RetrofitNY: Christopher Court Net Zero Energy Retrofit Schematic Design

Final Report | Report Number 19-22 | May 2019

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Mission Statement:

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

Vision Statement:

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

RetrofitNY: Christopher Court
Net Zero Energy Retrofit Schematic Design

Final Report

Prepared for:

New York State Energy Research and Development Authority

Albany, NY

Christopher Mahase
Senior Project Manager

Prepared by:

King + King Architects

Syracuse, NY

Taitem Engineering

Ithaca, NY

Purcell Construction

Watertown, NY

Rock Property Management Company

Syracuse, NY

NYSERDA Report 19-22 NYSERDA Contract 126541 May 2019

Notice

Preferred Citation

New York State Energy Research and Development Authority (NYSERDA). 2019. "RetrofitNY: Christopher Court Net Zero Energy Retrofit Schematic Design Final Report," NYSERDA Report Number 19-22. Prepared by King + King Architects, Taitem Engineering, Purcell Construction Corp, Rock Property Management. nyserda.ny.gov/publications

Abstract

It has become clear that the largest hurdle to overcome in the building industry is devising a pathway to economically and feasibly take on deep energy retrofits of existing structures. Without this, global goals and initiatives set to curb carbon emissions by, or prior to, 2050 will not be possible. It is our responsibility as designers, builders, financiers, and owners to step up and challenge the "business as usual" approach to renovations; creating, real, measurable, and replicable solutions, thereby reducing energy consumption to levels applicable for onsite renewable energy generation, and simultaneously increasing building occupants' health and comfort.

Christopher Court is a 40-unit apartment complex located at 22 Maplehurst Drive in Phoenix, NY, 13135 constructed in 1991. The complex includes five two-story buildings, with eight apartments entered through an open air, exterior hall. Each building includes four one-bedroom and four two-bedroom apartments. One building has an attached office, resident laundry facility and a maintenance garage at level one. Total heated floor area of the residential buildings and the office/laundry/garage is 28,544 sq. ft. and 1,220 sq. ft. respectively, for a total complex heated floor area of 29,764 sq. ft. By enclosing the entry hallways of the residential buildings, the total heated floor area of the complex post-retrofit will be 31,856 sq. ft.

The complex currently uses 332,738 kWh of electricity and 417 gallons of propane for a typical meteorological year. This equates to a site energy utilization index (EUI) of 39.4 kBtu/sf/yr. The retrofit as proposed is predicted to reduce energy usage at the complex to 211,719 kWh/yr equal to a site EUI of 22.7 kBtu/sf/yr, before adding renewable energy (solar photovoltaics). The total yearly electricity production from the proposed solar photovoltaic system is projected to be 188,703 kWh/yr, resulting in a post retrofit EUI of 2.5 kbtu/sf/yr for the complex.

Keywords

RetrofitNY. Deep energy retrofit. Net-zero energy. Net-zero retrofit. Net-zero energy building. Energiesprong. Site Energy Utilization Intensity. Multifamily Energy Retrofit. Energy Efficiency.

Table of Contents

Acronyms and Abbreviations

ft	feet
kWh	kilowatt hours
m/s	meters per second
MW	megawatts
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
W	watts
ERV	energy recovery ventilator
EUI	Energy Use Intensity
NZE	Net Zero Energy
kBtu/sf/yr	kilo-British Thermal Units per square foot of conditioned building area per year
PV	Photovoltaic
DHW	Domestic hot water
PSC	Public Service Commission
LED	Light-emitting diode lighting
O&M	Operations and Maintenance
LCC	Life Cycle Cost Analysis

Glossary

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

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

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

Energy Recovery Ventilator: A ventilation system that exchanges heat and moisture between the exhaust and make-up air stream for a building.

Executive Summary

Christopher Court is a 40-unit apartment complex located at 22 Maplehurst Drive in Phoenix, NY constructed in 1991. The complex includes five two-story buildings, with eight apartments entered through an open air, exterior hall. Each building includes four one-bedroom and four two-bedroom apartments. One building has an attached office, resident laundry facility and a maintenance garage at level one. Total heated floor area of the residential buildings and the office/laundry/garage is 28,544 sq. ft. and 1,220 sq. ft. respectively, for a total complex heated floor area of 29,764 sq. ft. By enclosing the entry hallways of the residential buildings, the total heated floor area of the complex post-retrofit will be 31,856 sq. ft.

The buildings are constructed primarily of a 4" reinforced concrete slab on grade, concrete masonry unit frost wall foundations with reinforced poured-in-place concrete footings, 2x6 load bearing wood framed wall construction, 2x10 wood floor joists, and 2x wood trusses at attics. Foundations are believed to have 2" rigid insulation extending from top of slab down inside face of foundation wall to top of concrete footing. Walls are insulated with 5 ½" thick fiberglass batt insulation, exterior sheathing and clapboard siding (pressed OSB, or fiber cement where recently replaced). Roofs are pitched 4:12 with asphalt shingles and 18" of blown-in cellulose insulation (R62.5) in attics. Soffits and ridges are vented. The main entry door to each apartment is from a central hallway, which is currently open air.

The buildings are currently heated by electric resistance radiant baseboard heat, with a propane unit heater in the maintenance garage. Air conditioning is provided by through the wall air conditioners located in living rooms of the apartments and the office space. Approximately 50% of residents reportedly install air conditioners during the summer months. Hot water is provided by electric resistance storage water heaters located in each apartment and one electric resistance storage water heater in the office serving the office, laundry facility and maintenance garage, all appliances are electric. Windows and patio doors are original double paned aluminum framed, exterior entry doors are insulated steel.

Apartments are direct metered for electricity and there is one common meter at each building for building and site lighting. Building #3 common meter also services the office, laundry, and garage. The complex is on municipal water and sewer.

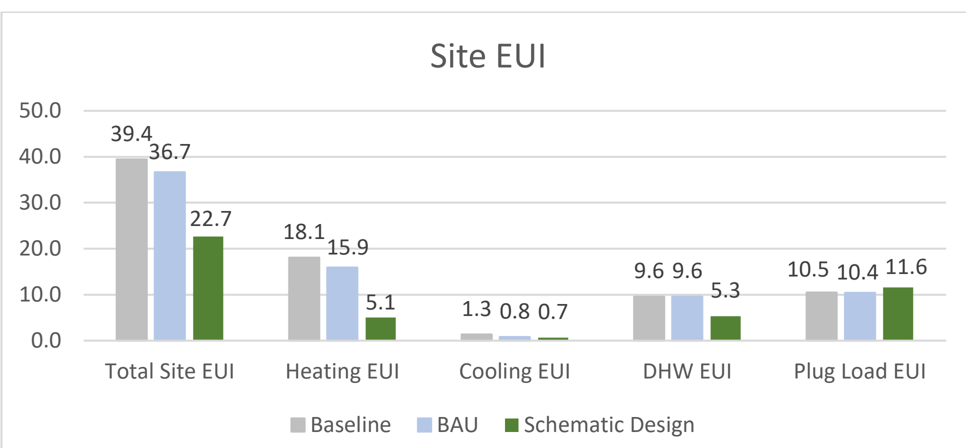
The resident population is made up primarily of seniors and families. The buildings are maintained at close to 100% occupancy with units being unoccupied typically for only a limited period of time to complete apartment basic turn-over maintenance. As of June 2018, there were 66 residents in the 40 apartments, of which 54 are adults and 12 are children (under 16 years old), averaging 1.1 occupants/bedroom.

Rock PMC has already taken steps to improve the energy efficiency of the buildings. A list of these upgrades is included as follows:

Fully sealed attic plane
18" of cellulose insulation installed in attics
Most pipe penetrations in apartments air sealed
Low-flow faucet aerators and showerheads installed
All refrigerators are Energy Star models
Energy efficient lighting

- Site lighting LED
- Office, laundry, garage lighting LED
- Apartment exterior entry lighting de-lamped fluorescent
- CFLs/LED installed in all hard-wired fixtures in apartments

The complex currently uses 332,738 kWh of electricity and 417 gallons of propane for a typical meteorological year. This equates to a site energy utilization index (EUI) of 39.4 kBtu/sf/yr. The retrofit as proposed is predicted to reduce energy usage at the complex to 211,719 kWh/yr equal to a site EUI of 22.7 kBtu/sf/yr, before adding renewable energy (solar photovoltaics). A summary of the baseline building EUI, business-as-usual scope EUI, and RetrofitNY scope EUI is shown in the following table.



The RetrofitNY proposed scope of work is listed in the table below along with projected energy savings for each improvement.

Christopher Court RetrofitNY Scope of Work	**Electricity Savings (kWh/yr)**	**Propane Savings (Gal/yr)**	**Final Site EUI (kbtu/sf/yr)**	**EUI Savings (kbtu/sf/yr)**
Baseline (adjusted ft^2)	--		36.8	
Enclose Corridor	25,339	--	34.1	2.7
Triple Pane Windows & Doors	35,241	(1)	30.4	3.8
Air Sealing	13,046	156	28.5	1.8
Air Source Heat Pumps	39,194	145	23.9	4.6
ERV - Central	(38,086)	--	28.0	-4.1
DHW – Heat Pump - Central	40,020	--	23.7	4.3
Garage Attic Insulation + Garage doors	24	117	23.3	0.3
Programmable Thermostats in Common Areas	1,016	--	23.2	0.1
Energy Star Clothes Washers	1,567	--	23.1	0.2
Plug Load Savings	3,658	--	22.7	0.4
Solar PV	188,703	--	2.5	20.2
TOTALS	**309,721**	**417**	**2.5**	**34.4**

In addition to the scope of work listed in the table, there will also be water conservation measures implemented at the property including low-flow toilets, shower heads, and faucet aerators.

The total yearly electricity production from the proposed solar photovoltaic system is projected to be 188,703 kWh/yr, resulting in a post retrofit EUI of 2.5 kbtu/sf/yr for the complex.

1 Project Narrative

Building Envelope

Key design criteria to consider	How does your design address the criteria?
Thermal performance	A strategically targeted thermal performance improvement is proposed. Our team has elected not to replace or enhance the existing thermal envelope in its entirety due to the high cost and long payback, combined with a reasonable performance of existing building site EUI of 39.4 kBtu/sf/year and an existing peak heating and cooling load of 10.7 kBtu/sf and 9.8 kBtu/sf respectively. Secondarily, the existing envelope is in fairly good condition, and does not warrant major repair or full replacement at this stage. Blower door tests were performed by our team and we have identified areas where air sealing is proposed (electrical boxes, pipes, duct to drywall connections, drywall to sill plate, remove AC sleeves). Additionally, all new windows, patio and building entry doors will be high-performance triple glazed UPVC spec. We are proposing to enclose each existing exterior entrance and stair to significantly reduce exterior wall surface area and reduce heat loss from apartment entry doors (new walls and attic insulation will exceed code minimums, see drawings). Entry corridor wall and apartment entry doors will have to be one hour rated due to this enclosure. We proposed addition of 10” of blown-in cellulose to the maintenance garage (where insulation does not match thickness in rest of property and above the entry corridors where no insulation exists.
Sealing performance	Blower door tests were performed by our team (4.47 ACH50 existing) and we have identified areas where air sealing is proposed include at electrical boxes, pipe penetrations, duct to drywall connections, and garage attic perimeter. New garage overhead doors are proposed. Existing window unit air conditioning sleeves will be removed. New windows and patio doors installations will also reduce total building air leakage.
Moisture performance	Existing exterior envelope has been well maintained and is generally performing in an adequate manor. Siding and trim repairs are necessary in select areas (new fiber cement clapboard and trim is proposed). New windows, patio doors, and entry doors will be well detailed to maintain air and weather barriers, see drawings. Refer to ventilation section below for indoor air quality and humidity control.
Structural performance and long-term integrity of materials	The existing buildings have been well maintained and no structural deficiencies are identified. Where exterior cladding repairs are required, fiber cement clapboard and trim are proposed. Aluminum drip edges proposed at window head and sill to manage bulk water shedding where exterior siding is in worst condition.

