RetrofitNY: Bright Power Net Zero Energy Retrofit Schematic Design

Final Report | Report Number 19-20 | May 2019

NYSERDA's Promise to New Yorkers:

NYSERDA provides resources, expertise, and objective information so New Yorkers can make confident, informed energy decisions.

Mission Statement:

Advance innovative energy solutions in ways that improve New York's economy and environment.

Vision Statement:

Serve as a catalyst – advancing energy innovation, technology, and investment; transforming New York's economy; and empowering people to choose clean and efficient energy as part of their everyday lives.

RetrofitNY: Bright Power
Net Zero Energy Retrofit Schematic Design

Final Report

Prepared for:

RetrofitNY
New York State Energy Research and Development Authority

Albany, NY

Christopher Mahase
Senior Project Manager

Prepared by:

Bright Power

New York, NY

Marion Ligneau
Manager of Building Rehabilitations

NYSERDA Report 19-20 NYSERDA Contract 125708 May 2019

Notice

Preferred Citation

New York State Energy Research and Development Authority (NYSERDA). 2019. "RetrofitNY: Bright Power Net Zero Energy Retrofit Schematic Design," NYSERDA Report Number 19-20. Prepared by Bright Power. nyserda.ny.gov/publications.

Abstract

NYSERDA issued a request for proposals to design building renovations of affordable New State buildings achieving net-zero energy performance while being financed by existing financial sources in addition to gap funding provided by NYSERDA as part of a subsequent request for proposals. This report presents a renovation scope for two pre-war 21-unit buildings located at 300 and 304 East 162nd Street, Bronx, NY. This scope meets NYSERDA's requirements in terms of energy efficiency, technology use, fuel use and functionality but is not currently viable financially. As designed, the buildings, once rehabbed, would achieve a site EUI of 29.6 kBtu/ft^2/yr based on energy modeling, approximately 78% less than their current consumption. Key design innovations that would allow the project to reach this performance include high performance windows, roof insulation, a variable refrigerant flow (VRF) system, an ERV and a heat pump water heater. Under this scope of work, 31% of the remaining consumption will be offset by onsite solar PV system, and an additional 57% is expected to be offset by residents and the owner enrolling in community solar. In total, our analysis shows the project could achieve 3.7 kBtu/ft^2/yr of net energy consumption. The overall projected cost of $174,000/unit appears to be too high to meet the owner and housing agency financing requirements, based on analysis by the owner. While not the subject of this report, the project expects to proceed with a reduced scope of work to include high performance windows, roof insulation and a heat pump water heater.

Keywords

Net zero, Retrofit, Variable refrigerant flow system, Energy recovery ventilation, Heat pump water heater, Solar panels, Photovoltaic, Prefabricated insulation panels, Low-flow plumbing fixtures, LED, Insulation, Air-sealing, Double-pane windows, Integrative design process.

Acknowledgments

Bright Power gratefully acknowledges Volmar Construction, Magnusson Architecture and Planning, Dagher Engineering and Olive Branch Consulting for their role as active members of the design team. Sara Bayer from Magnusson Architecture and Planning, Josephine Zurica from Dagher Engineering, Ajay Vempati from Volmar Construction and Alison Cody from Volmar Construction each contributed significantly to this report, creating a comprehensive document.

John Boecker from Seven Group insightfully guided the team as an Integrative Design Process coach.

The New York State Energy Research and Development Authority provided continuous support and flexibility, allowing the team to receive technical support from the National Renewable Energy Lab.

Energiesprong made it possible for RetrofitNY teams to learn first-hand about net zero retrofits in the Netherlands by graciously hosting all RetrofitNY teams.

Bright Power also acknowledges the Housing Preservation and Development New York City agency and the Community Preservation Corporation for their innovative role in creating a financing plan for the renovation project.

Table of Contents

Acronyms and Abbreviations

ADA	Americans with Disabilities Act
CCD1	Construction Code Determination
CPC	Community Preservation Corporation
DIY	Do It Yourself
DOB	Department of Buildings
EPS	Expanded Polystyrene
ERV	Energy Recovery Ventilation
EUI	Energy Use Intensity
ft	feet
GC	General Contractor
HPD	Housing Preservation and Development
HVAC	Heating Ventilation and Air-Conditioning
kWh	kilowatt hours
LED	Light Emitting Diode
m/s	meters per second
MEP	Mechanical Electrical Plumbing
MW	Mineral Wool
MW	megawatts
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
PV	Photovoltaic
NZE	Net Zero Energy
VRF	Variable Refrigerant Flow
W	Watts

Glossary

Energy Use Intensity. The total amount of site energy consumed by the building on an annual basis divided by the gross floor area in kBtu/ft^2/yr.

Multifamily building. Residential building with five or more residential units.

Net Zero Energy Performance. Total site energy consumed by the Building being less than or equal to the amount of renewable energy created by solar photovoltaics or other distributed energy resources located on the Building or elsewhere on the site, calculated on an annual basis.

Executive Summary

This report describes the process of designing a near net zero retrofit for two adjacent pre-war buildings located at 300 and 304 East 162nd Street in Bronx, NY. Both buildings are masonry buildings, with three-wythe brick load bearing walls, wood joist floors, and a roof cavity. They are currently served by a one-pipe steam system for heating and window air-conditioners, windows provide natural ventilation. The buildings do not have any existing envelope insulation and have outdated double-pane windows.

The design team consisted of the following members:

Volmar Construction, owner of the buildings and general contractor for the project
Bright Power, energy consultant and project coordinator
Magnusson Architecture and Planning, architect
Dagher Engineering, MEP engineer
Olive Branch Consulting, cost estimator

The primary goal of the project was to design a retrofit solution for the buildings that achieves net zero energy performance. The project also stipulated the installation (1) be implemented with residents in place, (2) coverd basic renovation needs of the building, (3) improved the residents' comfort and experience, and (4) was financed by existing financing sources (in addition to NYSERDA's gap funding).

Design Process

The team utilized an integrative design process as a methodology to design its retrofit solution. Throughout the design phase, energy modeling and cost estimating were used in combination in an iterative process. A parametric analysis was performed in the energy model and led to calculate the investment cost of each kBtu saved for each measure. It guided the team towards measures with the lowest investment cost per kBtu saved. Different efficiencies and insulation values were also tested using the same method, which refined each scope item's performance.

The team first worked to create a “Most Efficient” scope, which was then reduced (using the parametric analysis described above) to arrive at the scope presented in this report, the “NYSERDA Compliant” scope. A key change between the scopes is that the exterior wall insulation was removed. Even with this change, the scope still meets all of NYSERDA’s requirements to be eligible for the $40,000 per apartment gap funding.

Deep Retrofit Scope of Work

The particulars of the “NYSERDA Compliant” scope is as described in Table 1.

Table 1. NYSERDA Compliant Scope of Work

		NYSERDA Compliant Scope
Envelope	Cladding	Existing uninsulated walls
	Roof	R-30 Blown cellulose in roof cavity R-16 Rigid insulation above roof deck
	Air-Sealing	Targeted air-sealing informed by blower door testing Air-tightness target: 2.33 ACH50
	Windows	Tilt & Turn double glazed U-0.277 - SHGC 0.4
Mechanical Electrical Plumbing	Heating & Cooling	VRF
	Ventilation	Central ERV with exterior risers
	DHW	Heat pump water heater and low flow plumbing fixtures
	Lighting	LEDs throughout the buildings Daylight and occupancy sensors in common areas
Appliances	Stoves	Standard Electric
	Refrigerators	Existing
	Range Hood	ENERGY STAR® range hoods

Table 2. NYSERDA Compliant Scope of Work (continued)

		NYSERDA Compliant Scope
Solar	Solar Array	Solar photovoltaic (PV) pergola 42 kW per building
Non-Energy Items	Laundry Room	One installed in each building
	Kitchens & Baths	No renovation
	Apartment Doors	Replaced as needed

The team explored several design innovations while defining this scope, which do not all appear in the scope above. With inspiration from what was engineered for Energiesprong projects in the Netherlands, prefabricated insulation panels were explored in collaboration with two U.S. manufacturers that were starting to create prototypes. For all elements of the design, the team researched options that were the least disruptive to the tenants. For instance, the solar array and the heat pump water heaters offer large efficiency or grid energy reduction impacts and were deemed feasible, because they are not expected to affect tenants during construction. The creative ducting and piping layout related to the variable refrigerant flow (VRF) and energy recovery ventilation (ERV) systems also aim to minimize tenant disruption and control costs. Refrigerant piping is run through existing plumbing chases that are concurrently open during bathroom renovations, while insulated ducts are run outside of the buildings on exterior walls. Supply ventilation air is brought to the back of the VRF indoor units located in the bathroom ceilings and is then supplied to the apartments by new horizontal ducts to the bedrooms and living rooms.

Deep Retrofit Impact

The scope described above achieves a site EUI of 29.6 kBtu/ft^2/yr based on the Equest energy model created. The baseline energy model has been calibrated using existing utility data from the buildings.

The construction schedule of this deep retrofit is challenging because of the additional in-unit work (VRF and ERV) required compared to the typical retrofit. However, this challenge can be overcome by performing apartment work in two distinct phases, maintaining as much usable apartment space as possible at any given time.

By providing heating and cooling though a central VRF system and continuous ventilation, the renovation will significantly increase comfort and is expected to have a positive impact on residents' health by improving indoor air quality.

The scope was created with the goal of it being scalable to similar buildings in New York City and beyond. All exterior measures, including numerous rooftop equipment and ducts that run on the outside of the exterior walls, are seen as elements of the scope that would be easily replicable on similar buildings. The one-pipe steam heating system, however, is viewed as a barrier to scalability because none of its distribution can be re-used in a deep retrofit scenario, requiring significant in-unit work to decommission the old system and install elements of the new system.

Deep Retrofit Feasibility

Generally, for such innovative and expensive projects, owners and lenders may require a performance guarantee to ensure them that utility and maintenance expenses will remain as expected. This allows the owner to cover their other obligations, including debt-service. Typically, the general contractor (GC) or the energy service company provides this performance guarantee. In this case, the owner and the GC are the same entity: Volmar Construction. Volmar expects to work internally to ensure the performance of the project, relying on manufacturer guarantees and utilizing an energy monitoring system.

The cost of the "NYSERDA Compliant" scope is estimated at $174,000 per apartment. In assessing whether this cost was financeable, a limited amount of incentives were assumed to be part of the financing plan, as well as $40,000 per apartment of gap funding from NYSERDA. The owner then sought to secure the required amount of financing through loans for the remainder of the project cost. However, the owner deemed the project financially infeasible due to the high cost and low rents. The financial model showed that even with NYSERDA's gap financing, the expected net cash-flow at the property would not be sufficient to meet their financial requirements.

1 Project Narrative

Building Envelope

Key design criteria to consider	How does your design address the criteria?
Thermal performance	**Wall insulation**: Walls will not be insulated as part of the scope because the cost of this measure is too high in relation to its associated energy cost savings. **Prefabricated panels:** Although the current design does not include prefabricated panels, the team has been working with two manufacturers to create prototypes for the panels described below: The prefabricated panel is being designed as a rain screen system arriving to the site in approximately 10 x15 foot panels and attached to the existing building off of a few pre-installed clips. The panels will provide the continuous airtightness and insulation layer, and protective cladding. By allowing the cladding to provide the airtight and insulating layers itself, it would not need to weave into the existing layers of the existing walls. Therefore, it could be supported by a few clips back to the existing structure and stand off the building which would bypass issues of an irregular substrate. Their structure will be of thermally non-conductive fiber reinforced polymer, so as to minimize the thickness of the overall assembly, and one manufacture is looking into possibly also incorporating UPVC window frames into the design of the frame. The infill will be stone wool, and a sheet membrane on a glass fiber sheathing will provide the airtightness layer. The cladding type can be determined by the designer with a current weight limit of 10 lbs. per square foot. **Windows**: The windows will be replaced with U-PVC tilt & turn efficient windows (U-0.277 Btu/(h.ft^2.F) and SHGC 0.38). The team looked into triple pane windows, but the incremental energy savings were minimal compared to the added cost. For the design using exterior insulation, insulation would cover part of the window jambs. **Roof insulation**: The roof cavity insulation will be insulation with blown-in cellulose (R-30), and stone wool board insulation (R-16) will be installed on the roof deck. The intent is to keep the sheathing layer above 45°F to prevent condensation, as we are converting the roof from vented to unvented and bringing it into the thermal envelope. **Basement ceiling insulation**: Insulation will be installed under the first floor over the part of the basement that is unconditioned. **Adjacent building to the west**: There is a 5 to 7 inch seismic air gap between 300 East 162nd Street and 294 East 162nd Street. When exploring prefabricated panels, the team considered a way to reduce the heat loss of the wall adjacent to 294 East 162nd Street. We explored several solutions. The preferred solution was to tie into the adjacent building's insulation to create an adiabatic condition at the wall junction. Thus, an agreement would need to be reached with the neighbor. The feasibility of this solution needs to be confirmed.

Key design criteria to consider	How does your design address the criteria?
Sealing performance	We are targeting 2.33 ACH50 as the air-sealing level, to allow for a relatively tight building. For reference, the existing air-tightness has been estimated to be at 5.65 ACH50. Blower door testing should be performed in the existing building to help identify areas that would require specific air-sealing. Thermal imaging will also be conducted to identify extreme areas where heat loss is occurring, which is expected to be found mostly at junction points. The existing brick on all facades except the street had been previously painted (about 30 years ago) and show relatively little sign of damage or moisture build up. The brick will be repainted with a vapor permeable paint. This will aid in the air sealing of the walls; however, it is assumed that 3-wythe brick is itself relatively air tight. Brick repointing at the street façade will increase the air-tightness as well. When the windows are replaced the entire penetration will be air sealed, which will contribute significantly to improvement in the air sealing. The roof contains a few existing abandoned mechanical penetrations such as kitchen vents. These will receive caps sealed tightly to the brick structure. These stacks and the old boiler chimney will receive a new parget coat. When new roofing is installed, this new airtight layer will be adhered to the existing brick parapet. The coping stones on the parapet will also be replaced as necessary and re-sealed to the brick. All areas are important, but roof air sealing is considered even more critical due to stack effect forcing more air vertically. Windows and exterior doors will meet strict air-tightness requirements. We are targeting infiltration levels of 0.10 CFM/ft^2 for windows.
Moisture performance	**Walls:** Existing materials are vapor permeable and the paint on the roof's rear facades will be vapor permeable. The existing brick shows little sign of moisture build up; therefore, this work will not have an adverse effect on moisture performance. **Roof:** Installing rigid insulation on the roof deck will ensure that cavity insulation stays warm and above dew point to prevent condensation. The roof has been brought into the air sealed thermal envelope which will increase its durability with condensation prevention. The improved moisture management from the balanced ventilation and conditioned air cooling will also contribute to less moisture entering the roof. See Ventilation section explaining the role of the ERV bypass in moisture control and Resident Health Summary.

Key design criteria to consider	**How does your design address the criteria?**
Structural performance and long-term integrity of materials	**Structural performance**: Our solution has been informally exposed to a structural engineer which gives us confidence that it is structurally viable. For this scope of work solution, calculations of the load of the new insulation and solar panels and pergola will need to be carefully studied. The pergola supports are anticipated not to rest on the existing parapet, but on the joists near the load bearing connection to the exterior masonry walls. **Integrity of materials**: **Windows**: U-PVC have proven to be resilient in Europe, and more recently in the U.S., and are rot resistant. **Roof insulation**: see Moisture Performance section.
How will the new design affect resident life? Are there custom/atypical design features that require careful consideration?	High-performance windows and roof insulation allow for a warm ceiling and window surface temperature, which in turn results in increased thermal comfort. Residents will have to be trained on the new tilt and turn windows and get used to them. Air-sealing will also increase comfort by substantially reducing drafts in apartments.
Maintenance of solution	No change in maintenance procedures is expected.
Sustainability of solution	**Windows**: UPVC can be recycled up to seven times. The team plans to install windows with an argon fill, as it is almost impossible to achieve the U values without the fill. However, if installed in a vacuum application, argon fill leaks out significantly less than by the injection method. **Roof**: Cellulose is one of the most sustainable insulation materials with a Global Warming Potential (GWP) of 0 and a low-embodied energy (2.1 MJ/kg). It can have a large recycled content (88%). Cellulose seems to have a relatively low toxicity during manufacturing, installation, and for occupants.
Replication potential at scale	Most buildings of similar typology should be able to receive similar envelope solutions. This solution reaches a low energy use intensity (EUI) without over cladding, which the team foresees as a potentially scalable solution. Insulating the roof from the outside solely minimizes the time that residents have to vacate their apartment.

