NEWBURYPORT WEST END FIRE STATION PROJECT

NET ZERO ENERGY REPORT:

Projected Facility Energy Usage & On-Site Generation Analysis

October 27, 2022

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I. NET-ZERO ENERGY STUDY

A. Achieving a Net-Zero Energy Building

The path to achieving a Net-Zero Energy Building begins with on-site energy production. In the case of the new Newburyport West End Fire Station, electric power is planned to be generated through the installation of 258 photovoltaic energy panels mounted to the roof. The building also needs to conserve its energy through construction of a super-insulated, air-tight building envelope. This will be accomplished by installing well insulated, high-mass walls using an Integrated Concrete Form (ICF) wall system. Natural light reduces the need for artificial lighting, thereby reducing energy consumption. We selectively located thermally broken, triple-glazed, windows to provide natural lighting, where needed, while limiting their total area to maintain a high insulative value of the building envelope.

Heating, Ventilation and Cooling represent a substantial portion of a buildings' energy consumption so finding a system that is very efficient for this size and type of building is critical to achieving Net-Zero Energy success. The two most efficient HVAC systems are Variable Refrigerant Flow (VRF) heat-pump systems in either an air-to-air heat exchange type or a geothermal system. Equipment of each system is similar in cost, but the geothermal system requires the additional & costly installation of wells as means to temper liquid refrigerant. This represents a higher initial cost can sometimes be offset by its greater efficiency over time. What follows is our evaluations and conclusions for each of these major building components.

1. <u>Energy Production – Solar Panel Selection</u>

The selection of solar panels is critical to producing as much, or more, energy than will be consumed by the new fire station. At the outset we understood the new fire station building, and site, to be small and thus not able to accommodate a large enough array of photovoltaic panels to generate all the power needed. Our intention was to produce as much power as possible and the City would supplement any additional power needs through the purchase of Green Power from outside sources. This goal drove the design to feature a flat roof to effectively fit as many, southerly oriented solar panels, as possible to maximize the on-site production of electricity.

We investigated two types of Solar Panels, the "Standard 300W Polycrystalline Panel" and a developing technology of "Thin Film Panels" that can provide full coverage of the roof, as they can be walked upon and not require a service walkway. These panels have a slightly lower energy production per panel but the configuration covering the entire roof posed a net gain in power production for the Thin Film Panel. However, as a developing technology there is not a long track record of information available as to their performance and durability aside from marketing information. In the end it was decided by the City's Administration and the Design Team that the standard, tried-and-true, Polycrystalline Solar Panel would be a more prudent path to follow. With this selection we can provide 258, 300W solar panels upon the building's roof using a U.S. made Sunflare LITEMOUNT 60 panel as our design basis for this study. Please note panel technology and efficiency is improving so the actual panel used may differ when bid. The electrical specifications will provide panel requirements and total roof output, but the contractor has the choice of which specific panel to deliver within those parameters.

<u>SOLAR PANEL SELECTION</u>: 300 W POLYCRYSTALLINE SOLAR PANELS (258 Panels)

2. <u>Envelope and Insulation</u>

After establishing a flat roof to maximize energy production our next task was to determine the best wall and roof systems to provide the highest possible insulative value, or R-value, for the building. Our investigation had us narrow the selection to two finalists for walls: An <u>Integrated Concrete Form (ICF) system</u> or a <u>Double Wood Stud Wall system</u>. Both would provide a high R-value, but the ICF wall system was selected based on the recent pandemic economy of wood vs. concrete. During this time wood demonstrated wild dramatic upswings in cost and periods of limited availability while concrete presented a slow upward curve in cost and remained readily available. The ICF solution also has the added benefit of providing a high thermal mass that will resist daily fluctuations of outdoor temperatures while providing a very sturdy envelope that can withstand even the worst storms that New England has to offer. The longevity of the ICF System is another positive benefit. The cost of both systems were similar.

The roof structure will be supported by wood timber and wood joist construction with R-60 insulation covered by a metal standing seam roofing system. Approximately 258 solar panels will be attached, using specialized clips, to the standing seams of the metal roof to provide a lower profile than is typical. This enables the building to retain a residential, lower scale appearance which is more compatible with the neighborhood.

<u>WALL SYSTEM SELECTION</u>: INTEGRATED CONCRETE FORM (ICF) SYSTEM - R30 INSULATION

<u>ROOF SYSTEM</u>: METAL STANDING SEAM WITH, R60 INSULATION

3. <u>Energy Efficient Heating & Cooling: Variable Refrigerant Flow (VRF) Air System vs. Ground Sourced Heat Pumps</u>

The third major decision for a Net-Zero Energy Building is determining the most energy efficient heating and air conditioning system for the building as it operates 24-hours a day, seven days a week. Our conclusion at the end of the Study Phase was that the economics of a geothermal system would not pan out due to the high initial cost of the geothermal well field and the system only yielding a 4% greater efficiency than a VRF Air-cooled Heat Pump System. However, Winter Street was informed that there was still interest in pursuing a geothermal heating and cooling system. In response Winter Street did some additional research and found an interesting report on a study performed by *Oklahoma State University and Oak Ridge National Laboratory* that evaluated the relative heating and cooling performance of a VRF Air-to-Air and a Geothermal system that had been installed, on separate floors, at the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) headquarters in Atlanta.

When ASHRAE contracted a major renovation of their two-story, 66,700-sq-ft building in Atlanta, it established a "living lab" for the evaluation of commercial-building energy and sustainability performance. ASHRAE contracted a research team from Oklahoma State University and Oak Ridge National Laboratory to evaluate, over a two-year period, the relative performance of the VRF Air-to-Air system and Ground Sourced Heat Pump systems that they had installed in each of the first and second floors of their Atlanta headquarters. The VRF system serves spaced on the first floor, while the Ground Sourced Heat Pump system primarily served spaces on the second floor. A dedicated outdoor-air system, meanwhile, supplied fresh air to both floors. The study of heating and cooling performance at the ASHRAE building proved that over a two-year period—with all variables accounted for—energy use by the geothermal system averaged 44 percent less than the VRF system.