How will the new design affect resident life? Are there custom/atypical design features that require careful consideration?	The proposed option maintains the resident's storage areas and frees up an additional storage closet (former hot water tank closets). At the interior, select areas will require ceiling soffits to conceal new ductwork. The main entry way will be enclosed making, the experience of entering and existing apartments more comfortable.
Maintenance of solution	Since entire building envelope replacement is not proposed, there is little to no additional maintenance for the thermal envelope beyond the current condition. Proposed new windows and patio doors are triple pane and will not have the same condensation issues as the current windows, reducing maintenance.
Sustainability of solution	See maintenance of solution section above.
Replication potential at scale	In our experience, there are several similar types of apartment complexes across upstate New York (two-story, wood framed). The proposed materials are off-the-shelf and commonly available. Additional design development should seek to make the cost/residential unit lower.

Other Questions	Team Response
What challenges have you encountered in designing an envelope solution that meets the RFP requirements? How are you addressing them?	Very few, since we are not replacing the entire exterior envelope (see above). One design challenge still being developed is the exact route of new attic ductwork and easiest and most effective solution to include ductwork inside thermal envelope (encapsulating in attic). A second potential design change is the cost of roof replacement in the future with roof mounted PV system.
Are there any unresolved major issues? What would it take to resolve them?	Please refer to regulatory barriers section of our conceptual report, the most critical being the method of metering electricity to take advantage of solar PV solution.

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	A new central ventilation system will be installed with an energy recovery ventilator (ERV). The system will provide 20 CFM and 25 CFM continuous exhaust in the one-bedroom and two-bedroom apartment bathrooms respectively. The system will provide 25 CFM and 30 CFM continuous exhaust in the one-bedroom and two-bedroom apartment kitchens respectively. Bedrooms will have 20 CFM and 15 CFM of make-up air in the one-bedroom and two-bedroom apartments respectively. Living areas will have 25 CFM of make-up air in both one-bedroom and two-bedroom apartments. The design will provide 45 CFM of make-up air for the one-bedroom apartments (max occupancy of two persons = 36 CFM) and 55 CFM of make-up air for the two-bedroom apartments (max occupancy is currently three person = 54 CFM required make-up air). Adjustable constant air flow regulators will be installed in all exhaust/supply grilles, which will make it easy to adjust the air-flow rates if required. The ERV will be commissioned to produce 0.2" w.c. at the furthest vent to ensure ventilation rates are achieved. Air flows will be tested to confirm.

Prevention of mold, mildew, pests and other environmental triggers of respiratory or other ailments	Existing apartments do not have adequate ventilation. The bathroom exhaust fans do not appear to be used frequently and no dedicated make-up air is provided to the apartments. Indoor air quality is reported to be sub-optimal. The new ventilation system will provide proper exhaust and make-up air to each living space. The ERV will be fitted with air filters to remove contaminants from the air prior to supplying it to the apartments. The apartments currently have air conditioning in the living rooms only. Our proposed retrofit will provide air conditioning in all rooms which will help reduce the humidity of the apartment and prevent mold and mildew development. Existing windows are old, have broken seals, and are metal framed. They are reported to be a source of condensation and mold/mildew build-up. The new windows will be triple-paned with low conductivity thermally broken frames, which will result in warmer surface temperatures and prevent mold/mildew growth.
Active ventilation to reduce volatile organic compounds and other potential internal air contaminants	A minimum of 45 CFM and 55 CFM of continuous ventilation will now be provided to the one-bedroom and two-bedroom apartments respectively.
Maintenance of solution	The central ventilation systems will need to have its filters checked and changed on a bi-annual basis. The constant air flow regulators will need to be checked for dust/dirt build up every three years and cleaned as necessary. The constant air flow regulators settings will need to be adjusted in the two-bedroom apartments if more than three occupants are living in the apartment.
Sustainability of solution	The proposed central ventilation system with an ERV will recover >65% of the heat from the exhaust air stream. This will allow the indoor air quality to be improved in the buildings without significantly increasing energy usage.
Replication potential at scale	There are many buildings in upstate New York that are of similar construction. The attached mechanical shed, in which the ERV will be contained, is viewed as highly replicable to other projects. While typically it is advised to keep mechanical systems out of the attic, we believe that developing an insulated plenum system, in which the ERV ductwork can run, could be an excellent solution for this building stock, where there are no other good locations for locating the ERV equipment and ductwork.

Question	Team Response
What challenges have you encountered in designing an IAQ solution that meets the RFP requirements? How are you addressing them?	There is some concern that the air source heat pumps may be slightly oversized for the cooling load and may not adequately address the latent loads in the summer. It's possible the thermostat setpoint will be met prior to the latent load having been addressed. To address this, we are recommending the smallest capacity air source heat pumps available and that the heat pump will be variable speed compressors. In order to address latent loads in make-up air stream we contemplated installing a split system heat pump with a DX coil located in the make-up stream. At this point in time we are not pursing this option since this solution was not offered from ERV manufactures for the equipment size needed.
Are there any unresolved major issues? What would it take to resolve them?	There were some reports of mold forming in the corner of closets, which had been tightly filled with tenants' belongings. Unfortunately, we were unable to recommend an exterior insulation improvement, so it is likely there will still be cold spots in these closets. By more actively controlling indoor humidity levels with continuous ventilation, we hope this will help address the issue.

Space Heating/Cooling

Key design criteria to consider	How does your design address the criteria?
Space heating/cooling EUI of not more than 11 kBtu/ft^2/year	Our design achieves a site EUI for heating/cooling of 5.7 kBtu/sf/year. We've been able to reduce loads by improving on the building's already efficient envelope by enclosing the common entryway (to reduce total exterior surface areas), installing triple pane windows and patio doors, and performing air sealing. The reduced load is then addressed with air source heat pumps, which are significantly more efficient than the existing electric resistance baseboard.
Maintaining heating and cooling comfort (including humidity)	All living spaces and bedrooms will have their own air source heat pump indoor unit with a wall mounted thermostat. Humidity will be addressed by providing air conditioning in each living space and using an ERV on the central ventilation system.
Innovative ways to improve system efficiency	Selection of the most efficient cold climate air source heat pumps. Not necessarily innovative, but very important to achieving greatest efficiency.
Required sensors and controls	Wall-mounted thermostats for each air source heat pump indoor unit.
Maintenance of solution	Indoor unit filter cleanings, every six months or as otherwise necessary. Outdoor coils once every three years or as otherwise necessary.

Sustainability of solution	Air source heat pumps are more than two times as efficient as the existing electric resistance heaters (for our project we predict a heating season cop of 2.2). Although improvements have been made in the global warming potential of refrigerants, refrigerant 410a still has a very high global warming potential (1725). If the refrigerant leaks out an air source heat pump system, it will ultimately set-back the carbon/climate change benefits of the improved efficiency of the system by about six years (given the grid emissions in upstate New York is 600 lbs. of CO2/MWh). What's more, is that these emissions would be released immediately rather than overtime as would be the case with keeping the inefficient system. Therefore, it is incredibly important to ensure that there are no refrigerant leaks. We are working on a detailed specification for testing the air source heat pump system for leaks prior to charging it with refrigerant. The specification will also have very specific requirements for maintenance and future decommissioning of the equipment.
Replication potential at scale	Air source heat pumps have become standard in the marketplace and are a very scalable retrofit because of their familiarity with designers, contractors, owners, and service technicians.

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?	We were unable to justify a full envelope retrofit since the building was already very efficient and there were limited savings opportunities to work with. However, our approach has still achieved the requirements of the RFP.
Are there any unresolved major issues? What would it take to resolve them?	None to report.
Other comments	In designing the retrofit for this project, it has become apparent that performing energy efficiency upgrades through a piecemeal process may seriously impact the feasibility of completing a whole-building net-zero retrofit. In the case of Christopher Court, the building owner has already been pro-active and has completed several cost-effective measures. As a result, there are no quick payback measures to help pay for the longer deeper energy savings measures.

Domestic Hot Water

Key design criteria to consider	How does your design address the criteria?
DWH system design and sizing	We have designed a central air to water heat pump domestic hot water system. This would be a new central domestic hot water system that would be piped to each existing storage water heater closet in the apartments. The system was sized using the guidelines in ASHRAE Fundamentals.
Innovative ways to improve system efficiency (i.e., heat recovery)	We considered installing drain heat recovery on the shower drains of the second-floor apartments but determined that it was too expensive, required significant demo in the tenants' apartments, and would not be cost-effective.

Required sensors and controls	An aqua stat will control the DHW recirculation loop to maintain proper loop temperature while not operating the pumps unnecessarily.
Maintenance of solution	The air to water heat pump coil will need to be cleaned once every three years or as otherwise necessary. We expect that after the system has been installed and commissioned there will be very little maintenance.
Sustainability of solution	The air to water heat pump uses CO2 as a refrigerant which has the lowest global warming potential of all refrigerants.
Replication potential at scale	We are installing the air to water heat pump system in a pre-fabricated mechanical shed. We intended that this mechanical shed could be further developed to reduce costs and provide a scalable solution. In addition, as air to water heat pumps come down in cost, we believe this system will have an even greater potential to scale.

Other Questions	Team Response
What challenges have you encountered in designing a DHW solution that meets the RFP requirements? How are you addressing them?	Because the existing building is all electric, we are unable to determine actual DHW usage from the utility bills. We've made some conservative assumptions (assuming low usage so savings are not overstated) based on the existing system, current occupancy, the design requirements in the RFP, and experience on other projects. We installed two kWh meters on the existing DHW electric storage tanks and recently received the first month of usage data. The usage confirms that our estimates in the energy model are accurate.
Are there any unresolved major issues? What would it take to resolve them?	In order to reduce the amount of new equipment at the site, and to keep the DHW usage on the tenant's bill, we were hoping to find an air source heat pump system that could also provide DHW heating. Basically, we want a system where we could have one outdoor unit serving both heating/cooling/DHW.
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 building owner, Rock PMC, is working with an experienced consultant to address tenant education and plug loads. As of the schematic design deliverable the team has not yet put together a formal plan, but some suggestions include: Free installation of LED lamps in all resident owned fixtures (during the retrofit and thereafter on tenant move-in) Smart strips to reduce phantom loads Tenant education Maintenance staff education

Variation in consumption between occupants	Though our utility bill analysis we identified that usage between different apartments was quite varied. However, since we analyzed all fuel bills, we were able to develop an accurate baseline of the existing building energy usage. Even with changes in residents, we expect the overall energy usage at complex to stay fairly consistent. With 40 apartments in total the variations between apartments tend to average out.
Maintenance of solution	Tenant education will need to be continuous. LED lamps will need to be kept on hand and available to all residents, especially on move-in.
Sustainability of solution	Many buildings have similar issues with MEL. We do not claim to have the solutions yet, but we hope that through the development of education materials and a LED lamp program we can continue to develop techniques that can be used for other projects.
Replication potential at scale	To be determined.

Other Questions	Team Response
What challenges have you encountered in designing a MELs solution that meets the RFP requirements? How are you addressing them?	For our schematic design phase, we do not yet have a formal plan developed to address plug loads/tenant education. This will be developed with the owner and their outside consultant as the project move forwards. Therefore, we don’t have a good sense of what kind of savings to expect. We assumed 5% savings of the total plug load usage due to the MEL measures that will be implemented.
Are there any unresolved major issues? What would it take to resolve them?	None to report.

Distributed Energy Resources (DER)

Key design criteria to consider	How does your design address the criteria?
DER relevant to/included in the retrofit design	For this project we have focused on on-site, rooftop, solar PV as source of distributed energy generation.
Onsite DER capacity vs. offsite	With some tree removal/trimming we projected that onsite distributed energy generation will be sufficient to just achieve a net-zero on an annual basis. This is for first year production numbers only. Although we’ve selected high efficiency panels, with the industry’s best power production over time, we do expect that onsite solar generation may fall below onsite usage over time. Depending on adjustments to the improvement package and savings projections during schematic design, we may also consider a carport PV system over the parking lot on the east side of building #1. The cost for the carport system is greater than roof mount systems, so we are only looking at this as a last resort.
How to integrate DER into HVAC and other major end uses	Currently we have not integrated the solar PV into any of our other systems. We will be looking to design the new system such that it in the future battery back-up could be easily implemented and that the ERV and DHW system be operated by this battery back-up system.

