RetrofitNY: The Levy Partnership Net Zero Energy Retrofit Schematic Design

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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: The Levy Partnership Net Zero Energy Retrofit Schematic Design

Final Report

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Abstract

NYSERDA's RetrofitNY program is seeking to establish a self-sustaining market for deep energy retrofits of affordable multifamily buildings in New York State. The program tasks design teams with developing a comprehensive strategy for drastically reducing a building's energy use, while converting to electric-only energy use, which can then be offset with renewable onsite or community solar production. The Levy Partnership targeted a 21-unit multifamily building in upper Manhattan for a net zero energy retrofit. This report outlines the design process and final schematic design, while also discussing the challenges that future projects may face, as well as opportunities that emerging technologies and industry trends offer.

Keywords

Net zero energy, deep energy retrofit, multifamily, electrification, heat pump, heat pump water heater, VRF, RetrofitNY, overcladding, New York City

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Acronyms and Abbreviations

ft	feet
kWh	kilowatt hours
m/s	meters per second
MW	megawatts
NYS	New York State
NYC	New York City
NYSERDA	New York State Energy Research and Development Authority
W	watts
EUI	energy use intensity
NZE	net zero energy
kBTU	kilo British thermal unit
VRF	variable refrigerant flow
ERV	energy recovery ventilation
HPWH	heat pump water heater
HP	heat pump
EIFS	exterior insulation and finish system
AHU	air handler unit
AC	air conditioning
EPS	expanded polystyrene
XPS	extruded polystyrene
Low-e	low emissivity
BAU	business as usual
MEP	mechanical, electrical, plumbing engineer
CD	construction documents

Glossary

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

Multifamily building: Residential building with five or more living units.

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

Site Energy: The total amount of energy consumed at a building.

Source Energy: The total amount of energy that is required to operate a building, incorporating all transmission, delivery, and production losses.

Thermal Bridge: An area or component of a building enclosure element that has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer.

Executive Summary

RetrofitNY is an initiative of the New York State Energy Research and Development Authority (NYSERDA) to develop and demonstrate net zero energy retrofits of affordable multifamily buildings in New York State. Six projects were initiated and taken through the schematic design phase. This report documents one of these retrofit designs, led by The Levy Partnership (TLP), with a core team including building owner Joint Ownership Entity (JOE) NYC, CTA Architects, P.C., mechanical engineers Peterson Engineering Group, structural engineers MacLaren Engineering Group, and a construction firm, M Square Builders. Solar One, Harvest Power, Sentient Buildings, Passive Dwellings, and Rocky Mountain Institute also provided support. The team worked to develop a design strategy for bringing an existing 20-year-old multifamily low-income building in Harlem to near net zero energy use, while also improving indoor environmental quality and building resiliency without displacing residents during construction.

The building is an infill site representative of much of New York City's contemporary low-income urban fabric and the design challenges inherent in renovating it. The mid-block building consists of one floor of community facility space and five stories of apartments. The façade is a minimally ornamented brick cavity wall with concrete masonry unit (CMU) backup masonry and a bearing-wall-and-concrete-plank structural system.

The strategy developed by the team calls for additional envelope insulation from the cellar to the roof. The exterior framed walls have three inches of fiberglass batt insulation, and given the limited floor area, insulating more on the interior was not an option. The design calls for panelized or site applied exterior insulation and finish system (EIFS) over the existing brick veneer and four inches of polyisocyanurate underneath a new bituminous roof. Code restrictions preclude expanding past the lot line toward the street, so the current design calls for four inches of EIFS over-cladding at the exposed rear and side walls only. Similarly, the design calls for new windows at the rear face of the building only. This decision was driven primarily by the budget but was also made with the goal of minimizing resident disturbance in mind, to consolidate front façade work to a time when the EIFS can be installed as well.

A decommissioned trash chute and the existing corridor supply shaft will be repurposed to house ductwork bringing supply air to each apartment. Other options, such as cutting openings in the plank construction of the occupied apartments, were deemed too complex, costly, and disruptive to the residents. Existing exhaust shafts will be used to extract stale air from apartments and corridors and connected to rooftop energy recovery ventilators (ERVs). The ground floor and basement community spaces will have separate ERVs.

The existing fossil-fueled space and water heating systems will be decommissioned and replaced with all-electric systems. Domestic water will be heated by CO2-refrigerant based heat pumps connected to the existing central recirculating system, which will be outfitted with additional insulation and demand controls.

A central variable refrigerant flow heat pump system with individual air handlers in each room will replace the existing boiler and hot water distribution system. The new system also will provide space cooling, which will be an added amenity for residents.

A sizable PV array is planned for the roof level to defray the use of grid electricity, and energy-efficient appliances, lighting, and low-flow plumbing fixtures will reduce electricity usage in individual apartments. Part of the project's larger vision is to provide replicable solutions throughout New York City's multifamily housing stock, so all the proposed systems are selected, and their implementation planned, with replicability in mind.

While the retrofit will include items directly benefiting residents, such as the new cooling system, improved ventilation, and new appliances, tenant engagement will be critical to the long-term success of the project and the replicability of the retrofit approach. For this reason, a series of resident meetings will be conducted to present preliminary plans and gather feedback on resident behavior and preferences.

Preliminary energy modeling predicts an approximately 72% decrease in site energy use based on the proposed solutions thus far, which include an extensive canopy-mounted full-roof PV array that would produce about 60,000 kWh per year.

Figures

Figure 1 439 West 125th Street

Figure 2 Existing Roof

Figure 3 Boiler room

1 Project Narrative

Building Envelope

Key design criteria to consider	How does your design address the criteria?
Thermal performance	The rear and exposed side walls will have 4" of EPS EIFS (R-20), and new double pane low-e windows with u-value of glass at 0.25, frame .176, and SHGC of 0.52. The roof will be replaced and have 4" of polyisocyanurate installed underneath (R-31). The EIFS at the rear will wrap over the parapets to connect with the roofing insulation and eliminate thermal bridging. The EIFS will also extend past the window frames at the top and sides to limit thermal bridging.
Sealing performance	Air sealing will be improved through the liquid applied water resistive barrier on the rear and side walls prior to the EIFS installation. New airtight windows will be installed on the rear wall. The new roof and roof insulation will improve air sealing at the roof. In the basement we will do targeting air sealing of penetrations with spray foam. Unit compartmentalization was not practical given the limitations of a tenant-in-place retrofit, and the amount of disturbance that process would cause.
Moisture performance	Moisture management will be maintained via a new modified bituminous roof, maintenance of the existing drainage plane at all walls, and the addition of a liquid applied weather resistive barrier prior to the installation of EIFS at the rear and exposed side walls. Window installation will allow for moisture drainage at the sill.
Structural performance and long-term integrity of materials	No proposed envelope work requires additional structural analysis. Long term integrity of materials will be maintained by following manufacturers' recommendations for routine maintenance, cleaning, and repair. This includes recoating of EIFS at periodic intervals.
How will the new design affect resident life? Are there custom/atypical design features that require careful consideration?	The main feature of the envelope design that will impact resident life is the new windows at the rear. The new tilt/turn windows will operate differently than the existing double hung windows, and will prevent installation of window AC units. The rear and side walls with have a new aesthetic with the EIFS overcladding, which will be visible from the rear yard of the building.
Maintenance of solution	The envelope will be maintained in accordance with manufacturers recommendations for routine maintenance to maximize the life of systems and materials used. This includes periodic inspection, cleaning, and recoating of the EIFS.
Sustainability of solution	Where more sustainable material choices exist (eg. mineral wool EIFS as opposed to EPS) the cost was a prohibitive factor, at a ~35% premium.
Replication potential at scale	We believe all elements included in the design of the building envelope to be replicable at scale and applicable to most building typologies, with some opportunities for cost compression.

Other Questions	Team Response
What challenges have you encountered in designing an envelope solution that meets the RFP requirements? How are you addressing them?	Meeting net zero energy at this time is not feasible. This is in part due to limited roof area, and the achievable EUI (in part due to restrictions on overcladding the front façade). While a variance may be pursued to establish a precedent for overcladding that encroaches on the right-of-way, this will likely not be included in the design due to timing.
Are there any unresolved major issues? What would it take to resolve them?	The main unresolved issue is the building code restriction on overcladding encroaching on the public right of way. Section 27-335.1 from the 1968 code.
Other comments (optional)	

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	Via the existing exhaust points, 20 CFM will be extracted from the bathrooms and 25 CFM from the kitchens. This will connect to central rooftop ERVs, and supply air will be delivered to the apartments through new registers.
Prevention of mold, mildew, pests and other environmental triggers of respiratory or other ailments	MERV 13 filters will be present at the rooftop ERV units, and MERV 8 filters will be installed in the air handlers in the dwelling units.
Active ventilation to reduce volatile organic compounds and other potential internal air contaminants	Active balanced ventilation will be provided and exhaust from the kitchens and bathrooms of dwelling units and deliver fresh supply air to the entryway of all dwelling units. New range hoods will help ensure grease does not foul ERV units.
Maintenance of solution	A maintenance schedule will be developed that outlines how frequently filters should be changed at the rooftop ERV units, as well as at the in-unit air handlers. Residents will be engaged in the functionality of the design, instructed on how to clean the filters in their air handlers, and building management will also be available to assist with this if necessary.
Sustainability of solution	The design solution contributes to the overall sustainability of the project by reducing energy use for heating and cooling by pre-conditioning incoming supply air. It also positively impacts occupant health and comfort.
Replication potential at scale	The decision to reuse the decommissioned trash chute for bringing supply air to the hallways and units is not necessarily a replicable and scalable solution. The design solution is also not replicable for buildings that do not have existing exhaust at bathrooms and kitchens, as those were reused with shafts connected to the rooftop ERVs.

Question	Team Response
What challenges have you encountered in designing an IAQ solution that meets the RFP requirements? How are you addressing them?	Developing a ventilation strategy that is replicable on other buildings was a hurdle. The opportunity to reuse the existing exhaust shafts, and the existing trash chute, was a cost-effective solution for the project. However, these options may not be available to future projects. Another option was running insulated ventilation ductwork down the exterior of the building, however without overcladding the front wall, this strategy would be complicated and aesthetically challenging.
Are there any unresolved major issues? What would it take to resolve them?	It would be preferable to deliver supply air to bedrooms rather than the apartment foyers. However, this would have required more extensive ducting via soffits. With 8-foot ceilings, soffits would have reduced ceiling height below desirable levels. Soffits would also require more work within apartments.
Other comments (optional)	

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/ft2/year	The design replaces the existing window and through-wall AC units, and boiler/forced hot water baseboard heating system with a new VRF system with in-unit evaporators. This VRF system provides heating at 0.7 kBtu/ft2/year, and cooling at 2.2 kBtu/ft2/year, for a cumulative 2.9 kBtu/ft2/year going to space conditioning requirements. These loads were brought down in part by the envelope improvements, as well as by the higher efficiency of the VRF system as compared to window/through wall AC units and the forced hot water system.
Maintaining heating and cooling comfort (including humidity)	Tenants will now have control over both cooling and heating, where they previously only had control over their personal AC units. The in-unit evaporators will have individual controls. The system will automatically switch from heating to cooling depending on the outside ambient temperature, or by the number of residences calling for heating or cooling. The four VRF units will each provide heating/cooling to a line of apartments, which should have similar conditioning requirements due to their placement and orientation on the building. The ERV units will have bypass capability to control humidity in the winter.
Innovative ways to improve system efficiency	The VRF system has the capability to establish automatic temperature setbacks, which tenants can override by adjusting thermostats. Because the building owner will be paying for heating and cooling, set point limits will be established to prevent overheating or overcooling.
Required sensors and controls	Controls are discussed under innovative ways to improve efficiency, above.
Maintenance of solution	The filters in the in-unit evaporators will need to be cleaned periodically. This can likely be done by tenants, or with the assistance of building management. The VRF system will be commissioned by an appropriate agent to maintain eligibility for the warranty.

