cycle cost analysis may be warranted.

Carbon Reduction

Much of the motivation to reduce fossil fuel usage is to address climate change by reducing carbon and greenhouse gas emissions. New York State currently has one of the cleanest electric grids in the nation, and has goals of 70% renewable supply by 2030, and 100% by 2050. However, natural gas still remains less carbon intensive per unit of energy than electricity, due to the fossil fuels required to produce and distribute electricity, which is often counter-intuitive. With the New York's focus on renewable energy, that is likely to change, especially over the lifespan of equipment with long expected life.

Greenhouse Gas Emissions			
	Carbon Consumption	Savings vs. Existing Consumption	
Option	(mt CO_2e)	(mt CO_2e)	(%)
Baseline-Existing	216	--	--
Option 1: PVAV	173	43	19.7%
Option 2: VAV	177	39	18.0%
Option 3: VRF	195	21	9.7%
Option 4: WSHP	213	3	1.4%
Option 5: GSHP	172	44	20.4%

Utility Cost Inflation

New York State has aggressive carbon-reduction goals, which require the electrification of heating systems to succeed. One method of encouraging the switch from natural gas to electric heating in our climate is to provide financial incentives and penalties. Already, NYSERDA and NYSEG have incentive programs to mitigate first costs. In the future, the economic incentives may migrate to utility rates themselves, in the form of electric rate subsidies or carbon taxes. For example, in 2018, Canada implemented a carbon tax based on consumption meant to penalize excessive fossil fuel use. While the future of energy is unknown, it is a possibility to consider.

Additional Energy Efficiency Measures

When designing a high-efficiency HVAC system with a high first cost, such as a geothermal heat pump system, it is important to include a range of additional energy efficiency measures. If the load of the HVAC system can be reduced, so can the geothermal equipment size, which decreases the cost premium required for the high-efficiency option. It is encouraged to include as many energy efficiency measures as feasible to ensure both a high-performing building as well as to mitigate some of the central plant equipment costs. At Schematic Design, due to the level of detail, not all of these energy efficiency measures can be captured or are even known.

Project Stage

This project is in Schematic Design, and as such, many assumptions and generalizations must be made to create the energy model. It is prudent to make conservative assumptions in order to avoid overstating energy savings or cost implications. As the design progresses, the model can be refined, and typically more energy savings are demonstrated.

MEASURES RECOMMENDED FOR FUTURE STUDY

The following potential measures were identified during the site visit, but are outside of the scope of this project.

- Envelope Improvements
  - Based on a review of the existing drawings, the exterior envelope insulation is well below current code, and possible energy saving could be attained by upgrading it.
- Interior Lighting and Controls
  - The facility contains a mix of lighting technologies and primarily manual lighting controls. Possible savings could be achieved by upgrading to LED lighting technology and installing occupancy / vacancy sensors in areas with high transient occupancy.
- Renewable Energy Systems
  - There is significant rooftop space available for the installation of Photovoltaic (PV) cells, which could decrease MiSci's utility as well as its effect on the grid.

POTENTIAL INCENTIVE AND COST REDUCTION OPPORTUNITIES

NYSERDA Incentive Programs (Applicable to All-Electric Projects Only):

- As a substantial renovation, this project could qualify for NYSERDA New Construction Program incentives.
  - **Support Level 1: First Look**
    - Technical support to review design phase plans or proposed equipment selections and provide a summary of energy savings suggestions
      - NYSERDA contribution: $5,000
  - **Support Level 2 Carbon Neutral Ready**
    - Energy Modeling, Analysis and Report:
      - Engage with the Applicant and project design team to identify, model and analyze potential energy savings and electrification opportunities. Include analysis of ventilation and related building envelope and HVAC system needs to optimize buildings to meet COVID-19 related health and safety guidance.
    - Integrated Project Delivery:
      - Provide additional technical support for Applicants who incorporate and execute Integrated Project Delivery in the project design.
    - Smart Buildings:
      - Provide additional technical support for Applicants who incorporate and execute a suite of Smart Building features in the project design and construction.
    - Embodied Carbon:
      - Suggest, evaluate and quantify embodied carbon reduction opportunities. Prepare and submit a separate report of the embodied carbon analysis to the Applicant and NYSERDA.
    - NYSERDA Contribution:
      - NYSERDA will pay 100% of the technical support costs up to a maximum $200,000.
      - For projects seeking to reduce embodied carbon by at least 20%, NYSERDA will pay an additional 10% of the Technical Support costs to identify and quantify strategies that reduce embodied carbon.