Other Questions	Team Response
What challenges have you encountered in designing an envelope solution that meets the RFP requirements? How are you addressing them?	**Prefabricated panels**: Due to the limited options of prefabricated panels in the U.S. and their current cost, the current scope does not include such a solution. **GWP and embodied energy of insulation materials**: In line with New York State's carbon emission reduction goals, our team is trying to select materials with a low GWP and embodied energy so that carbon emission reductions achieved by energy savings are not significantly offset by additional installed materials. Factoring in these parameters limits options for insulation materials, but we think our current scope addresses our concerns while achieving high-thermal performance. **Plastic insulation:** The 1968 building code, section 27-335.1, limits the use of plastic insulation to 4 inches in thickness. This would have limited in the above grade wall insulation to 4 inches, should the walls have been insulated with EIFS (stone wool EIFS is currently new to the U.S. market and about one-third more expensive). The team does not advocate a change to this code section. **Fire escapes**: If our scope included exterior insulation of the walls, existing fire escapes would have added complexity to wall insulation. We could not add 6 inches of insulation along with the rest of the walls, because local regulations require a minimum clearance on fire escapes. Our solution could have included 4 inches of insulation at fire escapes which would not significantly affect the energy performance of the building. The fire escapes are also expected to add complexity to the installation of prefabricated panels but are not considered an unsurmountable obstacle. The team has considered larger panels in the areas of the walls without fire escapes and smaller panels, potentially thinner as discussed above, at fire escapes. **Slab insulation**: One of the investigated options was to insulate the slab of the building where the cellar is conditioned. We found the added energy savings to be relatively minimal (2.2%) and the added cost to be prohibitive. Our analysis resulted in not including this item in the scope. **Existing uneven substrate**: When considering exterior wall insulation from the outside, the team faced that the existing brick wall was not perfectly level at the street façade; therefore, the cladding attachments at the wall needed to be shimmed. The rear brick is even more uneven, but the stone wool EIFS solution could have accommodated this irregularity at the rear.

Other Questions	Team Response
Are there any unresolved major issues? What would it take to resolve them?	If the scope included wall insulation, it would probably not have relied on prefabricated panels given the limited options available in the U.S. and the cost associated to this solution. Using prefabricated panels would involve either of the following: Import panels from a factory in the Netherlands, compromising our willingness to factor in GWP and embodied energy. But it is potentially useful to test this product in NYC. Using one of the U.S. manufacturers. Currently, there are very few (if any) manufacturers who construct prefabricated panels for a retrofit application. The team has started working with manufacturers on developing a prototype for this project. The team would like to find a window that has a more reliable lifetime performance U-value by not using a heavy gas (Argon) fill. The Stone Wool EIFS is being released in the U.S. This appears to be a great product for multiple reasons, but its cost is currently a bit higher than foam based EIFS. The benefits of stone wool are: Impact resistance Fire resistance Vapor diffusion Availability of darker colors Sound control Elimination of the white dust during sanding/smoothing Can most likely accept more imperfections in the smoothness of the substrate With half of the GWP/climate impact (at least).
Other comments (optional)	N/A

Ventilation and Indoor Air Quality

Key design criteria to consider	How does your design address the criteria?
RFP requirement of greater of 20 cfm/ bathroom + 25 cfm/kitchen and 18 cfm/ person	Kitchen CFM: 25 CFM Bathroom CFM: 20 CFM A central 945 CFM ERV serves all 21 apartments. Assuming 70.5 occupants in each of the buildings (1.5 for 1-BR, 3 for 2-BR and 4 for 3-BR), the solution is providing 13.4 CFM/occupant. Additionally, common areas are mechanically ventilated (only at 304 because there is no laundry room at 300): Laundry exhaust: 460 CFM (No ERV allowed) Laundry room intake: 480 CFM The ERV's fan power will use about 0.77 W/CFM.
Prevention of mold, mildew, pests and other environmental triggers of respiratory or other ailments	Several levers are used: Continuous ventilation, including well positioned exhaust and supply registers, allows for air circulation within all rooms of the apartments and will help ensure good indoor air quality. Air sealing of major holes and cracks within the building's envelope, including air-sealing around pipe and duct penetrations, will minimize pest entry.
Active ventilation to reduce volatile organic compounds and other potential internal air contaminants	Continuous mechanical ventilation will reduce volatile organic compounds and other contaminants.
Maintenance of solution	The maintenance of the central ERV will require periodic filter change and will be significantly less involved than the maintenance of individual ERVs for each apartment.
Sustainability of solution	ERV produces energy savings by reducing heat loss through ventilation.
Replication potential at scale	ERVs are already accessible in the U.S. market and are expected to become more and more available.

Question	Team Response
What challenges have you encountered in designing an Indoor Air Quality solution that meets the RFP requirements? How are you addressing them?	The team debated whether a central or unitized ERV solution should be selected for apartments. A central solution was selected due to concerns about accessibility for maintenance to ERVs located within apartments. Utilizing the ducted heating and cooling unit to also distribute the ventilation air to each room in the apartment helped reduce the amount of horizontal ductwork and maintain code compliant ceiling heights. The team tried to minimize tenant disruption and decided to run vertical riser ventilation ducts on the exterior, which will be covered with insulation. Horizontal ducts will run in apartments to distribute fresh and conditioned air. Moisture control was a challenge. Our system will include a modulating bypass based on a set allowable supply air moisture level. When indoor moisture content becomes too high during winter, the ERV will stop recovering heat and moisture.
Are there any unresolved major issues? What would it take to resolve them?	N/A
Other comments (optional)	It would be interesting to see manufacturers manufacture exterior insulated duct products.

Space Heating/Cooling

Key design criteria to consider	How does your design address the criteria?
Space heating/cooling EUI of not more than 11 kBtu/ft^2/year	The project includes a variable refrigerant flow (VRF) system for heating and cooling of the entire building including apartments and cellar common areas. The system is very efficient with an average 3.6 Coefficient of Performance (COP) and 20.4 Integrated Energy Efficiency Ratio (IEER). Each apartment will have one indoor unit ducted to living rooms and bedrooms. **Heating EUI**: 300: 5.6 kBtu/ft^2/yr 304: 5.8 kBtu/ft^2/yr **Cooling EUI**: 300: 0.9 kBtu/ft^2/yr 304: 1.1 kBtu/ft^2/yr

Key design criteria to consider	How does your design address the criteria?
Maintaining heating and cooling comfort (including humidity)	The energy model was ran assuming 68°F indoor temperature for heating and 74°F for cooling. Dehumidification will be performed by the ERV and VRF system during the summer. The ERV will help maintain some humidity during the winter.
Innovative ways to improve system efficiency	Understanding that the VRF system is a very efficient system type, the team focused on reducing heating and cooling loads as well as configuring the system to use the least amount of refrigerant and piping materials.
Required sensors and controls	Residents will control their apartment's indoor temperature with a thermostat located in each apartment.
Maintenance of solution	Maintenance of the VRF system includes: Quarterly replacement or cleaning of indoor unit filters. Annual cleaning outdoor unit refrigerant to air heat exchangers. Annual manufacturer maintenance of system.
Sustainability of solution	The VRF system uses R-410A as a refrigerant. Although this refrigerant has a significant global warming potential (1725 times the one of carbon dioxide[1]), it has been determined by preliminary calculations that potential refrigerant leaks would only represent a few percent (7.2%) of expected equivalent carbon emission reduction across the useful life of the system.[2]
Replication potential at scale	VRF systems are now readily available in the U.S. market. The selected option (no heat recovery during simultaneous heating and cooling) is less costly than a heat recovery version. The VRF provides cooling throughout tenant apartments which is expected to become more and more desirable, helping with scalability.
Other Questions	**Team Response**
What challenges have you encountered in designing a space heating/cooling solution that meets the RFP requirements? How are you addressing them?	The team tried to minimize the number of shafts needed for the heating and cooling system which would potentially take up residential area and be costly. A mini-split solution including outdoor units located within the exterior walls at each apartment was investigated but is not feasible because of zoning restrictions. A VRF solution including outdoor units located on the roof has been selected and it includes refrigerant risers running in one existing shaft.
Are there any unresolved major issues? What would it take to resolve them?	N/A
Other comments	N/A

1 Based on this resource: https://www.engineeringtoolbox.com/refrigerants-properties-d_145.html

2 Assuming 100% of refrigerant load would leak every 12 years. See detailed analysis in the Appendix.

Domestic Hot Water

Key design criteria to consider	How does your design address the criteria?
DWH system design and sizing	The project includes a heat pump water heater system located on the roof: Total heating capacity: 120 kBtu/hr (2) 210 gal (191 gal of effective storage) storages tanks. COP ranging from 2.00 to 4.56 from 10°F to 90°F exterior temperature. Refrigerant: R-134a The scope includes low-flow plumbing fixtures: 1.5 gpm faucets for kitchen sinks. 1.5 gpm showerheads. 0.3 gpm bathroom faucets. While fixtures with lower flows exist for kitchen faucets and showerheads, our proposed flows are expected to be better accepted by the residents and in turn generate expected savings.
Innovative ways to improve system efficiency (i.e. heat recovery)	The team has considered grey water heat recovery as an option. This system is not included in the current scope because of the significant plumbing complexity involved. This system would likely require storage tanks in the cellar of the building and pumps to pump pre-heated water up to the roof where the heat pump water heaters are located. Given the significant added energy savings from this system, it is still seen as an option. Heat recovery from the cooling system during the summer has also been investigated.
Required sensors and controls	The sensors required to be installed are the following: Domestic hot water (DHW) supply temperature. DHW return temperature. Water meter on cold water inlet to DHW system.
Maintenance of solution	Maintenance of the heat pump water heaters include: Cleaning of the air filter once or twice a year. Clean drain pan and drain tube on a regular basis. Clean exterior heat exchanger coil once or twice a year. Lubricate blower bearings and belt on a regular basis.
Sustainability of solution	The heat pump water heaters use R-410A as a refrigerant. Similar to what is mentioned for the VRF system, potential refrigerant leaks are not expected to significantly offset carbon emission reduction achieved by using this system.
Replication potential at scale	The options for heat pump water heaters for multifamily application seem limited at the moment, but we are hopeful that they will become more available in the coming years. A significant advantage of the proposed system is that only two units are required to be installed which requires a limited roof area.

Other Questions	Team Response
What challenges have you encountered in designing a DHW solution that meets the RFP requirements? How are you addressing them?	In highly insulated buildings, DHW is one of—if not the—largest end-uses. To achieve net zero, it is imperative to reduce this load as much as possible. While installing a heat pump water heater system in combination with a grey water heat recovery system seems feasible in theory, it poses some practical challenges mentioned above.
Are there any unresolved major issues? What would it take to resolve them?	Can we install a grey water heat recovery system? See above.
Other comments	N/A

Miscellaneous Electric Loads (MELs)

Key design criteria to consider	How does your design address the criteria?
Strategies to minimize consumption of MELs (controls, motivate habit shift in occupants, replace devices with more efficient models, etc.)	1. Washers and dryers The existing buildings do not have laundry rooms and some residents have installed washers and dryers in their kitchens. The project includes one common laundry room in one of the two buildings as a way to provide a useful amenity to residents and to control electric and water use related to laundry equipment. Washers and dryers provided as part of this project will be high efficiency. 2. Refrigerators The current project does not include replacing refrigerators for cost reasons. ENERGY STAR® refrigerators were included in the Most Efficient Scope. 3. Cooking The project includes standard electric ranges. ENERGY STAR range hoods will be installed. 4. Plug loads The team is considering providing smart power strips to residents to reduce plug loads. Tenant education is expected to play a large role in reduced the MEL usage.
Variation in consumption between occupants	This has not been explored yet.
Maintenance of solution	It is expected that the laundry company providing the washers and dryers will also maintain them.
Sustainability of solution	No specific sustainable feature in addition to energy savings due to project scope.
Replication potential at scale	All systems included in the scope are readily available in the U.S. market.

Other Questions	Team Response
What challenges have you encountered in designing a MELs solution that meets the RFP requirements? How are you addressing them?	**Washers and dryers**: One option was to provide in-unit washers and dryers to all residents due to the fact that the buildings are walk-up. This had already proven to be an issue for laundry, as some residents had installed washers and dryers in their kitchens. This solution was eliminated because the owner would have to maintain all new in-unit washers and dryers. However, if a tenant has severe mobility issues, the owner will consider adding a washer to their apartment, as the new laundry room is only able to be accessed by stairs. **Induction Stoves**: These were first considered and were finally removed from the scope because induction stoves were cost prohibitive.
Are there any unresolved major issues? What would it take to resolve them?	N/A
Other comments (optional)	N/A

Distributed Energy Resources (DER)

Key design criteria to consider	How does your design address the criteria?
Distributed energy resources (DER) relevant to/included in the retrofit design	A 84.6 kW solar photovoltaic (PV) array is provided for both buildings using a pergola system which elevates the solar panels above the HVAC equipment located on the roof. A total of 4 inverters will be necessary for both buildings.
Onsite DER capacity vs. offsite	Our current scope only includes on-site DER. In addition, community solar is planned to offset tenant electric use, as well as the part of the owner's paid electric that would not be covered by the on-site solar array.
How to integrate DER into HVAC and other major end uses	The electricity produced by the solar array is intended to be used on the common area meter serving HVAC and DHW equipment, common area lighting and laundry equipment.
Structural performance	Our project may require the existing structure of the building to be reinforced. How this will be achieved is to be determined. The solar canopy will be attached to the roof joists.
Efficiency degradation	The solar production is assumed to degrade by 0.25% every year. This is not modeled yet.

Key design criteria to consider	How does your design address the criteria?
Required sensors and controls	An optimizer on each panel. kWh production measured by each inverter.
Maintenance of solution	No maintenance is required but inverters are expected to be replaced at year 15. The team is provisioning for 1.5 solar panel replaced every year on average in the case of vandalism.
Sustainability of solution	Renewable energies should be part of a sustainable electric grid.
Replication potential at scale	PV panels are readily available in the U.S. Buildings of the same typology as our buildings often have unused roof area. When roofs have a lot of obstructions like ours, a pergola system maximizes on-site capacity, although it is a more costly solution.

Other Questions	Team Response
What challenges have you encountered in designing a DER solution? How are you addressing them?	Based on our scope, getting to net zero cannot be achieved with on-site DER only. To get as close to net zero as possible, high-efficiency panels and an elevated system have been selected. In addition, community solar will be used to offset tenant electric uses as well as the part of the owner's paid electric that would not be covered by the on-site solar array.
Are there any unresolved major issues? What would it take to resolve them?	Getting to net zero at the site level does not currently appear feasible.
Other comments (optional)	N/A

Building Performance + Modeling and Life Cycle Cost Analysis

Key design criteria to consider	How does your design address the criteria?
Overall site EUI of not more than 30 kBtu/ft^2/year	300 and 304: 29.6 kBtu/ft^2/year
Determination of operational assumptions (Schedules, people densities, etc.)	Most schedules are assumed based on the ENERGY STAR Multifamily High-Rise Program modeling protocol. The in-unit lighting schedule was determined by comparing the results of the energy model and the actual tenant electric aggregate data. Washer and dryer schedules are based on NYSERDA's research and our integrative design process (IDP) coach. See details in the appendix.