Key design criteria to consider	How does your design address the criteria?
Sustainability of solution	The design team explored space conditioning strategies that would not use refrigerants in an effort to improve the sustainability of the design solution. However, all of these options were either cost prohibitive, less efficient or impractical. Two of these alternative strategies were the use of console WSHP's connected to the existing forced hot water distribution risers, valance distribution with hot/cold water, and the Innova 2.0-point source packaged heat pumps.
Replication potential at scale	VRF systems are widely available from several manufacturers and are applicable to cold climate conditions and most building typologies. This strategy is replicable at scale.

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?	Getting the refrigerant lines down from the central rooftop VRF units to the dwelling units was a challenge. In the final design, the lines are channeled through the EIFS in the rear, and through the brick façade in the front, and punch through the walls into each apartment. Once in the apartment they run to where the evaporator heads will be located. The condensate drain lines will follow the same path back and down these channels to terminate at drains at the ground floor.
Are there any unresolved major issues? What would it take to resolve them?	No major unresolved issues.
Other comments	

Domestic Hot Water

Key design criteria to consider	How does your design address the criteria?
DWH system design and sizing	The Sanden HPWH system was specified for DHW. The design calls for four 119-gallon storage tanks, paired with four heat pump units. The system was sized at 21 gallons/person/day, which was confirmed to be adequate based on metering of DHW usage.
Innovative ways to improve system efficiency (i.e. heat recovery)	Demand recirculation controls will be implemented to improve system efficiency. These controls only operate the recirculation pump when needed, resulting in 90+% reduction in pump runtime and up to 15% reduction in DHW heating needs.
Required sensors and controls	The demand control system uses temperature and flow sensors on the recirculation line and a dedicated controller. The Sanden has built-in controls and sensors.

Key design criteria to consider	How does your design address the criteria?
Maintenance of solution	The heat pumps will be installed outdoors, and so they will be exposed to the elements. Routine maintenance will include: Remove the top and side covers of the unit and check the evaporator for dirt or debris. On the Sanden Gen2 unit, there is a filter on the cold-water inlet connection which periodically needs to be removed and cleaned. Staff will check for leaks and for tears in insulation. To clean the condenser, staff will blow away debris/dirt with an air hose or spray it with water. Coil cleaning solutions can also be used. Routine annual or bi-annual inspections are recommended by the manufacturer and will be included in a maintenance contract for the system.
Sustainability of solution	The Sanden HPWH system uses CO2 as a refrigerant, and thus has a lower global warming potential than HPWHs that use other refrigerants. The system's greatly improved efficiency also reduces carbon emissions associated with DHW provided by water heaters that burn natural gas.
Replication potential at scale	The Sanden HPWH system is a scalable solution that can address DHW needs for a wide range of building sizes by ganging the heat pump units and adding more storage tanks. One caveat is that they require outdoor space for the heat pump units within 50 feet of the storage tanks. For some buildings this could be a prohibitive factor.

Other Questions	Team Response
What challenges have you encountered in designing a DHW solution that meets the RFP requirements? How are you addressing them?	The Sanden units do not provide hot water at a very fast rate, and so appropriately sizing the system design to the usage profile of the building is necessary to ensure there is enough hot water to meet peak demand.
Are there any unresolved major issues? What would it take to resolve them?	No major unresolved issues.
Other comments	

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.)	The design includes smart power strips, USB outlets in kitchens where retrofit electrical work will be completed as part of the retrofit scope, and new refrigerators. In addition to these measures, residents will be engaged via pre-construction workshops to understand how to use these technologies and other behavioral changes to reduce electrical consumption.
Variation in consumption between occupants	Unknown factor currently, as we only have access to aggregated residential consumption data. This will be addressed in the resident engagement workshops.
Maintenance of solution	Replacement LED bulbs and smart power strips will be available to residents from building management.

Key design criteria to consider	How does your design address the criteria?
Sustainability of solution	Any electrical consumption reductions achieved through the MEL strategy will contribute to the sustainability of the design.
Replication potential at scale	When a more tailored and comprehensive MEL strategy throughout the resident engagement workshops is developed it will serve as a framework that can be applied to future projects.

Other Questions	Team Response
What challenges have you encountered in designing a MELs solution that meets the RFP requirements? How are you addressing them?	A lack of data on individual residential consumption prevents a more detailed analysis of consumption. MEL strategies in large part require behavioral changes, which are difficult to assess prior to the resident engagement workshops.
Are there any unresolved major issues? What would it take to resolve them?	A more robust MEL strategy will be developed through the resident engagement workshops.
Other comments (optional)	

Distributed Energy Resources (DER)

Key design criteria to consider	How does your design address the criteria?
DER relevant to/included in the retrofit design	The design includes a 43 kW-DC rooftop solar canopy system. Preliminary analysis suggests this system will produce in 60,000 kWh/year, offsetting a significant portion of the owner-paid electrical bill.
Onsite DER capacity vs. offsite	The on-site solar canopy system will produce roughly 30% of the total building electrical consumption. A larger off-site system would be required to meet the full needs of the building.
How to integrate DER into HVAC and other major end uses	DER will offset the owner paid electric bill, which will cover common lighting, the elevator, and HVAC consumption. Residents will have the opportunity to participate in NYSERDA sponsored Solar-for-All community solar program, which will offset residential use.
Structural performance	Because the building has a plank roof, and the parapets are not load bearing, installers will need to core through the plank and fasten the canopy to the sides of the load bearing walls. The structural engineer believes this to be a feasible strategy.
Efficiency degradation	Efficiency degradation is factored into the consumption projections provided by the solar consultant and will be factored into any cost/benefit analysis used to underwrite savings.
Required sensors and controls	A smart interval meter will be installed to monitor usage as well as consumption, which will allow the building to be credited for any excess electricity generated and sent back to the grid.
Maintenance of solution	The maintenance of the solar system will be managed by the solar installer.
Sustainability of solution	The solar canopy system will contribute significantly to the sustainability of the design solution by generation on-site renewable electricity.

Key design criteria to consider	How does your design address the criteria?
Replication potential at scale	The solar canopy system is replicable at scale. Because of the block and plank construction this is a challenging application, so it will serve as a good case study in how to work around obstacles.

Other Questions	Team Response
What challenges have you encountered in designing a DER solution? How are you addressing them?	The billing rate structure is service class 9, which means the common meter gets charged a per kWh fee, as well as a demand charge fee based on the highest demand hour of the billing period. The solar energy will offset the per kWh charge, but will likely not reduce the peak demand, and so it will not reduce the demand charge for the building. This reduces the value of the solar PV and extends the payback period. This is being addressed by spreading some of the cost of the system among a larger building portfolio all of which are also pursuing solar systems. This enables the payback period for this system to be below 20 years, which makes it financeable. The plank construction, and the fact that the parapets are not load bearing, complicates building the solar canopy. The supports will be fastened to the side of the load bearing walls beneath the planks.
Are there any unresolved major issues? What would it take to resolve them?	The building cannot meet 100% of energy usage from on-site renewables due to limited roof space, and it is hard to get financing for a community solar program because of the billing structure. Because community solar would only offset the per kWh charge and not the demand charge, the cost of community solar would be higher than the cost of traditional electricity, and lenders view this as a poor financial decision with a high likelihood of default. Because of this, there is no clear strategy for achieving 100% renewable offset at this time.
Other comments (optional)	

Building Performance + Modeling & 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/ft2/year	The final site EUI is 30.2 before accounting for on-site solar production (which reduced this to 21.3). The EUI was achieved through envelope improvements to limit building loads, and the installation of high efficiency DHW and space conditioning systems, and the replacement of all lighting with LEDs with sensors and controls.
Determination of operational assumptions (schedules, people densities, etc.)	Metering was used to track DHW consumption and identify peak load and daily consumption per person. The lighting controls will be connected to occupancy sensors and timers and automatically shut off or dim and will not require knowledge of occupant schedules. Occupant densities were determined to be # of bedrooms +1 per dwelling unit.

Key design criteria to consider	How does your design address the criteria?
Operation and maintenance costs	Operational costs will be reduced due to the efficiency improvements. Analysis indicates that operational energy costs will go from ~$83,000/year to ~$43,000/year, a near 50% reduction. Maintenance costs are hard to estimate and could potentially be higher due to the addition of evaporators in each dwelling unit, as well as the addition of ventilation equipment, and the addition of four Sanden HPWHs. There will be more equipment to monitor and maintain.
Anticipated costs savings for 30 years relative to "business as usual" normal retrofit intervention	Replacement costs were calculated by taking the EUL of the systems as outlined by Fannie Mae estimated useful lifetime document. Analysis indicates ~$9,000 savings per dwelling unit as compared to business as usual, primarily from the increased cash flow as a result of energy improvements. Lifetime replacement costs for systems are similar in both scenarios, as are projected maintenance costs.
Retrofit business model + sustainability and scalability of solution	The business case for the retrofit is not quite there yet without subsidies or free financing. The cost savings from energy improvements are not enough to leverage for the full cost of the deep energy retrofit. Strategies like a carbon tax could help leverage the other benefits. Health benefits to residents are also not being accounted for when purely looking at the economics of the two scenarios.

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?	Achieving the adjusted EUI goal was difficult, but achievable. Energy modeling was conservative, as it does not factor in any MEL reduction due to the difficulty in quantifying the reduction.
What challenges have you encountered in modeling the solution's performance? How are you addressing them?	Modeling MEL reduction was a challenge as discussed above. They depend in large part on occupant behavior.
What challenges have you encountered in completing an LCCA? How are you addressing them?	It was difficult to determine maintenance costs into the LCCA, because these can vary, and the frequency of maintenance is unknown. Similarly, there is information that is unknown regarding the business as usual case and existing conditions, and so there are some assumptions made regarding replacement costs and maintenance needs for the business as usual scope.
Are there any unresolved major issues? What would it take to resolve them?	No major unresolved issues.
Other comments (optional)	

Construction Budget

Key criteria to consider	How does your budget address the criteria?
Cost compression due to anticipated innovation	The main opportunities for cost compression seem to be at the manufacturing level, specifically with integrated panelized envelope solutions, and point source heat pump technologies.
Cost compression at scale	There is some opportunity for cost compression at scale, specifically with the windows and Sanden HPWHs, if they were to be ordered in bulk.
Current availability of required products	All selected products are currently available.
Anticipated future availability of required products	Point source, through-wall heat pumps that achieve VRF-level efficiencies are emerging and would benefit projects such as this by eliminating distribution of refrigerant and site installation labor.
Transportation of products/systems to project site	No issues anticipated.
On-site vs. off-site labor	The majority of labor for the proposed retrofit is on-site.

Other Questions	Team Response
What challenges have you encountered in producing a construction budget? How are you addressing them?	As with any retrofit, there are unknowns that will be uncovered when the work commences. This is especially true for the ventilation system, which will be reusing existing shafts, as well as for the in-unit energy work and non-energy retrofit work. Because every apartment unit was not accessed during design some conditions are unknown. A 10% cost contingency is included which will allow for overages and unknown conditions.
Are there any unresolved major issues? What would it take to resolve them?	No major unresolved issues.
Other comments (optional)	

Construction Schedule

Key criteria to consider	How does your schedule address the criteria?
Schedule compression due to anticipated innovation	The retrofit would not expect to see major schedule compression due to innovation. Future products such as point-source heat pumps and integrated wall panels could compress schedules on future projects.
Schedule compression at scale	The design elements of the retrofit do not lend themselves to increased schedule compression at scale.
Current availability and lead time of required products	All products specified are readily available with minimal lead time.
Anticipated future availability and lead time of required products	All products specified are expected to remain readily available with minimal lead time moving forward.
Transportation of products/systems to project site	Transportation of products and systems to the project site is not anticipated to be a restricting factor on the construction schedule.