Structural performance	Taitem's structural engineer has evaluated the existing roof system and confirmed that it can handle the load of the new solar photovoltaic systems.
Efficiency degradation	We have selected SunPower X22-360 panels, which maintain 92% of their power production at year 25. Due to the limited space at the site, and many trees, the solar photovoltaic system as designed appears will only be able to achieve net zero based on first year production. As production slowly drops over time, total electricity generated may not fully offset energy usage.
Required sensors and controls	A monitoring system will be installed to monitor production of each building's PV system.
Maintenance of solution	Solar PV is a very low maintenance improvement. Likely the only maintenance will be replacing the inverters around 15–20 years.
Sustainability of solution	Currently solar PV is very helpful to the grid as it helps address peak load during the summer. However, overtime as the grid is made up of more and more solar generation, solar will become less valuable (and sustainable) without the usage of storage. In the upstate New York climate, peak solar production is during the summer while peak energy usage is in the winter. This is a serious concern to the long-term sustainability of this solution. Current battery technology, even if cost was not an issue, would not be able to address this problem.
Replication potential at scale	The technology (solar) is a very replicable solution. However, metering is a much more difficult issue that is the real limitation to scaling this solution. While there is discussion to take advantage of NYSERDA's "Solar for All" community solar program for this project, we'd expect that program would not be available to all projects. We believe that the solar metering issue, along with properly valuing solar for netzero projects, is possibly one of the single biggest issues for the RetrofitNY program to scale.

Other Questions	**Team Response**
What challenges have you encountered in designing a DER solution? How are you addressing them?	The biggest challenge to designing the distributed energy solution is metering. See a more detailed discussion on this in our report.
Are there any unresolved major issues? What would it take to resolve them?	Metering is a big issue that still needs to be resolved both at this specific project and industry wide.
Other comments (optional)	The value of distributed energy resources (VDER) guidelines set-up by the PSC make evaluating future value of solar difficult. As a result, it is difficult to evaluate the finances of the solar PV system. For net zero projects it seems that going back to the old approach of valuing production on a kWh basis may be more appropriate. This is still how it is done for residential projects.

Building Performance + Modeling and Life Cycle Cost Analysis

Key design criteria to consider	How does your design address the criteria?
Overall site EUI of not more than 20 kBtu/ft2/year	Our current design achieves a site EUI of 22.7 kBtu/sf/year. We believe our solution is the most cost-effective way to achieve close to net-zero energy during this renovation cycle.
Determination of operational assumptions (schedules, people densities, etc.)	We modeled the existing building based on actual conditions, and where necessary, followed the modeling protocols that are set-forth in the Energy Star® Multifamily High-Rise Program.
Operation and maintenance costs	These are very rough and need to be refined during schematic design.
Anticipated costs savings for 30 years relative to "business as usual" normal retrofit intervention	See Budget and Finance template.
Retrofit business model + sustainability and scalability of solution	See scalability template.

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?	The biggest challenge was working to identify the most effective solution while still meeting the EUI requirements. We hope to work out the installed cost of our solution during schematic design and try to identify ways to reduce costs. However, we do not expect that a cost-effective solution will be feasible until further industry development and demand aggregation take hold.
What challenges have you encountered in modeling the solution's performance? How are you addressing them?	None to Report.
What challenges have you encountered in completing an LCCA? How are you addressing them?	There are some costs for the project that overlap many measures. As a result, at this time we were unable to break apart each improvement on its own. The LCCA shows installed cost for the whole project but costs savings, O&M costs, and repair/replacement costs for each improvement.
Are there any unresolved major issues? What would it take to resolve them?	None to report.

Construction Budget

Key criteria to consider	How does your budget address the criteria?
Cost compression due to anticipated innovation	Current solutions utilize technology and equipment that has been tested over time to produce known results. As such the cost of the solutions are for systems that have known past install costs.
Cost compression at scale	At scale the cost of the solutions should be reduced as contractors understand the program.
Current availability of required products	Chosen solutions utilize readily available products.
Anticipated future availability of required products	Technology advancements and construction compression in integrated DHW, Heat/Cool and Ventilation systems (similar to Factory Zero in the Netherlands) have great potential to benefit projects such as ours. Our proposed solution for integrated DWH and ventilation via a hydronic loop in the incoming stream is the first step in this direction. Exterior mechanical sheds will be built off site with components installed prior to delivery.
Transportation of products/systems to project site	There are no known obstacles with chosen solutions.
On-site vs. off-site labor	Exterior mechanical sheds and entry enclosures will be fabricated off site and installed as substantially finished components. Soffits and attic duct and piping plenums have the capability to be fabricated off site to reduce tenant intrusion and time on-site.

Other Questions	Team Response
What challenges have you encountered in producing a construction budget? How are you addressing them?	We looked at many different solution sets, so it was difficult to spend the time and energy to get detailed pricing on each one. However, in the end we priced a number of different options at a conceptual level and selected the most appropriate option from there. Once the gap funding cap was introduced, we went back and analyzed big line items in depth to find holistic retrofit solutions that meet or exceed all RFP requirements within gap funding. This is where our redesigned DHW solution came about, within exterior mechanical sheds with ERV integration.
Are there any unresolved major issues? What would it take to resolve them?	Metering configuration and solar PV implementation remain the biggest unknowns for this project. We believe that this is an industry wide problem that will require a separate focus group NYSERDA, PSC, Utilities, Owners, Solar Contractors, and financers to solve.

Construction Schedule

Key criteria to consider	How does your schedule address the criteria?
Schedule compression due to anticipated innovation	Solutions can be installed in many units concurrently. Off-site fabricated components, elimination of frost wall or frost protected haunch slabs through use of helical pile foundations.
Schedule compression at scale	Installation time may decrease at scale.
Current availability and lead time of required products	Accounted for product lead times. UPVC window and door lead times may be upwards of 20 weeks.
Anticipated future availability and lead time of required products	Chosen solutions are utilized regularly in the industry.
Transportation of products/systems to project site	No known issues.
On-site vs. off-site labor	Design incorporates a reasonable portion of offsite fabrication for the additional envelope components, at entry and mechanical shed. Since full envelope will not be replaced at this time, window installation must occur on site and must be highly coordinated to minimize tenant disruption.

Other Questions	Team Response
What challenges have you encountered in producing a construction schedule? How are you addressing them?	Completing solutions in occupied units.
Are there any unresolved major issues? What would it take to resolve them?	None to report.

2 Schematic Design Documents

2.1 Architectural

A-100	AERIAL SITE PLAN
A-101	FIRST FLOOR PLAN – UNIT ‘A’
A-102	SECOND FLOOR PLAN – UNIT ‘A’
A-104	FIRST FLOOR PLAN – UNIT ‘B’
A-105	SECOND FLOOR PLAN – UNIT ‘B’
A-401	ENTRY ENCLOSURE DETAILS
A-501	MECHANICAL CLOSET AND TYPICAL DETAILS

2.2 Mechanical

M-100	MECHNICAL SCHEDULES AND SCHEMATIC
M-101	AIR SOURCE HEAT PUMP SCHEMATIC – UNIT ‘A’ FIRST FLOOR
M-102	AIR SOURCE HEAT PUMP SCHEMATIC – UNIT ‘A’ SECOND FLOOR
M-103	AIR SOURCE HEAT PUMP SCHEMATIC – UNIT ‘B’ FIRST FLOOR
M-104	AIR SOURCE HEAT PUMP SCHEMATIC – UNIT ‘B’ SECOND FLOOR
M-105	ERV SCHEMATIC – UNIT ‘A’ FIRST FLOOR
M-106	ERV SCHEMATIC – UNIT ‘A’ SECOND FLOOR
M-107	ERV SCHEMATIC – UNIT ‘A’ ATTIC FLOOR
M-108	ERV SCHEMATIC – UNIT ‘B’ FIRST FLOOR
M-109	ERV SCHEMATIC – UNIT ‘B’ SECOND FLOOR
M-110	ERV SCHEMATIC – UNIT ‘B’ ATTIC

2.3 Plumbing

P-100	PLUMBING SCHEDULES AND SCHEMATIC
P-101	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘A’ FIRST FLOOR
P-102	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘A’ SECOND FLOOR
P-103	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘A’ ATTIC
P-104	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘B’ FISRT FLOOR
P-105	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘B’ SECOND FLOOR
P-106	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘B’ ATTIC

2.4 Electrical

E-100	ELECTRICAL SCHEDULES AND SCHEMATIC
E-101	ELECTRICAL – UNIT ‘A’ FIRST FLOOR
M-102	ELECTRICAL – UNIT ‘A’ SECOND FLOOR
M-103	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘A’ ATTIC
M-104	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘B’ FISRT FLOOR
M-105	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘B’ SECOND FLOOR
M-106	DOMESTIC HOW WATER SCHEMATIC – UNIT ‘B’ ATTIC

2.5 Preliminary Specifications

The following specifications apply to new work proposed as part of the RetrofitNY project.

2.5.1 Division 6 – Wood, Plastics, Composites

2.5.1.1 061600 – Insulated Wall Sheathing:

2.0-inch-thick ZIP composite insulation system (R=9.6) with integral air/water barrier, tape joints per system instructions.

2.5.1.2 062015 - Exterior Finish Carpentry:

Provide fiber cement trim and clapboard in size and dimensional exposure to match existing. James Hardie, or equal.

2.5.2 Division 7 – Thermal and Moisture Protection

2.5.2.1 072100 - Thermal Insulation

Foil Faced Polyisocyanurate Rigid Board Insulation: Dow or Owens Corning. Locations: Attic Plenum. Thickness: two inches.

Mineral-Wool Blanket: Unfaced, Rockwood or equal. Locations: New exterior entrance wall, exterior walls of mechanical shed, A/C sleeve infill. Thickness: Full depth of framing, refer to drawings.

Cellulose Loose-Fill Insulation: US Greenfiber, Greenfiber Cellulose Insulation or equal. Locations: Attics above common hallway, garage attic, locations in attics where insulation is disturbed through other work, mechanical shed attic. Total settled depth = 18” (R-Value 62.5 min).

2.5.2.2 072700 – Air Barriers

Air seal apartments to reduce total leakage to outdoors to less than 2.0 ACH50. Air sealing must be confirmed through a whole building blower door test. Locations to seal include duct-to-drywall connections, outlet/switch/cable box to drywall connections, all holes within outlet/switch/cable boxes, pipe to drywall connections, and window rough openings, at a minimum. Through the wall AC sleeves will be complete removed, insulated, and air sealed. Air sealing will be guided by blower door testing. Sealing will be done after new work is done (such as hot water, ventilation, and heat pumps), and include sealing of new penetrations. Attention will be directed to sealing holes covered by new work, such as piping and wiring holes behind new wall-hung fan coils. Interior and exterior of new windows/doors will be caulked.

Air seal office by sealing duct-to-drywall connections, outlet/switch/cable box to drywall connections, all holes within outlet/switch/cable boxes, pipe to drywall connections, and window rough openings. Through-the-wall AC sleeve will be completely removed, insulated, and air sealed.

Air sealing maintenance garage by sealing duct-to-drywall connections, outlet/switch/cable box to drywall connections, all holes within outlet/switch/cable boxes, pipe to drywall connections, all penetrations within ceiling to attic (including backs of electrical boxes), and new garage doors.

2.5.2.3 076200 – Vapor Barrier

6-mil poly vapor barrier installed on winter warm side (inside) of studs of exterior walls.
Connect continuously to existing poly vapor barrier.

Aluminum Duct Sealing Tape. Location: Attic Plenum

2.5.3 Division 8 – Openings

2.5.3.1 082550 – Fiberglass Doors and Frames

Provide one of the following manufacturers: Special-Lite or Therma-Tru. Locations: Mechanical Shed. U-value <0.14.

2.5.3.2 081316 –Building Entry Doors

Basis of Design: Zola Thermo uPVC, triple-pane, outswing entry door. Factory glazing, fully tempered. Glazing U-Value = 0.105. Frame U-Value = 0.158. Glass SHGC = 0.50. NFRC U-Value = 0.16. NFRC SHGC = 0.31. Color = White/White. No lockset hardware on building entry doors

2.5.3.3 081316 – Patio Doors

Basis of Design: Zola Thermo uPVC, triple-pane, outswing entry door with full sidelight. Factory glazing, fully tempered. Glazing U-Value = 0.105. Frame U-Value = 0.158. Glass SHGC = 0.50. NFRC U-Value = 0.16. NFRC SHGC = 0.31. Color = White w/ upgrade color foil on exterior side. Lockset hardware.