      - Incentive of $2/sf if 15% better than code.
      - For more information: Commercial New Construction Program - NYSERDA

NYS Clean Heat Statewide Heat Pump Program:

- This project could qualify for the NYS Clean Heat Statewide Heat Pump Program, which has a potential incentives of:
  - Up to $1,500/10,000 Btu/h of full load heating capacity for systems < 300,000 Btu/h.
  - Up to $80/MMBtu for systems > 300,000 Btu/h
- For more information: Incentive-Application-National-Grid-NYSEG-RGE.pdf

Federal Tax Incentives for Commercial Geothermal Heat Pumps:

- Ten Percent Energy Income Credit:
  - 10% of total system cost
  - No time limit on when construction must be completed

  - No limit to total credit amount
  - Can offset both regular income taxes and alternative minimum taxes
- Accelerated Depreciation of Energy Property:
  - Classified as 5-year property
  - 100% bonus depreciation in the first year

ANALYSIS CONCLUSIONS

	Energy Model Results						Annual Utility Savings				Annual Utility Cost Savings			Est. Costs		Est. Incentives		Payback Analysis		
HVAC System	Est. Electricity (kWh/yr)	Est. Electricity Peak (kW/yr)	Est. Nat. Gas (therms/yr)	Est. Total Energy (MMBtu/yr)	EUI (kBtu/sf)	Est. Energy Cost ($/yr)	kWh Savings	kW Savings	Natural Gas Savings Therms	MMBtu Savings	Electricity Cost Savings $/yr	Nat. Gas Cost Savings $/yr	Total Cost Savings $/yr	Est. HVAC Equipment Cost	Est. Annual Maintenance Cost	Est. National Grid Clean Heat Incentive	Est. NYSERDA New Construction Incentive	Simple Payback (No Incentive) (yrs)	Simple Payback (Best Incentive) (yrs)	Recommended
Baseline-Existing	333,937	86.4	9,140	2,053	48.9	$32,429	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Option 1: PVAV	218,934	133.6	11,966	1,944	46.3	$25,347	115,003	-47.2	-2,826	109.8	$9,856	-$1,482	$8,374	$443,299	$3,452	N/A	N/A	52.9	N/A	Yes
Option 2: VAV	237,950	159.1	10,891	1,901	45.3	$26,383	95,987	-72.7	-1,751	152.4	$8,227	-$890	$7,337	$665,530	$6,048	N/A	N/A	90.7	N/A	No
Option 3: VRF	389,189	257.6	0	1,328	31.6	$33,338	-55,252	-171.2	9,140	725.5	-$4,728	$5,110	$382	$571,425	$5,759	$82,595	$84,000	1,495.4	1,275.6	Yes
Option 4: WSHP	337,774	182.0	8,222	1,975	47.0	$33,464	-3,837	-95.6	918	78.7	-$324	$580	$256	$602,331	$7,291	$30,853	N/A	2,348.7	2,228.4	No
Option 5: GSHP	343,195	181.3	0	1,171	27.9	$29,398	-9,258	-94.9	9,140	882.4	-$788	$5,110	$4,322	$2,442,681	$5,298	$95,150	$84,000	565.2	543.2	No

<u>Option 1:</u>

Option 1 yielded acceptable energy and cost savings, and is recommended if an all-electric building is not being sought, and minimal maintenance is desired.

<u>Option 2:</u>

Option 2 yielded higher overall energy savings than Option 1, but lower cost savings. Depending on what actual equipment is selected, it may perform better than option 1. This measure is recommended for further study.

<u>Option 3:</u>

Option 3 yielded the second-highest overall energy savings, but was penalized due to the higher cost of electricity vs. natural gas. This option is recommended if an all-electric building is desired, as the overall capital cost is lower than that of Option 5, which had the highest energy savings.

<u>Option 4:</u>

Option 4 yielded the lowest overall energy savings when compared to the other options, but the actual performance may end up improving with different equipment selections. The intent of this option is to prepare the building for eventual geothermal conversion, but is not recommended due to poor relative performance.

<u>Option 5:</u>

Option 5 yielded the highest overall energy savings, but is not recommended due to the high capital cost, as well as limited space for the installation of the ground-source wells. This option would align with the Climate Leadership Action Plan goals for carbon reduction - 40% reduction by 2030. In addition, if photovoltaics were provided, it could make the building net zero, and likely bring the payback down below 10 years.

Appendix A - Additional Modeling Inputs

HVAC Option 3

WSHP Capacities and Efficiencies:

	Cooling			Heating			
	Clg kBtu/h	EER	SEER	Htg kBtu/h	COP	HSPF	CondUnit
DOAS-1	757.742	9.3		779.132	2.05		1
VRF-B-1	32.904		13	33.736		7.7	2
VRF-B-2	9.601		13	9.842		7.7	2
VRF-B-3	9.795		13	10.042		7.7	2
VRF-B-5	7.331		13	7.516		7.7	2
VRF-B-6	44.503		13	45.621		7.7	2
VRF-B-7	51.797		13	53.103		7.7	2
VRF-B-8	9.595		13	9.836		7.7	2
VRF-B-9	29.354		13	30.091		7.7	2
VRF-B-10	60.234		13	61.775		7.7	2
VRF-B-11	97.649	10.8		100.128	3.3		3
VRF-1-1	111.178	10.8		114.163	3.3		3
VRF-1-2	36.587		13	37.574		7.7	2
VRF-1-3	8.726		13	8.960		7.7	2
VRF-1-4	566.404	9.3		581.600	2.05		1
VRF-1-5	217.009	10.4		222.832	2.25		4
VRF-1-6	38.160		13	39.184		7.7	2
VRF-1-7	69.172		13	71.022		7.7	2
VRF-1-8	51.161		13	52.525		7.7	2
VRF-1-9	50.613		13	51.967		7.7	2
VRF-1-10	54.490		13	55.950		7.7	2
VRF-1-11	60.087		13	61.692		7.7	2
VRF-1-12	54.316		13	55.798		7.7	2
VRF-2-1	19.245		13	19.762		7.7	2
VRF-2-2	7.403		13	7.601		7.7	2
VRF-2-3	23.539		13	24.169		7.7	2
VRF-2-4	12.510		13	12.846		7.7	2
VRF-2-5	26.121		13	26.822		7.7	2
VRF-2-6	7.835		13	8.045		7.7	2
VRF-2-7	32.819		13	33.705		7.7	2
VRF-2-8	46.001		13	47.239		7.7	2
VRF-2-9	4.742		13	4.869		7.7	2

HVAC Option 4

WSHP Capacities and Efficiencies:

	Cooling		Heating	
	Clg kBtu/h	**EER**	**Htg kBtu/h**	**COP**
DOAS-1	565.415	13.0	706.769	3.2
WSHP-B-1	24.276	13.0	30.345	3.2
WSHP-B-2	7.132	12.2	8.915	3.2
WSHP-B-3	7.252	12.2	9.065	3.2
WSHP-B-5	5.428	12.2	6.785	3.2
WSHP-B-6	32.941	13.0	41.177	3.2
WSHP-B-7	38.44	13.0	48.05	3.2
WSHP-B-8	7.154	12.2	8.942	3.2
WSHP-B-9	21.854	13.0	27.317	3.2
WSHP-B-10	45.923	13.0	57.404	3.2
WSHP-B-11	71.797	13.0	89.746	3.2
WSHP-1-1	69.308	13.0	86.636	3.2
WSHP-1-2	24.212	13.0	30.265	3.2
WSHP-1-3	5.41	12.2	6.763	3.2
WSHP-1-4	351.085	13.0	438.856	3.2
WSHP-1-5	133.138	13.0	166.422	3.2
WSHP-1-6	25.245	13.0	31.556	3.2
WSHP-1-7	45.616	13.0	57.02	3.2
WSHP-1-8	31.486	13.0	39.358	3.2
WSHP-1-9	28.457	13.0	35.571	3.2
WSHP-1-10	32.481	13.0	40.601	3.2
WSHP-1-11	38.822	13.0	48.527	3.2
WSHP-1-12	39.217	13.0	49.021	3.2
WSHP-2-1	13.208	12.2	16.51	3.2
WSHP-2-2	5.213	12.2	6.516	3.2
WSHP-2-3	13.983	12.2	17.479	3.2
WSHP-2-4	8.767	12.2	10.958	3.2
WSHP-2-5	17.455	12.2	21.819	3.2
WSHP-2-6	5.358	12.2	6.698	3.2
WSHP-2-7	22.048	12.2	27.56	3.2
WSHP-2-8	31.587	13.0	39.584	3.2
WSHP-2-9	3.437	12.2	4.296	3.2

HVAC Option 5

GSHP Capacities and Efficiencies

	Cooling		Heating	
	Clg kBtu/h	EER	Htg kBtu/h	COP
DOAS-1	490.725	18.0	613.406	3.2
WSHP-B-1	26.783	18.0	20.087	3.2
WSHP-B-2	7.381	18.0	9.227	3.2
WSHP-B-3	7.394	18.0	9.243	3.2
WSHP-B-5	5.151	18.0	6.439	3.2
WSHP-B-6	33.583	18.0	41.979	3.2
WSHP-B-7	39.186	18.0	48.982	3.2
WSHP-B-8	7.350	18.0	9.187	3.2
WSHP-B-9	21.602	18.0	27.002	3.2
WSHP-B-10	37.517	18.0	46.896	3.2
WSHP-B-11	50.763	18.0	63.454	3.2
WSHP-1-1	70.657	18.0	88.321	3.2
WSHP-1-2	24.686	18.0	30.857	3.2
WSHP-1-3	4.625	18.0	5.872	3.2
WSHP-1-4	357.928	18.0	447.410	3.2
WSHP-1-5	135.733	18.0	169.666	3.2
WSHP-1-6	25.737	18.0	32.171	3.2
WSHP-1-7	46.505	18.0	58.132	3.2
WSHP-1-8	32.100	18.0	40.124	3.2
WSHP-1-9	29.012	18.0	32.265	3.2
WSHP-1-10	33.114	18.0	41.392	3.2
WSHP-1-11	39.579	18.0	49.473	3.2
WSHP-1-12	38.192	18.0	47.739	3.2
WSHP-2-1	13.078	18.0	16.348	3.2
WSHP-2-2	5.315	18.0	6.643	3.2
WSHP-2-3	14.257	18.0	17.821	3.2
WSHP-2-4	8.939	18.0	11.173	3.2
WSHP-2-5	17.797	18.0	22.246	3.2
WSHP-2-6	5.462	18.0	6.828	3.2
WSHP-2-7	20.878	18.0	26.098	3.2
WSHP-2-8	28.608	18.0	35.760	3.2
WSHP-2-9	3.503	18.0	4.379	3.2