This was a very compelling story in favor of geothermal heating/cooling and Winter Street, with our consulting engineering team of Andelman/Lelek Engineers (ALE) and C.A. Crowley Engineering, once again assumed the task of comparing the two systems. ALE created and evaluated an eQUEST energy model of each HVAC system based on Winter Street's building design. Unfortunately, our new study yielded comparable results to our initial study. The Geothermal Heat-Pump system was only 4% more efficient than the VRF Air-to-Air heat pump system but required the additional expense of installing six (6) geothermal wells, around 400-500 feet deep, that would cost approximately $120K more than the Air VRF system. Additionally, installation of the well field would delay the overall construction of the building by 3-4 weeks, adding additional General Conditions costs to the project. It was concluded that the design team would proceed with employing the VRF Air-to-Air Heat Pump System for the project. See the following cost comparative table for additional details.

HVAC SYSTEM SELECTION: VRF Air-to-Air Heat Pump

LIFE CYCLE COST ANALYSIS - COMPARISON OF AIR-SOURCE VRF AND GEOTHERMAL HEAT PUMP SYSTEMS

Newburyport Fire Station 2 HVAC Options	Annual Electricity Cost	Installation Cost	Annual Maintenance Costs	Cumulative Life Cycle Cost Over a 20 Year Period
Option 1: Air-sourced VRF	$21,383	$396,000	$11,880	$891,671
Option 2: Geothermal VRF	$19,332	$496,600	$14,898	$940,651

Assumptions (per project team):

Installation cost:			
Air source heat pumps (VRF)	$	408,000	based on $60/sf (6,800 sf)
Geothermal heat pumps (VRF)	$	541,600	based on $62/sf (6,800 sf) + $20,000/geothermal well and 6 wells
NGrid incentive (heat pump adder):			
Air source heat pumps (VRF)	$	12,000	based on $1,200 per ton of capacity and 10 tons
Geothermal heat pumps (VRF)	$	45,000	based on $4,500 per ton of capacity and 10 tons
Net installation cost:			
Air source heat pumps (VRF)	$	396,000	
Geothermal heat pumps (VRF)	$	496,600	

Annual maintenance cost — based on 3% of installation cost

Useful life of equipment
Air source heat pumps (VRF) — 20 years
Geothermal heat pumps (VRF) — 50 years ground wells, 20 years all other elements

Why did our study vary so much from the ASHRAE Atlanta Headquarters study? Scale and location are two major factors. The Atlanta facility is over ten times the size of the West End Fire Station and is located at a prime latitude for geothermal heating/cooling due to the balanced thermal needs of both in that climate. Here in the North-East we have a colder, more heating centric climate. IThese facts, together with the examples cited during the Study Phase substantiate our findings that support the implementation of a VRF air-to-air system.

HVAC SYSTEM SELECTION: VRF AIR-TO-AIR HEAT PUMPS

B. SUMMARY OF METHODS EMPLOYED TO ACHIEVE A SUSTAINABLE, NET-ZERO ENERGY BUILDING

1. **Wall Insulation:** Super-Insulated / High Thermal Mass Wall Construction Utilizing Integrated Concrete Form (ICF) System with Minimal Air Infiltration and R-30 Insulation Value

2. **Openings**: Triple-Pane Insulated Windows Strategically Employed to Provide Natural Light Where Needed to Reduce the Use of Man-Made Lighting but Limited to Provide a High Level (R30) of Wall Insulation

3. **Apparatus Room Bi-Fold Doors and Air Locks**: Bi-Fold Doors are Faster Acting than Standard Overhead Doors for the Apparatus Room to Minimize Air-Infiltration Coupled with Air Locks (Vestibules) to Provide a Baffle Between the Exterior and Apparatus Room Environments and the Conditioned Living and Office Spaces

4. **Roof**: Metal Standing Seam Roof with "Clip" System to Support Low-Profile Photovoltaic Panels (258); Supported by Wood Timber Structure and having an R-60 insulation value.

5. **Sustainable Exterior Siding**: Long-Life/Low maintenance Cementitious Siding for a Durable Exterior with Residential Aesthetic

6. **High Efficiency Heating, Ventilation, and Air Condition (HVAC) System**: Provide an All Electric, State-of-The-Art, Variable Refrigerant Flow (VRF) Air-to-Air Heat Pump System with a Building Management System to Improve Economy and Efficiency

7. **Energy Efficient LED Lighting and Electric Appliances and Equipment**: All Appliances to be Energy-Star Rated and LED Lighting Installed Throughout

8. **Occupancy Sensors**: To Control Lighting Operation and Reduce Energy Use by Turning Lights Off in Vacant Areas of the Building

9. **Low-Flow Plumbing Fixtures:** All Plumbing Fixtures and Fittings to be of the Low-Flow Type to Conserve Water

10. **Utilize Drought Resistant Landscape and Native Species**: Employ Plant Species that are Native and Drought Tolerant to Reduce Water Consumption and Require Little Maintenance

11. **Electric Vehicle (EV) Ready Charging**: Providing Conduit from the Electric Panel to Parking Area for Future Installation of a Charging Station

C. Electricity Generation vs. Energy Consumption

Solar Power Generation

We are able to install 258 standard-sized (65.6"x 39.2") 300W photovoltaic panels on the roof of the new West End Fire Station. Using a basic Photovoltaic Watts Calculator available on the internet and filling out our location and several parameters of our intended system we calculated energy production to be approximately **118,462kWh/Year**, as shown below.