2.5.3.4 083700 – Overhead Garage Doors

Install two new insulated garage doors in maintenance garage. Minimum R-9 and full weather-stripping air sealing package. Provide automatic openers. Overhead Door Company, or equal.

2.5.3.5 085313 – Vinyl Windows

Basis of Design: Zola Thermo uPVC, triple-pane, tilt turn window. Factory glazing, standard non-tempered. Glazing U-Value = 0.09. Frame U-Value = 0.193. Glass SHGC = 0.50. NFRC U-Value = 0.16. NFRC SHGC = 0.31. Color = White w/ upgrade color foil on exterior side. Provide screens for operable windows.

2.5.4 Division 9 – Finishes

2.5.4.1 092900 – Gypsum Board

5/8" thick type 'X' gypsum board system by USG or equal. Match existing as required.

½" thick type 'X' gypsum board system by USG or equal. Match existing as required.

2.5.5 Division 11 – Equipment

2.5.5.1 113013 – Residential Appliances

Any refrigerator scheduled for replacement must be replaced with an Energy Star® rated model.

2.5.5.2 112173.26 – Commercial Washers

Replace five existing clothes washers with new front loading, coin-operated, Energy Star® commercial clothes washers.

2.5.6 Division 22 – Plumbing

2.5.6.1 220700 – Plumbing Insulation

Domestic hot water recirculation loop piping located will be insulated as follows: all piping located in mechanical shed and apartments will be insulated to code. Any piping located in insulated plenum in attic will be insulated with a minimum 2" thick insulation with a maximum thermal conductivity 0.29 $btu*in/hr*ft^2*F$ at 100 deg F. Any piping located outdoors or outside of the insulated plenum in attic will be insulated with a minimum 3" thick insulation with a maximum thermal conductivity 0.29 $btu*in/hr*ft^2*F$ at 100 deg F. Insulation will be installed such that it is continuous throughout the length of pipe. Valves and fittings to be insulated to match appearance and efficiency of adjacent pipe insulation. Exterior insulation will be UV-protected by UV paint or a UV-resistant jacket.

2.5.6.2 221119 – Domestic Hot Water Specialties

Hot water coil served from air to water heat pump will be installed in ventilation supply air stream and properly controlled to maintain 65° F air temperature during the heating season.

Install mixing valve for domestic hot water to apartments set at 125° F.

2.5.6.3 221120 – Domestic Water Pumps

All hot water pumps to have electronically commutated motors and sized to meet load.

Recirculation loop pump on aqua-stat set-up to recirculate domestic hot water when furthest apartment hot water return line temperature drops below 110° F.

2.5.6.4 223300 – Electric, Domestic-Water Heater

Air-to-water heat pump, Sanden SanCO2. Two heat pump per residential building and one heat pump for office, laundry, maintenance building. Two 119 Gallon tanks to be installed per each residential building and one 83-gallon tank to be installed for office, laundry, and maintenance portion of the common building.

2.5.6.5 224000 – Plumbing Fixtures

Replace all toilets with new WaterSense rated models. Effective flush volume not to exceed 1.28 gallons.

Replace all bathroom sink faucet aerators with 1.0 GPM rated aerators by Niagara Conservation or similar.

Replace all kitchen sink faucet aerators with 1.5 GPM rated dual-spray swivel aerators with pause valves, Niagara Conservation N3115P-FC or similar.

Replace all showerheads with new 1.75 GPM flow rate by Niagara Conservation or similar.

2.5.7 Division 23 – HVAC

2.5.7.1 230593 – Testing, Adjusting, Balancing for HVAC

Energy recovery ventilation system to be balanced and tested to confirm airflow rates at each ventilation grille are at with 10% of design: 20 CFM exhaust for bathrooms in one-bedroom apartments, 25 CFM exhaust for bathrooms in two-bedroom apartments, 25 CFM exhaust for kitchens in one-bedroom apartments, 30 CFM exhaust for kitchens in two-bedroom apartments, 20 CFM make-up for bedrooms in one-bedroom apartments, 15 CFM make-up air for bedrooms in two-bedroom apartments, 25 CFM for living rooms.

Energy recovery system ductwork to be tested to confirm total duct leakage, including at duct to drywall connections, is less than 15 CFM at 0.4-inch w.c.

Energy recovery ventilation system to be adjusted such that exhaust air and supply air fans run at minimum speed while still providing proper ventilation rates.

2.5.7.2 230719 – Pipe Insulation

See section 220700 for domestic water pipe insulation requirements including domestic hot water recirculation loop.

All refrigerant line set piping must be insulated with a minimum 1” thick insulation, even if located within the thermal envelope. Insulation must have a maximum thermal conductivity 0.29 btu*in/hr*ft^2*F at 100° F with class 1 vapor barrier coating. Insulation will be installed such that it is continuous throughout the length of pipe. Valves and fittings to be insulated to match appearance and efficiency of adjacent pipe insulation. All refrigerant lines located outside must be enclosed in PVC jacket or other UV-resistant protection, such as UV-resistant paint.

2.5.7.3 230713 – Duct Insulation

All supply air ductwork located in mechanical shed and within apartment thermal envelope will be insulated with minimum R-8 mineral fiber blanket insulation with class 1 vapor barrier coating.

All ductwork located in the insulated plenum in the attic will be insulated with 2” thick mineral-fiber blanket insulation with class 1 vapor barrier coating.

All ductwork between outdoors and the ERV will be insulated with 2” thick mineral-fiber blanket insulation with class 1 vapor barrier coating.

2.5.7.4 233113 – Metal Ducts

All ductwork will be single-wall sheet-metal. Ductwork will be sealed with water-based duct mastic sealant at all joints, seams, and connections. After mastic is installed, provide field-applied application of Aeroseal based duct sealant on exhaust and make-up air ductwork in order to achieve total system leakage of less than 15 CFM at 0.4” w.c.

Constant volume regulators by Young Regulator company will be installed within all branch ductwork to provide design airflow at exhaust and supply air vents. Model CVR-04L adjustable from 10-30 CFM within the system operations pressures of 0.2” w.c. to 1.0” w.c.

Related sections include specification 230593, specification 233600, and specification 237200.

2.5.7.5 237200 – Air-to-Air Energy Recovery Ventilator

Air-to-air energy recovery ventilator with enthalpy plate core; RenewAire EV450IN or similar. Energy recovery ventilator to be capable of providing the full range between 350 CFM and 450 CFM. Minimum sensible effectiveness heating of 75% at 400 CFM and minimum total effectiveness cooling of 58% at 400 CFM.

Speed control to be installed on fans to reduce speed to minimum possible while still providing required air flow rates. Pressure in system at furthest constant volume regulator should be 0.2” w.c.

2.5.7.6 238140 – Air Source Heat Pump

Install air source heat pumps for apartments, office, laundry, and garage. One outdoor unit should be installed per apartment and for the office, laundry, garage building, each serving multiple indoor units. Daikin AURORA 2MXL18QMVJU (one bedroom) and 3MXL24RMVJU (two bedroom). One indoor unit will be provided to each living space, defined as bedroom and living room. Daikin Aurora CTXS07LVJU. Bathrooms and kitchens will not have indoor unit installed. Total heating capacity of installed units as per the following table:

Area served	Total # of Outdoor Units	Outdoor Unit Size[1]	Total # of Indoor Units	Indoor Unit Size[2]
1-bedroom apartments	20	18,000 Btu/hr	40	7,000 Btu/hr
2-bedroom apartments	20	24,000 Btu/hr	60	7,000 Btu/hr
Office, Laundry, Garage	1	24,000 Btu/hr	3	7,000 Btu/hr

1. Outdoor units will be sized to provide the minimum listed btu/hr at 5° F in the table above. If necessary, for the number of connected indoor units, outdoor units may be upsized to the maximum listed btu/hr at 5 deg F in the table above.
2. Indoor unit size is based on the maximum heat output in btu/hr at 5° F.

Air source heat pumps will be Northeast Energy Efficiency Partnership's Cold Climate Air Source Heat Pump listed. Heat pumps for apartments must achieve a total system output capacity of 12,000 btu/hr at 5° F, a minimum COP of 2.3 at 5° F when operating at maximum capacity, and be able to operate to temperatures as low as -13° F. Heat pump for the office, garage, and laundry system will achieve a total system output capacity of 18,000 btu/hr at 5° F, a minimum COP of 2.3 at 5° F when operating at maximum capacity, and be able to operate to temperatures as low as -13° F.

Air source heat pumps refrigerant line sets must be carefully installed and properly tested for leaks to ensure there are no leaks in the system prior to charging with refrigerant. Any leakage of refrigerant must be fixed immediately, total estimated leakage amount quantified, and reported to the owner.

Each air source heat pump indoor unit to be controlled by a wall-mounted thermostat located on an interior wall in the same room. Office, laundry, and maintenance garage will have seven day programable thermostats installed set to the following schedule:

Area	Schedule	Heating Season 10/1–5/15	Cooling Season 5/16–9/30
Office	9 a.m. – 5 p.m. M – F	72° F	76° F
	All other times	60° F	80° F
Laundry	7 a.m. – 11 p.m. M – Su	70° F	78° F
	All other times	60° F	80° F
Maintenance Garage	7:30 a.m. - 5:30 p.m. M – F	66° F	78° F
	All other times	55° F	80° F

Include outdoor unit stand to maintain 24" minimum clearance with ground level. Outdoor units will be installed in location away from potential snow fall build up from roof. Include base pan heater for all outdoor units.

2.5.7.7 23 83 33 – Electric Resistance Heat

Remove all electric resistance baseboard heat in the apartments, except for in the bathrooms. Electric resistance heaters in the bathroom to have new control installed to prevent use when temperature is >68° F. In addition, educational materials to be developed and provided to all residents about limiting the use of electric heat. Details on controls will be finalized during schematic design.

Install 750 W electric resistance heater in new mechanical shed with thermostat that is lockable and set to 40° F.

2.5.8 Division 26 – Electrical

2.5.8.1 263100 – Photovoltaic System

Install 169.56 kW roof-mounted solar photovoltaic system as per drawings. Photovoltaic panels will be SunPower X22-360 and have minimum 25-year warranty as provided by manufacturer. Power production of photovoltaic panels will be at least 92% of minimum peak performance rating after 25 years.

3 Scalability Strategy

After creating a baseline energy model of existing conditions, our first step in evaluating a retrofit solution was to determine whether a full exterior envelope insulation retrofit was necessary and/or cost effective. The site energy usage of the building was already low, and the owner had already performed substantial weatherization work in the attics through the Weatherization Assistance Program. In addition, the aesthetics and condition of the buildings did not warrant a new façade. After an initial analysis it was clear that a full exterior applied insulation retrofit would not be cost effective, even if it was assumed aggressive pricing based on scalability.

From work on other USDA projects in Upstate New York, it is apparent many of these buildings are of similar style and in similar condition as they have also had several energy upgrades through the Weatherization Assistance Program. In addition, buildings being built to current code standards would fall into a similar level of performance. The team wanted to evaluate and recommend a retrofit that would not only be applicable for the project, but for others in a similar position. It was believed the targeted envelope approach with a heavy focus on HVAC and DHW is both scalable and replicable. A critical component of the approach is an accurate baseline model cross-referenced with real energy bills and on-site verification to determine the most appropriate retrofit scope.

In the original conceptual design, a ground source heat pump domestic hot water system and the construction of a site-built mechanical shed was recommended. After additional analysis and consideration, it was determined that an air-to-water heat pump was a more appropriate application for domestic hot water production and much more likely to be scalable because it did not rely on drilling wells, requiring sufficient land and appropriate soils. The construction approach for the mechanical sheds was changed to be prefabricated and include installation the ERV and DHW equipment off-site. Since five identical mechanical sheds were needed, having a prefabricated system made economic sense for the project. It is believed that a prefabricated mechanical solution is also necessary to drive cost down on future projects, in a similar approach to retrofit solutions seen in Europe.