Key criteria to consider	How does your schedule address the criteria?
On-site vs. off-site labor	The majority of labor is on-site and will be a driving factor of the construction schedule. The schedule allots two weeks of construction for each dwelling unit, and any circumstances that prevent and/or delay in-unit work may cause the schedule to slip. This will be discussed and reviewed at the resident engagement workshops in an effort to optimize and coordinate the construction schedule with the needs and schedules of residents.

Other Questions	Team Response
What challenges have you encountered in producing a construction schedule? How are you addressing them?	Similar to the construction budget, there are some unknown factors that could cause the construction schedule to slip. The condition of the apartments is one factor that could affect the ability to complete the work in each dwelling unit on time. The GC believes that two weeks per unit is an appropriate amount of time to account for these unknowns.
Are there any unresolved major issues? What would it take to resolve them?	No major unresolved issues.
Other comments (optional)	

2 Schematic Design Documents

The following documents are included in Appendix A: Schematic Design Documents

- Architectural CDs
- MEP CDs
- Equipment and material specifications

3 Scalability Strategy

Scalability was a primary driving factor throughout the evolution of the retrofit design. Whenever technologies, materials, and strategies were introduced, they were considered in the context of their applicability to other buildings, primarily in New York City or similar urban environments, and the potential to deploy the strategy at scale. Design strategies that had higher potential for replicability and cost reduction at scale were prioritized over those with comparable cost and performance but would not be as replicable.

For example, early in the design process a ground source heat pump was one of the contending strategies for the DHW system. The project site has a rear yard that would provide the space necessary for this type of system, but it was not pursued, in part because this strategy would be far less replicable for most of New York City.

The biggest barrier to scalability, and cost reductions at scale, seems to be on the side of manufacturers both for mechanical equipment and industrialized envelope solutions. The schematic design primarily uses systems and materials that are readily available now, and so they are scalable, with varying opportunities for cost compression. For further cost compression and scalability, manufacturers will need to develop (or provide to the U.S. market) new product solutions at competitive price points that are tailored to these types of retrofits.

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	The reuse of the decommissioned trash chute was pursued primarily due to its relative convenience and cost savings over other strategies. This is not necessarily the most scalable solution, as other buildings may not have a trash chute, or the flexibility to use it for other means. The reuse of existing exhaust shafts to capture returning air at central rooftop ERV's is replicable on any building with existing exhaust. While rooftop ERV units allow the supply air intake to be located away from the street level where more pollutants and contaminants are present.	The alternative strategy was to run the ductwork down the exterior of the building. On the rear this would be channeled into the EIFS. In the front, where overcladding is not permitted, the brick would be channeled out and architectural treatments as allowed by code would cover and insulate the ductwork. This approach is more replicable. Limitations on this approach relate to the shape and size of ductwork. Other RetrofitNY teams have discussed working to get varied materials approved for ductwork applications, which would provide more flexibility and opportunity for cost savings using this approach.

Space Heating/ Cooling	The primary space conditioning strategy uses central VRF equipment with wall or floor mounted AHU's in each room of the apartments. Refrigerant lines will run down the exterior of the building to limit work inside the apartments. The lines will connect to wall or floor mounted AHU's along the exterior wall, or on an adjacent wall. On the rear, where EIFS will be installed, refrigerant lines will be channeled into the backside of the EIFS. On the front façade where no EIFS will be used, lines will be channeled into the brick. The use of a VRF system is applicable to most building typologies, and the strategy of running refrigerant lines along the exterior of the building can be replicated on retrofit projects that are employing an overcladding solution, or that have brick cavity walls.	A number of space conditioning options were considered. One of these was the use of terminal water source heat pumps (WSHP) in the apartment units, paired with a central air-to-water HP plant, and reusing the existing hydronic distribution pipes to bring the supply water to the WSHP units. However, the existing distribution piping was too small to accommodate the flow necessary for the WSHP units and replacing it would have caused this approach to be non-competitive. WSHP terminal units were estimated at ~\$2,500-\$3,000 each, but these costs may come down with bulk purchasing. Two other solutions were considered that would have reused the forced hot water distribution pipes with a central air-to-water HP. One was a valance system, which uses wall mounted head units which have hot/cold water circulated through coils. As air passes over the coils it is heated or cooled. This system looked to be similar in cost the VRF system, but there was concern that labor costs might be higher as a result of the plumbing work required. There was also concern about the temperature of the water when the system was operating in cooling mode causing condensation on the distribution pipes in the risers. The presence and/or quality of insulation on the forced hot water distribution pipes was unknown, and they most likely would have needed to be reinsulated. The other solution used a central air-to-water HP paired with radiant ceiling panels in the dwelling units. The increased surface area of these radiant panels as compared to the valance system allows them to operate at higher temperature in cooling mode, which would avoid potential condensation. Preliminary analysis indicated that costs would be higher than the VRF system, and the manufacturer that we were looking into (EU Systems) did not have the necessary certifications and UL listings to install in NYC.

Space Heating/ Cooling (continued)	One Alternative we considered was the potential to run the refrigerant lines through the existing hydronic piping risers. The downside of that approach is that it would require removing the hydronic pipes, which would likely add cost, along with increasing the amount of work inside the dwelling units.	Another potential solution is the use of terminal through-wall heat pumps that can provide heating and cooling. Commonly used PTHPs are not efficient enough, especially given that most revert to electric resistance heating below about 40°F ambient. However, a product just becoming available in the U.S. (Innova Energie Air Conditioner 2.0) shows promise that PTHPs may be evolving toward an efficient retrofit-friendly solution. This product can run off of a 110v circuit and requires two or three small openings on the exterior of the building for air exchange and condensate vapor dispersal. Cold climate performance is reported to be far better than standard PTHPs but below typical VRF systems. This, or future generations of this product, may be a viable retrofit solution once more cold climate data becomes available.
Domestic Hot Water	The Sanden CO2 HPWH provides a cost-effective solution for electrifying water heating. However, there are some design constraints that may preclude its use in some multifamily applications: 1) The distance between the storage tanks and the heat pump units is recommended by the manufacturer to be less than 50 which limits where the equipment can be placed. 2) Space is necessary for the condensing units (ideally outside of the building), and the storage tanks inside of the building near the existing DHW distribution point (typically the boiler room). 3) The comparatively slower response time, and therefore the need to oversize the system storage to meet peak demand. The Sanden system is most suitable for smaller buildings with space outside within close proximity to the boiler room Due to its longer recovery time, it is necessary to have a larger storage capacity than with standard natural gas water heaters. The retrofit design calls for four heat pumps with four storage tanks to replace the two existing storage tanks.	The Sanden system was our top solution and seems to have the best potential for scalability. Other commercial HPWSs are available that eliminate some of the drawbacks, but at higher cost.

Miscellaneous Electric Loads	To reduce tenant MELs, building management will engage residents in the retrofit goals as well as provide education on energy efficiency as follows: 1) In order to gain buy-in from residents, the engagement will include briefings on the retrofit goals and plans. Residents will be given an opportunity to provide feedback on choices available within the retrofit design strategies, such as appliance selection, heat pump air handler placement, and overall look of the building exterior. 2) Education on how investments in energy efficient appliances such as TV's can help save money on electricity usage. 3) Management will provide LED lighting in warm and cool colors for resident preferences and provide building staff with replacement bulbs. 4) Provide smart power strips with USB ports to limit use by charging devices, which can also be programmed to turn off/on at certain periods to limit vampire loads. 5) The installation of USB outlets where electrical work will take place as part of the retrofit. All these strategies are easily replicable and implemented across any building typology.	N/A.
Façade	The EIFS insulation on the exterior of the building is replicable to most building types, with the caveat that current code prohibits post-1968 buildings from encroaching on the public right of way, and so buildings that are built fully to the lot line will need to address this hurdle. One strategy for circumventing this restriction is to strip the brick (on brick cavity wall buildings) and install EIFS in its place. Pursuing a variance is also an option for projects with flexible timelines. There is some discussion as to whether petroleum-based insulation products (like EPS or XPS) may require the building to have sprinklers. If this is the case, mineral wool EIFS products are an alternative, albeit about 35% more costly.	
Roof	The Siplast roof with polyisocyanurate insulation is applicable to most building typologies. Traditional roofing methods like this are well established and offer little opportunity for cost reduction through economies of scale.	

Distributed Energy Resources	The solar component of the retrofit provided more challenges than initially thought. Due to the bulkhead, existing rooftop equipment, the installation of additional rooftop equipment, and restrictions on fire pathways and setbacks, a traditional ballasted rooftop PV system would be severely limited in size. The answer to this is a canopy system mounted nine feet above the surface of the roof, that would allow it to go over the bulkhead and rooftop equipment, and avoid interfering with fire access pathway requirements, maximizing the system size. However, a canopy system is more expensive than a ballasted system and engenders structural considerations. For a block and plank building such as 439 W 125th, the cost is even higher than a typical canopy because the plank (and the parapets) cannot support the weight of the canopy, and so mounting hardware for the canopy must go through the plank and mount to the sides of the load bearing walls. The increased cost of the canopy system makes the payback period longer than the projected lifetime of the PV system, which makes securing financing difficult (although the canopy structure has a significantly longer lifetime). Another complication is that the nonprofit owner of the building is ineligible for the federal investment tax credit, or for similar state level incentives. These will need to be captured through PPA structures. The final strategy for solar is to try to reduce costs of the system however possible, secure traditional financing for the portion of the solar project that is eligible, and use a small portion of the NYSERDA gap/BAU budget to make up the difference. The building owner has a portfolio of buildings that are all getting solar, and a small portion of the cost of the canopy solar system will be spread between those other projects. This will bring the payback period for the canopy system below what is required to secure traditional financing. The owner will enter into a pre-paid PPA, which will unlock some of the available tax equity, and reduce the cost of the system further.	

The following table outlines potential cost savings for design elements implemented at scale.

Table 1. Cost compression at scale

Location	Pilot Project (1 unit)	10 units	100 units	1,000 units	10,000 units
Ventilation and IAQ	As listed	Unknown	Unknown	Unknown	Unknown
Space Heating/Cooling	As listed	Unknown	Unknown	Unknown	Unknown
Domestic Hot Water	As listed	5%-10% reduction depending on scale	5%-10% reduction depending on scale	5%-10% reduction depending on scale	5%-10% reduction depending on scale
Miscellaneous Electric Loads	As listed	Unknown	Unknown	Unknown	Unknown
Façade	$17-$20/SF	$17-$20/SF	$17-$20/SF	$17-$20/SF	$17-$20/SF
Roof	$22/SF	$22/SF	$22/SF	$22/SF	$22/SF
Distributed Energy Resources	$5/Watt	$4.90/Watt	$4.70/Watt	$4.50/Watt	

4 Budget and Financing Plan

A budget was developed for the retrofit project by identifying costs (or cost ranges where applicable) and quantities necessary for all design strategies. These costs were then compared for each design element to directly evaluate the costs in the context of other deciding factors like the impact on resident health, disturbance to residents, energy impact, replicability, and scalability. Costs were accounted for and managed by analyzing the energy impacts of each design strategy option and selecting those that had the greatest energy savings per dollar spent.