Appendix B - eQUEST Output Files

Existing Building Model

```
MiSci_v0                                                                              DOE-2.3-50h    6/14/2021    15:04:54  BDL RUN  1

REPORT- BEPS Building Energy Performance                                                         WEATHER FILE- Albany       NY TMY2
---------------------------------------------------------------------------------------------------------------------------------
```

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	248.6	0.0	260.0	273.2	129.0	0.0	11.5	65.4	0.0	0.0	69.2	16.4	1073.4
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	965.5	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	971.7
MBTU	248.6	0.0	260.0	1239.0	129.0	0.0	17.6	65.4	0.0	0.0	69.2	16.4	2045.1

```
TOTAL SITE ENERGY      2045.07 MBTU     41.0 KBTU/SQFT-YR GROSS-AREA     41.0 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY    4191.81 MBTU     84.1 KBTU/SQFT-YR GROSS-AREA     84.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  1.78
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.08
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =   156

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
```

MiSci_v0 DOE-2.3-50h 6/14/2021 15:04:54 BDL RUN 1

REPORT- BEPU Building Utility Performance WEATHER FILE- Albany NY TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
KWH	72846.	0.	76178.	80057.	37805.	0.	3360.	19155.	0.	3.	20274.	4818.	314496.
FM1 NATURAL-GAS													
THERM	0.	0.	0.	9655.	0.	0.	62.	0.	0.	0.	0.	0.	9717.

TOTAL ELECTRICITY	314496. KWH	6.308 KWH	/SQFT-YR GROSS-AREA	6.308 KWH	/SQFT-YR NET-AREA
TOTAL NATURAL-GAS	9717. THERM	0.195 THERM	/SQFT-YR GROSS-AREA	0.195 THERM	/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE	=	1.78
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED	=	0.08
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE	=	0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE	=	156

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

HVAC Option 1: PVAV with HW Reheat

```
MiSci_v0                                                                               DOE-2.3-50h    6/14/2021    15:07:18  BDL RUN  1

REPORT- BEPS Building Energy Performance                                                          WEATHER FILE- Albany        NY TMY2
---------------------------------------------------------------------------------------------------------------------------------
```

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	248.6	0.0	260.0	6.0	73.7	0.0	17.4	56.0	0.0	0.0	69.1	16.4	747.2
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	1197.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1196.6
MBTU	248.6	0.0	260.0	1203.0	73.7	0.0	17.4	56.0	0.0	0.0	69.1	16.4	1943.8

```
TOTAL SITE ENERGY       1943.79 MBTU     39.0 KBTU/SQFT-YR GROSS-AREA     39.0 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY     3438.22 MBTU     69.0 KBTU/SQFT-YR GROSS-AREA     69.0 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.00
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =     0

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
```

```
MiSci_v0                                                                    DOE-2.3-50h    6/14/2021    15:07:18  BDL RUN  1

REPORT- BEPU Building Utility Performance                                           WEATHER FILE- Albany      NY TMY2
---------------------------------------------------------------------------------------------------------------------------------

                          TASK     MISC     SPACE    SPACE     HEAT     PUMPS     VENT    REFRIG  HT PUMP   DOMEST    EXT
               LIGHTS    LIGHTS    EQUIP   HEATING  COOLING   REJECT   & AUX     FANS   DISPLAY  SUPPLEM  HOT WTR   USAGE     TOTAL
              -------   -------   -------   -------  -------  -------  -------  -------  -------  -------  -------  -------  --------

EM1  ELECTRICITY
    KWH        72846.        0.    76178.     1743.   21606.       0.    5107.   16399.       0.       0.   20235.    4818.   218934.

FM1  NATURAL-GAS
    THERM          0.        0.        0.    11966.       0.       0.       0.       0.       0.       0.       0.       0.    11966.


           TOTAL ELECTRICITY     218934. KWH          4.391 KWH     /SQFT-YR GROSS-AREA    4.391 KWH     /SQFT-YR NET-AREA
           TOTAL NATURAL-GAS      11966. THERM        0.240 THERM   /SQFT-YR GROSS-AREA    0.240 THERM   /SQFT-YR NET-AREA

           PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.00
           PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.00
           HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     0
           HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =     0

           NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
```

HVAC Option 2: VAV with HW Reheat and CHW Cooling

MiSci_v0 DOE-2.3-50h 6/14/2021 15:06:10 BDL RUN 1

REPORT- BEPS Building Energy Performance WEATHER FILE- Albany NY TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	248.6	0.0	260.0	4.5	101.9	6.7	33.0	71.8	0.0	0.0	69.1	16.4	812.1
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	1089.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1089.1
MBTU	248.6	0.0	260.0	1094.0	101.9	6.7	33.0	71.8	0.0	0.0	69.1	16.4	1901.2