RESULTS

Print Results

118,462 kWh/Year*

System output may range from 113,700 to 122,774 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	2.11	5,357
February	2.99	6,846
March	4.16	10,656
April	5.24	12,329
May	5.91	14,284
June	6.18	14,105
July	6.40	14,917
August	5.58	13,053
September	4.63	10,620
October	3.05	7,417
November	2.02	4,833
December	1.65	4,046
Annual	4.16	118,463

Location and Station Identification	
Requested Location	153 Storey Ave Newburyport MA
Weather Data Source	Lat, Lng: 42.81, -70.9 1.1 mi
Latitude	42.81° N
Longitude	70.90° W
PV System Specifications	
DC System Size	100 kW
Module Type	Premium
Array Type	Fixed (roof mount)
Array Tilt	2°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2
Performance Metrics	
Capacity Factor	13.5%

Figure 1-Photo Voltaic Watts Calculator

The calculator cautions that there are variables that may not be reflected in the actual system such as variations in PV Technologies, site specific characteristics, plug loads, actual thermostat set points, and such, but our Electrical Engineer has vouched that this calculator it has been fairly accurate in her past work. It also features a 20% hedge factor to make up for such variables. The energy use model also has assumptions, variables and caveats as to its ultimate accuracy but at this point we are looking at the general nature of the system. We have informed the City that should the photovoltaic system fall short of required production then Green Power is to be purchased to subsidize the system to maintain the City's goal of Net-Zero Energy. That said, at this point we are optimistic that the system will produce enough electricity to power the new station. See anticipated energy consumption below.

Energy Consumption

Andelman and Lelek Engineers developed an eQUEST Energy Model of the new fire station based on the latest design utilizing the VRF Air-to-Air HVAC system to simulate the building's actual energy consumption. Below is a table generated by the eQUEST software demonstrating the anticipated monthly power consumption of the building, for a year. The total consumption estimated to be 85,698 kWh/year and **represents an amount nearly 27% less than the anticipated energy generation.**

```
Newburyport Fire Wizard                                   DOE-2.3-50h   9/08/2022   19:29:40  BDL RUN  1
REPORT- ES-E Summary of Utility-Rate:      NGRID G-3 2021                 WEATHER FILE- BOSTON LOGAN INT' MA
--------------------------------------------------------------------------------------------------------------

     RESOURCE: ELECTRICITY        DEMAND-INTERVAL  15                3413. BTU/KWH
  BILLING-DAY: 31                 RATE-LIMITATION:  0.0000
       METERS: EM1
 POWER-FACTOR: 0.80              EXCESS-KVAR-FRAC:  0.75         EXCESS-KVAR-CHG:  0.0000

 RATE-QUALIFICATIONS       BLOCK-CHARGES                DEMAND-RATCHETS              MIN-MON-RATCHETS
 -------------------------  ---------------------------  ---------------------------  ---------------------------
   MIN-ENERGY:        0.0  NGrid Electric Peak
   MAX-ENERGY:        0.0
   MIN-DEMAND:        0.0
   MAX-DEMAND:        0.0
 QUALIFY-RATE:   ALL YEAR
 USE-MIN-QUAL:         NO
```

MONTH	METERED ENERGY KWH	BILLING ENERGY KWH	METERED DEMAND KW	BILLING DEMAND KW	ENERGY CHARGE ($)	DEMAND CHARGE ($)	ENERGY CST ADJ ($)	TAXES ($)	SURCHRG ($)	FIXED CHARGE ($)	MINIMUM CHARGE ($)	VIRTUAL RATE ($/UNIT)	TOTAL CHARGE ($)
JAN	11979	11979	34.9	34.9	2565	415	0	0	0	30	0	0.2512	3010
FEB	9944	9944	28.1	28.1	2129	334	0	0	0	30	0	0.2507	2493
MAR	9321	9321	22.1	22.1	1996	263	0	0	0	30	0	0.2455	2288
APR	7177	7177	17.0	17.0	1537	202	0	0	0	30	0	0.2465	1769
MAY	5207	5207	14.3	14.3	1115	170	0	0	0	30	0	0.2526	1315
JUN	4743	4743	12.1	12.1	1016	144	0	0	0	30	0	0.2509	1190
JUL	5430	5430	13.7	13.7	1163	163	0	0	0	30	0	0.2497	1356
AUG	5261	5261	12.8	12.8	1126	152	0	0	0	30	0	0.2487	1308
SEP	4420	4420	10.8	10.8	946	128	0	0	0	30	0	0.2498	1104
OCT	5307	5307	13.4	13.4	1136	160	0	0	0	30	0	0.2499	1326
NOV	7363	7363	21.9	21.9	1577	260	0	0	0	30	0	0.2536	1867
DEC	9546	9546	23.7	23.7	2044	282	0	0	0	30	0	0.2468	2356
TOTAL	85698	85698	34.9		18350	2673	0	0	0	360		0.2495	21383

Figure 2- Estimated Fire Station Energy Consumption

D. SUMMARY

We have taken a step-by-step analysis and selected building systems to provide the City of Newburyport the best value in construction of a new Net-Zero Fire Station. We reduced the size of the building during the Study Phase to keep construction cost minimal and have selected building materials and systems based on achieving a Net-Zero Energy Building. We evaluated our choices by developing an eQUEST Energy Model of the building to demonstrate its power use and calculated the anticipated energy produced by the rooftop PV Panels. The results are promising that Net-Zero Energy is achievable without a Green Power subsidy. If not, the building will still produce most of the energy it consumes with minimal subsidy required.