The biggest barriers to scalability are the low cost of fuels, high cost of construction in the current market and delivery model, challenges around monetizing solar PV production, and regulatory restrictions around federally and State-funded construction projects.

In terms of reducing construction costs, the regulatory restrictions on design-build teams, along with the associated bidding requirements and limitations on overhead and profit will likely stifle the growth of this industry. If a procurement platform was developed for true design-build firms that could act as solution providers, it's more likely that construction costs could be compressed to align retrofit work scopes with existing capital improvement projects.

One of the biggest challenges we see is how to reward architects, engineers, manufactures, contractors and/or solution providers for innovation. Our current design-bid-build process is not designed for key players to put in the time, effort, and resources to innovate.

In order to help solve this challenge, we need to develop a better way of procuring these retrofits. The design-bid-build process and many of the competitive bid requirements (for subcontractors) are going to stifle innovation. This will require the regulators and financiers to develop and accept new ways of doing business.

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	We opted to go with a central ventilation system for this project so as to reduce the amount of ductwork/soffits in the apartment and reduce maintenance requirements (only one system per bundling not eight). We believe that continuing to develop this solution will be helpful for other buildings, specifically by developing ductwork installation strategies (prefab standard lengths and pre-insulated) and the prefabricated mechanical shed.	See comments below on Minotair Pentacare unit. We believe there is a market for a mid-size ERV (~250 CFM – 1000 CFM) range that includes dx coils connected to a heat pump. This would prevent the need to install a hot water coil in the air stream and would reduce the load requirements on the DHW air to water heat pump system.

<table>
<tr><td>Space Heating/Cooling</td><td>Air source heat pumps are already a very common technology in the marketplace. The biggest areas for improvement in order for installing this solution at scale are the following:
Incentivize manufacturers to produce multi-split systems with better turn down ratios for proper use in low-load buildings
Development of interior line set covers that are attractive, efficient to install, and low cost. This may not dramatically reduce full cost but would be helpful in providing a quick and easy installation which may simplify location of the indoor heads (since line set is easily covered may be able to locate in areas where you may otherwise not have).
Working with manufacturers to bring the price down for floor mounted indoor units, which as of schematic design we have decided not to use on our project due to the increased cost.
Development of a sleeve for installation of line set through exterior walls that is air sealed, efficient to install, and aesthetically pleasing.</td><td>We looked closely at the MINOTAIR PENTACARE-V12 compact air treatment system. For a variety of reasons, we did not select this equipment for our project. However, if improvements are made to the equipment and ductwork/soffit installation it may provide a solution that is better able to scale. Improvements to consider would be:
Variable speed compressor to help regulate supply air temperatures better (so not cycling between compressor on and off)
Removal of electric resistance heat by improving cold weather performance and/or integration of hot water coil served by DHW system (which would in turn need to be served by an air to water heat pump).
Since new ductwork would likely need to be run in the apartments, the cost and time to install this ductwork is a big driver for cost and scalability of this solution. Improvements in ductwork may include pre-insulated fabricated sections. And pre-fabricated soffits with special mounting clips to make installation quick and efficient.</td></tr>
<tr><td>Domestic Hot Water</td><td>Integration of DHW into space-heating/cooling heat pump system may help reduce the cost and space required for additional outdoor units and compressors.</td><td>We would really like to see an option where DHW could be generated from the same heat pump that heating/cooling is served by. This may reduce installed costs, keep DHW on the resident meters, reduce space required for equipment, and reduce maintenance.</td></tr>
<tr><td>Miscellaneous Electric Loads</td><td>This is a big area for improvement, but also very challenging. Miscellaneous electrical loads are closely tied with resident behavior.</td><td></td></tr>
</table>

Façade	We are prefabricating the new front entry wall and the mechanical sheds. We believe with scale the cost of this prefabrication will come down. Also, we plan to place the new wall and mechanical shed on helical piles. By improving the industries' knowledge of, and by purchasing the correct equipment, the cost for helical piles should also come down dramatically. We have already received very competitive pricing from triple pane window manufacturers. By continuing to build a relationship with these manufacturers we expect pricing to continue to come down and more US manufactured windows to become available. Patio doors and ADA doors have been a difficult and costly component of our solution. It is an issue that manufacturers are aware of and are working on solutions. Especially with regard to durable commercially applicable solutions that incorporate ADA thresholds without the need to custom details.	The cost to retrofit the exterior walls with additional insulation was cost prohibitive. We did look at the $/sf cost and even if a pre-fabricated product was available, we still think it would end up being hard to justify the cost. The true benefits of the exterior insulation can be hard to capture with the exiting utility rate structure (low and no demand chargers for resident meters). If panelized solutions could be developed to bring down costs, while at the same time the true value of additional insulation was quantified, then we would likely see the full envelope retrofit happen. For our project we decided that this full exterior insulation retrofit could happen at a later date when products/solutions are more readily available during a subsequent capital improvement, or in conjunction with future adjacent property capital projects to aggregate scale locally with a single owner and fabricator. Since this retrofit is happening with tenants in place and it is not a full renovation, we decided not to recommend Aerobarrier. For a future project Aerobarrier may be a better solution to achieve the desired air sealing results.
Roof	The roof is being replaced as part of the business-as-usual estimate and it is not included in the RetrofitNY scope and therefore do not provide an evaluation of scalability here.	
Distributed Energy Resources	The biggest issue we are facing for successfully implementing solar PV on our project is metering. This has been discussed elsewhere in our schematic design documents so will not be repeated again here. If this issue can be addressed, solar PV could provide a potential revenue stream for building owners who wish to pursue net zero retrofits that could help offset costs the monthly debt service for the net-zero retrofit loan. See regulatory barriers.	

Project unit cost* for reproducing the retrofit solution at scale.

Location	Pilot Project (1 unit)	10 units	100 units	1,000 units	10,000 units
Ventilation and IAQ	$5,200	$5,200	$4,400	$3,800	$3,100
Space Heating/Cooling	$5,100	$5,100	$4,800	$3,600	$3,100
Domestic Hot Water	$6,700	$6,700	$6,300	$4,200	$3,800
Miscellaneous Electric Loads	$300	$300	$300	$200	$200
Façade**	$12,200	$12,200	$12,100	$10,700	$9,600
Roof***					
Distributed Energy Resources****	$14,100	$14,100	$13,700	$12,700	$11,300
Total	**$43,600**	**$43,600**	**$41,600**	**$35,200**	**$31,100**

* For the purpose of this exercise we have assumed that one-unit is equal to the cost for the system/component on a per apartment basis. Therefore, if a system/component was central, we divided the cost by the number of apartments it serves. The 1-unit and 10-unit numbers shown below are really 40-unit numbers based on our actual costs for this project. If one were only to do one apartment with this scope the cost would likely be higher. In addition, costs listed above do not include general conditions/requirements nor overhead and profit for the general contractor/construction manager. Nor do the cost below include soft costs such as project development, architecture, and engineering.

** We considered façade thermal envelope including windows, doors, insulation, and air sealing

*** The roof is being replaced as part of the BAU estimate and it is not included in the RetrofitNY scope. As such, we did not evaluate the per-unit costs and potential for cost reductions at scale.

**** Distributed Energy Resources cost do not include incentives/grants nor any special metering / interconnection / tree removal requirements such as new master meters and submeters for our project as well as some tree trimming / removal. Budget and financing plan does include these measures.

4 Budget and Financing Plan

Rock PMC is already planning to complete a major capital project at the Christopher Court apartments as part of refinancing. This "business-as-usual" capital project is being funded by USDA and is mostly focused on general rehab items such as kitchens, bathrooms, windows, and site work. As we developed our net-zero scope of work, we were able to identify areas where the business-as-usual and net-zero scope overlapped. In these cases, we were able to apply the funds already set aside in the business-as-usual approach to our net-zero scope. Applying these funds helps off-set the incremental cost of the net-zero retrofit scope. The project's full budget, including both the "business-as-usual" and net-zero retrofit scope of work can be found in Appendix C.

In order to help finance the net-zero retrofit, NYSERDA will be issuing a funding Program Opportunity Notice (PON). The team has not yet explored other financing options for the net-zero retrofit scope as we are awaiting clarification from NYSERDA on their offering first. Once the NYSERDA Project Opportunity Notice for funding is released, and details understood, the owner will explore additional funding streams to complete the full net-zero retrofit scope of work, including USDA, incentives from National Grid and/or NYSERDA for heat pumps, PACE (if it is adopted by the local municipality), NYCECC, and others.

Underwriting the energy savings for this project will be difficult for a variety of reasons. The total value of the energy savings is very low compared to the incremental cost for the retrofit, resulting in the retrofit having a very long payback (~100 years). Even if energy costs were greater, and therefore, the resulting energy savings valued higher, and construction costs were lowered significantly, it would be very challenging to underwrite the savings since the apartments are direct metered and usage is paid by the residents.

We worked closely with Purcell Construction throughout conceptual and schematic design process to understand the financial impacts of our design decisions on construction timeline and cost. Purcell priced many different design solutions, beginning early in conceptual design, in order to help the team fully understand the impacts of design decisions.

Early in the project we decided not to pursue a full exterior wall insulation upgrade due to the high initial cost and long period of return. The ground source heat pump DHW solution originally in our conceptual design was also eliminated due to lack of scalability, high installation cost, and limited technology available. Aside from the change in the type of domestic hot water system, between conceptual and schematic design, we did not make any major changes to the scope. We did make some design and selection changes to reduce costs, but the basic scope of work remained the same.

The one element removed from the owner's scope is the design and installation of onsite solar PV. The owner is currently in discussion with National Grid regarding their interest to complete a community solar pilot project on the property. This would allow the distributed energy recourse (solar PV) to be developed onsite without the need for the owner to finance and/or maintain the system.

A life cycle cost analysis for the proposed scope of work is complete. Unfortunately, the property is already in very good condition and the existing systems are relatively simple and require little maintenance (dedicated exhaust fans in bathrooms and kitchens, electric resistance baseboard, and electric resistance hot water tanks). As a result, many of the recommended solutions increased maintenance and operation cost, thus having a negative impact on the overall NPV.

There are several elements of the proposed solution that will improve the durability of the building, which could reduce future maintenance costs. The addition of continuous ventilation with energy recovery to the project will help the building maintain appropriate humidity levels throughout the year. Additionally, cooling will be supplied to all areas of the building, helping to maintain humidity levels during the summer months.

Interior surface temperatures of the proposed triple pane windows will be above the dewpoint temperature for most, if not all, of the winter, including at the sight line from the use of non-metallic glazing spacers. This will prevent condensation build up and mold growth potential, which occurs at the existing double pane aluminum framed windows circa 1991.

The heat pump systems proposed for heating, cooling, and domestic hot water are less durable than the existing systems, electric resistance and through-the-wall ACs, as they require additional maintenance and include equipment located outdoors with potential to be impacted by extreme weather events. However, with proper design, installation, operation, and maintenance heat pumps can achieve their expected durability and service life.

The design solution proposed will reduce onsite energy usage through efficiency measures by 38%, and with onsite generation will reduce total yearly energy consumption by 93%. The business-as-usual approach would have reduced yearly onsite energy usage by approximately 7%. In a typical business-as-usual approach to an energy efficiency upgrade, we see yearly energy reductions of about 15% to 30%, given a property with minimum previous weatherization and efficiency upgrades.

5 Projected Construction Schedule

The project team is looking forward to securing financing so that design development and preconstruction services can continue. During this next phase, the project construction schedule will be fully developed and analyzed to ensure it can be implemented effectively and efficiently. Our entire team has been actively involved in the conceptual design and schematic design phase of this project and given our scope of work do not believe our project will require a significantly different approach to scheduling as compared to the business-as-usual approach.

The tentative construction schedule for the project is included in Appendix D. While the initial start date may be delayed, the overall timeline for the project and project schedule is expected to remain the same. For example, the total construction time from initial site prep and demolition to project closeout is expected to be five months.

In order to ensure proper implementation in a timely fashion, the design team has budgeted more construction administration and site visit time than what may typically be required for a business-as-usual approach. It is anticipated this will become less necessary as deep retrofit projects become more familiar to construction teams.