TOTAL SITE ENERGY 1901.21 MBTU 38.1 KBTU/SQFT-YR GROSS-AREA 38.1 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 3525.44 MBTU 70.7 KBTU/SQFT-YR GROSS-AREA 70.7 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.00
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

MiSci_v0 DOE-2.3-50h 6/14/2021 15:06:10 BDL RUN 1

REPORT- BEPU Building Utility Performance WEATHER FILE- Albany NY TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
KWH	72846.	0.	76178.	1325.	29871.	1975.	9663.	21039.	0.	0.	20235.	4818.	237950.
FM1 NATURAL-GAS													
THERM	0.	0.	0.	10891.	0.	0.	0.	0.	0.	0.	0.	0.	10891.

TOTAL ELECTRICITY	237950. KWH	4.773 KWH	/SQFT-YR GROSS-AREA	4.773 KWH	/SQFT-YR NET-AREA
TOTAL NATURAL-GAS	10891. THERM	0.218 THERM	/SQFT-YR GROSS-AREA	0.218 THERM	/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.00
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

HVAC Option 3: VRF System

MiSci_v0 DOE-2.3-50h 6/14/2021 15:08:30 BDL RUN 1

REPORT- BEPS Building Energy Performance WEATHER FILE- Albany NY TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	248.6	0.0	260.0	504.6	73.2	0.0	60.7	95.6	0.0	0.0	69.2	16.4	1328.3
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MBTU	248.6	0.0	260.0	504.6	73.2	0.0	60.7	95.6	0.0	0.0	69.2	16.4	1328.3

TOTAL SITE ENERGY 1328.29 MBTU 26.6 KBTU/SQFT-YR GROSS-AREA 26.6 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 3984.87 MBTU 79.9 KBTU/SQFT-YR GROSS-AREA 79.9 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 6.43
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 198

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

MiSci_v0 DOE-2.3-50h 6/14/2021 15:08:30 BDL RUN 1

REPORT- BEPU Building Utility Performance WEATHER FILE- Albany NY TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
KWH	72846.	0.	76178.	147849.	21444.	0.	17777.	28010.	0.	0.	20265.	4818.	389189.
FM1 NATURAL-GAS													
THERM	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL ELECTRICITY 389189. KWH 7.806 KWH /SQFT-YR GROSS-AREA 7.806 KWH /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 6.43
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.00
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 198

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

HVAC Option 4: WSHP with Boiler and Heat Rejection

MiSci_v0 DOE-2.3-50h 6/14/2021 15:09:34 BDL RUN 1

REPORT- BEPS Building Energy Performance WEATHER FILE- Albany NY TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	248.6	0.0	260.0	326.1	74.8	1.6	41.6	114.5	0.0	0.0	69.2	16.4	1152.8
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	822.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	822.2
MBTU	248.6	0.0	260.0	1148.0	74.8	1.6	41.6	114.5	0.0	0.0	69.2	16.4	1975.0

TOTAL SITE ENERGY 1975.02 MBTU 39.6 KBTU/SQFT-YR GROSS-AREA 39.6 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 4280.65 MBTU 85.9 KBTU/SQFT-YR GROSS-AREA 85.9 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.23
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.13
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 7

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

MiSci_v0 DOE-2.3-50h 6/14/2021 15:09:34 BDL RUN 1

REPORT- BEPU Building Utility Performance WEATHER FILE- Albany NY TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
KWH	72846.	0.	76178.	95542.	21918.	455.	12187.	33555.	0.	0.	20275.	4818.	337774.
FM1 NATURAL-GAS													
THERM	0.	0.	0.	8222.	0.	0.	0.	0.	0.	0.	0.	0.	8222.

TOTAL ELECTRICITY	337774. KWH	6.775 KWH	/SQFT-YR GROSS-AREA	6.775 KWH	/SQFT-YR NET-AREA
TOTAL NATURAL-GAS	8222. THERM	0.165 THERM	/SQFT-YR GROSS-AREA	0.165 THERM	/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.23
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.13
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 7

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

HVAC Option 5: GSHP System

MiSci_v0 DOE-2.3-50h 6/14/2021 15:11:03 BDL RUN 1

REPORT- BEPS Building Energy Performance WEATHER FILE- Albany NY TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	248.6	0.0	260.0	273.2	129.0	0.0	11.5	65.4	0.0	0.0	69.2	16.4	1073.4
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	965.5	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0	971.7
MBTU	248.6	0.0	260.0	1239.0	129.0	0.0	17.6	65.4	0.0	0.0	69.2	16.4	2045.1

TOTAL SITE ENERGY 2045.07 MBTU 41.0 KBTU/SQFT-YR GROSS-AREA 41.0 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 4191.81 MBTU 84.1 KBTU/SQFT-YR GROSS-AREA 84.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.78
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.08
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE = 0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE = 156