Key design criteria to consider	How does your design address the criteria?
Operation and maintenance costs	Costs for both buildings: Maintenance cost—traditional renovation: $23,000/year Maintenance cost—Net Zero solution: $36,000/year Utility Costs (owner paid)—traditional renovation: $88,487/year Utility Costs (owner paid)—deep retrofit solution: $49,002/year
Anticipated costs savings for 30 years relative to a traditional retrofit intervention	For both buildings, including tenant cost savings: **Energy and Water Cost Savings**[3]: $3,703,125
Retrofit business model + sustainability and scalability of solution	From a technology and installation perspective, the proposed solution is relatively easy to replicate, assuming contractors get some training on new technologies and installation techniques (ERVs, air-sealing, etc). From a financial perspective, it would be necessary to underwrite almost—if not—100% of the owner's cost savings (currently 50% are underwritten), which would likely require an entity to guarantee the performance of the buildings. In our case, we are not relying on an external entity to guarantee the performance.

Other Questions	Team Response
What challenges have you encountered in designing a solution that meets the RFP's EUI requirement? How are you addressing them?	Getting to net zero, even with renewable energies, is challenging. Unless off-site energy resources are used or the scope is drastically changed, the building will not be net zero.
What challenges have you encountered in modeling the solution's performance? How are you addressing them?	Equest was used as the modeling software for this project. Comparing energy modeling outputs of different software is not easy. Equest did not allow the modeling of thermal bridges directly. A 10% derating factor is applied to the wall insulation value to account for thermal bridges created by fire escapes.
What challenges have you encountered in completing an LCCA? How are you addressing them?	N/A
Are there any unresolved major issues? What would it take to resolve them?	N/A
Other comments (optional)	N/A

[3] Assuming a 3% yearly escalation rate in energy rate.

Construction Budget

Key criteria to consider	How does your budget address the criteria?
Cost compression due to anticipated innovation	Prefabricated panels are anticipated to eventually be less expensive than existing forms of insulation such as EIFS.
Cost compression at scale	See 03. Scalability Strategy document.
Current availability of required products	All products included in the proposed scope are already available in the U.S. market.
Anticipated future availability of required products	Prefabricated insulated ducts may be created to run ducts outside of a building. For projects including prefabricated insulation panels, these products may become available in the near future.
Transportation of products/systems to project site	While considering exterior wall insulation of the exterior walls, the team considered sourcing the project's stone wool from a Rockwool plant in West Virginia. Transportation for other materials has not been investigated yet.
On-site vs. off-site labor	The proposed solution does not include prefabricated envelope panels; therefore, it is not expected to reduce on-site labor.

Other Questions	Team Response
What challenges have you encountered in producing a construction budget? How are you addressing them?	Several of the materials and installation techniques included in the project are innovative; therefore, cost estimating is more challenging.
Are there any unresolved major issues? What would it take to resolve them?	N/A
Other comments (optional)	N/A

Construction Schedule

Key criteria to consider	How does your schedule address the criteria?
Schedule compression due to anticipated innovation	Construction is expected to take less time when contractors have experience with similar deep retrofits.
Schedule compression at scale	Construction is expected to take less time when contractors have experience with similar deep retrofits.
Current availability and lead time of required products	HVAC equipment is readily available with lead times of around six weeks. Lead time of other materials have not been investigated yet.

Key criteria to consider	How does your schedule address the criteria?
Anticipated future availability and lead time of required products	For projects including prefabricated envelope panels, new products may become available in the near future. Lead times are expected to go down as some products are sold in larger volumes in the U.S.
Transportation of products/systems to project site	While exploring exterior insulation of the exterior walls, the team considered sourcing the project's stone wool from a Rockwool plant in West Virginia. Transportation for other materials has not been investigated yet.
On-site vs. off-site labor	The proposed solution does not include prefabricated envelope panels; therefore; it is not expected to reduce on-site labor.

Other Questions	Team Response
What challenges have you encountered in producing a construction schedule? How are you addressing them?	Reducing the displacement of residents while also trying to reduce the time required for retrofit. Tenants are not relocated with the current scope, which is possible by minimizing the amount disruptive work. The ventilation risers that run outside the building are part of the strategy. Providing temporary accommodations to residents while doing internal work and associated costs. The bathrooms and kitchens are not fully renovated as part of the scope, so there is no need for temporary accommodations.
Are there any unresolved major issues? What would it take to resolve them?	We still need to explore how pests are removed during construction.
Other comments (optional)	N/A

2 Schematic Design Documents

Updated schematic design documents are included in the Appendices and consist of the following:

Architectural drawings including critical details
MEP drawings
Renderings
Equipment/materials specs (HVAC, DHW, envelope, renewables)

3 Scalability Strategy

The buildings selected are typical of NYC pre-war buildings with the standard mechanical equipment, such as one-pipe steam system, no mechanical ventilation, and window ACs.

The solution was meant to be scalable to other buildings of the same typology, and the design assumed that the renovation would be performed with tenants in place to make it as replicable as possible—as the renovation would be more cost-effective for owners.

Many pieces of equipment in the design are located on the roof. Most NYC pre-war buildings have a significant amount of space available on the roof. The ventilation ducts are to be run on the exterior of the exterior walls, which is expected to be less disruptive to tenants, making this a scalable solution.

The type of existing heating distribution (one-pipe steam) is a barrier to scalability in the sense that it cannot remain and be utilized in the proposed solution as a hydronic solution may have been. Significant work has to be done within tenant spaces, which is disruptive and costly.

The development of some concepts in the building industry would make net zero retrofits more scalable:

> Given the building typology, a heat pump water heater system with solar panels is very attractive and could be packaged as a solution. Therefore, solar installers could start adding this to their standard capabilities, or mechanical contractors could provide this as a system. It is also clear that the price of gas is too low for a full-scale switch to electric to make economic sense.
>
> On the manufacturing side, in regard to the solution presented in the Final Report, it seems a prefabricated product for exterior ductwork down the wall of a building that comes pre-insulated with attachments (to the building and to sleeves), could be something that lowers cost of this installation and does not seem too difficult to engineer from available materials.
>
> The scope presented in the Final Report achieved a low EUI without over-cladding, but some buildings will not be able to achieve this without over-cladding. As a result, it appears the market will still need prefabricated insulated panels. If a low EUI is achieved, however, without spending the embodied energy and carbon of a new shell, and the grid is carbon neutral, it appears this is the best solution from a carbon life cycle analysis stand point.
>
> Creating a prefabricated panel that could easily be installed on existing buildings seems a solution the construction industry needs in general, as a market already exists in those buildings that need a large façade overhaul anyway. The team believes good progress was made with the two manufacturers so far and would be interested in working with them to develop ideas further.

Forming close relationships with building material stores mostly targeted to single-family houses (like Home Depot and Lowes), to help them promote smaller-scale solutions like heat pumps for both heating/cooling and DHW, low HFC spray foam or non-plastic insulation, ERVs etc., might be very helpful to get the DIY population who is practical but skeptical, comfortable with the concepts, and scale up adoption.

Building System	**Describe strategy for successfully measuring, producing and installing the solution at scale on similar buildings. Include detail on building system sub-components (e.g. piping, windows, etc.)**	**If design solutions with a better potential for scalability were considered, describe the solutions and explain why they did not make it to the final design (e.g. cost, product availability, aesthetics, etc.)**
Ventilation and IAQ	Ventilation ducts will be run outside of the building, in the wall insulation, reducing costs and tenant disruption. Penetrations through the façade are seen as less risky as penetrations through floor joists which condition can be problematic in existing buildings. Pre-insulated ducts potentially available in the future could make this even more scalable.	In some buildings, the horizontal supply and return ducts may be left uncovered, using pre-painted ducts. This would reduce labor costs and tenant disruption. The owner of 300 and 304 East 162 decided to cover the ducts for aesthetic reasons.
Space Heating/Cooling	VRF systems are readily available in the US. However, maintenance will likely be more expensive and potentially more challenging than maintenance of the existing heating system, making it a barrier to scalability. The property management will have to train their building staff and use service companies for specific equipment maintenance.	In some buildings, the horizontal supply and return ducts may be left uncovered, using pre-painted ducts. This would reduce labor costs and tenant disruption. The owner of 300 and 304 East 162 decided to cover the ducts for aesthetic reasons. Running the refrigerant piping in the exterior wall insulation outside of the building, similar to the ventilation ducts, was investigated. The current proposal is to run refrigerant piping in an existing plumbing chase, which ends up being less expensive than running them outside and it presents little disruption to the tenants. A less expensive solution that would be less disruptive to the tenants: keep the steam distribution, upgrade the steam boiler and controls, and install ENERGY STAR window units.

Building System	Describe strategy for successfully measuring, producing and installing the solution at scale on similar buildings. Include detail on building system sub-components (e.g. piping, windows, etc.)	If design solutions with a better potential for scalability were considered, describe the solutions and explain why they did not make it to the final design (e.g. cost, product availability, aesthetics, etc.)
Domestic Hot Water	Most mid-rise buildings in New York City have available room on their roof to install heat pump water heaters. Most of these buildings also have some room in the basement to install storage tanks. The limited work required on the DHW distribution in order to install a heat pump water heater makes it a relatively easy measure in existing buildings. In addition, the high energy savings per dollar invested for this measure makes it an appealing scope item for existing building owners, especially when paired with solar PV panels which can offset most of the heat pump water heater electric use. Unfortunately, there are currently limited options of heat pump water heaters in the U.S. and costs are still high. However, this technology has proven to appropriately work in other countries and its cost is expected to decrease in the U.S.	Condensing boilers have been considered as they are more readily available and a better-known technology. However, they require relining existing chimneys which is costly and does not address fossil fuel elimination.
Miscellaneous Electric Loads	Recirculating range hoods are replaced with ENERGY STAR® appliances. These are readily available in the U.S. and are easily installed.	
Façade	Minimal air-sealing and window replacement are not expected to be very disruptive to tenants.	Prefabricated wall insulation has been investigated. However, they currently do not seem to be a good application for our project: For the side and rear walls, accessibility is challenging as it would likely require a large crane able to reach the back of the buildings. This would likely require street closure (especially because of the small one-way street on which the project is located) and appears to be costly. For the street façade, prefabricated panels seem technically feasible, but are cost prohibitive.

Building System	Describe strategy for successfully measuring, producing and installing the solution at scale on similar buildings. Include detail on building system sub-components (e.g. piping, windows, etc.)	If design solutions with a better potential for scalability were considered, describe the solutions and explain why they did not make it to the final design (e.g. cost, product availability, aesthetics, etc.)
Roof	The roof will be insulated from the top of the building, which won't disturb tenants. Cellulose and mineral wool are two well available materials. Blowing insulation in the roof cavity is a solution that is replicable for many pre-war buildings with roof cavities.	
Distributed Energy Resources	Our solution includes a canopy that maximizes the area covered by solar panels by covering HVAC equipment and bulkheads.	A ballasted system has also been considered. Its benefits include: A less expensive installation A quicker installation No penetrations through the roof The team chose to use a canopy system, which has a bigger capacity, so that its electric production offsets a greater portion of the building's electric use.

Project unit cost for reproducing the retrofit solution at scale.

Location	Pilot Project (1 unit)	10 units	100 units	1,000 units	10,000 units
Ventilation and IAQ	$633,500	$6,208,300	$57,015,000	$475,125,000	$4,434,500,000
Space Heating/Cooling	$1,075,708	$10,541,938	$97,889,428	$752,995,600	$6,992,102,000
Domestic Hot Water	$310,800	$3,014,760	$27,972,000	$233,100,000	$1,864,800,000
Miscellaneous Electric Loads	$600,300	$5,882,940	$54,627,300	$480,240,000	$4,202,100,000
Façade	$204,400	$1,982,680	$18,396,000	$153,300,000	$1,226,400,000
Roof	$244,000	$2,391,200	$21,960,000	$195,200,000	$1,708,000,000
Distributed Energy Resources	$404,000	$3,999,600	$38,784,000	$343,400,000	$3,232,000,000

4 Budget and Financing Plan

The primary sources of funding of the project are a loan from HPD and CPC, and gap funding as a grant from NYSERDA. Secondary sources of funding include NY Sun, an incentive program from NYSERDA for solar projects, tax benefits related to the solar system and incentives for energy efficiency measures from Con Ed. The owner of the project had already worked with HPD and CPC for other projects, and the energy consultant was familiar with incentive programs and tax benefits related to energy efficiency measures.

In order to manage the various costs of the project, the team performed a parametric analysis through energy modeling, which showed the impact on the building's energy performance of each scope item and paired this analysis with the cost associated to each measure. The team also considered how much each measure would be invasive to the tenants and tried to select measures that would be the least intrusive.

As a result of the value engineering process, these main elements were removed from the scope:

- Non-energy scope items: a trash chute in each building and full kitchen and bathroom renovations
- Exterior insulation and air-sealing to a higher level of all exterior walls
- Slab insulation
- Triple pane windows to the benefit of high efficiency double pane windows
- ENERGY STAR refrigerators
- Induction ranges replaced with standard electric ranges

The life cycle analysis incorporates the cost of operating and maintaining the building over the course of 30 years. Operating costs include the projected utility costs (energy and water), based on the energy model built for the project. Energy costs were assumed to increase with a 3% escalation rate. Maintenance costs were estimated by the owner based on their experience and based on equipment literature.

The deep retrofit is expected to increase the durability of the building, specifically as it relates to adding mechanical ventilation. Mechanical ventilation will maintain a good indoor air quality, including a stable moisture content which will have a positive impact on finishes. Although the owner was able to secure funding for the entire project, it was deemed financially infeasible due to the high cost and low rents. The financial model showed that even with NYSERDA's gap financing, the expected net cash-flow at the property would not be sufficient to meet their financial requirements.

5 Projected Construction Schedule

Maintaining tenants in place is adding difficulty to the schedule but is also more replicable than relocating tenants because of the complexity and cost associated with tenant relocation. Keeping tenants in place is even more challenging for deep retrofits because of the amount of work performed within the units: VRF and ERV work including equipment in apartments and new ducts.

Several deep retrofit components, however, are barely disruptive to the tenants because they occur on the exterior of the buildings: rooftop solar array, heat pump water heater and exterior wall insulation (although not part of the scope).

Scheduling is an important factor to consider while carrying out RetrofitNY style projects. If all influencing factors, including work by different trades, weather, and tenant movement, are not properly accounted for it can lead to time and cost overruns. This may also lead to conflicts with tenants if not considered and properly addressed before hand. It is very important to engage tenants from the early stages of projects of this nature and account for the impacts on the tenants living conditions during project. The summary of scope of work proposed for this project is as follows:

	Area	Measures
1.	Kitchens	Upgrading existing gas oven to electrical oven Installation of ENERGY STAR range hoods Upgrading existing light to LED light fixtures Upgrading existing water fixtures to low flow water fixtures Installation of ventilation systems Electrical wiring for new appliances
2.	Bathrooms	Upgrading existing water fixtures and toilets to low flow fixtures Upgrading existing lighting to LED lighting Installation of ventilation systems
3.	Rest of Apartments	Installation of central VRF system for heating and cooling Installation of ERV system for ventilation Upgrading all light fixtures to LED light fixtures Upgrading electrical panels Installation of double glazed UPVC windows Replacement of apartment entrance doors where necessary. Repainting the apartments Replacement of apartment signages

	Area	Measures
4.	Common Areas	Upgrading all light fixtures to LED light fixtures Repair and repainting of stairs Replacement of postal boxes Replacement of entrance doors and storefronts Replacement of DHW boiler with heat pump water heater Repainting of common area Installation of new trash receptacles Central VRF and ERVs for heating cooling and ventilation with exterior ducting. Installation of central laundry facility
5.	Exterior	Installation of roof insulation and new roofing membrane Installation of pergola solar panels to offset common area electricity consumption. Installation of canopy on exterior stairs to access central laundry and trash room located in cellar Repair and repaint front and rear façade. Repoint front façade as necessary Replacement of roof cap stones and chimney's parged as needed Capping and sealing of old vent stacks

Given the project involved window replacement, installation of VRF and ERV and replacement of the existing hot water boiler with heat pump water heater, it was important to consider the time of year these activities will be performed. It was critical to coordinate window installations with the mechanical and electrical work to minimize the disturbance to tenants. Also, the removal of existing heating system and DHW system needed to be coordinated with the installation of new HVAC system and heat pump water heater. There were no temporary facilities proposed for the project, so the phasing of the work inside the apartments had to ensure there was minimal disturbance to tenants and the work was done at the quickest time possible and that interior work in each apartment would take no more than seven days.