II. APPENDIX

A. Rendered Landscape Plan – MDLA
B. West End Fire Station Floor Plan – WSA
C. West End Fire Station Elevations - WSA
D. Exterior Building Rendering - WSA
E. Energy Use Intensity Report (EUI) - ALE
F. Preliminary Load Calculations Option 1 – Owl Engineers
G. Preliminary Load Calculations Option 2 – Owl Engineers
H. Life Cycle Cost Analysis – ALE
I. Anticipated Yearly Energy Consumption Table - ALE


WINTER STREET ARCHITECTS
JOHN F. CUTTER JR. FIRE STATION
NEWBURYPORT, MA
Project Number: 4139.0000
PERMIT SET
Date Issued: 28 SEPTEMBER 2022
ILLUSTRATIVE SITE PLAN
L1.1
1 ILLUSTRATIVE SITE PLAN
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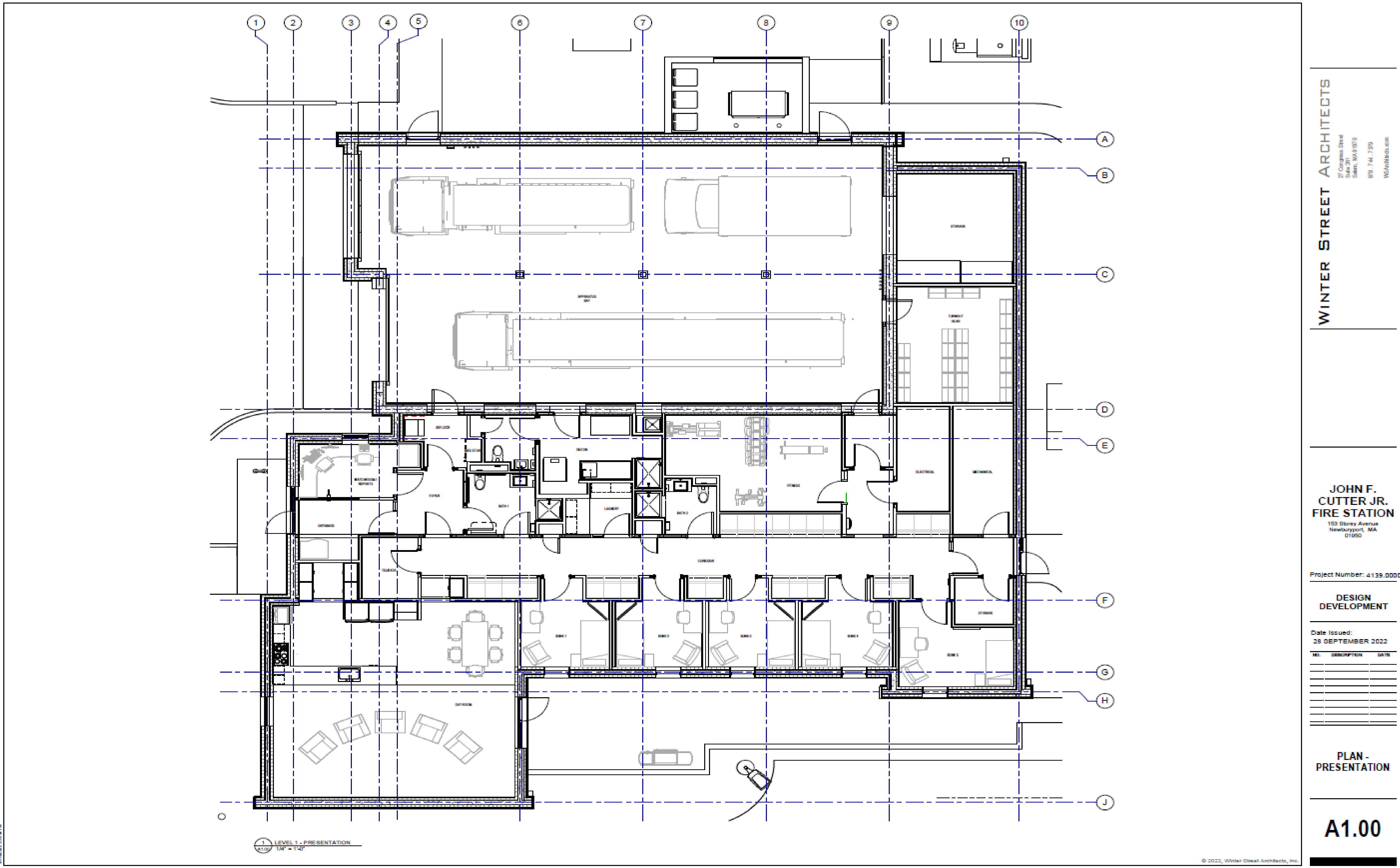
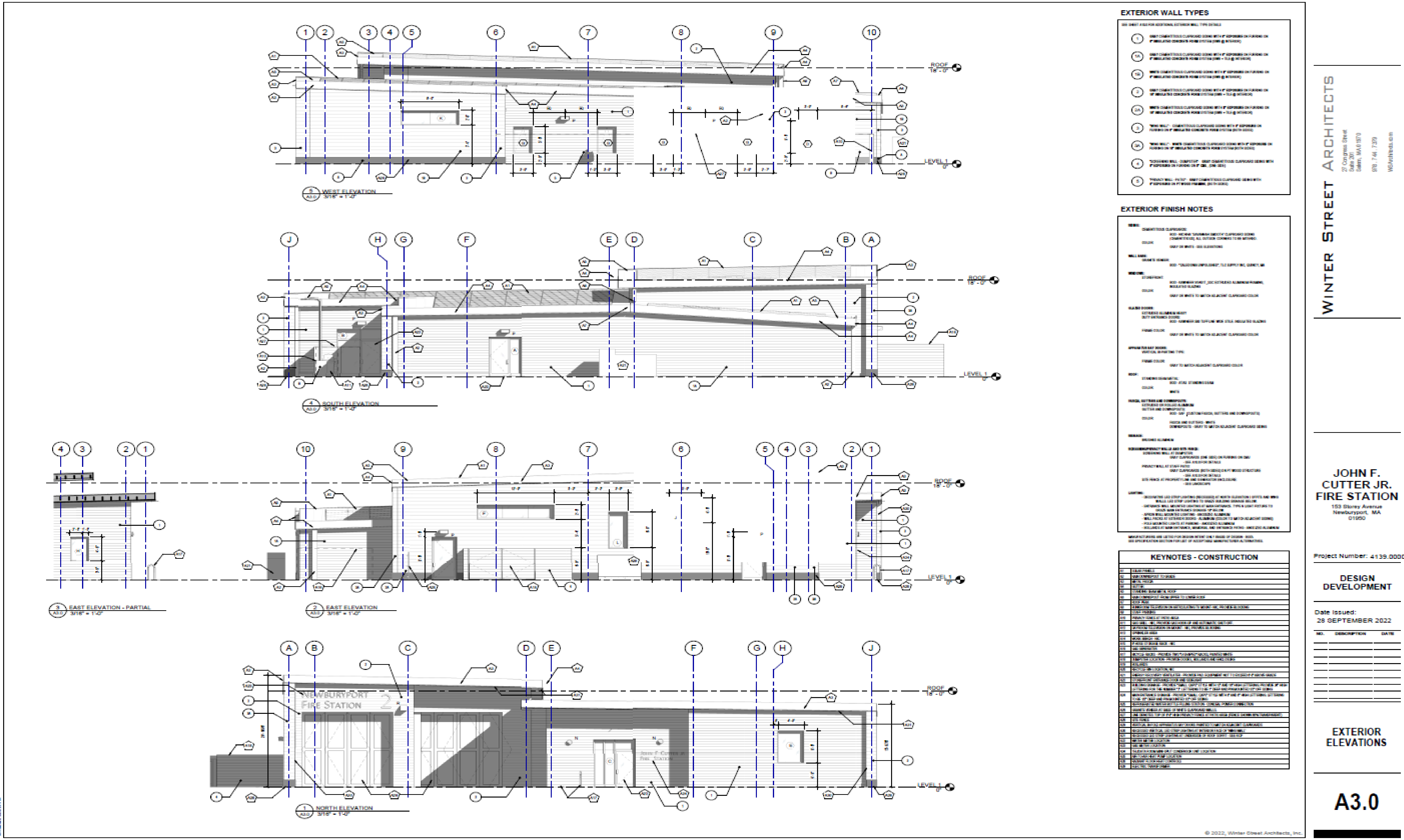