The owner typically performs their renovations with tenants in place. As a result, the level of coordination of the proposed net-zero retrofit is not substantially different than the business-as-usual approach. The one area that may require special care and attention is the building of soffits for the ventilation ductwork and refrigerant line sets. During design development and procurement, the team will work closely together to evaluate solutions and ideas to reduce the need to perform plaster/finishing work on the soffits. One idea is to fabricate these soffits onsite, so they can be customized for each specific scenario, but to perform finishing work in an onsite location that is not in the units prior to installation.

There will be some additional coordination required for the switch over between the existing domestic hot water system and the new central system; however, the plan is to complete the central system first so that the system can be switched over seamlessly.

6 Building Performance Summary

Our initial goal for this project was to achieve net-zero onsite energy usage on an annual basis, as originally required and defined by NYSERDA. In order to reach this goal, NYSERDA had also outlined a requirement that total site energy usage be less than 20 kbtu/sf/yr prior to onsite distributed generation. However, after NYSERDA reviewed the conceptual design submittals for the six Retrofit NY project's, the onsite energy usage requirement (prior to distributed generation) was relaxed to 27 kbtu/sf/yr.

Even after NYSERDA eased up the total site EUI requirement, the Christopher Court team decided to stick to the original goal of approaching 20 kbtu/sf/yr and net-zero energy on an annual basis. The greatest energy reduction possible through efficiency was sought in order to achieve this, without having to perform a complete envelope insulation retrofit, and then offset the remaining usage with rooftop solar PV. In total, the projection is a 38% reduction in energy usage from the energy efficiency measures and a 55% reduction from solar PV generation, for a total project reduction of 93% and a final EUI of 2.5 kbtu/sf/yr. See Appendix E for a more detailed summary including projected savings and the specific building performance components of the retrofit.

The projected energy savings reported are first year savings. Due to budget limitations, and the fact that it is unlikely the energy savings will be underwritten (see Budget and Financing Plan section above), energy performance over time was not analyzed. With proper maintenance and care, the project is anticipated to perform nearly as well in year 20 as year one. A life cycle cost analysis was performed for the project and can be found in Appendix C Budget and Financing Plan.

The scope of work recommended is balanced in terms of the energy savings of various building components. Triple pane windows have a 3.8 kbtu/sf/yr reduction, air to water heat pumps for domestic hot water have a 4.3 kbtu/sf/yr reduction, and air source heat pumps for heating/cooling have a 4.8 kbtu/sf/yr reduction.

It is also worth noting that the addition of continuous ventilation, even with an energy recovery ventilator, is expected to increase total energy usage by approximately -4.1 kbtu/sf/yr. This was accounted for in our energy model and analysis and the overall performance of our project, with solar PV generation, is still projected to be 2.5 kbtu/sf/yr. All energy modeling was performed with eQUEST and reported savings are interactive.

We appreciated the reviewer's feedback and especially agreed with their concern about the replicability of a ground source heat pump system for domestic hot water. This concern, along with the high cost, led us to switch to an air to water heat pump for domestic hot water generation.

The domestic hot water system involved the greatest discussion and evolution of design. The current system, electric resistance storage tanks in each apartment, is very efficient from a distribution point of view. Each tank is centrally located between the kitchen and bathroom so there are very little piping losses.

The original hope was to install a heat pump water heart in each apartment. This would allow the distribution system to remain the same, the hot water usage to remain on the resident's bill, while still delivering significant savings by converting generation from electric resistance to heat pump. Unfortunately, the closet that the existing hot water tank was in was not large enough to fit any of the heat pump water heaters on the market. Other potential issues with the individual heat pump hot water heater approach were concerns about the noise and cold air that is generated by this technology.

The next iteration of design was to install a central ground source heat pump system for domestic hot water. Ground source was considered since it was going to achieve the maximum efficiencies and if converting to a central system, we might as well select the highest efficiency system. Pricing on this system was received right before completing the conceptual design. The cost was very high, but keeping it in the scope of work provided the best chance to achieve the target site EUI of 20 kbtu/sf/yr, before renewables.

After conceptual design, and NYSERDA reported that the site EUI requirement was eased to 27.0 kbtu/sf/yr, the team quickly decided to drop the ground source heat pump system due to costs and the required site disturbance. There were also some concerns about the temperature of the ground loop slowly dropping because the system would never add heat back into the ground.

The team attempted to develop another solution for domestic hot water, which represents a substantial portion of the building's energy usage. Leaving in place the electric resistance storage water heaters was considered, which could have been done and still met the EUI goal of 27.0 kbtu/sf/yr. However, since the plan was to use the existing water heater closets to run the ventilation ductwork and to share costs to build and install the mechanical shed between the ventilation and domestic systems, removing the central hot water system from our design had a ripple effect. In addition to the physical and design impacts of removing the central domestic hot water system from our scope, the team and Rock PMC were still interested in achieving close to net zero performance.

Since a central domestic hot water system was critical to our design, we decided to go with an air to water heat pump system for hot water generation. This system utilizes our already planned mechanical shed and has the potential to be pre-installed in the shed offsite.

6.1 Utility Analysis

6.1.1 Baseline Consumption

The team obtained two years (2016 and 2017) of fuel bills for the property and performed a weather-normalized linear regression analysis on each fuel bill (including all apartment meters) to properly baseline the current energy usage of the complex. This weather-normalized analysis provides baseline energy consumption for a typically meteorological year using TMY3 weather data for Syracuse, NY. See table below for the weather normalized electricity usage.

From	To	Days	Average Temp (°F)	HDD ref 65°F	CDD ref 65°F	Heating (kWh)	Cooling (kWh)	Baseload (kWh)	Total (kWh)	Total kWh/ Day
Jan 1	Jan 31	31	26.0	1,209	0	30,571	0	14,852	45,423	1,465.3
Feb 1	Feb 28	28	25.4	1,110	0	28,138	0	13,421	41,559	1,484.2
Mar 1	Mar 31	31	37.4	860	6	19,962	0	14,838	34,800	1,122.6
Apr 1	Apr 30	30	47.9	518	6	9,912	0	14,364	24,276	809.2
May 1	May 31	31	59.9	191	32	1,714	803	14,820	17,337	559.3
Jun 1	Jun 30	30	66.4	66	109	322	2,569	14,331	17,221	574.0
Jul 1	Jul 31	31	71.8	4	213	43	4,187	14,819	19,050	614.5
Aug 1	Aug 31	31	68.0	31	123	241	3,099	14,831	18,171	586.2
Sep 1	Sep 30	30	60.7	181	53	1,433	984	14,352	16,769	559.0
Oct 1	Oct 31	31	49.5	481	0	8,858	0	14,860	23,718	765.1
Nov 1	Nov 30	30	40.9	723	0	16,206	0	14,399	30,605	1,020.2
Dec 1	Dec 31	31	27.7	1,155	0	28,943	0	14,866	43,809	1,413.2
	TOTALS:	**365**		**6,529**	**542**	**146,345**	**11,643**	**174,751**	**332,738**	

Annual propane usage, for the maintenance garage unit heater, is 417 gallons/year.

6.1.2 Energy Costs

Electricity rates used to calculate cost savings were determined by analyzing the most recent 12 months of common area and apartment utility costs. The per unit rate for electricity (without the monthly meter service fee) for the apartments was calculated to be $0.106/kWh and for the common areas the rate is $0.103/kWh. For the analysis, it was assumed that the per-unit rate for all electricity savings is $0.106/kWh.

Propane rates used to calculate cost savings were determined by analyzing the last two years of propane bills. The per unit rate for propane was calculated to be $5.74/gallon. Even with achieving net zero performance, there will still be monthly meter fees to pay. For the common area meters the fee is $27.00/month and for the apartment meters the fee is $17.00/month.

6.2 Blower door test results

Blower door tests were performed at one of the five buildings. Since the front entry to each apartment is through an exterior hallway in the middle of the building, we were unable to perform a whole building blower door test. Instead, the air leakage to the outdoors was measured for four apartments on one side of the building by performing guarded blower door tests. Results from these tests are included in the following table.

Test Apartments		CFM_{50} Results	
Apartment #	**# of Br**	**Compartmentalized**	**Guarded**
7	2	607	427
8	1	402	314
4	1	541	387
3	2	747	566
Half building CFM			1,694
Whole building CFM			3,388
Total building air volume (ft^3)			45,440
ACH50			4.47

6.3 Energy Modeling

In order to evaluate energy efficiency improvements and to project energy savings from the proposed retrofit, the eQUEST DOE2 energy modeling software was used. Two baseline energy models were created: one for the residential building and one for the office, laundry, and maintenance garage spaces. Since all five residential buildings are identical (with the exception of some very minor differences in building #3), only one residential building was modeled, and the results extrapolated to all five buildings.

The eQUEST model for each building was compared against the actual baseline energy consumption for a typical meteorological year to confirm usage matched and to ensure all improvements were modeled against accurate baseline conditions.

Envelope and load reduction improvements were modeled first, with equipment replacement modeled second. This approach favors improving the efficiency of the building envelope prior to improving the efficiency of the equipment.

6.4 Exterior Envelope Insulation Analysis

An analysis was performed early on during conceptual design on the energy savings and total cost of retrofitting the buildings with exterior wall insulation. As described in the energy modeling approach above, the savings from adding exterior insulation prior to replacing the heating system was modeled (so savings were based on the existing efficiency of 100% not the proposed efficiency of 220%). Results from our analysis are shown in the following table.

	Installed Cost ($)	Energy Savings (kWh/yr)	Cost Savings ($/yr)	Payback (years)
Exterior Insulation - R-8	$458,792	17,447	$1,849.33	248
Exterior Insulation - R-12	$470,970	29,688	$3,146.88	150
Exterior Insulation - R-20	$533,989	35,207	$3,731.89	143

Even if there were cost reductions through off-site fabrication and/or through replicable projects, the exterior insulation measure does not appear to be a cost-effective solution for this project, nor other similar building types that do not already need siding replacement. In addition, if the team were to model the improved air source heating system and model the exterior insulation savings off this new heating efficiency, the savings would be reduced by about 50% and the projected payback would double.

6.5 Heating and Cooling Loads

Peak heating and cooling loads for the residential buildings are shown in the following table.

	Peak Heating Load (kBtu/sf)			Peak Cooling Load (kBtu/sf)		
	Baseline	Proposed	Reduction	Baseline	Proposed	Reduction
Apartment Average	10.7	10.4	3%	9.8	8.4	15%

6.6 Distributed Energy Resources Summary

The project site has a fair amount of roof area that can be utilized for the installation of solar PV. Utilizing a high-efficiency panel allows us to maximize production for the roof area available. Due to the layout of the site, there is not much area for a ground-mount solar PV system. A carport over one of the parking lots was considered, but it was determined that it would be more costly to install than rooftop solar PV.

In order to maximize solar PV production, a few trees will need to be trimmed and a large area of trees to the south of building #3 will need to be removed. The plan is to replant the trees south of building #3 further back and with species that do not grow very tall. Given the tight site area and existing tree locations, the solar PV design focused on a roof mounted system.

The current plan is to work with National Grid on a pilot project to implement a rooftop community solar model. The goal of the project is to maximize production so as much of the complex's energy usage could be offset by the solar production. The actual electricity generated by the solar PV would be assigned by National Grid, so it would necessarily be directly linked with the common areas and/or specific apartments.

6.7 Rooftop Solar PV

The project site is located in Upstate New York at the following longitude and latitude 43.240941, -76.298089. Due to limited space at the project site, the most feasible distributed energy resource to achieve the project goals is solar photovoltaics.

There are numerous trees located around the site, which provide a welcoming atmosphere and pride of place for the residents. The owner wishes to maintain as many of the existing trees as possible while still achieving the project's goal of net zero and being mindful of total installed costs for photovoltaics. The approach is to focus on rooftop solar photovoltaic systems installed on the highlighted roof areas in Figure 1.