The detailed scheduling and coordination of various activities led to shorter lead times for material procurement as well as reduction in duration of the construction phase. This has also led to creation of major renovation exercise with minimal disruption to tenants, though there was higher complexity in tenant engagement and coordination of movement of tenants. The anticipated duration for each phase of the project is as follows:

Task Name	Duration
PRECONSTRUCTION	**60 days**
Resident Management	18 days
CDs Complete	30 days
Permits Pulled	30 days
Construction Contract Finalized	30 days
Project Closing Date	30 days
PROCUREMENT	**45 days**
CONSTRUCTION	**209 days**
Site Prep and Demolition	209 days
Building Envelope	194 days
Interior Demolition	31 days
Ovens and Hoods	3 days
DHW Boiler Demolition	14 days
Construction	196 days
Exterior Renovation	185 days
Building Envelope	140 days
Mechanical Systems	90 days
Exterior Painting	75 days
Interior Renovation	136 days
Kitchens	24 days
Mechanical Systems Installation	126 days
Interior Painting	120 days
CLOSEOUT	**22 days**
Equipment Start up and Testing	7 days
Commissioning of Systems	7 days
Punchlist Inspection	3 days
Correction of Punchlist Items	3 days
Final Inspection	2 days

The scope of work planned for this project does not include major bathroom and kitchen renovations, so there were no need for tenant relocation in this project. All work will be done with tenants in place. This was planned in four phases for each apartment. Each phase involved simultaneous and coordinated work in five apartments in the same line at a time.

To ensure minimal disturbance to tenants during in unit renovations, the cycle time for each kitchen and bathroom was brought down to four days with window replacement adding another two days. It was planned to complete demolition and replacement of key equipment in bathrooms and kitchens the same day to ensure minimal disruption to tenants' day-to-day activities.

Even though there was substantial cost savings associated with keeping tenants in place during renovation, the level of coordination required in these types of projects is very complex. The coordination of various trades had to be precisely planned. The project team had to account for the weather along with time the tenant's critical services could be disrupted to reduce any impact on tenant living conditions. This also involves high-level tenant engagement at every stage of the project. The entire construction is expected to last less than 210 days.

6 Building Performance Summary

The team used Equest as a modeling software and followed the ENERGY STAR® Multifamily High-Rise program Simulation Guidelines. It was assumed that equipment would maintain performance by being well maintained over time.

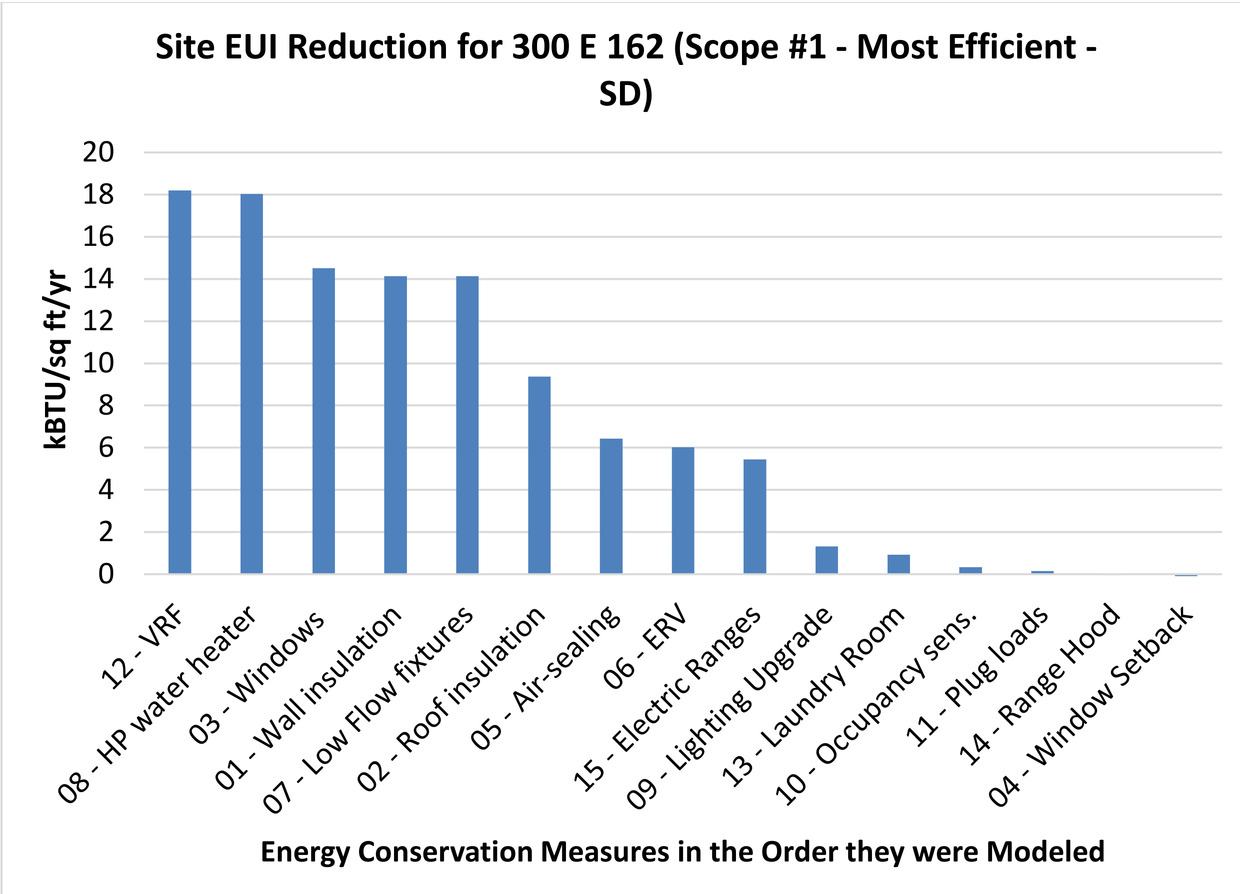
In order to achieve the performance requirements prescribed by NYSERDA, the team utilized an integrative design process including all stakeholders' needs (specifically the residents). Concerning net zero design, the following thought process was used:

1. Minimize the building's heating and cooling loads by improving the envelope of the buildings.
2. Improve the equipment efficiencies and switch fuel to eliminate all fossil fuels (although there was an allowance for gas to be used for domestic hot water and/or cooking if needed).
3. Offset the remainder of the site energy use with on-site renewables to the greatest extent possible, then with off-site renewables.

The proposed scope is achieving a site EUI of 30 kBtu/ft^2/year (before PV), which is a 78% reduction from the 134 kBtu/ft^2/yr existing EUI.

Figure 1 shows the biggest energy savings drivers as identified by building an energy model for our "Most Efficient" scope incorporating one measure after the other. This approach of calculating energy savings accounts for interactivity between measures (especially between envelope measures and heating and cooling measures).

Figure 1. Site EUI Reduction for "Most Efficient" Scope



The "most efficient" scope represents the scope that the owner would have been ready to implement, in terms of construction feasibility and aesthetics. This scope was studied before the team came up with the scope presented in this report. It included exterior insulation of the side and rear walls.

The sequence in which measures were integrated into the energy model leading to Figure 1 is as follows:

1. Wall insulation
2. Roof insulation
3. Windows
4. Window Setback
5. Air-sealing
6. ERV
7. Low Flow fixtures
8. HP water heater
9. Lighting Upgrade
10. Occupancy sensors
11. Plug loads
12. VRF
13. Laundry Room
14. Range Hood
15. Electric Ranges

For each major scope item, several scenarios representing different energy efficiencies were analyzed both in the energy model through a parametric analysis and by pricing these options. The team compiled these data by calculating the cost of incremental energy savings (in $/kBtu) for each scope item and selected efficiency options based on this metric.

Here is an example of a parametric analysis run on windows:

> A complete retrofit scope, which was considered realistic at the time of this analysis Windows in two different ways and compared the overall results of the models:
>
> - Option A: Tilt & Turn / Casement (triple glazed), U-0.203, SHGC 0.206
> - Option B: Tilt & Turn / Casement (double glazed), U-0.277, SHGC 0.258
>
> Results: Option B reduced the whole-building energy and cost savings by only 0.9% compared to Option A. Given the significant cost differential between double and triple pane windows, the team decided to install highly efficient double pane windows (Option B).

6.1 Distributed Energy Resources Summary

Both buildings have flat roofs that can accommodate solar panels. They are mostly unshaded and unobstructed but will receive several pieces of HVAC and DHW equipment as part of the renovation. This configuration and the team's willingness to offset as much of the common area electric load with solar power led to a photovoltaic pergola design, which goes over the rooftop equipment and bulkheads.

The current system is expected to offset 62% of the owner paid electric meter load on an annual basis. A ballasted system, while being significantly less costly, would produce a lot less electricity due to the rooftop equipment and the bulkheads.

6.2 Supplemental Renewables Plan

Community solar is expected to offset the remainder of site energy use not already offset by on-site solar photovoltaic. The owner will enroll in a community solar project and a third-party entity, such as Solar One, will also do tenant outreach to convince tenants to subscribe. Ideally, 100% of the tenants will enroll. Realistically, 50-75% of tenant subscription is to be expected. The owner and tenants will save 10% on their electric bill by subscribing to community solar. Assuming that the owner and 75% of the tenants enroll into a community solar program, the net energy use of the building would be 3.7 kBtu/ft^2/yr.

7 Resident Management Plan

A detailed extensive communication plan has been prepared consisting of notices and tenant meetings before and during construction that involve the owner, the property manager, and exterior parties. The project and the reason why it is implemented will be explained to residents before construction starts while training on new equipment; specifically, new thermostats and stoves will be performed after construction.

The construction schedule is divided into two phases, which will be completed subsequently. This will ensure that apartments keep as much usable space as possible at any given time, minimizing disruption to tenants. Residents are expected to generally react positively to the changes, although construction will affect their daily life and they will have to adjust to the new heating and cooling system and new electric stoves. In order to promote resident engagement in energy conservation, explaining the concept of the renovation will be key. An energy savings challenge on a voluntary basis is also being considered.

7.1 Management Plan

7.1.1 Goals

The goals of this management plan are to:

1. Ensure minimal disturbance and inconvenience to residents during renovation
2. Ensure timely and accurate information dissemination to residents to reduce pushback during renovation
3. Engage residents to ensure proper maintenance of the new systems to be installed in the buildings

7.1.2 Length of construction phase

Approximately 17 months.

7.1.3 Length of resident management plan

Approximately 24 months.

7.1.4 Plan for resident notifications and communication

All residents will be notified about the planned retrofit activities upon confirmation of project financing, all planned improvements to their apartments in advance of the beginning of demolition work, and the progress of any work that might have a direct impact on them. The residents will be informed via written notices and in-person meetings. Communication and engagement will be carried out by the owner, the property management company, and external consultants like Solar One, Acacia Network, and similar organizations that serve affordable housing communities. The expected timeline for resident notification is as follows:

Initial Notices to residents – Immediately upon confirmation of project financing

- Initial notice of planned retrofit activities, along with a request that each tenant attend the initial meeting with the Project Team

Initial meeting with Project Team – 15 days after Initial Notice

- In-person meeting at each building to inform tenants about the overall project scope and the nature of work inside each apartment
- Meeting will include a discussion about community solar projects and enrollment with Solar One (see below)
- Meeting will address any concerns the tenants might have

Pre-demolition Meeting for each apartment line – 15 days before the beginning of interior demolition work

- Inform residents about the expected duration of construction work
- Explanation of the resources available to minimize frustration

Pre-completion Meeting for each apartment line – 15 days before completion of renovation in each apartment

- Inform residents about the new systems installed in the apartments and their proper use
- Create awareness about do's and don'ts to ensure optimal maintenance of the new systems
- Distribute user manual for all equipment and facilities provided

Please refer to the project schedule for the estimated timelines for each of these activities

7.1.5 Resident liaison or resident groups

We intend to engage Solar One, Acacia Network, or a similar organization to enroll residents in community solar projects and to engage residents in energy-efficient initiatives in the building. The team will form one Champions Group per building to include residents who have lived in the building the longest. This group would be able to easily communicate their concerns with the construction team.

7.1.6 In-unit construction plan

The interior retrofit work under this project involves the renovation of kitchens and bathrooms, the installation of new windows, the installation of a VRF system in each apartment, the replacement of entrance and bathroom doors, and painting. The interior renovation will be done in two phases.

<u>Phase A:</u>

This phase will include:

Replacement of existing water fixtures
Installation of energy-efficient light fixtures
Addition of VRF evaporator units in bathroom
New refrigerant lines for VRFs
New kitchen and bathroom ventilation
Replacement of existing ovens

This work will be carried out on one line (consisting of five residential units) at a time.

<u>Phase B:</u>

This phase will include the installation of VRF and ventilation duct work, replacement of windows, installation of VRF controls, and painting the apartment. The replacement of the windows will be carried out one apartment line at a time, and each window will be removed and replaced in the same day so as to minimize disruption to the tenants. This work will also be carried out one line at a time, and with tenants in place. All requisite steps will be taken to ensure minimal inconvenience to residents. Each work area will be cleared of any equipment, debris and dust at the end of each working day. This phase is expected to take 10 to 15 days.

In each building, construction will be sequenced so that two different lines in the building will be under construction at the same time, one under Phase A and one under Phase B. Additionally, contractors will ensure that only one phase is done at a time in each apartment, thus providing as much usable space as possible to tenants during renovation work.

Please refer to project schedule for the actual planned timelines for each of these activities.

7.1.7 Exterior construction plan

The exterior work will include:

Insulation of roof and membrane
Installation of VRF's outdoor units on roof
Installation of ventilation ducts and ERV unit on roof
Installation of solar PVs and inverters
Heat pump water heater
Painting and Repointing of Brick

The work is sequenced to minimize the time required for completion, as well as to reduce the impact on residents. Sidewalk sheds will be constructed to protect residents from falling debris, and all feasible precautions will be taken to minimize dust generation.

7.1.8 Parking impacts

The building does not have parking facilities. Street parking is expected to be impacted during the following activities:

Delivery of equipment and raw materials
Installation of front façades

Permits to block the street for this work will be obtained from the DoT before commencement of each of these activities. In order reduce inconvenience to those in the community who use the street and rely on parking in this area, raw materials and equipment will only be transported between 10 a.m. and 3 p.m. All tenants and neighboring building residents will be informed about the expected impact well in advance, through notices sent from the property management company.

7.1.9 Plan for special needs

Any tenant with special needs including people with disabilities, the elderly, and those with language and literacy barriers will be given adequate additional resources to ensure proper communication and movement. Elderly tenants and those with disabilities will be provided with support to assist during interior renovation. For those with language and literacy barriers, notices will be sent in multiple languages and the property management company will utilize the assistance of translators to ensure that communication is effective, thorough, and understood by each resident.

7.1.10 Expected areas of pushback

Based on prior experience with residents, there may be pushback in the following ways:

- When kitchens and bathrooms get new plumbing and lighting fixtures and residents must use basement facilities for a small amount of time (Phase A)
- During installation of VRFs and ducting in apartments (Phase B)
- When existing in-unit laundry units are removed and tenants are asked to only use common laundry facilities
- When residents are informed that the building is now a no smoking building
- When windows are replaced and tenants learn they cannot open more than 4” and they are advised to keep them closed to keep the building airtight when they are using the heating and cooling system

NOTE: Apartment 5C in Building 304 has completed an extensive renovation, including a new kitchen with new appliances and laundry machines. We expect significant pushback from them during this renovation and need to handle this appropriately.