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

```
MiSci_v0                                                          DOE-2.3-50h    6/14/2021    15:11:03  BDL RUN  1

REPORT- BEPU Building Utility Performance                                      WEATHER FILE- Albany       NY TMY2
-----------------------------------------------------------------------------------------------------------------------
```

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
KWH	72846.	0.	76178.	80057.	37805.	0.	3360.	19155.	0.	3.	20274.	4818.	314496.
FM1 NATURAL-GAS													
THERM	0.	0.	0.	9655.	0.	0.	62.	0.	0.	0.	0.	0.	9717.

```
TOTAL ELECTRICITY    314496. KWH         6.308 KWH     /SQFT-YR GROSS-AREA    6.308 KWH     /SQFT-YR NET-AREA
TOTAL NATURAL-GAS      9717. THERM       0.195 THERM   /SQFT-YR GROSS-AREA    0.195 THERM   /SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  1.78
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.08
HOURS ANY ZONE ABOVE COOLING THROTTLING RANGE                =     0
HOURS ANY ZONE BELOW HEATING THROTTLING RANGE                =   156

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
```

Appendix C - Costing Information

Probable Equipment Costs:

M/E ENGINEERING, P.C.	**BUDGET EQUIPMENT PRICING**			
Mechanical/Electrical	PROJECT NAME: MiSci			
Engineering Consultants	M/E REFERENCE:	213013	DATE:	6/15/2021
SUITE 320, 60 LAKEFRONT BLVD.	DIVISION:	HVAC	BY: TGG	TGG
BUFFALO, NY 14202				

ITEM	DESCRIPTION	QTY.	UNIT	LABOR COST	MATERIAL COST	TOTAL ITEM COST
CONCEPT 1.0 PVAV w/ HW Coils						
BASE-1	No upgrades	0	LS	$0	$0	$0
	TOTAL BASECASE					$0
	CONCEPT 2.0: PVAV W/ HW COILS					
PROP-1.1.0	Gas Boiler, 1,028 MBH	2	EA	$4,700	$14,200	$37,800
PROP-1.0.1	Boiler Equipment, Expansion Tank, Controls, Air Seperator, etc.	1	EA	$2,200	$27,000	$29,200
PROP-1.0.2	PVAV RTU, 23 ton	1	EA	$11,506	$37,400	$48,906
PROP-1.0.3	PVAV RTU, 71 ton	1	EA	$16,317	$79,500	$95,817
PROP-1.1.4	PVAV RTU, 10 ton	1	EA	$7,050	$12,400	$19,450
PROP-1.0.5	HW Pump, 108 gpm	2	EA	$2,988	$11,200	$28,376
PROP-1.0.6	VAV Boxes, 800 cfm	30	EA	$3,750	$2,375	$183,750
	TOTAL PROPOSED					$443,299
	TOTAL INCREMENTAL COST					**$443,299**
CONCEPT 2.0: VAV w/ HW and CHW Coils						
BASE-1	No upgrades	0	EA	$0	$0	$0
	TOTAL BASECASE					$0
	CONCEPT 1.0: VAV W/ HW AND CHW COILS					
PROP-1.0.0	Gas Boiler, 696 MBH	2	EA	$4,700	$14,200	$37,800
PROP-1.0.1	Boiler Equipment, Expansion Tank, Controls, Air Seperator, etc.	1	EA	$2,200	$27,000	$29,200
PROP-1.0.2	Chiller, Air Cooled, Remote, 107 ton	1	EA	$11,900	$87,500	$99,400
PROP-1.0.3	VAV RTU, 5,665 cfm, 11,701 cfm, 2,564 cfm	3	EA	$9,416	$73,000	$247,248
PROP-1.1.4	HW Pump, 73 gpm	2	EA	$2,988	$11,200	$28,376
PROP-1.0.5	CHW Pump, 242 gpm	2	EA	$4,078	$15,800	$39,756
PROP-1.0.6	VAV Boxes, 800 cfm	30	EA	$3,750	$2,375	$183,750
	TOTAL PROPOSED					$665,530
	TOTAL INCREMENTAL COST					**$665,530**