The storefront glazing, storefront overcladding, below grade wall insulation, and electric cooking conversion, were all removed due to high cost concerns and relatively minimal energy impacts. Some alternative space conditioning strategies were discarded due to high costs, in part due to the work that would need to be done on the pipe risers to make them feasible. The use of WSHPs and radiant ceiling panels would have required new piping, or pipe insulation to be installed, both of which would have increased occupant disturbance, as well as incurred increased cost.

Annual operational savings resulting from the energy retrofit measures, and subsequent decreases in energy costs over the 30-year life of the retrofit were factored into the NPV analysis. Energy costs are projected to drop by roughly 50% after the retrofit, which captures significant NPV savings over 30 years. Using a 3% discount rate, the NPV of these savings is about $52,008 per DU (or $45,020 at 4% and $39,293 at 5%). Replacement and maintenance costs for the retrofit were projected to be higher than the BAU case, primarily due to the addition of new building systems and the associated replacement costs over the life of the retrofit. The NPV of this increased replacement cost was estimated at $16,602 per DU.

The retrofit will be overcladding with EIFS at the rear and side exposed walls. EIFS is less durable than the existing brick façade, but its lifetime can be extended with routine maintenance that includes cleaning and recoating. The roof system and interior finishes will be similar in nature to the BAU rehab and will not significantly impact durability and maintenance costs.

The building at 439 West 125th street was funded through Low-Income Housing Tax Credits (LIHTC) in 1997. The nonprofit partner in the LIHTC deal is ECDO. Along with this property, ECDO pledged two additional portfolios into the JOE, totaling 18 buildings, and as such, the financials of this building must be considered in context of the larger portfolio. The plan now is to combine them into one

18 building HDFC to cross subsidize the portfolios and take advantage of economies of scale. The properties are applying together for a single loan through HPD's year 15 program. One financing path relies entirely on HPD subsidy, while another would be to pursue a PLP loan with a participating first position lender. JOE has also applied for and received a RESO A commitment for $500,000 in discretionary funds, which will be applied to the ECDO portfolio. There is a current section-8 campaign, and the portfolio is also undergoing rent restructuring. After these actions are completed, it will be determined if the portfolio can support private debt. At that point JOE will speak with CDC and HDC as two potential private lenders and discuss the potential to underwrite 50% of energy savings. Buildings not participating in the RetrofitNY program will be working through the NYSERDA MPP program as an additional source of funding for the overall portfolio.

This proposed design solution lays out a comprehensive approach to improving the energy performance of the building, while also greatly reducing the energy costs associated with operating the building throughout. These reduced operational costs are directly translated into increased net cash flow for the building owner. The proposed design solution is projected to bring utility expenses from $70,193 down to $43,207, a ~39% reduction. The reason for the comparatively larger reduction in energy use is due to the transition of fuels from natural gas to electricity. Natural gas is cheap and energy dense when compared to electricity, and so despite the ~74% reduction in energy use, energy cost only comes down ~39%. The proposed design solution is expected to cost more to maintain over time, with total capital replacement costs over the projected 30-year life of the retrofit expected to cost $1,796,452, as compared to $1,447,800 for the BAU scenario. This increased capital replacement cost is due in part to the number of products required to meet the DHW, ventilation, and space conditioning requirements, and the associated replacement costs of the additional systems. For example, two gas fired DHW storage tanks are being replaced with four storage tanks and four HPWHs. Two gas fired boilers for space conditioning are being replaced with four VRF units. While these products all have similar life expectancies, the number of units can increase the lifetime capital replacement costs. A major retrofit project such as this has complications that traditional renovations, or less comprehensive energy retrofits don't face, as evidenced in the tradeoff between reduced utility expenses and potentially increased capital replacement costs. Retrofit projects that are looking to maximize energy benefit while minimizing the impact on capital replacement costs could prioritize measures like improving the insulation and replacing lighting with LEDs, rather than replacing major building systems, which may increase replacement costs. A full budget and financing plan can be found in Appendix C.

5 Projected Construction Schedule

Completing a tenant-in-place retrofit adds complications to developing the construction schedule. Scheduling conflicts on the part of contractors or tenants both have the potential to stop work from being completed on time. These issues will be discussed with tenants during the resident engagement workshops, and coordination will be managed through the designated building management point person throughout construction. Scheduling changes and conflicts will need to be identified as early as possible and communicated to all necessary parties to ensure work can be completed and the larger schedule is not impacted.

To minimize disturbance to occupants while still allowing enough time to complete all necessary finish and energy related retrofit work, all major in-unit work is planned to be compressed into a 14-day period in each apartment. The complete construction time including all apartments and common area work is expected to be about eight months. A full construction schedule is included in Appendix D.

6 Building Performance Summary

The team began by identifying potential retrofit strategies for each major building system and component. A building energy model was then created for the existing building and calibrated to match the historical energy consumption data. Each potential retrofit measure was explored using the model to estimate the post-retrofit energy consumption.

The largest reductions in energy use came from DHW and space heating systems. The addition of EIFS façade insulation and new roof insulation and windows contributed synergistically to the space heating energy reductions. Similarly, the installation of a recirculation pump controller and flow restriction devices contributed to the performance of the new DHW system. Below grade wall insulation contributed to the improved space conditioning energy usage but was ultimately cut from the design due to cost requirements. The retrofit proposal is projected to reduce site energy use from 772,877 kWh/year to 203,721 kWh/year, amounting to reduction of 74%. 60,000 kWh/year will be generated from the on-site solar canopy system. Some of the remaining site electric usage will be offset through residential participation in available community solar projects. See Distributed Energy Resources Summary for additional details regarding on-site energy usage and renewable offset.

Throughout the design process, NYSERDA facilitated reviews of the teams' retrofit solutions by professionals in related industries. These review sessions helped identify areas requiring more specificity in materials, components, and system design features. This included filters at rooftop ERV's and in-unit evaporators, the piping design and integration of recirculation to the Sanden DHW system, and low VOC finishes.

A VRF system was identified early in the process as one of the primary strategies for space conditioning, but there were several options that continued to be explored throughout the conceptual and schematic design phases. These included a central air-to-water heat pump unit paired with terminal WSHP's (Daikin, Mitsubishi, Ice-Air) in the dwelling units, an air-to-water heat pump unit paired with radiant ceiling panels (EU Systems) or terminal valance wall-mounted units (Edwards Valance) in the dwelling units, and PTHP's (Innova Energie Air Conditioner 2.0) installed in the dwelling units where the through-wall AC sleeves currently are. These strategies were explored primarily from a desire to avoid the use of distributing refrigerants throughout the building, both from a global warming perspective as well as an occupant health perspective. The WSHP, valance, and radiant ceiling panels all offered the opportunity to reuse the existing pipe risers for the forced hot water heating system, an approach that could potentially save considerable money on installation.

The valance system required low water temperatures to operate in cooling mode, and without better knowledge regarding the presence and quality of pipe insulation in the risers, it was not guaranteed that there would not be issues with condensation without opening up the risers to inspect and re-insulate. Running new water lines (perhaps on the exterior of the building) would be cost prohibitive.

The WSHP strategy was determined to be incompatible with the existing hydronic distribution piping, which were designed for approximately 1 GPM, while the WSHP units required 2-3 GPM of flow. To move forward with this strategy, it would have required repiping, which would have increased costs beyond any of the other strategies.

The radiant ceiling panels could have solved the condensation problem, as they can operate at higher temperatures in cooling mode due to their comparatively increased surface area as compared to the valance system. However, preliminary talks with the manufacturer (EU Systems) indicated that they did not have the necessary UL and other listings required for installation in New York City. The representatives also indicated that the cost is generally higher when compared to a VRF system, with the main benefit being comfort, and so customers need to be aware of and value that tradeoff.

The Innova heat pump, while a promising emerging product in the U.S., does not have sufficient cold-climate heating data or service infrastructure existing yet to recommend using it in New York City at the present time.

Given the financial limitations, the VRF system made the most sense in the near term. Nevertheless, these three alternative technologies are promising for future retrofit scenarios in buildings with existing forced hot water distribution (or through-wall sleeves in the case of the Innova product). The building performance summary is included in Appendix E.

6.1 Distributed Energy Resources Summary

The southwest side of 439 West 125th Street faces 125th street. Across the street, the large NYCHA buildings are set back from the street and the adjoining buildings are approximately the same height as the subject building. The rear of the building (oriented northeast) faces a small yard and a construction site. The result is that 439 West 125th has excellent solar access.

If mounting a traditional ballasted rooftop system, the rooftop area is severely limited by the existing equipment and bulkhead, as well as the necessary placement of components related to the retrofit, and the required FDNY setbacks and pathways. A solar canopy system installed at least 9' up would be able to go over all of the existing equipment and the bulkhead maximizing available roof area, while still complying with FDNY setback requirements. A canopy system designed in this way was determined to be able to fit ~43kW-DC array, which would produce about 60,000 kWh/year, offsetting about 30% of the total site energy use. This system would be tied into the common meter, offsetting the owner paid electric bill.

The available space at the rear of the building brought up the possibility of a ground source heat pump. However, because of the difficulty in getting a drilling rig into the yard and due to lack of scalability for this strategy, it was abandoned.

Figure 4. Aerial view of 439 West 125th Street

6.2 Supplemental Renewables Plan

Tenants will be invited and encouraged to enroll in community solar through NYSERDA's Solar for All program. A path has not been identified to offset the additional owner-paid common space electricity usage. Community solar for the common meter was determined to not be a viable solution, as the per kWh rates for community solar are more expensive than the existing commercial service class 9 per kWh rates. This means that no financing organizations would fund the project because it would be seen to have a high likelihood of default.

7 Resident Management Plan

The team plans to begin resident engagement workshops prior to construction start to bring residents on board with the intent of the design and review the ways in which the building appearance and operation will be changing. Residents will have a say in what equipment or material gets installed, in an effort to build trust and get them bought into the project. These include wall vs. floor mounted evaporator units, low-flow shower fixtures, cool and warm LED lighting, and other measures related to MELs. Direct resident benefits include quiet cooling units in every room, control of heating thermostat setpoints, which they do not currently have, and fresh air ventilation.

The best method of promoting resident engagement regarding energy conservation is to tie it directly to their bills. The less they use, the more they save, and the education, tools, and strategies provided by the plan will help them save. Among other things, the elimination of through wall and window AC units will be discussed in terms of the improved comfort and control, the increased efficiency and reduced operating costs, so that residents do not feel like they are losing out.

Reducing resident disruption was also a primary determining factor throughout the design process, and factored into many decisions including space conditioning strategies, DHW strategies, type of windows, and ventilation design. A resident management plan is included below, and in Appendix F.

7.1 Resident Management Plan

7.1.1 Goals

- Facilitate smooth execution of work be ensuring access to all spaces
- Maintain services to residents (heating, cooling, ventilation and hot water)
- Ensure clean, safe and healthy environment throughout construction period

7.1.2 Length of construction phase

Eight months.

7.1.3 Length of resident management plan

Eleven months, from a preconstruction through a month after construction closeout.

7.1.4 Plan for resident notifications and communication

A schedule and regular notices will be distributed in advance of each construction activity that impacts residents. These include:

- Demo of roof
- Demo of interiors
- Core drilling
- Erection of scaffolding and street bridge
- Installation of new roof
- Exterior wall chase
- Closure of AC sleeves
- Insulation of exterior walls
- Installation of windows
- Interior apartment fitouts
- HVAC installation
- ERV installation
- DHW installation
- Modernization of elevator
- Concrete paving repair at front and rear

7.1.5 Resident liaison or resident groups

Resident liaison will be designated from the management company. This person will be the point person to communicate all activities and gather all feedback from residents. The will coordinate resident concerns, schedule changes, etc. with the construction/contractor representative.