WINTER STREET ARCHITECTS
JOHN F. CUTTER JR. FIRE STATION
153 Storey Avenue
Newburyport, MA 01950
Project Number: 4139.0000
DESIGN DEVELOPMENT
Date Issued:
28 SEPTEMBER 2022
PLAN - PRESENTATION
A1.00
LEVEL 1 - PRESENTATION
1/4" = 1'-0"
© 2022, Winter Street Architects, Inc.


EXTERIOR WALL TYPES
EXTERIOR FINISH NOTES
KEYNOTES - CONSTRUCTION
WEST ELEVATION
SOUTH ELEVATION
EAST ELEVATION - PARTIAL
EAST ELEVATION
NORTH ELEVATION
WINTER STREET ARCHITECTS
JOHN F. CUTTER JR. FIRE STATION
153 Storey Avenue
Newburyport, MA
01950
Project Number: 4139.0000
DESIGN DEVELOPMENT
Date Issued:
28 SEPTEMBER 2022
EXTERIOR ELEVATIONS
A3.0
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NEWBURYPORT
FIRE STATION 2

JOHN F. CUTTER JR FIRE STATION

Newburyport, MA

Energy Use Intensity (EUI) Report
Based on Progress Set dated July 22, 2022

Final Report
August 31, 2022

PREPARED FOR

Winter Street Architects, Inc
27 Congress Street
Salem, MA 01970

PREPARED BY

Andelman and Lelek Engineering, Inc.
1408 Providence Highway
Norwood, MA 02062
(781) 769-8773

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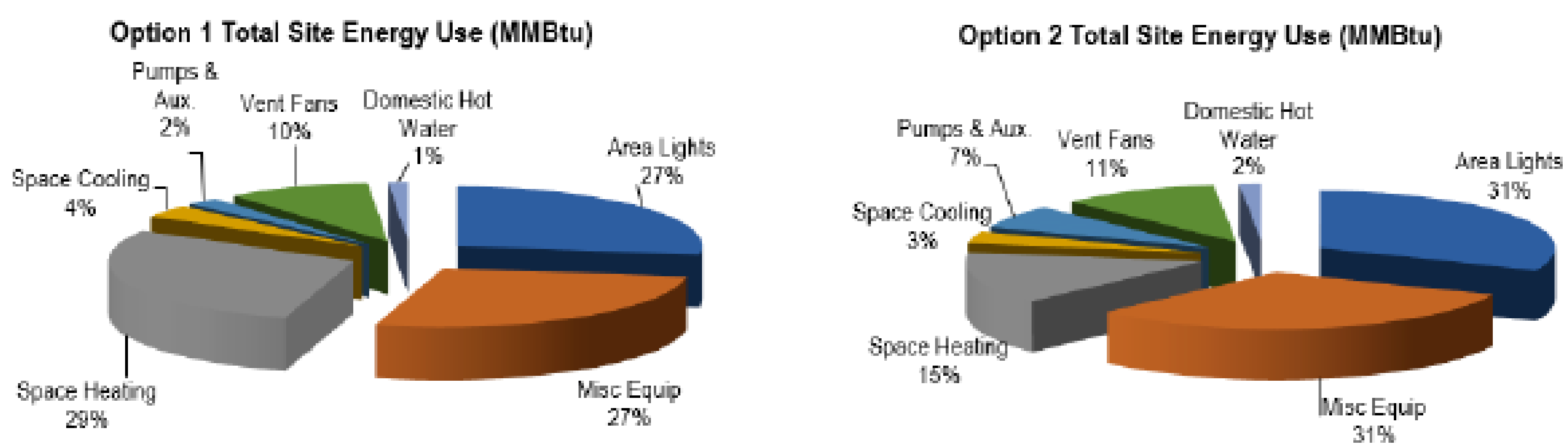
EXECUTIVE SUMMARY

Andelman and Lelek Engineering, Inc. (ALE) was retained by Winter Street Architects, Inc. to complete an energy performance analysis for the new fire station in Newburyport, MA. The main objective of the study is to create an energy consumption simulation model in order to estimate annual energy use for the building and to determine the building's hourly electric demand for 8760 hours of the year in order to aid the ongoing design of a new PV system for the site.