CONCEPT 3.0: VRF SYSTEM						
BASE-1	No upgrades	1	EA	$0	$0	$0
	TOTAL BASECASE					$0
	CONCEPT 3.0: VRF SYSTEM					
PROP-2.0.0	VRF Heat Pump Units, 1-ton	10	EA	$3,700.00	$2,775.00	$64,750
PROP-2.0.1	VRF Heat Pump Units, 2-ton	5	EA	$5,500.00	$3,850.00	$46,750
PROP-2.0.2	VRF Heat Pump Units, 3-ton	4	EA	$7,275.00	$4,325.00	$46,400
PROP-2.0.3	VRF Heat Pump Units, >4-ton	11	EA	$7,525.00	$4,650.00	$133,925
PROP-2.0.4	VRF Condensing Unit, 40-ton	4	EA	$6,050.00	$22,500.00	$114,200
PROP-2.0.5	VRF DOAS Unit, 63-ton	1	EA	$17,900.00	$147,500.00	$165,400
	TOTAL PROPOSED					$571,425
	TOTAL INCREMENTAL COST					**$571,425**
CONCEPT 4.0: WSHP w/ Boiler and Cooling Tower						
BASE-1	No upgrades	1	EA	$0	$0	$0
	TOTAL BASECASE					$0
	CONCEPT 4.0: WSHP w/ Boiler and Cooling Tower					
PROP-4.0.0	WSHP Units, 1-ton, ducted horizontal	12	EA	$3,700.00	$2,775.00	$77,700
PROP-4.0.1	WSHP Units, 2-ton, ducted horizontal	5	EA	$5,550.00	$3,850.00	$47,000
PROP-4.0.2	WSHP Units, 3-ton, ducted horizontal	10	EA	$7,275.00	$4,325.00	$116,000
PROP-4.0.3	WSHP Units, >4-ton, ducted horizontal	3	EA	$7,525.00	$4,650.00	$36,525
PROP-4.0.4	WSHP DOAS Unit, 47 ton	1	EA	$15,800.00	$140,000.00	$155,800
PROP-4.0.5	Gas Boiler, 519 MBH	2	EA	$3,700.00	$9,400.00	$26,200
PROP-4.0.6	Boiler Equipment, Expansion Tank, Controls, Air Seperator, etc.	1	EA	$2,200	$27,000	$29,200
PROP-4.0.7	Cooling Tower, 95-ton	2	EA	$8,675.00	$28,400.00	$74,150
PROP-4.0.8	Loop Pump, 312 gpm	2	EA	$4,078.00	$15,800.00	$39,756
	TOTAL PROPOSED					$602,331
	TOTAL INCREMENTAL COST					**$602,331**
CONCEPT 5.0: GSHP						
BASE-1	No upgrades	1	EA	$0	$0	$0
	TOTAL BASECASE					$0
	CONCEPT 5.0: GSHP					
PROP-5.0.0	Vertical Well	105	EA	$14,000.00	$6,000.00	$2,100,000
PROP-5.0.1	GSHP Units, 1-ton	9	EA	$1,400.00	$2,425.00	$34,425
PROP-5.0.2	GSHP Units, 2-ton	7	EA	$1,725.00	$3,275.00	$35,000
PROP-5.0.3	GSHP Units, 3-ton	4	EA	$1,850.00	$3,450.00	$21,200
PROP-5.0.4	GSHP Units, >4-ton	10	EA	$1,900.00	$3,750.00	$56,500
PROP-5.0.5	GSHP DOAS Unit, 44 ton	1	EA	$15,800.00	$140,000.00	$155,800
PROP-5.0.6	Loop Pump, 464 gpm	2	EA	$4,078.00	$15,800.00	$39,756
	TOTAL PROPOSED					$2,442,681
	TOTAL INCREMENTAL COST					**$2,442,681**

Pricing from RSMeans Building Cost Data. Includes items related to energy efficiency only.

Probable Maintenance Costs

CONCEPT 1.0 PVAV w/ HW Coils

		Unit Costs			
DESCRIPTION	QTY	BARE MATERIAL	BARE LABOR	TOTAL UNIT O&P	TOTAL COST
Gas Boiler, 1,028 MBH	2	$110.00	$282.00	$575.00	$1,150
PVAV RTU, 23 ton	1	$44.00	$55.00	$139.00	$139
PVAV RTU, 71 ton	1	$193.00	$71.00	$350.00	$350
PVAV RTU, 10 ton	1	$44.00	$55.00	$139.00	$139
HW Pump, 108 gpm	2	$15.00	$64.00	$117.00	$234
VAV Boxes	30	$7.00	$26.00	$48.00	$1,440
				Est. Total Maintenance Cost	**$3,452**

CONCEPT 2.0: VAV w/ HW and CHW Coils

		Unit Costs			
DESCRIPTION	QTY	BARE MATERIAL	BARE LABOR	TOTAL UNIT O&P	TOTAL COST
Gas Boiler, 696 MBH	2	$97.50	$267.00	$530.00	$1,060
Chiller, Air Cooled, Remote, 107 ton	1	$70.00	$695.00	$1,175.00	$1,175
VAV RTU, 5,665 cfm, 11,701 cfm, 2,564 cfm	3	$365.00	$115.00	$635.00	$1,905
HW Pump, 73 gpm	2	$15.00	$64.00	$117.00	$234
CHW Pump, 242 gpm	2	$15.00	$64.00	$117.00	$234
VAV Boxes	30	$7.00	$26.00	$48.00	$1,440
				Est. Total Maintenance Cost	**$6,048**