7.1.6 In-unit construction plan

In-unit work to be compressed such that as much work as possible is conducted in the shortest amount of time in each apartment, including window replacement, air handler, AC sleeve patching, radiator removal, ventilation supplies, other non-energy upgrades. We have allotted 14 days per apartment for this work.

7.1.7 Exterior construction plan

Impacts include:

- Sidewalk bridge to be in place for four months.
- Rear yard—portion to be fenced off for storage and staging by contractor.
- Scaffolding to be in place on rear façade for six months.
- EIFS work on rear façade for 16 weeks—workers will be present outside windows; some noise and dust. Residents will be instructed to keep windows closed during work hours and windows/AC grilles will be masked off in work areas.

7.1.8 Parking impacts

None. No on-site parking.

7.1.9 Plan for special needs

All communications will be provided in English and Spanish.

Elevator service will be down for specified days/hours per day over the construction period. During this time a mobility plan will be developed for all residents who require regular access to the elevator. These time periods will be determined at a later date in coordination with the elevator contractor.

7.1.10 Expected areas of pushback

- In-unit access for installation of heating/cooling system.
- In-unit access and window covering modifications during window replacement.
- Shutdown of elevator for modernization.
- Elimination of through wall / window AC units.

7.2 Residents' Meeting Plan

7.2.1 Plan for initial resident outreach

An all-resident meeting will be held in the building community room to introduce the residents to the retrofit. This will cover the overarching context of the RetrofitNY project, the primary goals of the program, design strategies implemented, and the residents' active role in a successful retrofit. There are certain areas that we have identified where residents can play an active role in decision making, and the initial or subsequent meetings will provide an opportunity to gauge their interest and opinion on these issues.

7.2.2 Kickoff event

Goals of the kick-off meeting include:

- Introduce residents to the retrofit concept and goals
- Describe benefits of the retrofit to the residents
- Achieve buy-in by residents for these benefits and goals
- Get initial feedback from residents on preferences for aspects of the retrofit
- Plan subsequent engagement activities

7.2.3 Resident update meetings

Meetings will be held approximately monthly during the retrofit period to update the residents on the progress of construction and next steps.

7.2.4 Trainings

Resident trainings will be conducted by building management staff with possible assistance of manufacturers to cover the following items close to the time of installation:

- Heating/cooling units
- Windows
- DHW system performance and limitations
- LED lighting replacement
- Ventilation supply and return points

Building staff training will be conducted by installer or manufacturer representatives to cover the following items shortly after installation:

- Windows
- Heating/cooling units
- VRF units
- Ventilation units
- Water heater
- EIFS

7.2.5 Other Resident Activities

Samples of select products will be made available for residents to view, including:

- Air handler unit and remote control
- Low flow shower fixtures
- Warm and cool LED lighting options
- Smart power strips

7.2.6 Method to gauge resident participation and track achievements

The attendance at initial resident engagement meetings, as well as attendance and appetite for subsequent resident engagement meetings will be a preliminary indicator of resident participation in and awareness of the retrofit project. The ability to stay on schedule and get into units as scheduled and complete work on time will be another indicator of resident participation and successful engagement.

7.2.7 Residents' Guidelines

Include guidelines directed specifically toward residents beneath each heading or submit the guidelines as separate attachments.

7.2.8 Operations and maintenance guidelines

Residents will be provided with owner's manuals for newly installed space conditioning equipment. Residents will be made aware of replacement LED stock that can be accessed through building management.

7.2.9 Health and safety guidelines

Residents will be provided with health and safety information for in-unit AHU's and windows. In addition, residents will be provided with a document overviewing the ways in which the retrofit pursued occupant comfort and health as a primary goal. Residents will be informed of the low VOC materials being used throughout the building for work, with the goal of limited toxic exposure.

7.2.10 Residents' guide to understanding the utility bill

Residents utility bills should not change from their existing format. Residents may see a bill reduction as a result of cooling being moved off their meter.

7.2.11 Schedule of routine in-unit maintenance

Residents will be made aware of routine maintenance necessary to maintain the functional operation of in-unit systems, the primary one being the in-unit air handlers. A maintenance schedule will be developed showing residents how frequently maintenance staff would need access to the unit. A system can be developed for residents to sign up for times when the maintenance staff will be on site to improve access availability.

8 Performance Guarantee Pathway

The team looked at the available warranties and extended warranties and divided the life of the retrofit into six 5-year periods during which the risk of maintaining the system increases as warranties expire, and systems get older and more likely to fail. If a solution provider were going to develop a performance guarantee, the cost of that would need to increase as the risk to the provider increases over this time (see Figure 5).

As many of the systems and technologies being developed are new, it is hard to understand all the challenges to maintaining them for the life of the project in a way that makes economic sense for both building owners and performance guarantee providers. A performance guarantee pathway is included below, and in Appendix G

8.1 Guaranteed Energy Performance Parameters

Which of your solution's energy performance parameters can be guaranteed? For example, 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).

Only items that can be measured at a reasonable cost are included:

1. kWh per hear for total building heating - VRF system and commercial ducted mini-split heat pumps
2. On-site PV kWh production – PV system
3. Gallons DHW at a specified temperature per day – heat pump water heater

8.1.1 Warranty Term Lengths

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

1. VRF system
    a. Standard one-year parts warranty for a qualified system. Additional six-year compressor part warranty – compressor is warranted for an additional six-year period after the end of the applicable standard part warranty period.
    b. Installation, repair, maintenance and service must be performed by authorized third party service providers.
    c. "Extended Warranty: The standard warranty period and the compressor warranty period are extended to a total of 10 years for qualified systems that have been (a) commissioned by a party that has completed the current Training Requirements, (b) such commissioning

is pursuant to LG’s current published instructions, and (c) the system commissioning results and supporting documents are entered correctly into LG’s online commissioning system. Commissioning of a system requires one hour of LG monitoring view (LGMV) data. Commissioning results must be entered into LG’s online commissioning system within 60 days of system startup.”

2. Ducted mini-split heat pumps
   a. See Above for LG products.
3. Heat pump water heater
   a. From Sanden SANCO$_2$ Heat Pump Water Heater Technical Information October 2017
      - “The Sanden warranty is 10 years on the Heat Pump refrigeration circuit, 10 years on all other parts, 15 years (prorated after 10 years) on the tank, and three years on labor costs.”
4. ERV
   a. “Fantech ERV’s have a warranty that is limited to five years on all parts, five years on energy recovery core and seven years on the motors from the date of purchase, including parts replaced during this time period. If there is no proof of purchase available, the date associate with the serial number will be used for the beginning of the warranty period.”
   b. Ventacity
      i. Two years for unit and 10 years on the core.
      ii. No extended warranty offered.
5. Windows
   a. 20 yrs profile material and workmanship
      10 yrs hardware
      20 yrs foil lamination
      5 yrs glass
6. EIFS
   a. 15-year limited warranty.
7. Roof
   a. Product Guarantees available up to 20-year warranty on membrane/roofing system. Subject to in-progress and post construction final inspection by Siplast Representative.

8.1.2 List of High-Level Maintenance Needs

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.

1. **VRF system**
    a. Schedule Annual service inspections to ensure system performance. Follow manufacturers recommendations for servicing and maintenance.
2. **Ducted mini-split heat pumps**
    a. Annual/Biannual general maintenance on outdoor units and indoor air handlers.
3. **Heat pump water heater**
    a. Follow GS3-45HPA system maintenance guidelines for annual routine maintenance.
    b. **Water Supply Quality**: Chloride and PH In areas with a high concentration of chloride in the water, that water can cause corrosion and subsequent failures. Where the chloride level exceeds 0.1 ounces per gallons (200 mg/litre), the warranty is no longer valid on to the heat pump unit and tank unit. PH is a measure of whether the water is alkaline or acid. In an acidic water supply, the water can attack the parts and cause them to fail. No warranty coverage is given on the heat pump unit and tank unit where the PH is less than 6.0. Supply Water with a PH less than 6.0 may be treated to raise the PH. It is recommended that an analysis of the Supply Water be conducted before connecting the Heat pump unit to the system.
    c. Heat Pump If the heat pump unit is installed outdoors, it will be exposed to the elements. Remove the top and side covers of the unit and check the evaporator for any dirt or debris. On the Gen2 unit, there is a filter on the cold-water inlet connection – periodically, it needs to be removed and the filter cleaned. Check for leaks of any kind from pipes and tears in insulation. To clean the unit, simply blow away the debris with an air hose or spray the unit down with a water hose, coil cleaning solutions can be used without problem.
    d. System Draw water from the tank via a faucet: check the delivered mixed temperature vs customer requirement. Adjust the mixing valve if needed. Draw water from the tank to start the heat pump. Check the unit parameter mode to check delivered water temperature vs set-point. Check error history. Note any recent or new error codes If drain down freeze protection system is installed, cycle the power to check valve operation – restart system and ensure unit operation.
    e. Tank Open the pressure relief valve to prevent sticking, ensure water is discharged. Check the thermistor connection in to the thermistor well and the wiring connection to the terminals (both sides of the terminal).
4. **ERV**
    a. "It is recommended to check and clean the unit every six months; however, the intervals must be adapted to specific operating conditions. It is recommended to thoroughly clean the unit once a year. If the unit is
    b. Filter replacements
    c. Annual system inspections and cleanings
    d. More frequent inspections the first year to assess how system is performing and ensure there are no site conditions leading to unexpected/ accelerated system degradation.
5. **Windows**
    a. Periodic cleaning.

6. **EIFS**
    - **a.** Manufacturer recommends level 1 clean and recoat at end of warranty period and every 15 years thereafter. "A basic program to remove dirt, mold and mildew, while refreshing or updating the color of the façade. The Clean & Recoat program involves pressure washing, minor patching, and recoating with a high-performance Sto Coating that will resist future soiling, cracking or fading."
    - **b.** Sto provides 10-year warranty on recoating/restoration.
7. **Roof**
    - **a.** Little maintenance needed prior to end of warranty period. General inspection and patching as necessary beyond 20-year projected life.

8.1.3 Aligning and Coordinating Maintenance Schedules and Warranties

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.

1. VRF system
    - a) The cost and provision of routine maintenance can be brought under the performance guarantee provider.
    - b) Performance guarantee provider performs necessary commissioning tasks to obtain extended warranty for VRF equipment, and performs routine maintenance as specified by manufacturer to maintain best system operation.
2. Ducted mini-split heat pumps
    - a) The cost and provision of routine maintenance can be brought under the performance guarantee provider.
    - b) Performance guarantee provider performs necessary commissioning tasks to obtain extended warranty for VRF equipment, and performs routine maintenance as specified by manufacturer to maintain best system operation.
3. Heat pump water heater
    - a) Follow GS3-45HPA system maintenance guidelines for annual maintenance. Performance guarantee provider performs annual maintenance to ensure best system operation.
4. ERV
    - a) The cost and provision of routine maintenance can be brought under the performance guarantee.
5. Windows
    - a) n/a
6. EIFS

a) Periodic inspections of EIFS system should begin as limited warranty reaches end of life to assess need for refinishing and recoating. At the time of recoating/refinishing of EIFS system, extended 10-year warranty is obtained.

7. Roof
    a) Annual inspections of roof system should begin after warranty expires, unless otherwise indicated by manufacturer.