Figure 1. Arial photo of the Christopher Court apartment complex showing the roof space intended for solar PV

For this design, there will need to be some tree removal and trimming, specifically for building #3. Details on tree removal and trimming can be found in section 6.7.7. The design approach for the rooftop solar PV system was to maximize production while minimizing tree removal and trimming/pruning. Buildings 1, 3, and 5 all have sloped roofs, which face due south. Building 2 has a mostly unobstructed sloped roof that faces east and an unobstructed sloped roof that faces west. Building 4 has an unobstructed sloped roof that faces east. All roofs are 4/12 pitch.

6.7.3 Equipment

As detailed in specification 263100, the photovoltaic panels chosen for this project are SunPower X22-360 panels, which are high-efficiency panels that maximize the power density of the installed system. These panels also have an extended power production warranty of 92% of minimum peak power rating at year 25, which will help maintain the project's net zero performance over time. The system will be DC based with inverters installed for each building to convert power to AC.

6.7.4 System Size and Layout

In total, 471 panels can fit on the selected roofs for an installed capacity of 169.56 kW (DC). The Aurora Solar modeling software was used to layout panels on the roofs of buildings 1, 2, and 3. This layout considers actual sizing and spacing requirements as well as fire code requirements. The east roof of building 4 has the same layout as the west roof of building 2, and the south of building 5 has the same layout as the south roof of building 1. See Figure 2 for roof layout.

Figure 2. Arial photo of buildings 1, 2, and 3 at the Christopher Court complex with the solar PV panels laid out for spacing and size

6.7.5 Metering and Interconnection

Each building's photovoltaic system will be connected to a new meter located at each building. This meter may be an upgraded common meter for the building and/or may be a meter dedicated to the solar PV system. The current electrical feed to each building is 400 amps, which is enough to handle the new PV load.

An interconnection analysis will need to be performed by National Grid to ensure that their system and transformers can handle the on-site power generation. This analysis typically requires a formal interconnection application and fee, which the project will pursue during schematic design. Additional metering considerations are discussed in detail in the Regulatory Barriers section.

6.7.6 First Year Annual Production

Total projected first year annual production is estimated to be 188,703 kWh/yr. Total annual production was calculated using the Aurora solar production modeling software and Taitem Engineering's internal production estimation spreadsheets. Projected annual production numbers take into account all system losses, including shading, pitch, azimuth, inverter efficiency, system efficiency, and losses due to snow cover.

Roof Pitch	4/12					
Panel	SunPower X22-360					
Watts/Panel	360					
	Building 1	**Building 2**	**Building 3**	**Building 4**	**Building 5**	**All Buildings**
Total # of Panels	69	159	105	69	69	471
Direction of Roof	South	East and West	South	East	South	-
Average Daily Solar Radiation Factor (NREL)	4.31	3.73	4.31	3.73	4.31	-
Total installed wattage (kW)	24.84	57.24	37.8	24.84	24.84	169.56
Total annual production (kWh/yr)	30,534	58,635	43,555	25,445	30,534	**188,703**

6.7.7 Tree Removal

The large grove of tall trees directly to the south of building 3 will need to be removed in order to prevent shading of the photovoltaic system on building 3's south facing roof. Once removed, these trees could be replaced with smaller varieties that would not grow large enough to shade the solar array.

The large tree located on the southeast corner of building 2 will need to be removed in order to prevent shading of the photovoltaic system on building 2. The small tree on the northeast corner of building 4 will need to be removed in order to prevent future shading of the photovoltaic system on building 4.

6.8 Supplemental Renewables Plan

After the retrofit is completed and solar PV is installed, the total annual energy demand is expected to be around 2.5 kbtu/sf/yr or 23,015 kwh/yr. There is no intent to procure additional onsite or offsite renewables to meet this load as part of this retrofit. After the retrofit is complete and at least a years' worth of utility bills is analyzed, if the complex has not achieved net zero usage on an annual basis, the team will make additional recommendations to Rock PMC on additional measures to reduce energy usage and other options for procuring additional renewables to achieve net zero performance.

7 Resident Management Plan

The Owner has intentionally not involved residents at this stage, it has been unclear if the project will move forward. Until funding is secured, the Owner's preference has been to not engage the tenants as to not cause confusion about what work is to occur and what impact it will have. The plan to engage the residents is detailed in the Resident Management Plan.

Once residents are engaged, it is expected that the majority of residents will be happy that the new heat pump systems will provide them with cooling in their bedrooms, which they did not previously have. There will also be a learning curve associated with new controls, as compared to the existing simplicity of electric resistance heating. Although, it is expected there may be some questions or concerns about the new ventilation system, with proper education and it is anticipated they will see this as a substantial benefit.

To limit resident impact, the foundation design at new construction was adjusted from frost protected foundation wall, this affects the entry and mechanical shed to helical piles. The amount of site work required has been limited as compared to typical poured concrete foundations and will reduce time required for installation of the new entrance wall and mechanical shed.

7.1 Goals

Ensure safety of our employees, owner, owner's representative and tenants throughout the renovation project.
Provide an acceptable work environment for employees and tenants.
Minimize disturbance to owner and tenants.
Perform quality workmanship.
Complete work on time.
Complete work within budget.

7.1.1 Length of construction phase

June 24, 2020 to November 29, 2020

7.1.2 Length of resident management plan

May 1, 2020 to November 29, 2020

7.2 Plan for resident notifications and communication

The general contractor will coordinate with the owner's representative for access to each individual apartment unit. The owner's representative will communicate and schedule work times with each tenant. A pre-construction meeting with the owner's representative, tenants and construction manager will be scheduled to present the construction management plan and inform all parties of the schedule, scope of work to be performed and provide time for tenants to ask questions. At this meeting, explanation of the safety plan will be presented. The on-site superintendent will manage the safety of tenants and employees. The superintendent will ensure adequate signage is posted and pathways are kept clear at all times. The superintendent will have a comprehensive checklist and ensure safety standards are being met.

Weekly construction meetings will be held. After each meeting any changes to the scope of work or schedule will be communicated by the owner's representative to the residents.

7.2.3 Resident liaison or resident groups

The owner's representative will appoint an individual to act as the liaison between the tenants and the contractor. This individual will coordinate access to each apartment for work to be performed.

7.3 In-unit construction plan

The renovation inside the apartment will consist of the installation of new heating/cooling units, new windows, doors, installation of ductwork and air sealing, and related work (thermostats, wiring, piping, etc.). The estimated time of construction will be approximately two weeks per apartment. Work will be performed in multiple apartments at the same time. Installation of doors and windows will be performed immediately after the removal of the old door or window and will cause minimal disturbance. The majority of the ductwork will be installed in the attic and come down through chases to feed the first floor. Miscellaneous air sealing will be performed at each apartment. Daily clean-up will be performed and as work is performed, steps will be taken to minimize dust and dirt.

7.4 Exterior construction plan

The mechanical sheds are designed to be prefabricated and are in a location that will not cause interruption to tenant activities. The new stair enclosure wall will also be prefabricated and set as one unit/wall panel. There will be preparatory work, consisting of the demolition of the existing sidewalks at the apartment entry and the installation of helical piles for the prefabricated wall foundation. The pre-fabricated wall panels will be set in one day. New entry door and window will be installed in one day. The concrete sidewalk infills will also be performed in one day. Demo, drywall and painting inside the new stair enclosure would be performed in two days. Each apartment entry is scheduled to be renovated in a seven-day time period.

7.4.4 Parking impacts

It is expected that an area for up to 20 vehicles to park will be required.

7.4.5 Plan for special needs

The project anticipated relocation expense for tenants with accessibility requirements if the need arises.

7.4.6 Expected areas of pushback

Any disruption, even if small, can be a source of frustration for residents. The team will manage this by having early and frequent communication with residents, so they are kept informed of the latest schedule and duration of disruption.

7.5 Residents' Meeting Plan

7.5.7 Plan for initial resident outreach

The property manager has begun outreach to establish reliable lines of communication via company website, email, and text. When project details are confirmed, tenants will be notified of planned rehab and anticipated schedule. Concerns can be raised at that time or anytime at the on-site office.

7.5.8 Kickoff event

Goals include presentation of detailed schedule, best channels of communication with contractor and education of new systems.

7.5.9 Resident update meetings

Updates will be posted on the website, community bulletin board or through direct outreach if needed.

7.5.10 Trainings

A community wide session will be held to train tenants on new systems, literature handed out, and in unit meetings for residents who cannot attend.

7.6 Other Resident Activities

7.6.11 Method to gauge resident participation and track achievements

The property manager has already completed an initial survey to track tenant satisfaction. This will be repeated in 12 months to track progress. Benchmarking of tenant energy use has been proposed to make it an interactive competition between tenants.

7.7 Resident's Guidelines

7.7.12 Operations and maintenance guidelines

The Architect and Engineer will develop an Operations and Maintenance Manual upon completion of the project. This O&M Manual will have a specific section of guidelines for the residents. It is expected to include the following:

Description of systems
Proper reporting process of water leaks and/or other water and energy related issues
Operation of air source heat pumps including controls and setpoints
Cleaning of air source heat pump indoor coil filters (this will also be handled under the owner's O&M section)
Cleaning of range hood recirculation fan filter
Operations of windows
Process for requesting new LED lamps for fixtures, including resident owned fixtures
Education on phantom loads and how to reduce them, including using smart strips

7.7.13 Health and safety guidelines

No smoking policy.
An indoor air quality guide will be provided to the tenants to help educate them on how their own actions impact indoor air quality. Recommendations will be provided on things they can do to improve indoor air quality.

7.7.14 Residents' guide to understanding the utility bill

The project is currently planning to switch from a direct metered to a master/submeter metering arrangement. The owner will be working with a third party to handle billing. Once the third party has been selected the owner will work with them to develop a training and guide for understanding their utility bill.

7.7.15 Schedule of routine in-unit maintenance

Work orders are promptly resolved when a tenant submits. Bi-annual servicing of new systems is anticipated by site maintenance staff and new preventative maintenance contracts are expected. The property manager does an annual property wide inspection and adjusts capital budgets as needed.

8 Performance Guarantee Pathway

Our team will not be providing a high-performance guarantee for this project. We do plan to include a request for pricing for extended warranties and service contracts from each subcontractor within the bid documents. This would be treated as an added extra to the construction cost and would allow the Owner to analyze both upfront costs and long-term warranty and service for each system.

At this early stage in the deep energy retrofit market, there is little precedent and understanding of how a performance guarantee is supplied, and who becomes the responsible entity for the future of the warranty. As an industry we have much understanding to gain from the successful performance guarantee models seen in European deep retrofit projects.

One of the biggest challenges we see in providing a long-term performance guarantee is the lack of knowledge amongst our team members on how to go about providing this offering. Additionally, the liability concern is holding a majority of traditional team structures from adequately being able to support such guarantees beyond typical manufacture warranties.

In order to overcome these challenges, more education to the industry, including architects, engineers, construction managers, and owners, would be helpful along with legal assistance regarding a long-term guarantee and how this applies to typical contract documents (AIA, for example).

The team would be interested in providing benchmarking and/or energy savings verification services as part of a long-term performance guarantee offering. Since the project is following the more traditional design-bid-build approach, the team does not see a role in directly providing these offerings.

8.1 Maintenance and Warranties

8.1.1 Performance Parameters

The following energy performance parameters could fall under a performance guarantee.

8.1.1.1 Heating slope (Btu/SF/HDD):

This performance guarantee supports the analysis of the total heat load (envelope/air leakage/ventilation rates) and the performance of the installed heating system. While there may be some variation in heating usage between apartments due to occupancy, the overall project will have a fairly consistent weather-normalized heating usage on a yearly basis that could be guaranteed.

8.1.1.2 Solar PV production (kWh/yr):

Production is guaranteed for a set timeframe by the designer/installer in a typical solar PV contract. This is expecedt this to be the case once the regulatory barriers are overcome and PV is feasible to install.

8.1.2 Warranty Term Lengths

The entire project will have a one-year construction warranty provided by the General Contractor Additional manufacturer warranties are listed as follows.

8.1.2.1 Air source heat pumps:

12-year warranty on compressor and parts.

8.1.2.2 Ventilation:

10-year warranty on ERV core and 5-year warranty on all other components.

8.1.2.3 Windows:

Five-year warranty on materials

8.1.2.4 Domestic Hot Water:

Air to water heat pump: three-year labor, 10-year heat pump parts, 15-year tank warranty. Circulation Pump (TBD): Manufacturer warranty expected to be two-year.