7.2 Residents’ Meeting Plan

7.2.1 Plan for initial resident outreach

Both during and after renovation, the property management company will be trained regarding its role in resident engagement. Outreach activities to tenants will begin immediately after finalization of financing for the project, and at least a month before the beginning of demolition and construction work. The residents will be sent notices along with a brochure containing a detailed explanation of the scope of work. Included in this will be an explanation of the impact the renovation will have on the tenants. During the project, the property management company will provide tenants with a “hotline” number to use for voicing concerns. Posters and other informational materials will be posted in the common areas informing residents of the upcoming activities and the timing.

7.2.2 Kickoff event

At least 15 days before the beginning of demolition and construction activity, a kickoff event will be conducted for tenants at the building premises. The kickoff meeting will be conducted at a convenient time on either Saturday or Sunday to ensure maximum tenant participation. The kickoff event and other resident engagement events will be facilitated by Solar One, Acacia Network or a similar organization, because of its experience in converting other buildings, and be attended by:

The developer/owner
Management company, including superintendent
Design team
Tenants

The main goals of kickoff event will be to:

Apprise tenants of planned activities and their impact during and after construction
Address any queries/concerns of tenants regarding this project
Apprise tenants of expected changes to rent structure including billing for cooling and heating services
Bring tenants on board and request support during the construction phase

7.2.3 Resident update meetings

The timing of resident update meetings is included as part of the project schedule.

7.2.4 Trainings

The following training activities are planned during or after completion of the project:

1. Management company/its representatives
    a. Resident engagement during renovation
    b. Building maintenance
    c. Billing residents for cooling and heating
2. Superintendent
    a. Building maintenance, hygiene and housekeeping practices
    b. Preventive maintenance of equipment
3. Tenants
    a. New policies, do’s and do not’s in the building during and after renovation
    b. Energy efficient use of individual apartments and common amenities
    c. Proper hygiene practices in the building
    d. New billing changes

7.2.5 Other Resident Activities

Tenants will be encouraged to form resident groups and will be provided with information (books/posters) in common areas on how to reduce energy consumption so that the building operates in an energy-efficient manner. Competitions will be conducted within the building for apartments with the lowest heating and cooling load for the month/year. Competitions will be conducted between both buildings for the building that achieves the lowest common area utility bills for the month/year.

7.2.6 Method to gauge resident participation and track achievements

Monthly or bi-annual surveys will be sent to tenants to gauge engagement in energy-efficient and hygienic behavior. Residents will be sent regular updates about building performance. The building's utilities consumption level will be regularly monitored and provided to the owner and the management company so as to ensure continuous engagement of everyone involved with the upkeep of the building.

7.3 Residents' Guidelines

7.3.1 Refer attached resident manual Operations and maintenance guidelines

Refer to attached resident manual.

7.3.2 Health and safety guidelines

Refer to attached resident manual.
Residents' guide to understanding the utility bill
Refer to attached resident manual.

7.3.3 Schedule of routine in-unit maintenance

Refer to attached resident manual.

8 Performance Guarantee Pathway

The project is specific as it relates to performance guarantee because Volmar is both the owner and the general contractor (GC) for the project. The owner still has an interest in ensuring the performance of the project by combining manufacturer guarantees for major pieces of equipment, thorough equipment maintenance and provisioning for equipment repairs, or replacement after the end of manufacturer warranty.

Performance guarantee will be enabled by an energy remote monitoring system. This system will monitor major equipment electric use and main data points and will be monitored by the owner. In cases where the owner and GC are not the same entity, guaranteeing the building performance is expected to be more challenging for a 15- or 30-year period because of the risk associated with it, which would then be reflected as a major cost addition. In that configuration, the GC or a third party, such as an energy consultant, may be envisioned as providing a performance guarantee to the owner of the building.

8.1 Maintenance and Warranties

Which energy performance parameters can be guaranteed (e.g., heat pump COP, on-site kWh production, Btu/person/HDD for heating, Btu/person/CDD for cooling, etc.)? Include a list that maps each parameter to its corresponding building system(s).

Solution	Energy Performance Parameters
Solar Panels	Efficiency in %
Heat Pump Water	COP
VRF	COP
ERV	Efficiency in %

What are the warranty term lengths for the various building systems included in your solution?

Building System	Warranty Term Lengths
Solar Panels	25 Years
Invertors for Solar Panels	12 Years
Roof	25 Years
VRF System	10 Years
EIFS Insulation	15 Years
Windows	10 Years
ERV	10 Years
Heat Pump Water Heater	10 Years
LED Lighting	5 Years

List the schedule of high-level maintenance needs through your project's lifetime for each building system including major interventions (i.e., heat pump compressor replacements). Include building systems that are expected to require little to no maintenance and specify as such.

Building System	Major Intervention
Heat Pump	Motors & Coil replacement
Roof	Flashing repairs Seams & Caulking
VRF	Condenser replacement Refrigerant refill Filter cleaning Coil replacement
Solar System	Cleaning Broken panel replacement Invertor replacement
ERV	Motor replacement
Lighting	LED bulb replacement

How should your solution's maintenance schedules and warranties be aligned/coordinated in order to provide a comprehensive extended warranty to last the duration of the project lifetime, ultimately becoming a performance guarantee? Break out by building system.

Volmar is both the General Contractor on the project and the Owner of the buildings. Thus, there is no need for a performance guarantee because the interests of Volmar, in these two roles, are aligned.

Who will provide the maintenance work and performance guarantee for each building system?

For each building system the installer of the actual system will provide maintenance work and a performance guarantee of their own work.

What is the cost of guaranteeing the energy performance of each building system in the solution beyond the warranty term (provide schedule of annual costs through project lifetime)?

Volmar estimates the annual cost of providing a warranty for each system to be 2% of the ongoing costs of installation.

How would the cost be impacted if the maintenance and guarantee provider is under contract for one hundred performance guarantees? For one thousand?

> The costs of performance guarantees from the installers are estimated to go down as the program scales up. Costs might be reduced by 10-15% for 100 systems, while in the long run such guarantees will be included as part of the installation costs without any additional costs to builder.

8.2 M&V

Who will be responsible for monitoring each of the building systems listed above? (e.g., solution provider, maintenance and guarantee provider, owner, tenant, etc.)?

> It is currently assumed that the owner would monitor the building systems in house.

List the components of each building system and of the overall solution that will be monitored

Energy

- Common area electric use
- ERV electric use (3 PH)
- VRF electric use (3 PH)
- Heat pump water heater electric use (3 PH)
- Solar
- DHW temp water heater outlet
- VRF usage and efficiency data to import from embedded control

Water

- Whole building meter
- Water leaks monitoring (EGC Option 2):
    - Cold riser meters
    - DHW cold water feed for all water heaters
    - Laundry room
    - Outdoor water

Temperatures

- 1st, 3rd, 5th floor * 2 lines
- ERV supply
- Outside air

Indoor Relative Humidity

- 1st, 3rd, 5th floor * 2 lines

List the technologies/products/protocols that will be used to monitor/measure each of the components listed above.

We are assuming that the monitoring system will be provided by Sentient. The materials creating the monitoring system include meters, sensors and communication devices:

Meters:

- Existing house water meter and smaller sub-meters with pulse output read by pulse meters.
- New common area electric meter with pulse output read by a pulse meter.
- Current Transducers (CTs) to meter the electric use of the ERV, VRF, and heat pump water heater.

Sensors:

- Exterior and interior temperature sensors.
- Humidity sensor.

Communication Devices:

- The VRF system already monitors several data points. The monitoring system will import usage and efficiency data from the VRF's embedded control.
- Wireless transmitters will transfer data from sensors and pulse meters to a T-star gateway via wireless repeaters. Data will flow using BACnet as a communication protocol and Project Haystack as a language.
- Data will be sent from the gateway to a cloud-based software, Inferstack (hosted by Skyspark) with a 4G modem.

The solar system will also be monitored, and its performance will be accessible on a web-platform.

What is the cost of instrumenting the building systems with these monitoring technologies?

The monitoring hardware is estimated to cost $1,700 per unit.

What is the cost of analyzing the data generated by these monitoring technologies?

The subscription cost is estimated to be $2,000/year. No energy management contract is assumed.

List the key performance indicators (KPIs) that will be measured corresponding to each of the components listed above.

Here are the KPIs that will be either directly measured or calculated based on measured metrics:
Total common area electric use per day
Heating electric use per Heating Degree Day
Cooling electric use per Cooling Degree Day
Efficiency of heating and cooling system
Total water use per day

DHW use per bedroom and per day
Heat pump water heater efficiency
Laundry room water use per day
ERV electric use
ERV supply air temperature
Baseload common area electric use per day
Solar electric use per day

List the sampling rate for each KPI.

Data points are measured and sent to the cloud every 15 minutes. KPIs are calculated based on these data points at the same rate.

How is the M&V program expected to improve the operational efficiency of the building systems and mitigate both the frequency and potential emergency nature of major maintenance interventions? Please quantify to the fullest extent possible.

KPIs will be compared to KPI targets and alerts will be generated when KPIs significantly differ from targets. Some troubleshooting will be done on the web software by looking at different metrics. Only when needed, a person will physically inspect equipment on site. In many cases, emergency breakdowns are expected to be avoided by receiving early alerts as pieces of equipment start failing.

What is the expected impact of the above-mentioned operational efficiency improvements and mitigated major maintenance interventions on the cost of providing the performance guarantee? Please quantify to the fullest extent possible.

The monitoring system will generate operation and maintenance savings through two different paths:

By limiting the frequency of maintenance inspection and repair visits.
By avoiding major breakdowns and cost associated to the use of temporary equipment.

9 Regulatory Barrier Summary

The team encountered several regulatory barriers while designing the deep retrofit solution. Some of them would have been faced with traditional renovations such as sprinkler or ADA requirements. Others are specific to deep energy retrofits, especially as it relates to exterior insulation of the exterior walls or a solar array.

The team addressed some barriers by changing the design such as adding less insulation at fire escapes while other barriers would require filing a Construction Code Determination with the Department of Buildings of NYC.

Please note that the items listed below are not all barriers to which we would fully support advocating exception. Also, some of these are restrictions on the design, but have work arounds and perhaps are not true “barriers.” Finally, not all of the items listed below pertain to the final submission, but the team has listed many items encountered during the various design options since the design changed significantly during the process, and we aim to share as much information as possible.

Regulation			Impediment	Action	Resolution		
Code	**Section**	**Description**	**Explain how this regulation impedes your ability to achieve the RetrofitNY criteria.**	**What action has the team taken to date to resolve this barrier?**	**Resolved**	**Resolution in Progress**	**Seeking Assistance with Resolution**
NYC BC 1968	27-355.1	Limits the amount of combustible insulation we can add to the exterior of a noncombustible building.	This section limits up to 4" of EPS or XPS since it is combustible and "more toxic than burning wood" (essentially). The limit exists in the old as well as newer codes.	The team is more interested in using stone wool as it is less toxic, has a lower GWP/embodied energy, and is fire rated. However, stone wool EIFS is about $10 more expensive than EPS or XPS.		For the December 2018 submission, the team was showing EPS in financial model but EUI is dependent on R-24 (the section in the newer code is NYC BC 2014: 2603.5.4).	
NYC BC 1968	3202.2.1	Limits the amount we can clad over the property line to 4".	Since this building existed before 1968, overclad max 4" beyond the property line is permitted.	According to our drawings and calculations we are just under this threshold (see architectural drawings).	Yes		
NYC BC 1968	27-380 (c)	Requires a 3' depth at the landing of the fire escape.	The preferable amount of insulation for the walls adjacent to the fire escape cannot be provided.	We have modeled 4" of insulation at these locations and taken the hit in the energy model. It does make our prefabricated panel design option, a bit more complicated, although the panels there would have to be a smaller size to fit up and around the fire escape railing anyway (and the panel joints at the railing etc).	Yes		
NYC ECC 2016	403.2.9	Requires ducts be insulated on the exterior ducts min R-8.	Showing R-8 (2" of insulation now) the amount of EPS needs to be reduced to 4" – one would see the ducts expressed on the exterior, which may not be an impediment but would detract from the project aesthetic.	Compliance with current energy code is assumed, although ASHRAE compliance will most likely be followed for mechanical reasons.	Yes, for now.		

Regulation			Impediment	Action	Resolution		
Code	Section	Description	Explain how this regulation impedes your ability to achieve the RetrofitNY criteria.	What action has the team taken to date to resolve this barrier?	Resolved	Resolution in Progress	Seeking Assistance with Resolution
NYC BC 2016	901.9.4	If filed permitted work exceeds 50% of the value of the building, that will trigger adding sprinklers to the building. Or if the work exceeds 30% of the value.	There is no budget to add sprinklers to the entire building.	The assessed value of the property may be low. Furthermore, it is not required to permit many items in our scope of work, since they are replaced in kind. Bathrooms and Kitchen fixtures will not be relocated. Finishes work does not need to be filed. A careful review of what is permitted and what is not will need to be done before DOB filing, as per Administrative section 28-104.4.2. This will require splitting up drawing sets and a bit more coordination for the team.	Yes, for now.		
NYC BC 2016	1101.3.2	If the filed permitted work exceeds 50% of the value of the building, it will trigger making the building ADA compliant.	There is no budget to add an elevator to access the apartments (even the first floor has stairs) nor is their space in the apartments to provide the fully accessible layouts.	Same as above. The new laundry room the cellar might need a CCD1; however, in order to confirm, it does not require an accessible route.	Yes, for now.		
NYC BC 1968	27-375 (i-4-c)	Interior stairs require skylight at the top, with fixed or moveable ventilators min 144 in in open area.	A solar canopy above the bulkhead would cover this skylight, and while not specifically prohibited in the ’68 code, we believe this would not meet the intent of the code.	Instead of a skylight, a window can be provided with louvers. Min 144 sq in in open area. This new window adds cost and is a low thermally performing element. We will remove at least one solar panel from the solar canopy, above the skylight, since the structural opening exists. Team will recommend a higher thermal performing skylight.		During design documents and plan examination this will be more closely reviewed to meet the intent of this skylight to provide light and (smoke) ventilation.	

Note – CCD1 is required to combine the ventilation at the roof from all the apartments, but this is seen as achievable and not a real impediment.

10 Resiliency Summary

The team viewed resiliency and net zero design integrated with each other as reducing a building's heating, cooling and hot water loads extends the period of time over which a building will remain comfortable in case of an electric blackout.

Insulation materials, air-sealing and efficient windows reduce the heating and cooling loads of the building which in turn allows the building to stay warm or cool longer if an electric blackout occurs.

Low flow plumbing fixtures extend the time over which residents can continue using hot water after a blackout, assuming the DHW system has some storage capacity, which is the case in this project. These features increase resiliency, which also improves residents' comfort in case of an electric blackout.

Electric blackouts were seen as the major resiliency concern for these specific building. They are not in a flood zone which makes a flood event unlikely and is the reason why flood resiliency was not investigated. In general, while being aware of resiliency concerns and trying to improve on them, the team decided to focus investments on the net zero goal.

The team's detailed resiliency strategy is described below.

Indicator	Design Solution
Protection: Identify strategies to reduce a building's vulnerability to extreme weather:	
Floodproofing or Flood Control	The buildings are not in a flood zone.
Sewer Backflow Prevention	A back-flow preventer already exists on the main water service line to the buildings.
Mechanical Equipment Protection and Location	The outdoor units of the VRF will be outside of the roof. They are not protected besides their own casing as they need to be exposed to ambient air to function efficiently.
Electrical Equipment Protect and Location	Meters and common area panels are located in the basement. Most of the electrical equipment for the solar panels will be on the roof.
Backup Power Location and Protection	N/A, no backup power is provided.
Communications	Internet, phone and intercom equipment are located at each apartment and are not being moved as part of this project.
Envelope Protection	The existing brick cladding serves as the building's structure. Repointing the brick and painting the rear and side walls will increase the longevity of the brick.
Fire Protection	No new fire protection elements are added as part of the scope.