8.1.4 Maintenance Work and Performance Guarantee

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

The team envisioned a third party that provides the performance guarantee package to the building owner in 5-year periods to account for the phasing out of standard manufacturers warranties, and the increased risk of decreased system performance. This third party would bundle the manufacturers warranties, and take necessary steps to obtain, purchase and provide extended warranties from manufacturers where available. This would include any commissioning tasks necessary to be eligible for extended warranty, along with any maintenance upkeep needs to remain eligible. Among other things, the performance guarantee provider could coordinate the routine maintenance for all building systems covered under the performance guarantee. The maintenance work would be contracted through the third-party organization, potentially with the original contractors where appropriate.

1. VRF system
2. Ducted mini-split heat pumps
3. Heat pump water heater
4. ERV
5. Windows
6. EIFS
7. Roof

8.1.5 Energy Performance Guarantee

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)?

The provider of the performance guarantee would act as an intermediary between building owners and manufacturers.

1. VRF system
2. Ducted mini-split heat pumps
3. Heat pump water heater
4. ERV
5. Windows
6. EIFS
7. Roof

Figure 5. Warranty schedule and performance guarantee period

	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Y16	Y17	Y18	Y19	Y20	Y21	Y22	Y23	Y24	Y25	Y26	Y27	Y28	Y29	Y30
VRF System	Parts																													
	Six year compressor warranty																													
	Extended standard warranty on parts and compressor w/ comissioning																													
Ducted mini-split heat pumps	Extended standard warranty w/ comissioning																													
HPWH	10 year warranty on heat pump refrigeration circuit																													
	15 year warranty on tank																													
ERV	5 year warranty on parts and energy recovery core																													
	7 year warranty on motors																													
Windows	5 year warranty on glass																													
	10 year warranty on hardware																													
	20 year warranty on foil lamination and profile material and workmanship																													
EIFS	15 year limited warranty																													
Roof	20 year limited warranty on membrane and roofing system																													
Performance Guarantee Period	Period 1					Period 2					Period 3					Period 4					Period 5					Period 6				

8.1.6 Cost Impacts of the Maintenance and Guarantee Provider

How would the cost be impacted if the maintenance and guarantee provider is under contract for 100 performance guarantees? For 1,000?

Risk could be spread out across the larger portfolio and the cost of providing performance guarantee would likely be reduced. Performance guarantee provider could also expand in-house expertise and capacity for performing maintenance and repairs where necessary.

8.2 M&V

8.2.1 Building System Monitoring

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

A third-party monitoring provider will instrument the building and provide the data interface and analytics. The solution provider will review the data periodically and identify and performance issues.

8.2.2 Building System Components

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

The following components will be monitored:

1. VRF system
2. Ducted mini-split heat pumps
3. Heat pump water heater
4. ERV
5. Interior space temperatures in each room served by the VRF system via the VRF Bacnet port

8.2.3 Technology and Product Protocols

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

Sentient Buildings building automation and management system using bacnet interface from Intesis and a T-Star gateway from Intelistar.

8.2.4 Monitoring Building Systems

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

- $500 per equipment item to be monitored for each of 12 items = $6,000
- Two gateways at $2,000 each including labor
- $2,500 miscellaneous wiring and labor
- $12,500 total installation

8.2.5 Analyzing Data

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

Annual hosting fee of $1,000 for 100 data points; $2,250 for 250 data points. Selection to be determined. Hosted analytics platform "Skyspark" permits flexible rules-based warnings and alerts.

8.2.6 Key Performance Indicators

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

Sentient has four standard KPIs:

1. Efficiency (incorporates runtime, fan speeds and outdoor air temp)
2. Comfort (device point temperatures read from central VRF unit)
3. Network status to verify connectivity
4. Operations – rules and alarms for performance assessment

For ventilation equipment, supply and exhaust air temperatures; for water heater, tank, supply, return and mains water temperatures.

8.2.7 List the Sampling Rate for Each KPI

Generally, 5-minute intervals.

8.2.8 Operation Efficiency with the M&V Program

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.

One way the monitoring system can improve operational efficiency is to implement auto-setback for each VRF air handler with occupancy override when thermostat is touched.

Another way the M&V program will improve operational efficiency is to monitor water usage throughout the year to ensure there are no leaks that could cause damage, as well as to ensure savings from water conservation are realized.

8.2.9 Impact of Operational Efficiency Improvements

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.

Ongoing monitoring will help ensure that the building systems are working properly and help identify any potential issues earlier than they otherwise might be.

9 Regulatory Barrier Summary

The main regulatory barrier that the team encountered was the code restriction on post-1968 buildings extending over-cladding past the lot line at the street, as this encroaches on the public right of way. Pre-1968 buildings are allowed to extend past the lot line up to four inches, but post-1968 buildings must currently pursue revocable consent from the DOB for this allowance. The 439 West 125th property was built in 1997, and as such would need to pursue revocable consent or a variance. The team is considering pursuing a variance so that EIFS overcladding could be installed at a future date, and to establish a precedent for other buildings. Regulatory barrier summary included below, and in Appendix H.

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**
2014 NYC Building Code	3202.2	Encroachments above grade	Encroachments subject to the area limitations notes that a veneer may be applied to the entire façade of a building erected before December 6, 1968, if such veneer does not project more than 4" beyond the street line. Technical affairs at the NYC DOB has confirmed the reading of the code that a new veneer is not permitted on the street façade of 439 W. 125th because it is a post 1968 building. Note that this projection is permitted for ornamentation less than 10SF within 100SF of wall area. Note also that an over-cladding does not satisfy the requirements of an encroachment not subject to wall area limitations. This code section exists in both the 2008 code (same code section) and 1968 (27-313a).	The DOB technical affairs office was contacted to confirm this code interpretation. DOB directed team members to the DOT, to pursue Revocable Consent to extend past the lot line. Once Revocable Consent was received the owner may approach DOB with a construction code determination (CCD1).	No		Maybe
1968	27.335.1	Thermal insulation; use in non-combustible construction	The code section limits the ability to install combustible insulation, such as an EIFS system, on a building classified as non-combustible.	Discussed the code section and design intent with DOB personnel. Reached out to STO, who are unfamiliar and not encountered this as a barrier.	Unsure if this is actually an issue		Maybe

10 Resiliency Summary

The proposed retrofit addresses resiliency mainly by increasing the building's ability to maintain habitable interior conditions throughout prolonged power outages and loss of building system operation. The increased insulation and high-performance windows contribute to the building's ability to maintain temperatures even when building systems are not operating due to loss of power.

Because of the building's location, it is not highly vulnerable to sea level rise, or flooding during heavy rainfall events. The primary risk is loss of power and the subsequent elevation or drop in interior temperatures, eventually reaching unsafe levels. High-performance buildings with increased insulation are better equipped to deal with this. The inclusion of operable windows also contributes to the resiliency of the design by allowing occupants to open windows and flush out the building with cool night air as opposed to running cooling, or at times when cooling is not available due to power outages.

Resiliency positively impacts long-term durability of the design decision, because it means the building will continue to provide comfortable interior conditions even in the face of climate change and the expected changes to temperature throughout the year. Resiliency summary included below, and in Appendix I.

Indicator	Design Solution
Protection: Identify strategies to reduce a building's vulnerability to extreme weather:	
Flood-proofing or Flood Control	No additional flood proofing or flood control. Building is located outside of flood plain.
Sewer Backflow Prevention	Existing backflow prevention.
Mechanical Equipment Protection and Location	New mechanical space conditioning and ventilation equipment will be located on rooftop, contributing to resilience from potential damage due to flooding, or ruptured water main, as well as healthier air quality being delivered to living spaces by pulling supply air from roof rather than street level. Domestic hot water storage tanks are located in basement due to location of existing distribution piping.
Electrical Equipment Protect and Location	No work being performed on electrical equipment.
Backup Power Location and Protection	No backup power being added.
Communications	No work on communication systems.
Envelope Protection	EIFS exterior insulation being added to rear and side walls. Solar canopy will provide buffer to roof from elements. Reduce weathering on rooftop equipment and roofing system.
Fire Protection	Upgrading smoke and fire alarm systems to be hardwired throughout the building.

Adaptation: Identify strategies that improve a facility's ability to adapt to changing climate conditions:	
Envelope Design	New windows, EIFS insulation, and additional roof insulation will contribute to buildings optimized energy performance, and enhanced comfortability. An optimized envelope makes the building perform better in hot and cold exterior temperature conditions, preparing it for the variability that NYC can expect to see.
Mechanical Equipment	High efficiency mechanical equipment will provide heating and cooling in all units. As temperatures change over the coming decades, this higher efficiency system will translate into increasing energy savings for residents as compared to operating window and through-wall AC units.
Passive Cooling or Ventilation Strategies	Operable windows provide opportunities for passive cooling. Solar canopy provides shading for the building.
In-unit	
Site	
Backup: Identify strategies that provide critical needs for when a facility loses power or other services:	
Critical Systems with Backup	N/a
Backup Power Type	N/a
Access to Potable Water and Sanitary Services	N/a
Safety Precautions for Mechanical Equipment Operations	N/a
Community: Identify strategies that encourage behavior which enhances resilience:	
Emergency Management Awareness for Residents	Emergency management will be discussed at the resident engagement workshops, along with strategies for increasing communication and coordination between residents, building management, and the larger local community during emergency scenarios. Message boards, both virtual and physical, can be put together to communicate aspects of the retrofit project throughout the remainder of the design phase as well as through construction. These forums can continue to be used by residents in whatever manner they find helpful moving forward with the coordination of building management.
Access to Manuals, Emergency Event Guidelines	We will encourage the development of an emergency management plan by building management in coordination with residents to cover proceedings in the event of a fire, flood, earthquake, building system failure, or other emergency scenario. This should outline any health and safety related concerns relating to the building design and functionality that may be compromised in event of an emergency situation.

11 Resident Health Impact Summary

The inclusion of balanced ventilation and the use of low VOC paints are two elements of the retrofit that will contribute positively to indoor air quality and improved resident health. The ERV rooftop units will be equipped with MERV 13 filters, while the evaporators in the dwelling units will have MERV 8 filters installed. Building management will be available to assist residents with cleaning and/or changing filter as necessary and will contract out routine maintenance for the ERVs. The evaporators will remove moisture from the air and drain condensate down to the street level to terminate in drains. Decisions around space conditioning were made with moisture management in mind. The new conditioning system should contribute to improved resident comfort, as will the addition of high-performance windows. A resident health impact summary is included in Appendix J.

Indicator	Location	Intervention	
		Design Solution	Maintenance Plan
Mold	Units - Kitchens	Maintain proper ventilation from kitchens.	Building does not currently have bulk water/ moisture issues in units or common spaces. Educate residents on proper functioning of balanced ventilation; ensure registers are not being blocked preventing adequate air exchange.
	Units - Bathrooms	Maintain proper ventilation from bathrooms.	Building does not currently have bulk water/ moisture issues in units or common spaces. Educate residents on proper functioning of balanced ventilation; ensure registers are not being blocked preventing adequate air exchange.
	Units - Windows and Exterior Doors	Double glazed high-performance windows in the rear will minimize condensation on/around windows due to extreme temperature differences.	Building does not currently have bulk water/ moisture issues in units or common spaces.
	Units - Mechanical Rooms	Air sealing of fresh air louver in basement boiler room.	No existing mold issues
	Common Areas - Windows and Exterior Doors	No existing mold issues	No existing mold issues
	Common Areas - Mechanical Rooms	No existing mold issues	No existing mold issues
	Below Grade	No existing mold issues	No existing mold issues
Pests	Units	Design solutions did not target pests at dwelling units	
	Common Areas	Design solutions did not target pests at common areas, beyond replacing exit doorway to rear.	
	Below Grade	Air sealing in basement, replacement of basement doors to exterior.	
	Exterior	Construction of a better trash storage area in the rear of the building to prevent pests getting into and being attracted to the trash.	