This report is based on information from the Progress Set dated 7/22/2022 and information provided by the design team, including a description of the proposed mechanical systems and equipment cut sheets.

Option 1 (air-cooled systems) is estimated to use 71,957 kWh per hour (38.7 kBtu/sf/yr of site energy) with an electric cost of $17,516. Option 2 (geothermal) is estimated to use 62,550 kWh (33.7 kBtu/sf/yr of site energy) with an electric cost of $15,041. Hourly electrical demand for both options is provided under separate cover in an Excel spreadsheet. The breakdown of energy by end use is shown in Figure 1 below.

Figure 1 – Summary of Annual Energy Consumption by End Use



Please note that there are many factors which may cause the building's actual energy use to differ from modeled energy use. These include weather, actual patterns of use, plug load variations, operating controls, etc.

FACILITY DESCRIPTION

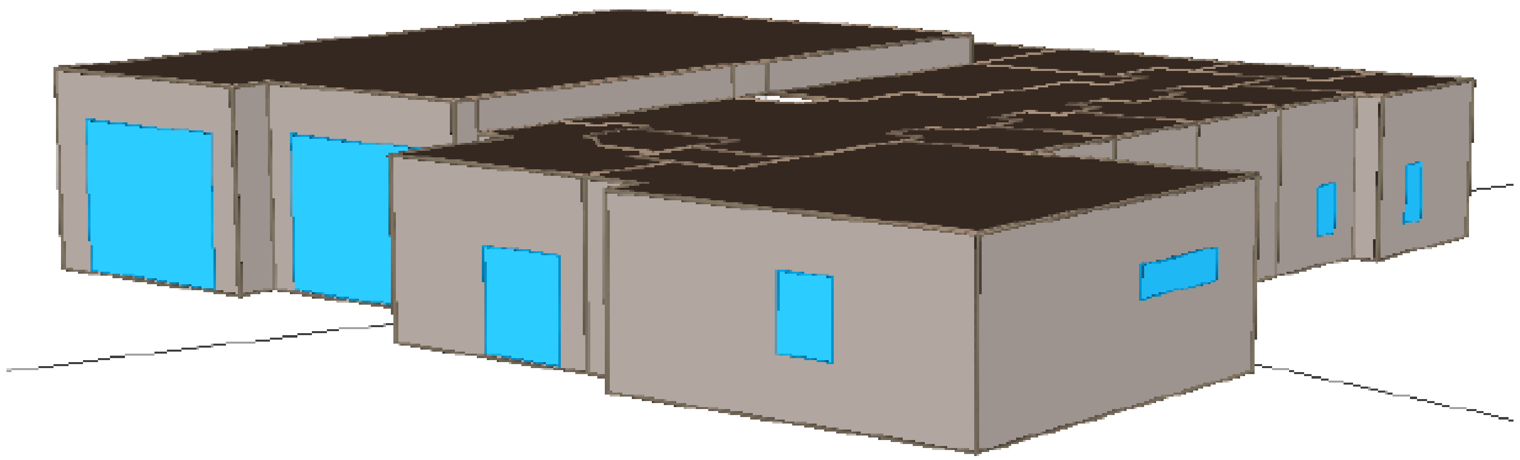


Figure 1: eQuest model of the Newburyport Fire Station

General

The John F. Cutter Jr. Fire Station is located at 153 Storey Avenue in Newburyport, MA. The building design occupancy was estimated to be 5 with a peak occupancy of 10 during shift changes. The building is assumed to be occupied 24/7.

Architectural

The building has one floor and an area of 6,340 sf (per eQuest model). Spaces include the apparatus bay, day room, bunk rooms, fitness room, watch room and storage.

Wall Constructions:

- 10" concrete walls with R-35 insulation. Overall U-0.027

Roof Constructions:

- Roof has 10" polyisocyanurate (min R-60). Overall U-value U-0.016

<u>Fenestration</u>

The building includes triple-glazed aluminum framed windows with assumed SHGC of 0.3 and overall U-value of 0.28. The window to wall ratio is approximately 13.7%. There are two 14'x14' doors for the apparatus bay.

Mechanical Systems

There are currently two options being considered. Both are all-electric designs.

Space temperature setpoints are assumed to be constant at 70°F in heating mode and 75°F in cooling mode.

Option #1: Air-cooled

- The apparatus bay is served by ERV-1 for ventilation.
  - ERV air-sourced heat pump:
    - Energy recovery effectiveness 68% (winter)/67% (summer)
    - Heating capacity of 28.6 MBh and efficiency of 5.9 COP
    - Cooling capacity of 75.8 MBh and *assumed* efficiency of 12.8 EER
  - Two air-to-water heat pumps provide hot water for radiant floor heating.
    - Heating capacity of 59,100 Btu/hr at 105°F HWST with 4.23 COP
    - Two (2) Pumps P-1&2 serve the heating loop.
    - Four (4) pumps P-3 thru 6 serve the individual zones.
- Most spaces are heated/cooled with air-source VRF heat pumps.
  - 10-ton condensing unit with cooling efficiency of 12.6 EER and heating efficiency of 3.7
- Electric unit heaters electrical/mechanical, foyer and storage spaces.
- An air-cooled heat pump serves the tel/data room, with cooling capacity of 12 MBh and cooling efficiency of 12.0 EER.