Indicator	Design Solution
Adaptation: Identify strategies that improve a facility’s ability to adapt to changing climate conditions:	
Envelope Design	The highly insulated and sealed roof and the new efficient windows will reduce the heating and cooling loads to a very low amount. The solar canopy will provide shading over the entire roof of the building which will help reduce the cooling load.
Mechanical Equipment	The proposed VRF system provides individual control over temperature to tenants.
Passive Cooling or Ventilation Strategies	Operable windows will provide some free cooling in shoulder seasons. The energy recovery ventilator will reduce the cooling and heating load of the building.
In-unit	The monitoring system will show apartment indoor temperatures as a piece of information used to manage the energy performance of the building.
Site	No landscaping nor storm management is provided in this project.
Backup: Identify strategies that provide critical needs for when a facility loses power or other services:	
Critical Systems with Backup	No backup power is provided. However, the building is designed to use a minimal amount of energy which would have a positive impact in case of a blackout: The highly insulated and sealed roof and the new efficient windows reduce the heating and cooling loads to a very low amount. Masonry walls act as a thermal mass which would help maintain an acceptable indoor temperature in case of a black out. All above grade spaces including kitchens, bathrooms and stairwells have windows providing natural daylight. Residents can open windows for ventilation when the ERV is off during a blackout.
Backup Power Type	N/A
Access to Potable Water and Sanitary Services	In case of a blackout, residents would be able to use cold water, as the building is supplied water by the city water pressure directly without the need for booster pumps or domestic water pumps. However, hot water would not be provided in case of a blackout.
Safety Precautions for Mechanical Equipment Operations	N/A, no gas fired equipment.
Community: Identify strategies that encourage behavior which enhances resilience:	
Emergency Management Awareness for Residents	Tenant engagement meetings will be held to train tenants on their renovated building. These sessions will include emergency management.
Access to Manuals, Emergency Event Guidelines	A resident manual including emergency guidelines will be provided to the tenants in compliance with the Enterprise Green Communities requirements.

11 Resident Health Impact Summary

The new continuous ventilation system will greatly improve the indoor air quality by reducing volatile organic compounds (VOC) and other air contaminants as well as mitigating mold and mildew growth by controlling air moisture content. Pest management will be achieved by performing targeted air-sealing of the envelope of the building and by installing new sealed metal trash containers.

In addition, the project aims at not incorporating additional air contaminants through new materials such as paints and adhesives, which will be low VOC.

Indicator	Location	Intervention	
		Design Solution	Maintenance Plan
Mold	Units - Kitchens	Continuous ventilation will be provided with exhaust in the kitchens and tenants have the option to open a window in the kitchen. If the scope included kitchen and bathroom renovation, non-paper sheet rock would be installed.	ERV maintenance including filter cleaning or replacement will be done by building staff on a regular basis. Tenants will be responsible for cleaning the ventilation registers located in their apartment.
	Units - Bathrooms	Continuous ventilation will be provided with exhaust in the bathrooms and tenants have the option to open a window in the bathroom. Condensate from the indoor units of the VRF system is to be run to a funnel drain below each sink in the bathroom. If the scope included kitchen and bathroom renovation, non-paper sheet rock would be installed.	ERV maintenance including filter cleaning or replacement will be done by building staff on a regular basis. Tenants will be responsible for cleaning the ventilation registers located in their apartment.
	Units - Windows and Exterior Doors	High-performance windows with low U-factors will reduce the risk of condensation on their interior surfaces.	-

Mold (cont)	Units - Mechanical Rooms	N/A	N/A
	Common Areas - Windows and Exterior Doors	High-performance windows and doors with low U-factors will reduce the risk of condensation on their interior surfaces.	-
	Common Areas - Mechanical Rooms		Mechanical rooms will be kept clean.
	Below Grade	N/A	N/A
Pests	Units	It is planned to perform a blower door test to help identify major air penetrations in the building's envelope. These penetrations would then be sealed. The scope does not include unit compartmentalization.	Any new penetration through the walls and roof will be sealed. Tenants are responsible for cleaning their apartment.
	Common Areas	Major penetrations to the walls will be sealed.	Common areas will be kept clean. Any new penetration through the walls will be sealed.
	Below Grade	Major penetrations to the walls will be sealed.	Common areas will be kept clean. Any new penetration through the walls will be sealed.
	Exterior	Existing trash and recycling containers will be replaced with sealed metal containers.	The courtyard of the building will be kept clean.
VOCs (enter level of VOCs in products: conventional, low- or no- VOC)	Units - Paints	Low or no VOC products will be used.	Low or no VOC products will be used.
	Units - Coatings	Low or no VOC products will be used.	Low or no VOC products will be used.
	Units - Primers	Low or no VOC products will be used.	Low or no VOC products will be used.
	Units - Adhesives and Sealants	Low or no VOC products will be used.	Low or no VOC products will be used.
	Units - Flooring Materials	N/A – not part of the scope.	Ceramic tiles and Luxury Vinyl Tiles with the Floorscore label would be used.
	Common Areas - Paints	Low or no VOC products will be used.	Low or no VOC products will be used.
	Common Areas - Coatings	Low or no VOC products will be used.	Low or no VOC products will be used.
	Common Areas - Primers	Low or no VOC products will be used.	Low or no VOC products will be used.

	Common Areas - Adhesives and Sealants	Low or no VOC products will be used.	Low or no VOC products will be used.
	Common Areas - Flooring Materials	N/A, no common area flooring included in the scope.	When replaced, flooring will include ceramic tiles or Floorscore labeled Luxury Vinyl Tiles.
Other Contaminants	Units	By not insulating the exterior walls from the inside, the project does not include any potentially harmful material on the interior of the walls such as spray foam.	Cleaning products will only be green products, specifically: nontoxic, low or no VOC, ammonia free and with a low irritation potential.
	Common Areas	By not insulating the exterior walls from the inside, the project does not include any potentially harmful material on the interior of the walls such as spray foam.	Cleaning products will only be green products, specifically: nontoxic, low or no VOC, ammonia free and with a low irritation potential.

Additional notes:

1. To help increase the indoor air quality and protect the ERV, MERV 13 filters will be installed at the outside air intake of the ERV and MERV 8 filters will be installed in indoor air handling units.
2. CAR dampers will be provided at ventilation registers to maintain a balanced system and ensure healthy air flows.
3. Uninsulated walls may create a risk of condensation. This will be addressed by a by-pass system with moisture sensors built into the ERV.

12 Overall Rehab Proposal

By way of an integrative design process, the team sought to not only satisfy the project's net zero goals, but also to meet the buildings' non-energy related renovation needs and improve the residents' quality of life. As a result, the scope includes a central laundry room in each building. The team initially wanted to renovate all kitchens and bathrooms, replace some apartment doors and install a trash chute, but these scope items were finally removed from the scope as part of the value engineering process.

The architect, in addition to completing construction documents, will work on pulling required permits from the city and will perform construction oversight. The MEP engineer will complete HVAC, plumbing and electrical construction documents. The energy consultant will perform construction oversight as it relates to energy efficiency and sustainability and will create an as-built energy model. The owner and GC will have an enhanced role in this project to ensure quality of installation.

Integrating a high performance retrofit scope represents several challenges:

1. Cost. The high-performance retrofit presented here was prohibitively expensive compared to a tradition retrofit for this project. Getting additional financing sources, such as subsidies, as well as being able to underwrite up to 100% of utility cost savings would help solve for this financing obstacle. Cost compression on innovative equipment, as well as experienced and trained contractors, are expected to reduce installation costs over time.
2. Tenant disruption. The high-performance retrofit includes a significant amount of in-unit work (compared to traditional retrofits) due to complete heating and cooling system replacement. Maximizing work done outside of the building, keeping existing terminal units when possible, would reduce disruption to residents.
3. Sequence of installation. Since the envelope work is expected to so considerably reduce the heating load, the construction schedule must ensure that the envelope work occurs prior to switching the heating system to the new, much smaller, heating system. If the sequence of installation is not created this way, the building could be at risk of under-heating until the insulation, air-sealing and window work is complete.

References and Bibliography

Resources about Global Warming Potential

Building Green. The Building Green Guide to Insulation. https://www.buildinggreen.com/continuing-education/insulation-report

Bionova Ltd, 2018. The Embodied Carbon Review Embodied Carbon Reduction in 100+ Regulations & Rating Systems Globally. https://www.oneclicklca.com/embodied-carbon-review/

Kathrina Simonen, 2014. Life Cycle Assessment.

Architecture 2030. https://architecture2030.org/new-buildings-embodied/

College of Built Environment, University of Washington. http://www.carbonleadershipforum.org/why/

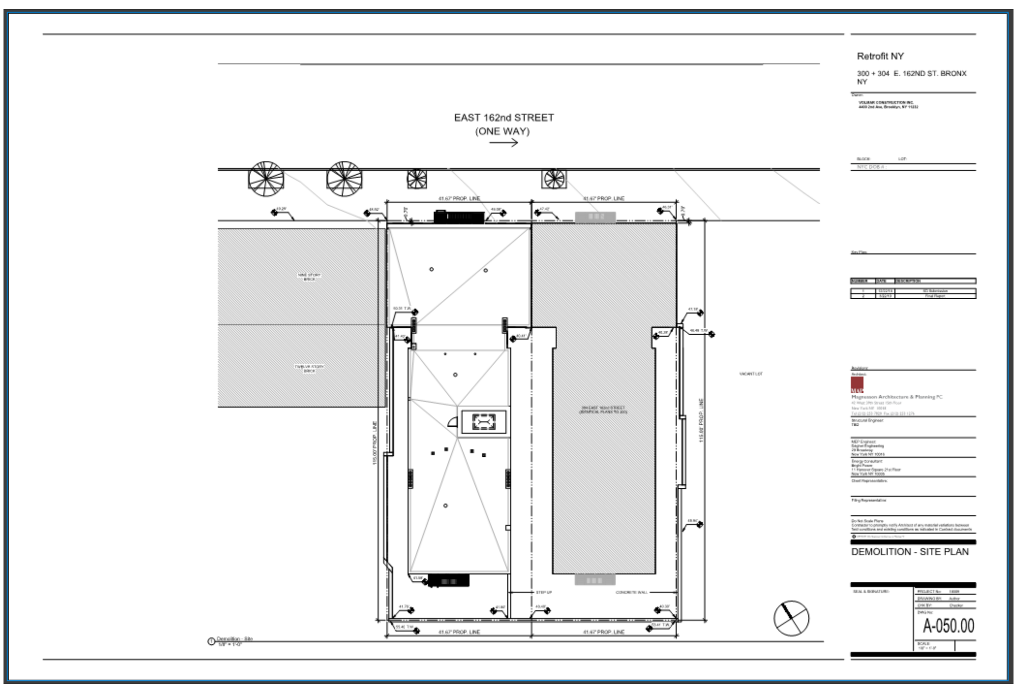
Paula Melton, 2018. The Urgency of Embodied Carbon and What You Can Do about It. https://www.buildinggreen.com/feature/urgency-embodied-carbon-and-what-you-can-do-about-it

Alex Wilson, 2010. Avoiding the Global Warming Impact of Insulation. https://www.buildinggreen.com/feature/avoiding-global-warming-impact-insulation

Engineering Tool Box. https://www.engineeringtoolbox.com/refrigerants-properties-d_145.html

Appendix A. Schematic Design Documents

(Click on image to access the rendering)



(Click on image to access the schematic drawings)

RetrofitNY - Volmar & Bright Power

Cut Sheets

(Click on image to access the cutsheets)

Appendix B. Scalability Strategy

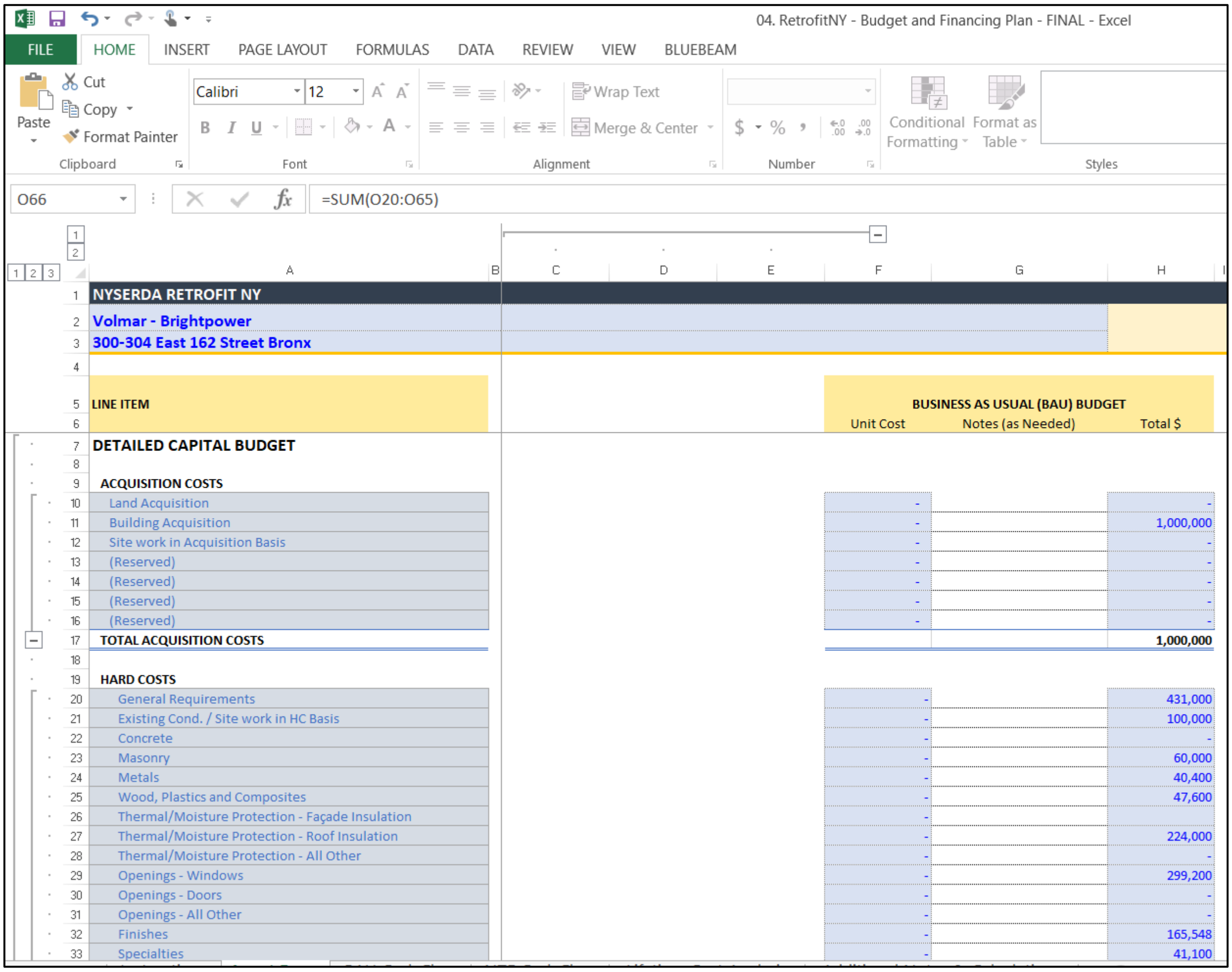
NYSERDA RetrofitNY – Schematic Design
Scalability Strategy
Team: Volmar & Bright Power

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Building System	Describe strategy for successfully measuring, producing and installing the solution at scale on similar buildings. Include detail on building system sub-components (i.e. piping, windows, etc.)	If design solutions with a better potential for scalability were considered, describe the solutions and explain why they did not make it to the final design (i.e., cost, product availability, aesthetics, etc.)
Ventilation and IAQ	Ventilation ducts will be run outside of the building, in the wall insulation, reducing costs and tenant disruption.	N/A
Space Heating/Cooling	VRF systems are readily available in the US.	- In some buildings, the horizontal supply and return ducts may be left uncovered, using pre-painted ducts. This would reduce labor costs and tenant disruption. The owner of 300 and 304 East 162 decided to cover the ducts for aesthetic reasons. - It was investigated to run the refrigerant piping in the exterior wall insulation outside of the building, similarly to the ventilation ducts. What is currently proposed is to run refrigerant piping in an existing shaft which ends up being less expensive than running them outside and presents little disruption to the tenants. - A less expensive solution is considered because it is cheaper and would be less disruptive to the tenants: keep the steam distribution, upgrade the steam boiler and controls, and install Energy Star window units.
Domestic Hot Water	Most mid-rise buildings in New York City have available room on their roof to install heat pump water heaters. Most of these buildings also have some room in the basement to install storage tanks. There are currently limited options of heat pump water heaters in the US and costs are still high.	Condensing boilers have been considered as they are more readily available and a better known technology. However, they require relining existing chimneys which is costly and do not address fossil fuel elimination.