VOCs (enter level of VOCs in products: conventional, low - or no- VOC)	Units - Paints	Low VOC, to be spec'd out in final CD's	Include low VOC materials in scope for continued renovations, painting between occupancies, general repairs.
	Units - Coatings	Low VOC, to be spec'd out in final CD's	Include low VOC materials in scope for continued renovations, painting between occupancies, general repairs.
	Units - Primers	Low VOC, to be spec'd out in final CD's	Include low VOC materials in scope for continued renovations, painting between occupancies, general repairs.
	Units - Adhesives and Sealants	Low VOC, to be spec'd out in final CD's	Include low VOC materials in scope for continued renovations, painting between occupancies, general repairs.
	Units - Flooring Materials	Low VOC, to be spec'd out in final CD's	Include low VOC materials in scope for continued renovations, painting between occupancies, general repairs.
	Common Areas - Paints	Low VOC, to be spec'd out in final CD's	Include low VOC materials for general upkeep of common spaces, miscellaneous repairs.
	Common Areas - Coatings	Low VOC, to be spec'd out in final CD's	Include low VOC materials for general upkeep of common spaces, miscellaneous repairs.
	Common Areas - Primers	Low VOC, to be spec'd out in final CD's	Include low VOC materials for general upkeep of common spaces, miscellaneous repairs.
	Common Areas - Adhesives and Sealants	Low VOC, to be spec'd out in final CD's	Include low VOC materials for general upkeep of common spaces, miscellaneous repairs.
	Common Areas - Flooring Materials	Low VOC, to be spec'd out in final CD's	Include low VOC materials for general upkeep of common spaces, miscellaneous repairs.
Other Contaminants	Units	MERV 11/13 filter in ERV to provide clean air for recirculation.	Regular filter replacement, routine servicing and cleaning of ERV units.
	Common Areas	MERV 11/13 filter in ERV to provide clean air for recirculation.	Regular filter replacement, routine servicing and cleaning of ERV units.

12 Overall Rehab Proposal

The general contractor will handle all work relating to both the energy retrofit and the non-energy retrofit scope. The architect will create final construction documents and specifications for all scopes of work, and the MEP engineer will handle all work relating to mechanical, electrical, and plumbing systems. Scheduling work for the in-unit renovation and energy retrofit work will require coordination between the multiple trades involved and the residents to ensure work is completed on schedule while minimizing the length of time that work within the dwelling units is taking place. The general contractor will be overseeing all aspects of construction and will work closely with the resident management point-person to ensure scheduling conflicts are identified early and accounted for. Energy retrofit work in the dwelling units consists of installing new HVAC equipment, new faucets and fixtures, ducting for ventilation supply air, and patching the AC sleeves. The energy retrofit work should take place prior to the conventional renovation scope to ensure interior finish work is not disturbed. Beyond scheduling issues, there are no foreseeable major complications with integrating the high-performance retrofit scope with the conventional renovation measures. The overall rehab proposal is included in Appendix K.

References

2014 New York City Building Code, Section 3202.2

Appendix A. Schematic Design Documents

(Click on image to access the schematic drawings)

CTA ARCHITECTS P.C.
151 West 26th Street - 8th Floor
New York, New York 10001-6810
Tel: 212.243.7404 info@ctaarchitects.com

RENDERING OF PROPOSED REAR ELEVATION
RetrofitNY
Project Address: 439 WEST 125TH STREET, NEW YORK, NEW YORK 10027

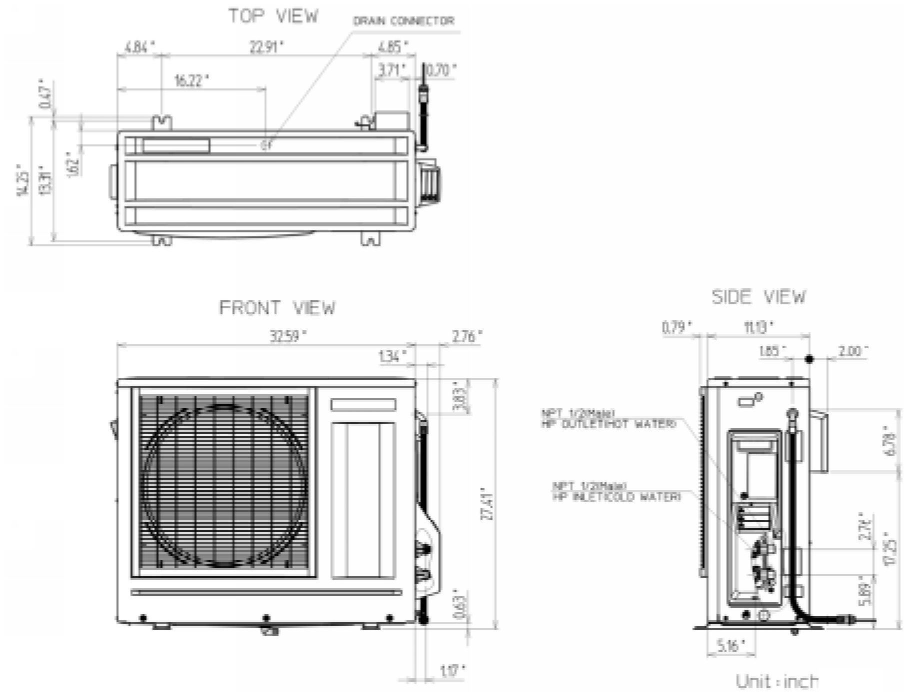
18116

SK-12

12.18.2018

(Click on image to access the rendering)

GS3-45HPA-US Dimensions



Specification

Refrigerant type	R744(CO2)
Mass volume	22 oz. (650g)
Setting Outlet water temp	130～175° F
Product weight	106lb (48 kg)
Thermal capacity	4.5 kw
Fan motor FLA	0.3A , 70W
Water pump FLA	0.2A , 30W
Compressor RLA / LRA	7.5 / 9.8A
MCA	13A
Circuit Breaker Size	15A
Design Pressure(High / Low)	1885 /1059 PSI
Max inlet water temperature	110° F
Protection Raining Class	IPX4
Max, Operating water Pressure	100PSI

(Click on image to access the cutsheets)

Appendix B. Scalability Strategy

NYSERDA RetrofitNY – Schematic Design
Scalability Strategy
Team:

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	The re-use of the decommissioned trash chute was pursued primarily due to its relative convenience and cost savings over other strategies. This is not necessarily the most scalable solution, as other buildings may not have a trash chute, or the flexibility to use it for other means. The reuse of existing exhaust shafts to capture returning air at central rooftop ERV's is replicable on any building with existing exhaust. Where existing shafts are not available to bring supply through the interior of the building, we recommend exterior ducting along the face of the building, covered with EIFS or other overcladding, or architectural treatments where overcladding is not possible. While having lower efficiency, rooftop ERV units allow the supply air intake to be located away from the street level where more pollutants and contaminants are present.	The alternative strategy we explored as a team was to run the ductwork down the exterior of the building. On the rear this would be channeled into the brick with EIFS going over. In the front, where EIFS is not permitted, we were going to channel into the brick and provide architectural treatments as allowed by code to cover and insulate the ductwork. This approach would be more replicable. Limitations on this approach relate to the shape and size of ductwork. Other teams have discussed working to get varied materials approved for ductwork applications, which would provide more flexibility and opportunity for cost savings using this approach.
	Our primary space conditioning strategy uses central VRF equipment with wall or floor mounted AHU's in each room of the apartments. We plan to run the refrigerant lines down the exterior of the building to limit work inside of the apartments, and bring the	We considered a few alternatives for space conditioning. One of these was the use of terminal water source heat pumps (WSHP) in the apartment units, paired with a central air-to-water HP plant, and reusing the existing hydronic distribution pipes to bring the supply water to the

Scalability Strategy

Structural Analysis

(Click on the links above to access the Sustainability Strategy and Structural Analysis)

Appendix C. Budget and Financing Plan

NYSERDA RETROFIT NY										
Lifetime Cost Cycle Analysis										
The Levy Partnership - 439 West 125th Street, New York, NY										
					Upfront Costs	**Y6**	**Y7**	**Y8**	**Y9**	**Y10**
BAU Capital Costs					1,225,574	3,250	111,150	0	0	43,005
NZE Capital Costs					2,456,614	0	0	0	0	21,971
NZE vs BAU Difference					1,231,040	-3,250	-111,150	0	0	-21,034

Max Outyear Analysis	30
Discount Rate for NPV Analysis	3.0%

Capital Replacement Summary	BAU	NZE	Difference	Per NZE Unit
Total Upfront Capital Costs	1,225,574	2,456,614	1,231,040	58,621
Total Capital Replacement Costs, Y0-30	1,447,800	1,796,452	348,652	16,602
Avg Annual Capital Replacement Cost	48,260	59,882	11,622	553

Economic Impact Measures, Capital Only	BAU	NZE	Difference	Per NZE Unit
Total Cost of Ownership*, Y0-30	2,673,373	4,253,065	1,579,692	75,223
Net Present Value Cost, Y0-30	1,915,876	3,255,579	1,339,703	63,795
Savings to Investment Ratio*, Y0-30			-0.283	

Net Operating Income	Y6	Y7	Y8	Y9	Y10
BAU Net Operating Income	-645	-3,069	-5,613	-8,283	-11,083
NZE Net Operating Income (without lender discount)	43,961	42,742	41,437	40,040	38,548
NZE vs BAU Difference	44,606	45,811	47,050	48,323	49,631

Economic Impact Measures, Capital plus Operational	BAU	NZE	Difference	Per NZE Unit
Net Present Value of NOI, Y0-30	-531,253	560,919	1,092,172	52,008
Total Cost of Ownership including NOI*, Y0-30	3,732,517	3,538,836	-193,681	-9,223
Net Present Value of Cost (incl NOI return), Y0-30	2,447,129	2,694,660	247,531	11,787
Savings to Investment Ratio (incl NOI return)*, Y0-30			1.157	

**Nominal Dollars*

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

Appendix D. Projected Construction Schedule

Input project start and completion dates for each task. Durations will calculate automatically in column G and appear in the Gantt chart to the right. Add rows as needed to delinate major project tasks not shown below or expand on those that are.