Option #2: Geothermal

- Geothermal wells: assumed there will be six 500-foot wells
- The apparatus bay is served by ERV-1 for ventilation.
  - ERV air-sourced heat pump:
    - Energy recovery effectiveness 68% (winter)/67% (summer)
    - Heating capacity of 28.6 MBh and efficiency of 5.9 COP
    - Cooling capacity of 75.8 MBh and *assumed* efficiency of 12.8 EER
  - Two water-to-water heat pumps provide hot water for radiant floor heating.
    - Heating capacity of 56,500 Btu/hr at 105°F HWST with 6 COP
    - Two (2) Pumps P-1&2 serve the ground water loop
    - Two (2) Pumps P-3&4 serve the heating loop.
    - Four (4) pumps P-5 thru 8 serve the individual zones.
- Admin & Living spaces are served by water-sourced VRF heat pumps
  - Cooling efficiency of 13.4 EER
  - Heating efficiency of 5.5 COP
  - Pump P-9 serves the condenser water/geothermal loop.
- Electric unit heaters electrical/mechanical, foyer and storage spaces.
- An air-cooled heat pump serves the tel/data room, with cooling capacity of 12 MBh and cooling efficiency of 12.0 EER.

Electric Lighting Systems

Lighting power density is 0.48 W/sf, as estimated by the electrical engineer. Total building light power is estimated at 3.1 kW (based on 6,340 sf)

Miscellaneous equipment loads are assumed to be as follows:

- 0.2 W/sf for bunk rooms
- 1.5 W/sf for mechanical/electrical rooms
- 0.5 W/sf for day room and watch room
- 0.1 W/sf for the apparatus bay
- 0.75 W/sf for fitness room
- 0.1 W/sf for corridors, stairs, storage, etc.
- The IT room is assumed to have equipment loads corresponding to 30% of the cooling capacity of the a/c unit serving the space.

Equipment (plug loads) loads comprise all non-HVAC equipment plugged into convenience outlets, including computers, printers, monitors, kitchen equipment, clothes washer and dryer, etc.

Domestic Hot Water Systems

The domestic hot water loads for this project are expected to include lavatory sinks, kitchen uses, clothes washer and showers. It was assumed the domestic hot water would be provided by an electric water heater.

ANALYSIS METHODOLOGY

To analyze the future energy consumption patterns of the building, a computer model of the facility was developed and building consumption simulations were performed using the eQuest building analysis program. eQuest uses the latest DOE-2.3 building energy analysis software as its calculating engine version (3.65 build 7165). This very flexible program permits modeling of a variety of building types and components including complex building geometry, lighting systems, HVAC systems, central plant equipment, and utility rate structure. Boston, MA TMY3 weather data was used in the analysis. The eQUEST model was compiled using information obtained from the Progress Set dated 7/22/2022 and information provided by the design team, including a description of the proposed mechanical systems and equipment cut sheets.

OWL

OWL Engineers
105 Abbot Street, Andover, MA 01810 t:978.6212391 w:owlengineers.com e:Info@owlengineers.com

Preliminary Load Calculation Option 1

Project phase: Preliminary
Trade Specification Section:
By: J.O'Brien Checked By: J.O'Brien

Project: Newburyport Fire Station
Newburyport Massachusetts
Project Number: 22022

Sheet 1 of 1
Date 08.15.22

Load Description	Load	Qty/SqFt	Watts	Demand	Total
Receptacle	180	90.0	16200	NEC	12,480.0
Interior Lighting	6500	0.5	3250	1.25	4,062.5
Exterior Lighting	250	1.0	250	1.25	312.5
Hand Dryers	1500	3.0	4500	1.00	4,500.0
Hot Water Heater	9000	1.0	9000	1.00	9,000.0
VRF	19523	1.0	19523	1.00	19,523.0
ACCU	2496	1.0	2496	1.00	2,496.0
Exhaust	960	1.0	960	1.00	960.0
ERV	11516	1.0	11516	1.00	11,516.0
EUH	2288	4.0	9152	1.00	9,152.0
CUH	1997	2.0	3994	1.00	3,994.0
Heat Pumps	7800	2.0	15600	1.00	15,600.0
Pumps	1961	1.0	1961	1.00	1,961.0
Door Operators	1500	2.0	3000	1.00	3,000.0
Fire Alarm	1500	1.0	1500	1.25	1,875.0
Uniform Washer	7500	1.0	7500	1.00	7,500.0
Uniform Dryer	12000	1.0	12000	1.00	12,000.0
Lift	3000	1.0	3000	1.00	3,000.0
Stove	12700	1.0	12700	1.00	12,700.0
Kitchen Branch Circuits	1500	2.0	3000	1.00	3,000.0
Dryer	5000	1.0	5000	1.00	5,000.0
Washer	1500	1.0	1500	1.00	1,500.0
Air Compressor	15000	1.0	15000	1.00	15,000.0
plymovent	6000	1.0	6000	1.00	6,000.0
Generator Equipment	2000	1.0	2000	1.00	2,000.0
Door Operators	3000	2.0	6000	1.00	6,000.0
				Total Wattage	174,132
				120/208V Load	482

OWL

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Preliminary Load Calculation Option 2

Project phase: Preliminary Trade Specification Section: By: J.O'Brien Checked By: J.O'Brien	Project: Newburyport Fire Station Newburyport Massachusetts Project Number: 22022	Sheet 1 of 1 Date 08.15.22