(Click on image to access the Sustainability Strategy)

Appendix C. Budget and Financing Plan



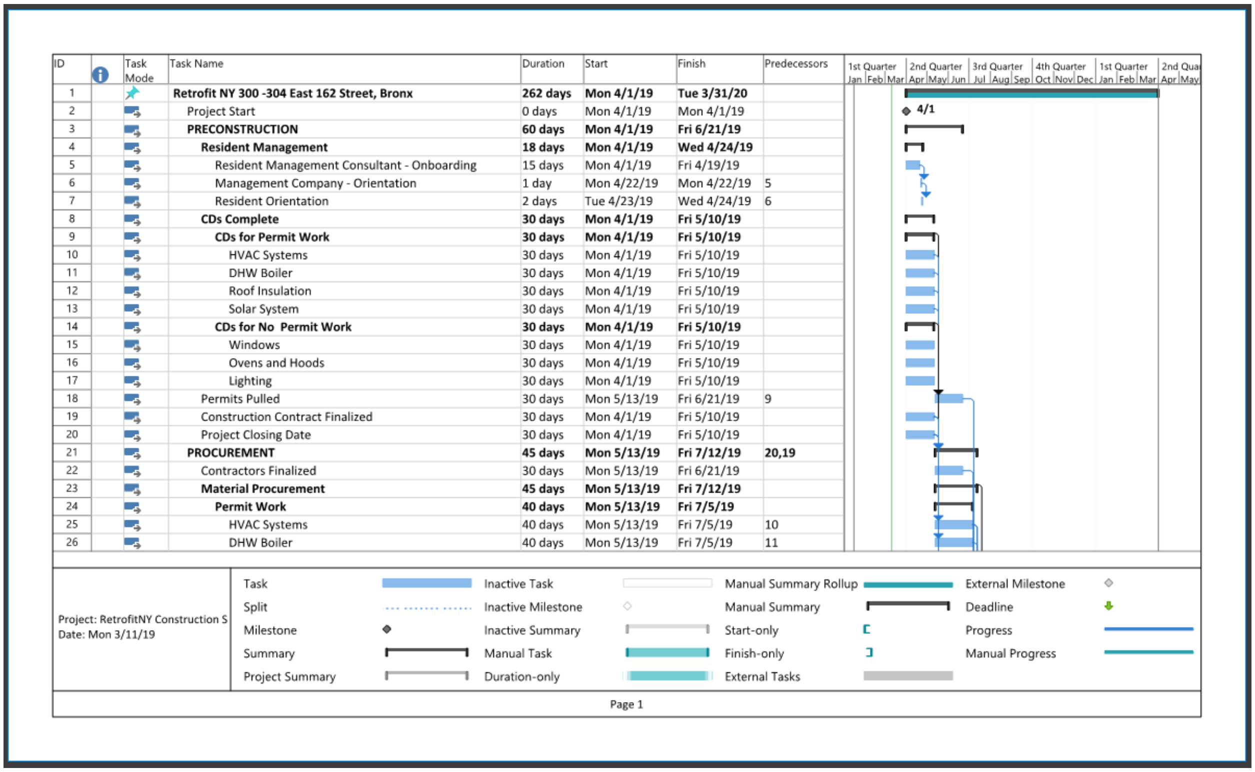
04. RetrofitNY - Budget and Financing Plan - FINAL - Excel

O66 =SUM(O20:O65)

NYSERDA RETROFIT NY			
Volmar - Brightpower			
300-304 East 162 Street Bronx			
LINE ITEM	**BUSINESS AS USUAL (BAU) BUDGET**		
	Unit Cost	Notes (as Needed)	Total $
DETAILED CAPITAL BUDGET			
ACQUISITION COSTS			
Land Acquisition	-		-
Building Acquisition	-		1,000,000
Site work in Acquisition Basis	-		-
(Reserved)	-		-
(Reserved)	-		-
(Reserved)	-		-
(Reserved)	-		-
TOTAL ACQUISITION COSTS			**1,000,000**
HARD COSTS			
General Requirements	-		431,000
Existing Cond. / Site work in HC Basis	-		100,000
Concrete	-		-
Masonry	-		60,000
Metals	-		40,400
Wood, Plastics and Composites	-		47,600
Thermal/Moisture Protection - Façade Insulation	-		
Thermal/Moisture Protection - Roof Insulation	-		224,000
Thermal/Moisture Protection - All Other	-		-
Openings - Windows	-		299,200
Openings - Doors	-		-
Openings - All Other	-		-
Finishes	-		165,548
Specialties	-		41,100

(Click on image to access the Budget and Financing Plan)

Appendix D. Projected Construction Schedule



ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			**Retrofit NY 300 -304 East 162 Street, Bronx**	**262 days**	**Mon 4/1/19**	**Tue 3/31/20**	
2			Project Start	0 days	Mon 4/1/19	Mon 4/1/19	
3			**PRECONSTRUCTION**	**60 days**	**Mon 4/1/19**	**Fri 6/21/19**	
4			**Resident Management**	**18 days**	**Mon 4/1/19**	**Wed 4/24/19**	
5			Resident Management Consultant - Onboarding	15 days	Mon 4/1/19	Fri 4/19/19	
6			Management Company - Orientation	1 day	Mon 4/22/19	Mon 4/22/19	5
7			Resident Orientation	2 days	Tue 4/23/19	Wed 4/24/19	6
8			**CDs Complete**	**30 days**	**Mon 4/1/19**	**Fri 5/10/19**	
9			**CDs for Permit Work**	**30 days**	**Mon 4/1/19**	**Fri 5/10/19**	
10			HVAC Systems	30 days	Mon 4/1/19	Fri 5/10/19	
11			DHW Boiler	30 days	Mon 4/1/19	Fri 5/10/19	
12			Roof Insulation	30 days	Mon 4/1/19	Fri 5/10/19	
13			Solar System	30 days	Mon 4/1/19	Fri 5/10/19	
14			**CDs for No Permit Work**	**30 days**	**Mon 4/1/19**	**Fri 5/10/19**	
15			Windows	30 days	Mon 4/1/19	Fri 5/10/19	
16			Ovens and Hoods	30 days	Mon 4/1/19	Fri 5/10/19	
17			Lighting	30 days	Mon 4/1/19	Fri 5/10/19	
18			Permits Pulled	30 days	Mon 5/13/19	Fri 6/21/19	9
19			Construction Contract Finalized	30 days	Mon 4/1/19	Fri 5/10/19	
20			Project Closing Date	30 days	Mon 4/1/19	Fri 5/10/19	
21			**PROCUREMENT**	**45 days**	**Mon 5/13/19**	**Fri 7/12/19**	**20,19**
22			Contractors Finalized	30 days	Mon 5/13/19	Fri 6/21/19	
23			**Material Procurement**	**45 days**	**Mon 5/13/19**	**Fri 7/12/19**	
24			**Permit Work**	**40 days**	**Mon 5/13/19**	**Fri 7/5/19**	
25			HVAC Systems	40 days	Mon 5/13/19	Fri 7/5/19	10
26			DHW Boiler	40 days	Mon 5/13/19	Fri 7/5/19	11

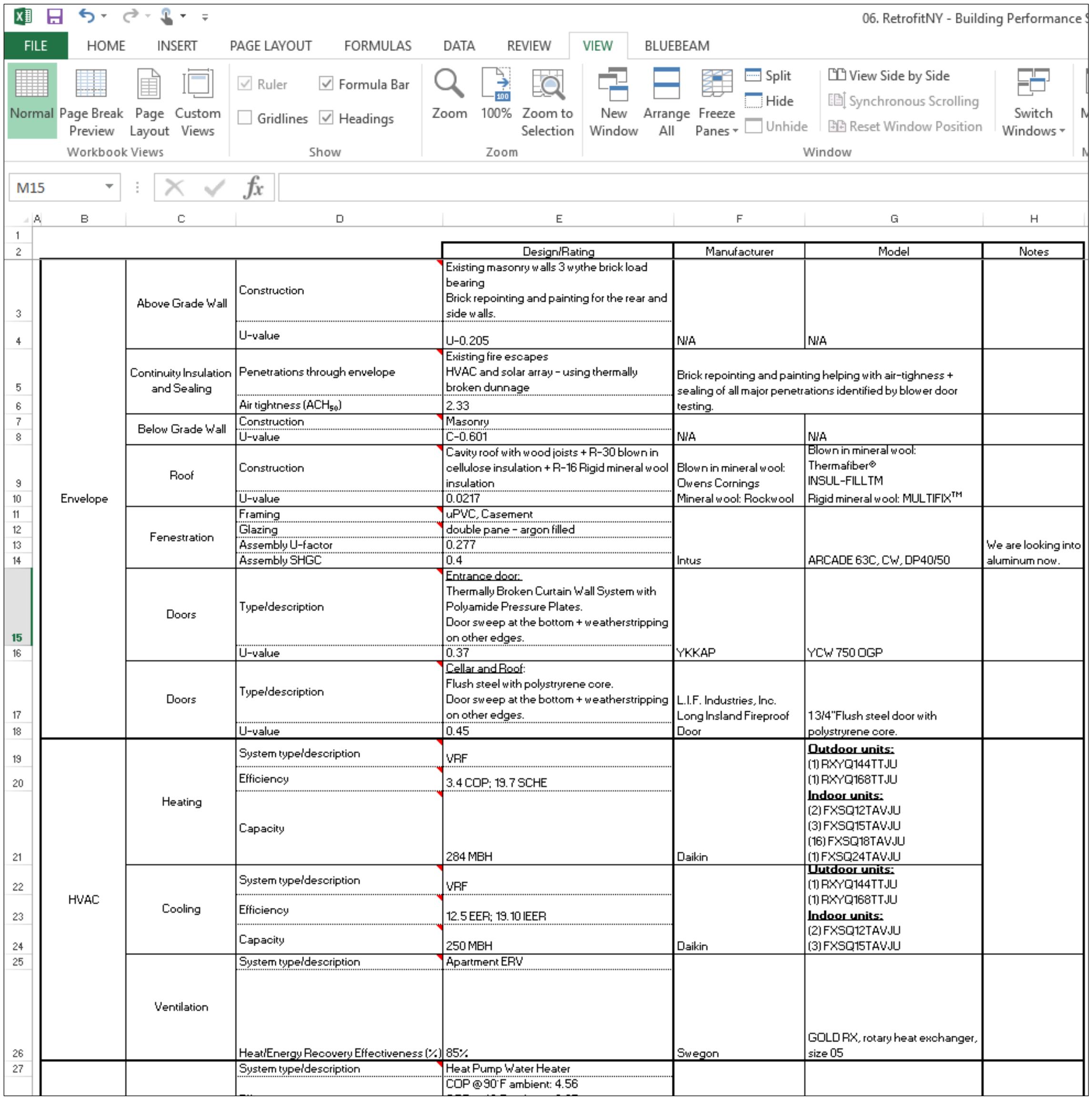
Project: RetrofitNY Construction S
Date: Mon 3/11/19

Task	Inactive Task	Manual Summary Rollup	External Milestone
Split	Inactive Milestone	Manual Summary	Deadline
Milestone	Inactive Summary	Start-only	Progress
Summary	Manual Task	Finish-only	Manual Progress
Project Summary	Duration-only	External Tasks	

Page 1

(Click on image to access the Projected Construction Schedule)

Appendix E. Building Performance Summary



			Design/Rating	Manufacturer	Model	Notes
Envelope	Above Grade Wall	Construction	Existing masonry walls 3 wythe brick load bearing Brick repointing and painting for the rear and side walls.			
		U-value	U-0.205	N/A	N/A	
	Continuity Insulation and Sealing	Penetrations through envelope	Existing fire escapes HVAC and solar array - using thermally broken dunnage	Brick repointing and painting helping with air-tighness + sealing of all major penetrations identified by blower door testing.		
		Air tightness (ACH_{50})	2.33			
	Below Grade Wall	Construction	Masonry			
		U-value	C-0.601	N/A	N/A	
	Roof	Construction	Cavity roof with wood joists + R-30 blown in cellulose insulation + R-16 Rigid mineral wool insulation	Blown in mineral wool: Owens Cornings	Blown in mineral wool: Thermafiber® INSUL-FILLTM	
		U-value	0.0217	Mineral wool: Rockwool	Rigid mineral wool: MULTIFIX™	
	Fenestration	Framing	uPVC, Casement			
		Glazing	double pane - argon filled			
		Assembly U-factor	0.277			We are looking into aluminum now.
		Assembly SHGC	0.4	Intus	ARCADE 63C, CW, DP40/50	
	Doors	Type/description	Entrance door: Thermally Broken Curtain Wall System with Polyamide Pressure Plates. Door sweep at the bottom + weatherstripping on other edges.			
		U-value	0.37	YKKAP	YCW 750 OGP	
	Doors	Type/description	Cellar and Roof: Flush steel with polystyrene core. Door sweep at the bottom + weatherstripping on other edges.	L.I.F. Industries, Inc. Long Island Fireproof	1 3/4"Flush steel door with	
		U-value	0.45	Door	polystyrene core.	
HVAC	Heating	System type/description	VRF		**Outdoor units:** (1) RXYQ144TTJU (1) RXYQ168TTJU	
		Efficiency	3.4 COP; 19.7 SCHE		**Indoor units:**	
		Capacity	284 MBH	Daikin	(2) FXSQ12TAVJU (3) FXSQ15TAVJU (16) FXSQ18TAVJU (1) FXSQ24TAVJU	
	Cooling	System type/description	VRF		**Outdoor units:** (1) RXYQ144TTJU (1) RXYQ168TTJU	
		Efficiency	12.5 EER; 19.10 IEER		**Indoor units:**	
		Capacity	250 MBH	Daikin	(2) FXSQ12TAVJU (3) FXSQ15TAVJU	
	Ventilation	System type/description	Apartment ERV			
		Heat/Energy Recovery Effectiveness (%)	85%	Swegon	GOLD RX, rotary heat exchanger, size 05	
		System type/description	Heat Pump Water Heater COP @ 90°F ambient: 4.56			

300-HP-DHW-Bundle

300-HP-DHW-MeasureByMeasure

300-HP-DHW-ProposedEnergyEndUse

304-HP-DHW-Bundle

304-HP-DHW-MeasureByMeasure

304-HP-DHW-ProposedEnergyEndUse

Building-Performance-Summary

eQuest-300inp

eQuest-300pd2

eQuest-300prd

eQuest-304inp

eQuest-304pd2

eQuest-304prd

(Click on links to access the Building Performance Summary and Modeling Report)

Appendix F. Resident Management Plan

NYSERDA RetrofitNY – Schematic Design
Resident Management Plan
Team: Volmar – Bright Power

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Management Plan

Goals

The goals of this management plan are to:

1. Ensure minimal disturbance and inconvenience to residents during renovation
2. Ensure timely and accurate information dissemination to residents to reduce pushback during renovation
3. Engage residents to ensure proper maintenance of the new systems to be installed in the buildings

Length of construction phase

Approximately 17 months

Length of resident management plan

Approximately 24 months

Plan for resident notifications and communication

All residents will be notified about the planned retrofit activities upon confirmation of project financing. The residents will be notified about all planned improvements to their apartments in advance of the beginning of demolition work, and will be continuously updated about the progress of any work that might have a direct impact on them. The residents will be informed via written notices and in-person meetings. The communication and engagement will be carried out by the owner, the property management company, and external consultants like Solar One, Acacia Network and similar organizations that serve affordable housing communities. The expected timeline for resident notification is as follows:

- Initial Notices to residents – Immediately upon confirmation of project financing
    - Initial notice of planned retrofit activities, along with a request that each tenant attend the initial meeting with the Project Team
- Initial meeting with Project Team – 15 days after Initial Notice
    - In-person meeting at each building to inform tenants about the overall project scope, the nature of work inside each apartment, and the timeline regarding the use of temporary kitchens and bathrooms in the basement
    - Meeting will include a discussion about community solar projects and enrollment with Solar One (see below)
    - Meeting will address any concerns the tenants might have
- Pre-demolition Meeting for each apartment line – 15 days before the beginning of interior demolition work
    - Inform residents about the expected duration of construction work requiring them to use temporary kitchens and bathrooms
    - Explanation of the resources available to minimize frustration
- Pre-completion Meeting for each apartment line – 15 days before completion of renovation in each apartment
    - Inform residents about the new systems installed in the apartments and their proper use
    - Create awareness about do's and don'ts to ensure optimal maintenance of the new systems
    - Distribute user manual for all equipment and facilities provided

Please refer to the project schedule for the estimated timelines for each of these activities

(Click on image to access the Resident Management Plan)

Appendix G. Performance Guarantee Pathway

NYSERDA RetrofitNY – Schematic Design
Performance Guarantee Pathway
Team: Volmar & Bright Power

Maintenance and Warranties

Which of your solution's energy performance parameters can be guaranteed (e.g. heat pump COP, on-site kWh production, Btu/person/HDD for heating, BTU/person/CDD for cooling, etc.)? Include a list that maps each parameter to its corresponding building system(s)

Solution	Energy Performance Parameters
Solar Panels	Efficiency in %
Heat Pump Water	COP
VRF	COP
ERV	Efficiency in %

What are the warranty term lengths for the various building systems included in your solution?