Highlight Date: 3/11/19

Work Package	Task	Start	Days	Completion
PRECONSTRUCTION	CDs Complete	W 10/30/19	4	T 11/05/19
	Permits Pulled	W 1/01/20	0	W 1/01/20
	Construction Contract Finalized	F 11/15/19	0	F 11/15/19
	Project Closing Date	M 12/2/19	0	M 12/02/19
PROCUREMENT	Procurement Period	M 12/16/19	0	M 12/16/19
CONSTRUCTION	Site Prep and Demolition	M 1/6/20	110	M 6/08/20
	-Building Envelope	M 1/6/20	110	M 6/08/20
	-Mechanical Systems	M 1/6/20	110	M 6/08/20
	Exterior Renovation	M 1/6/20	110	M 6/08/20
	-Building Envelope	M 1/6/20	110	M 6/08/20
	-Mechanical Systems	M 1/6/20	110	M 6/08/20
	Interior Renovation	M 2/3/20	150	M 8/31/20
	-Building Envelope	M 2/3/20	107	W 7/01/20
	-Mechanical Systems	M 2/3/20	107	W 7/01/20
	Installation Onsite Renewables	M 2/3/20	0	M 2/3/20
CLOSEOUT	Equipment Start up and Testing	W 7/1/20	0	W 7/1/20
	Commissioning of Systems	W 7/1/20	22	S 8/1/20
	Punchlist Inspection	S 8/1/20	21	T 9/1/20
	Correction of Punchlist Items	S 8/1/20	21	T 9/1/20
	Final Inspection	T 9/1/20	0	T 9/01/20
	Project Complete	T 9/1/20	0	T 9/01/20

(Click on image to access the Projected Construction Schedule)

Appendix E. Building Performance Summary

				Design/Rating
Envelope	Above Grade Wall	AG Wall Ambient	Construction	R-24.6: 4" EPS, 4" Brick, 8" CMU, 2x3 SS w/ FB, 5/8" gyp
			U-value	R-24.6
		AG Wall Front Façade	Construction	R-7.7: 4" Brick, 8" CMU, 2x3 SS w/ FB, 5/8" gyp
			U-value	R-7.7
		Adiabatic AG Wall	Construction	R-6.6: 8" CMU, 2x3 SS w/ FB, 5/8" gyp
			U-value	R-6.6
	Continuity Insulation and Sealing		Penetrations through envelope	On rear there will be no penetrations through continuous insulation except for window openings.
			Air tightness (ACH_{50})	2.0 ACH
	Below Grade Wall		Construction	R-0.84: 8" concrete
			U-value	R-0.84
	Roof		Construction	R-37.14: 4" Polyiso, 4" Concrete, 2x14 SS w/ 6" FB, 5/8" gyp
			U-value	R-37.14
	Fenestration		Framing	Vinyl framing
			Glazing	Double-pane, argon filled, low-e
			Assembly U-factor	Double Pane: U glass: 0.25, U frame: 0.176, SHGC: 0.52 (Uw 0.28)
			Assembly SHGC	Double Pane: U glass: 0.25, U frame: 0.176, SHGC: 0.52 (Uw 0.28)
	Doors		Type/description	
			U-value	
HVAC	Heating	Residential Spaces	System type/description	VRF with wall mounted or floor mounted in unit air handlers
			Efficiency	COP 3.25-3.59
			Capacity	
		Commercial Spaces	System type/description	Mini-split heat pump with wall mounted air handlers
			Efficiency	COP 3.22
			Capacity	
	Cooling	Residential Spaces	System type/description	VRF with wall mounted or floor mounted in unit air handlers
			Efficiency	COP 3.25-3.59
			Capacity	
			System type/description	Mini-split heat pump with wall mounted air

Building Performance Summary

WUFI Existing Site Energy Report

WUFI Final Iteration Site Energy report

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

Appendix F. Resident Management Plan

Management Plan

Goals

- Facilitate smooth execution of work be ensuring access to all spaces
- Maintain services to residents (heating, cooling, ventilation and hot water)
- Ensure clean, safe and healthy environment throughout construction period

Length of construction phase

8 months.

Length of resident management plan

11 months, from a preconstruction through a month after construction closeout.

Plan for resident notifications and communication

A schedule and regular notices will be distributed in advance of each construction activity that impacts residents. These include:

- Demo of roof
- Demo of interiors
- Core drilling
- Erection of scaffolding and street bridge
- Installation of new roof
- Exterior wall chase
- Closure of AC sleeves
- Insulation of exterior walls
- Installation of windows
- Interior apartment fitouts
- HVAC installation
- ERV installation
- DHW installation
- Modernization of elevator
- Concrete paving repair at front and rear

Resident liaison or resident groups

Resident liaison will be designated from the management company. This person will be the point person to communicate all activities and gather all feedback from residents. The will coordinate resident concerns, schedule changes, etc. with the construction/contractor representative.

In-unit construction plan

In-unit work to be compressed such that as much work as possible is conducted in the shortest amount of time in each apartment including: window replacement; air handler, AC sleeve patching, radiator removal, ventilation supplies, other

(Click on image to access the Resident Management Plan)

Appendix G. Performance Guarantee Pathway

<table>
<tr><th></th><th>Y1</th><th>Y2</th><th>Y3</th><th>Y4</th><th>Y5</th><th>Y6</th><th>Y7</th><th>Y8</th><th>Y9</th><th>Y10</th><th>Y11</th><th>Y12</th><th>Y13</th><th>Y14</th><th>Y15</th><th>Y16</th><th>Y17</th><th>Y18</th><th>Y19</th><th>Y20</th><th>Y21</th><th>Y22</th><th>Y23</th><th>Y24</th><th>Y25</th><th>Y26</th><th>Y27</th><th>Y28</th><th>Y29</th><th>Y30</th></tr>
<tr><td rowspan="3">VRF System</td><td colspan="1">Parts</td><td colspan="29"></td></tr>
<tr><td colspan="6">Six year compressor warranty</td><td colspan="24"></td></tr>
<tr><td colspan="10">Extended standard warranty on parts and compressor w/ comissioning</td><td colspan="20"></td></tr>
<tr><td>Ducted mini-split heat pumps</td><td colspan="10">Extended standard warranty w/ comissioning</td><td colspan="20"></td></tr>
<tr><td rowspan="2">HPWH</td><td colspan="10">10 year warranty on heat pump refrigeration circuit</td><td colspan="20"></td></tr>
<tr><td colspan="15">15 year warranty on tank</td><td colspan="15"></td></tr>
<tr><td rowspan="2">ERV</td><td colspan="5">5 year warranty on parts and energy recovery core</td><td colspan="25"></td></tr>
<tr><td colspan="7">7 year warranty on motors</td><td colspan="23"></td></tr>
<tr><td rowspan="3">Windows</td><td colspan="5">5 year warranty on glass</td><td colspan="25"></td></tr>
<tr><td colspan="10">10 year warranty on hardware</td><td colspan="20"></td></tr>
<tr><td colspan="20">20 year warranty on foil lamination and profile material and workmanship</td><td colspan="10"></td></tr>
<tr><td>EIFS</td><td colspan="15">15 year limited warranty</td><td colspan="15"></td></tr>
<tr><td>Roof</td><td colspan="20">20 year limited warranty on membrane and roofing system</td><td colspan="10"></td></tr>
<tr><td>Performance Guarantee Period</td><td colspan="5">Period 1</td><td colspan="5">Period 2</td><td colspan="5">Period 3</td><td colspan="5">Period 4</td><td colspan="5">Period 5</td><td colspan="5">Period 6</td></tr>
</table>

(Click on image to access the Performance Guarantee Pathway)

Appendix H. Regulatory Barrier Summary

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**
2014 NYC Building Code	3202.2	Encroachments above grade	Encroachments subject to the area limitations notes that a veneer may be applied to the entire façade of a building erected before December 6th 1968, if such veneer does not project more than 4" beyond the street line. Technical affairs at the NYC DOB has confirmed our reading of the code that a new veneer is not permitted on the street façade of 439 W. 125th because it is a post 1968 building. Note that this projection is permitted for ornament less than 10SF within 100SF of wall area. Note also that an over-cladding does not satisfy the requirements of an encroachment not subject to wall area limitations. This code section exists also in both the 2008 code (same code section) and 1968 (27-313a).	We have contacted representatives at the DOB technical affairs office for confirmation of our reading. We were directed by the DOB to the DOT, to pursue Revocable Consent to extend past the lot line. After we receive this, we could go to the DOB with a CCD1.	No		
1968	27.335.1	Thermal insulation; use in non combustible construction	The code section limits our ability to install combustible insulation, such as an EIFS system, on a building classified as non combustible.	Discussed the code section and design intent with DOB personnel	No		X

(Click on image to access the Regulatory Barrier Summary)

Appendix I. Resiliency Summary

NYSERDA RetrofitNY – Schematic Design
Resiliency Summary
Team:

Indicator	Design Solution
Protection: Identify strategies to reduce a building's vulnerability to extreme weather:	
Floodproofing or Flood Control	No additional flood proofing or flood control. Building is located outside of flood plane.
Sewer Backflow Prevention	Existing backflow prevention.
Mechanical Equipment Protection and Location	New mechanical space conditioning and ventilation equipment will be located on rooftop, contributing to resilience from potential damage due to flooding, or ruptured water main, as well as healthier air quality being delivered to living spaces by pulling supply air from roof rather than street level. Domestic hot water storage tanks are located in basement due to location of existing distribution piping.
Electrical Equipment Protect and Location	No work being performed on electrical equipment.
Backup Power Location and Protection	No backup power being added.
Communications	No work on communication systems.
Envelope Protection	EIFS exterior insulation being added to rear and side walls. Solar canopy will provide buffer to roof from elements. Reduce weathering on rooftop equipment and roofing system.
Fire Protection	Upgrading smoke and fire alarm systems to be hardwired throughout the building.

(Click on image to access the Resiliency Summary)

Appendix J. Resident Health Impact Summary

Click on image below to access the Resident Health Impact Study.

Indicator	Location	Intervention	
		Design Solution	Maintenance Plan
Mold	Units - Kitchens	Maintain proper ventilation from kitchens.	Building does not currently have bulk water/ moisture issues in units or common spaces. Educate residents on proper functioning of balanced ventilation; ensure registers are not being blocked preventing adequate air exchange.
	Units - Bathrooms	Maintain proper ventilation from bathrooms.	Building does not currently have bulk water/ moisture issues in units or common spaces. Educate residents on proper functioning of balanced ventilation; ensure registers are not being blocked preventing adequate air exchange.
	Units - Windows and Exterior Doors	Double glazed high performance windows in the rear will minimize condensation on/around windows due to extreme temperature differences.	Building does not currently have bulk water/ moisture issues in units or common spaces.
	Units - Mechanical Rooms	Air sealing of fresh air louver in basement boiler room.	No existing mold issues
	Common Areas - Windows and Exterior Doors	No existing mold issues	No existing mold issues
	Common Areas - Mechanical Rooms	No existing mold issues	No existing mold issues
	Below Grade	No existing mold issues	No existing mold issues
Pests	Units	Design solutions did not target pests at dwelling units	
	Common Areas	Design solutions did not target pests at common areas, beyond replacing exit doorway to rear.	
	Below Grade	Air sealing in basement, replacement of basement doors to exterior.	
	Exterior	Construction of a better trash storage area in the rear of the building to prevent pests getting into and being attracted to the trash.	
VOCs	Units - Paints	Low VOC, to be spec'd out in final CD's	Include low VOC materials in scope for continued renovations, painting between occupancies, general repairs.

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

Appendix K. Overall Rehab Proposal

439 W 125th Street

DATE: 12/20/18
Est. # 001

Project	439 W 125th St New York, NY 10001	**Estimator:**	David Clark
ADDRESS :	439 W 125th Street	**Project Manager:**	Paddy O'Halloran
CITY/STATE:	New York, NY	**Project Admin:**	William Schirrmeister
FLOOR (s):	10,001		

Client Contact Information

Client:	Allison van Hee		
Contact info:	Director of Asset Management, JOE NYC		
	Forsyth Street, 588 Broadway, Suite 1208, New York, NY 10012		
Architect :	Christa E. Waring | CTA ARCHITECTS P.C		
Contact info:	151 West 26th Street, 8th Floor		
	New York, New York 10001-6810	**Conditions**	4.00%
Engineer:		**Fee**	10.00%
Contact Info:		**Insurance**	4.00%
		Useable Square Footage	
Designer:			
Contact Info		**Rentable Square Footage**	0

M Square Builders Estimate

Overall rehab Proposal

PEG Proposal

(Click on links to access the Overall Rehab Proposal)

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Andrew M. Cuomo, Governor

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