CONCEPT 3.0: VRF SYSTEM

		Unit Costs			
DESCRIPTION	QTY	BARE MATERIAL	BARE LABOR	TOTAL UNIT O&P	TOTAL COST
VRF Heat Pump Units, 1-ton	10	$27.00	$65.00	$133.00	$1,330
VRF Heat Pump Units, 2-ton	5	$27.00	$65.00	$133.00	$665
VRF Heat Pump Units, 3-ton	4	$27.00	$65.00	$133.00	$532
VRF Heat Pump Units, >4-ton	11	$49.00	$76.00	$178.00	$1,958
VRF Condensing Unit, 40-ton	4	$107.00	$91.00	$274.00	$1,096
VRF DOAS Unit, 63-ton	1	$49.00	$76.00	$178.00	$178
				Est. Total Maintenance Cost	**$5,759**

CONCEPT 4.0: WSHP w/ Boiler and Cooling Tower

		Unit Costs			
DESCRIPTION	QTY	BARE MATERIAL	BARE LABOR	TOTAL UNIT O&P	TOTAL COST
WSHP Units, 1-ton, ducted horizontal	12	$27.00	$84.00	$163.00	$1,956
WSHP Units, 2-ton, ducted horizontal	5	$27.00	$84.00	$163.00	$815
WSHP Units, 3-ton, ducted horizontal	10	$27.00	$84.00	$163.00	$1,630
WSHP Units, >4-ton, ducted horizontal	3	$49.00	$67.00	$164.00	$492
WSHP DOAS Unit, 47 ton	1	$49.00	$67.00	$164.00	$164
Gas Boiler, 519 MBH	2	$97.50	$267.00	$530.00	$1,060
Cooling Tower, 95-ton	2	$46.00	$268.00	$470.00	$940
Loop Pump, 312 gpm	2	$15.00	$64.00	$117.00	$234
				Est. Total Maintenance Cost	**$7,291**

CONCEPT 5.0: GSHP

		Unit Costs			
DESCRIPTION	QTY	BARE MATERIAL	BARE LABOR	TOTAL UNIT O&P	TOTAL COST
GSHP Units, 1-ton	9	$27.00	$84.00	$163.00	$1,467
GSHP Units, 2-ton	7	$27.00	$84.00	$163.00	$1,141
GSHP Units, 3-ton	4	$27.00	$84.00	$163.00	$652
GSHP Units, >4-ton	10	$49.00	$67.00	$164.00	$1,640
GSHP DOAS Unit, 44 ton	1	$49.00	$67.00	$164.00	$164
Loop Pump, 464 gpm	2	$15.00	$64.00	$117.00	$234
				Est. Total Maintenance Cost	**$5,298**

Attachment B: Pre-Conference Walkthrough Attendance Sheet

	Schenectady County **Sign In Sheet**

SUMMARY OF WORK

Project Name: miSci Museum Structural and Building System Evaluation Services – Site Walkthrough
Date: April 30, 2024 – 1:00PM
County Representative: Stephen Feeney

Walk Through Sign in Sheet		
Name:	**Company:**	**Email:**
JOHN EDWARDS	SAGE ENGINEERING	JOHNE@SAGELLP.COM
MATTHEW D'ANGELO	EDM	mdangelo@edm-ae.com
Michael Dussault	Engineering Ventures	miked@engineeringventures.com
Beth Bilger	m/E Engineering	babilger@meengineering.com
LILLIAN KOLEHMAINEN	DELTA Engineers, Architects, Surveyors	lnkolehmainen@delta-eas.com
MICHAEL ROMAN	C2 DESIGN GROUP	Roman@C2-DESIGNGroup.com
DAN HEUKRATH	N K BHANDARI, A&E	dheukrath@nkbpc.com
Maya Bauer-Moshi	CHA Consulting	mbauermoshi@chasolutions.com
Patrick McFadden	GPI	pmcfadden@GPInet.com
Thomas Weber	Engineering Ventures	thomasw@engineeringventures.com
PAUL ROUIS	RYAN BIGGS CLARK DAVIS	prouis@ryanbiggs.com

	Schenectady County **Sign In Sheet**

SUMMARY OF WORK

Project Name: miSci Museum Structural and Building System Evaluation Services – Site Walkthrough
Date: April 30, 2024 – 1:00PM
County Representative: Stephen Feeney

Walk Through Sign in Sheet		
Name:	**Company:**	**Email:**
Chris Shaver	C.T. Male	c.shaver@ctmale.com
Matt Fuller	Barton & Loguidice	mfuller@bartonandloguidice.com
John Romeo	McLaren	jromeo@mgmclaren.com
Nick Cruden	MJ Engineering	ncruden@mjteam.com
Alex Alkhurhut	Sargon Engineering	Alex@SargonEngineering.com
Brett Reynolds	Colliers Eng & Design → brett.reynolds@collierseng.com	
Joe Cimino	CHA	jcimino@chacompanies.com
Mike Schafer	Schafer Engineering Assoc	SchaferM@SchaferEA.com
Daniel O'Neill	Delta E.A.S.	DOneill@Delta-Eas.com
John Rizzo	GPI	jrizzo@gpinet.com
Dan Olsted	CHA	dolsted@chasolutions.com
Ethan Wells	McLaren Engineering	~~Etha~~ ewells@mgmclaren.com