Building System	Warranty Term Lengths
Solar Panels	25 Years
Invertors for Solar Panels	12 Years
Roof	25 Years
VRF System	10 Years
EIFS Insulation	15 Years
Windows	10 Years
ERV	10 Years
Heat Pump Water Heater	10 Years
LED Lighting	5 Years

List the schedule of high-level maintenance needs through your project's lifetime for each building system including major interventions (i.e. heat pump compressor replacements). Include building systems that are expected to require little to no maintenance and specify as such

Building System	Major Intervention
Heat Pump	Motors & Coil replacement
Roof	Flashing repairs Seams & Caulking
VRF	Condenser replacement Refrigerant refill Filter cleaning Coil replacement
Solar System	Cleaning Broken panel replacement Invertor replacement
ERV	Motor replacement
Lighting	LED bulb replacement

(Click on image to access the Performance Guarantee Pathway)

Appendix H. Regulatory Barrier Summary

NYSERDA RetrofitNY – Schematic Design
Regulatory Barrier Summary
Team: Volmar & Bright Power

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Please note that the items listed below are not all barriers to which we would fully support advocating exception. Also, some of these are restrictions on the design, but have work arounds and perhaps are not true "barriers". Finally, not all of the items listed below pertain to the final submission, but the team has listed all items encountered during the various design options since the design changed significantly during the process, and we aim to share as much information as possible.

Regulation			Impediment	Action	Resolution		
Code	**Section**	**Description**	**Explain how this regulation impedes your ability to achieve the RetrofitNY criteria.**	**What action has the team taken to date to resolve this barrier?**	**Resolved**	**Resolution in Progress**	**Seeking Assistance with Resolution**
NYC BC 1968	27-355.1	Limits the amount of combustible insulation we can add to the exterior of a noncombustible building.	This section limits up to 4" of EPS or XPS since it is combustible and "more toxic than burning wood" (essentially). The limit exists in the old as well as newer codes.	The team is more interested in using stone wool as it is less toxic, has a lower GWP/embodied energy, and is fire rated. However, stone wool EIFS is about $10 more expensive than EPS or XPS.		For the December 2018 submission, the team was showing EPS in financial model but EUI is dependent on R-24 (FYI the section in the newer code is NYC BC 2014: 2603.5.4).	
NYC BC 1968	3202.2.1	Limits the amount we can clad over the property line to 4".	Since this building existed before 1968 we can overclad max 4" beyond the property line.	According to our drawings and calculations we are just under this threshold (see architectural drawings).	Yes		
NYC BC 1968	27-380 (c)	Requires a 3' depth at the landing of the fire escape.	We cannot provide the amount of insulation we would like to at the walls adjacent to the fire escape.	We have modeled 4" of insulation at these locations and taken the hit in the energy model. It does make our prefabricated panel design option, a bit more complicated, although the panels there would have to be smaller size to fit up and around the fire escape railing anyway (and the panel joints therefore at the railing etc).	Yes.		
NYC ECC 2016	403.2.9	Requires ducts be insulated on the exterior ducts min R-8.	We are showing R-8 (2" of insulation now) since we have to reduce the amount of EPS to 4" – one would see the ducts expressed on the exterior, which may not be an impediment but would detract from the project aesthetic.	We assume we need to comply with current energy code, although we most likely will use ASHRAE compliance for mechanical reasons.	Yes, for now.		

(Click on image to access the Regulatory Barrier Summary)

Appendix I. Resiliency Summary

NYSERDA RetrofitNY – Schematic Design
Resiliency Summary
Team: Volmar & Bright Power

Indicator	Design Solution
Protection: Identify strategies to reduce a building's vulnerability to extreme weather:	
Floodproofing or Flood Control	The buildings are not in a flood zone.
Sewer Backflow Prevention	A back flow preventer already exists on the main water service line to the buildings.
Mechanical Equipment Protection and Location	The outdoor units of the VRF will be outside of the roof. They are not protected besides their own casing as they need to be exposed to ambient air to function efficiently.
Electrical Equipment Protect and Location	Meters and common area panels are located in the basement. Most of the electrical equipment for the solar panels will be on the roof.
Backup Power Location and Protection	N/A, no backup power is provided.
Communications	Internet, phone and intercom equipment are located at each apartment and are not being moved as part of this project.
Envelope Protection	The existing brick cladding serves as the building's structure. Repointing the brick and painting the rear and side walls will increase the longevity of the brick.
Fire Protection	No new fire protection elements are added as part of the scope.
Adaptation: Identify strategies that improve a facility's ability to adapt to changing climate conditions:	
Envelope Design	The highly insulated and sealed roof and the new efficient windows will reduce the heating and cooling loads to a very low amount. The solar canopy will provide shading over the entire roof of the building which will help reduce the cooling load.
Mechanical Equipment	The proposed VRF system provides individual control over temperature to tenants.
Passive Cooling or Ventilation Strategies	Operable windows will provide some free cooling in shoulder seasons. The energy recovery ventilator will reduce the cooling and heating load of the building.
In-unit	The monitoring system will show apartment indoor temperatures as a piece of information used to manage the energy performance of the building.
Site	No landscaping nor storm management is provided in this project.
Backup: Identify strategies that provide critical needs for when a facility loses power or other services:	
Critical Systems with Backup	No backup power is provided. However, the building is designed to use a minimal amount of energy which would have a positive impact in case of a blackout: - The highly insulated and sealed roof and the new efficient windows reduce the heating and cooling loads to a very low amount. Masonry walls act as a thermal mass which would help maintain an acceptable indoor temperature in case of a black out. - All above grade spaces including kitchens, bathrooms and stairwells have windows providing natural daylight. - Residents can open windows for ventilation when the ERV is off during a blackout.
Backup Power Type	N/A
Access to Potable Water and Sanitary Services	In case of a blackout, residents would be able to use cold water as the building is supplied water by the city water pressure directly without the need for booster pumps or domestic water pumps. However, hot water would not be provided in case of a blackout.

(Click on image to access the Resiliency Summary)

Appendix J. Resident Health Impact Summary

NYSERDA RetrofitNY – Schematic Design
Resident Health Impact Summary
Team: Volmar & Bright Power

VOCs (enter level of VOCs in products: conventional, low- or no- VOC)	Units - Paints	Low or no VOC products will be used.	Low or no VOC products will be used.
	Units - Coatings	Low or no VOC products will be used.	Low or no VOC products will be used.
	Units - Primers	Low or no VOC products will be used.	Low or no VOC products will be used.
	Units - Adhesives and Sealants	Low or no VOC products will be used.	Low or no VOC products will be used.
	Units - Flooring Materials	N/A – not part of the scope.	Ceramic tiles and Luxury Vinyl Tiles with the Floorscore label would be used.
	Common Areas - Paints	Low or no VOC products will be used.	Low or no VOC products will be used.
	Common Areas - Coatings	Low or no VOC products will be used.	Low or no VOC products will be used.
	Common Areas - Primers	Low or no VOC products will be used.	Low or no VOC products will be used.
	Common Areas - Adhesives and Sealants	Low or no VOC products will be used.	Low or no VOC products will be used.
	Common Areas - Flooring Materials	N/A, no common area flooring included in the scope.	When replaced, flooring will include ceramic tiles or Floorscore labeled Luxury Vinyl Tiles.
Other Contaminants	Units	By not insulating the exterior walls from the inside, the project does not include any potentially harmful material on the interior of the walls such as spray foam.	Cleaning products will only be green products, specifically: non toxic, low or no VOC, ammonia free and with a low irritation potential.
	Common Areas	By not insulating the exterior walls from the inside, the project does not include any potentially harmful material on the interior of the walls such as spray foam.	Cleaning products will only be green products, specifically: non toxic, low or no VOC, ammonia free and with a low irritation potential.

Additional notes:

1. To help increase the indoor air quality and protect the ERV, MERV 13 filters will be installed at the outside air intake of the ERV and MERV 8 filters will be installed in indoor air handling units.
2. CAR dampers will be provided at ventilation registers to maintain a balanced system and ensure healthy air flows.
3. Uninsulated walls may create a risk of condensation. This will be addressed by a by-pass system with moisture sensors built into the ERV.

(Click on image to access the Resident Health Impact Summary)

Appendix K. Overall Rehab Proposal

Rehab Proposal for Net Zero Energy Retrofit of 300-304 East 162^{nd} Street, Bronx, NY

This project is proposed for two buildings located at 300-304 East 162^{nd} Street, Bronx, NY. Each building has 21 residential units. The current project intends to retrofit the existing buildings to Net Zero Energy buildings with an annual energy consumption of 29.6 kBtu/ft^2 leading to annual utility cost savings of approximately $30,000. Additionally, the project will dramatically improve resident comfort and well-being by providing additional services that include central cooling and heating of each apartment unit.

The team consists of Bright Power as the energy consultant, Magnusson Architect and Planning, PC as the architect, Dagher Engineering as the engineer, Volmar Construction Inc. as the contractor, and Olive Branch Consulting as the cost estimator.

The summary of the scope of work proposed for this project is as follows:

	Area	Measures
1.	Kitchens	- Upgrading existing gas oven to electrical oven - Installation of energy star range hoods - Upgrading existing light to LED light fixtures - Upgrading existing water fixtures to low flow water fixtures - Installation of ventilation systems - Electrical wiring for new appliances
2.	Bathrooms	- Upgrading existing water fixtures and toilets to low flow fixtures - Upgrading existing lighting to LED lighting - Installation of ventilation systems
3.	Rest of Apartments	- Installation of central VRF system for heating and cooling - Installation of ERV system for ventilation - Upgrading all light fixtures to LED light fixtures - Upgrading electrical panels - Installation of double glazed UPVC windows - Replacement of apartment entrance doors where necessary. - Repainting the apartments - Replacement of apartment signages
4.	Common Areas	- Upgrading all light fixtures to LED light fixtures - Repair and repainting of stairs - Replacement of postal boxes - Replacement of entrance doors and storefronts - Replacement of DHW boiler with heat pump water heater - Repainting of common area - Installation of new trash receptacles - Central VRF and ERVs for heating cooling and ventilation with exterior ducting.

1

(Click on image to access the Overall Rehab Proposal)

Appendix L. Carbon Emission Analysis

Appendix L.

A.Carbon Emission Analysis

One of our central goals for this project is to provide a solution that drastically reduces the global warming footprint/potential (or GWP) for buildings of this typology. The team recognizes the immediacy of the need to reduce emissions and therefore is interested in a much shorter time frame for analyzing the total GWP of the project, than is typically studied in a total life cycle GWP analysis which could encompass 100 years. The chart below from AIA2030 indicates that for a typical high performance new building, the impact of the embodied GWP of the materials is much greater in the first 10-30 years, which is the timeframe we are interested in drastically reducing now, so that we can truly mitigate our climate issues.

CARBON EMISSIONS FOR NEW CONSTRUCTION BUILDING

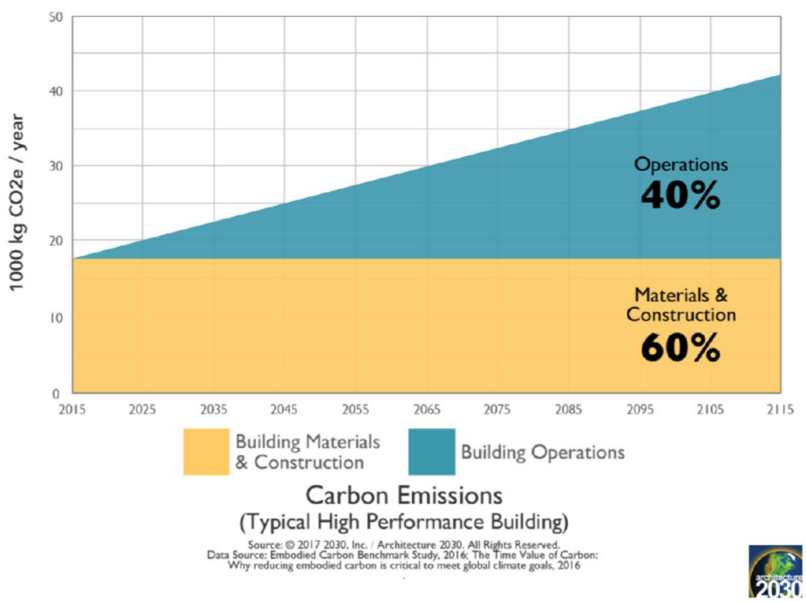


FIGURE 1: CARBON EMISSIONS FOR NEW CONSTRUCTION BUILDING

The chart shows a cumulative tally of the GWP of a typical high performance building.

Therefore the team recognizes that the physical materials we are using in the renovation process, have a significant impact on the total GWP performance of the building. Performing a complete greenhouse gas life cycle analysis however has been determined to be too time consuming at this stage but an analysis has been done on the use of mineral wool (MW) or Expanded Polystyrene (EPS) as insulation materials for the exterior walls and roof. This analysis was done while considering insulating exterior walls from the exterior and refers to the scope presented in the Schematic Design submission to NYSERDA in December 2018.

(Click on image to access the Carbon Emission Analysis)

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise, and support to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. NYSERDA professionals work to protect the environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York State since 1975.

To learn more about NYSERDA's programs and funding opportunities, visit nyserda.ny.gov or follow us on Twitter, Facebook, YouTube, or Instagram.

New York State Energy Research and Development Authority

17 Columbia Circle
Albany, NY 12203-6399

toll free: 866-NYSERDA
local: 518-862-1090
fax: 518-862-1091

info@nyserda.ny.gov
nyserda.ny.gov

State of New York
Andrew M. Cuomo, Governor

New York State Energy Research and Development Authority
Richard L. Kauffman, Chair | Alicia Barton, President and CEO