Load Description	Load	Qty/SqFt	Watts	Demand	Total		
Receptacle	180	90.0	16200	NEC	12,480.0		
Interior Lighting	6500	0.5	3250	1.25	4,062.5		
Exterior Lighting	250	1.0	250	1.25	312.5		
Hand Dryers	1500	3.0	4500	1.00	4,500.0		
Hot Water Heater	9000	1.0	9000	1.00	9,000.0		
VRF	15190	1.0	15190	1.00	15,190.0		
ACCU	2496	1.0	2496	1.00	2,496.0		
Exhaust	960	1.0	960	1.00	960.0		
ERV	11516	1.0	11516	1.00	11,516.0		
EUH	2288	4.0	9152	1.00	9,152.0		
CUH	1997	2.0	3994	1.00	3,994.0		
Heat Pumps	6884	2.0	13768	1.00	13,768.0		
Pumps	3067	1.0	3067	1.00	3,067.0		
Door Operators	1500	2.0	3000	1.00	3,000.0		
Fire Alarm	1500	1.0	1500	1.25	1,875.0		
Uniform Washer	7500	1.0	7500	1.00	7,500.0		
Uniform Dryer	12000	1.0	12000	1.00	12,000.0		
Lift	3000	1.0	3000	1.00	3,000.0		
Stove	12700	1.0	12700	1.00	12,700.0		
Kitchen Branch Circuits	1500	2.0	3000	1.00	3,000.0		
Dryer	5000	1.0	5000	1.00	5,000.0		
Washer	1500	1.0	1500	1.00	1,500.0		
Air Compressor	15000	1.0	15000	1.00	15,000.0		
plymovent	6000	1.0	6000	1.00	6,000.0		
Generator Equipment	2000	1.0	2000	1.00	2,000.0		
Door Operators	3000	2.0	6000	1.00	6,000.0		
				Total Wattage			169,073
				120/208V Load			468

LIFE CYCLE COST ANALYSIS

Newburyport Fire Station 2 HVAC Options	Annual Electricity Cost	Installation Cost	Annual Maintenance Costs	Cumulative Life Cycle Cost Over a 20 Year Period
Option 1: Air-sourced VRF	$21,383	$396,000	$11,880	$891,671
Option 2: Geothermal VRF	$19,332	$496,600	$14,898	$940,651

Assumptions (per project team):

Installation cost:

Air source heat pumps (VRF)	$	408,000	based on $60/sf (6,800 sf)
Geothermal heat pumps (VRF)	$	541,600	based on $62/sf (6,800 sf) + $20,000/geothermal well and 6 wells

NGrid incentive (heat pump adder):

Air source heat pumps (VRF)	$	12,000	based on $1,200 per ton of capacity and 10 tons
Geothermal heat pumps (VRF)	$	45,000	based on $4,500 per ton of capacity and 10 tons

Net installation cost:

Air source heat pumps (VRF)	$	396,000
Geothermal heat pumps (VRF)	$	496,600

Annual maintenance cost — based on 3% of installation cost

Useful life of equipment

Air source heat pumps (VRF)	20 years
Geothermal heat pumps (VRF)	50 years ground wells, 20 years all other elements

Newburyport Fire Station

M magda@andelmanlelek.com
To 'Molly Ettenborough'
Cc Paul Durand; Dana Weeder

REPORT- ES-E Summary of Utility-Rate: NGRID G-3 2021 WEATHER FILE- BOSTON LOGAN INT' MA

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   RESOURCE: ELECTRICITY        DEMAND-INTERVAL  15             3413. BTU/KWH
BILLING-DAY: 31                 RATE-LIMITATION: 0.0000
     METERS: EM1
POWER-FACTOR: 0.80              EXCESS-KVAR-FRAC: 0.75          EXCESS-KVAR-CHG: 0.0000

RATE-QUALIFICATIONS    BLOCK-CHARGES          DEMAND-RATCHETS        MIN-MON-RATCHETS
MIN-ENERGY:     0.0    NGrid Electric Peak
MAX-ENERGY:     0.0
MIN-DEMAND:     0.0
MAX-DEMAND:     0.0
QUALIFY-RATE:   ALL YEAR
USE-MIN-QUAL:   NO
```

MONTH	METERED ENERGY KWH	BILLING ENERGY KWH	METERED DEMAND KW	BILLING DEMAND KW	ENERGY CHARGE ($)	DEMAND CHARGE ($)	ENERGY CST ADJ ($)	TAXES ($)	SURCHRG ($)	FIXED CHARGE ($)	MINIMUM CHARGE ($)	VIRTUAL RATE ($/UNIT)	TOTAL CHARGE ($)
JAN	11979	11979	34.9	34.9	2565	415	0	0	0	30	0	0.2512	3010
FEB	9944	9944	28.1	28.1	2129	334	0	0	0	30	0	0.2507	2493
MAR	9321	9321	22.1	22.1	1996	263	0	0	0	30	0	0.2455	2288
APR	7177	7177	17.0	17.0	1537	202	0	0	0	30	0	0.2465	1769
MAY	5207	5207	14.3	14.3	1115	170	0	0	0	30	0	0.2526	1315
JUN	4743	4743	12.1	12.1	1016	144	0	0	0	30	0	0.2509	1190
JUL	5430	5430	13.7	13.7	1163	163	0	0	0	30	0	0.2497	1356
AUG	5261	5261	12.8	12.8	1126	152	0	0	0	30	0	0.2487	1308
SEP	4420	4420	10.8	10.8	946	128	0	0	0	30	0	0.2498	1104
OCT	5307	5307	13.4	13.4	1136	160	0	0	0	30	0	0.2499	1326
NOV	7363	7363	21.9	21.9	1577	260	0	0	0	30	0	0.2536	1867
DEC	9546	9546	23.7	23.7	2044	282	0	0	0	30	0	0.2468	2356
TOTAL	85698	85698	34.9		18350	2673	0	0	0	360		0.2495	21383

Thank you,
Magda

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