8.1.2.5 Solar PV – SunPower:

25-year warranty on products (labor, parts, shipping, etc.).

8.2 Project Lifetime High-level Maintenance Needs

The following is a list of the high-level maintenance needs for the project's lifetime

8.2.3 Air source heat pumps:

Indoor filter cleaning bi-annual.
Outdoor coil cleaning – once every three years
Refrigerant leak check – once every three years, coordinated with coil cleaning
Compressor replacement if failures occur
Full replacement of both indoor and outdoor units may be necessary around 20 years.

8.2.4 Ventilation:

ERV filter replacement bi-annual (two filters per ERV/building)
Constant volume regulators cleaned once every three years by maintenance staff
Hot water coil cleaning – once every three years

8.2.5 Domestic Hot Water

Outdoor coil cleaning – once every three years
Full replacement may be necessary around 20 years

8.2.6 Air sealing

No specific maintenance necessary. Include in O&M manual that any new holes in drywall must be properly air sealed.

8.2.7 Windows

No specific maintenance necessary.

8.2.8 Solar PV

Inverter replacement will likely be necessary at around 15 years.
Expected life of system is 25 to 30 years

8.2.9 Washing Machines

Assume full replacement after 12 years

8.2.10 LED Lamps for Apartments

Assume that ongoing replacement will be necessary, specifically for apartment owned fixtures as apartments turn over.

8.3 Aligning Maintenance Schedules and Warranties

Subcontractors can provide preventative maintenance contracts and may be willing to work this into these contracts an extended warranty that could extend the life of the project. However, it becomes difficult when equipment is expected to reach the end of its useful life prior to the duration of the project. For example, an HVAC contractor may be open to signing a preventative maintenance and/or extended warranty for an air source heat pump system they installed, but they would be unlikely to include the cost of replacement, which may be necessary after 15 to 20 years.

8.4 Assignment of Warranties and Performance Guarantee

The Christopher Court RetrofitNY team will not be providing on-going maintenance and/or a performance guarantee for this project. The one-year construction guarantee will be provided by the general contractor and warranty issues will be handled directly with the manufacturers and/or general contractor.

The owner will need to contract directly with subcontractors to perform the required maintenance for the heat pump systems. The plan is to bid out these maintenance contracts at the same time as the construction work so that the owner can look at the holistic cost for each system, rather than installed cost and maintenance costs separately.

The ERV filters will be maintained by the owner's staff.

8.5 Cost of Guaranteeing Energy Performance

Warranties provided by manufacturers almost exclusively are for parts/components only and do not cover labor (except for the solar system). As such even just extending warranty to include labor will incur cost.

Performance of systems are interactive and are also dependent on occupancy, weather, and occupant behavior. As such, we believe that a performance guarantee for the entire project is more appropriate than for each specific building system. This also allows the solution provider team to focus energy/time/resources on the systems that are influencing the overall performance the greatest.

The existing yearly energy cost for Christopher Court Apartments is $37,518/year. The proposed yearly energy cost without solar is $21,047.

In order to provide a full maintenance, warranty, and energy performance guarantee for the lifetime of the project (30 years), we anticipate an annual cost of $25,000/year. In addition to operations and maintenance for new energy systems, this annual cost includes replacement the following equipment when it has reached the end of its useful life DHW systems (heat pump/tanks/pumps/etc.), air source heat pumps (indoor units, outdoor units, lineset), ventilation system (ERV, hot water coil, pump, fans, constant volume regulators), solar PV (panels, wiring, inverters).

Providing a full maintenance and performance guarantee for the length of the project is also challenging because some of the equipment may need replaced toward the very end of the project life, so the provider of this maintenance/performance contract will need to carry the cost for this replacement work, but the benefits of the new equipment will mostly be realized after the contract is over.

It is unclear if energy consuming equipment that is not currently in the scope (refrigerators, dryers, apartment lighting) would need to be included in the service provider contract for future replacement since their replacement will impact energy usage. For this exercise, it is assumed that these costs are not included.

8.5.11 Performance Guarantee at Scale

The operations, maintenance, and performance guarantee could be reduced if there was one contract to cover more than one project and/or many units. For the purpose of this analysis we have assumed an estimated reduction in cost based on number of units. For 100 units, ~10% reduction in cost of this guarantee may be expected.

If 1,000 units, a ~20% reduction in cost may be expected.

These reductions are strictly estimates. To fully evaluate this would require a major change in the building industry and significant analysis, which has not yet been done at this time.

8.6 Monitoring and Verification

8.6.12 Monitoring Responsibility

As of this schematic design deliverable, our project is not planning to monitor individual equipment. Utility bills and PV production will be analyzed by the Christopher Court Retrofit NY team at six-month, 12-month, and 18 months post-construction, that will each coincide with a site visit and meeting with the owner to review performance and equipment operation.

Submeters were considered but since the proposed plan is to have Solar PV installed and maintained by National Grid, the project is no longer considering the master meter>submeter option.

8.6.13 Components Monitored

Solar PV production will be monitored through installed inverters.
Apartment electricity usage will be monitored through resident utility bills.
House panel usage (corridor lighting, exterior lighting, domestic hot water, and ventilation) will be monitored through utility bills.

8.6.14 Monitoring Cost

Monitoring will be performed through utility bills, so there is no additional cost for monitoring equipment.

If submeter was installed, the costs would be ~$15,000-$20,000 for equipment and installation. This does not include the cost for new master meters would could run as much as $50,000 for the whole project.

Monthly fees for submetering will be included in resident's utility bills but will average about $5/month/apartment or $200/year.

8.6.15 Cost of Analyzing Data

A fee of $3,500 is included in the retrofit proposal to perform renewable generation and post-construction utility bill analysis at six-month, 12-month, and 18-months. No other data will be analyzed so no other costs are included.

8.6.16 Key Performance Indicators (KPIs)

Weather normalized site EUI for heating, cooling, DHW, and miscellaneous electrical loads.

Total annual kWh production for solar PV system.

8.6.16.1 Sampling Rate

Weather normalized site EUI for heating, cooling, DHW, and miscellaneous electrical loads will be evaluated every six months for the first 18 months.

Total annual kWh production for the solar PV system will be calculated every six months for the first 18 months.

8.6.16.2 Operational Efficiency

Analysis of utility bills and solar production at six, 12, and 18 months will provide the team an understanding of how the project is performing and will allow us to determine if any systems are under performing. This will help focus the associated inspections to determine if equipment is operating incorrectly.

8.6.16.3 Expected Impact Operational Efficiency Improvements

Since a performance guarantee will not be provided for the project, O&M is not expected to impact the cost of this guarantee.

However, if a performance guarantee was provided, O&M practices and costs would be included directly into this guarantee as they go hand in hand.

9 Regulatory Barrier Summary

The approach to resolving regulatory barriers involves communication with the parties involved, both in this current design phase, and as the project progress through future design phases to appropriately resolve foreseen barriers.

While no significant building code regulatory barriers were encountered that changed the project's design, several were identified that could affect our ability to reach the net zero project goals and are summarized.

The property's financing is via USDA which requires a traditional design, bid, build general contractor procurement process and do not necessarily reward property Owners for energy efficiency upgrades which lead to reduced utility expenses. Key stakeholders USDA have been engaged throughout the design process and are actively involved in meetings and discussions in efforts to create incentives toward other USDA funded project to approach substantial refinancing with concepts of deep energy retrofits. Additionally, a significant regulatory barrier involves the utility provider, National Grid, and the Public Service commission's regulatory structure related to metering arrangements to maximize solar photovoltaic opportunities.

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**
NY		No building/fire code regulatory barriers identified at this time.			X		
USDA		USDA Rural Development Financing	NYSERDA solutions/incentives need to coordinate and be compatible with USDA program. Based on this current metering configuration savings from energy efficiency improvements would be realized by the tenants in the short term. However, because of the utility allowance/income-based rent structure, these savings would be charged back in the form of rent once annual rent/UA adjustment is made. Since savings do not go to the owner, financing the energy retrofit becomes more difficult as the energy savings cannot help off-set any upfront costs/loan payments (see Metering section below for other metering options). In summary, neither the owner nor the tenant sees the long-term direct benefit of energy efficiency measures.	USDA has been engaged early on this project, and they are actively involved in meetings and discussions.		X	

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**
USDA		USDA Rural Development Competitive Bid Requirements.	USDA typically requires competitive bidding (traditional "design-bid-build" process) above rehab of $12,000/apt. Waiver request per RD instruction 1924.13 (e) (1) (VII) necessary. General Contractor/CM is part of current RetrofitNY concept design team as integral team member.	Will GC/CM soliciting subcontractor bids from all trades be acceptable within USDA framework? How would competitive bid requirements be handled and/or waived for a future solution provider that does work in house and therefore would not be soliciting subcontractor pricing?		X	
HCR		HCR Financing	Not currently financing Christopher Court, but they are involved with owner's neighboring property (Patrick Court). Owner desires solutions for Christopher Court to be immediately replicable at Patrick Court, both properties undergoing renovation concurrently.	Will NYSERDA solution coordinate and be compatible with HCR? HCR is interested in cross collaboration between agencies and actively sits in on USDA quarterly meetings. See previous comments about competitive bid requirements that may apply for HCR projects as well.		X	

x		National Grid / Public Service Commission – Metering for Photovoltaic System	The current plan is to switch the buildings from direct metered to master metered with submeters for each apartment. This requires PSC approval and is a lengthy process. In addition, because all the load would be on one meter, the owner would now incur demand charges. It is hard to predict the cost of these demand charges and, therefore, it is hard to evaluate the feasibility of the solar project. Demand charges in general loom as a potential major obstacle to both heat pumps and solar PV in master-metered buildings, substantially reducing savings. Note the catch 22: In many instances, projects require master metering in order to be viable, but master metering cannot be done cost effectively due to demand charges. Another issue is that commercial meters have to follow the Value of Distributed Energy Resources value stack calculator. This adds additional complexity in evaluating the feasibility and financial benefit from solar. If a community solar array is developed on the roof of the buildings either by the owner, or a third party (possibly in Partnership with the owner), then the residents of the complex could elect to participate. However, what is unclear is what happens if the residents do not participate and/or if a resident participates but then leaves the complex. In order to alleviate this burden on the owner, the NYSERDA Solar for All program (see below) could be helpful. However, because rooftop solar is typically more expensive then solar installed in a large field, this community solar project would be less competitive versus other projects and may not be able to offer as competitive rates.	OPTION 1 – MASTER METER/SUB METER AGREEMENT: Switch each building from individual apartment meters to one master meter and then submeters to each apartment. This would need to be done per the NYS Public Service Commission's guidelines and an approved submetering company/billing agency would likely need to be used. This could allow Patrick (Christopher Court) to pay for the installation of the solar PV system and then have the tenants pay it off over time by continuing to pay for their electricity usage. Because all usage would be on the common meter, the account would have demand charges and would be subject to the Value of Distributed Energy Resources guidelines. With this option the economics of solar become more unclear. OPTION 2 – COMMUNITY SOLAR: If a community solar array is developed on the roof of the buildings either by the owner, or a third party (possibly in Partnership with the owner), then the residents of the complex could elect to participate. However, what is unclear is what happens if the residents do not participate and/or if a resident participates but then leaves the complex. In order to alleviate this burden on the owner, the NYSERDA Solar for All program (see below) could be helpful. However, because rooftop solar is typically more expensive then solar installed in a large field, this community solar project would be less competitive versus other projects and may not be able to offer as competitive rates. OPTION 3 – POWER PURCHASE AGREEMENT: Leave buildings direct metered and install solar PV on Rock PMC's master meter. Rock PMC provides tenants with option to sign Power Purchase Agreement for electricity on lease signing		X	

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**
				at reduced cost as compared to National Grid. Solar PV generation is assigned to tenant bills through accounting procedure (similar to community solar). This option would also have similar issues as option 2 above regarding the solar production being regulated under the Value of Distributed Energy Resources guidelines. Next Step: Need to propose solution and present to National Grid.			

10 Resiliency Summary

While we were unable to justify a full exterior envelope upgrade during this capital improvement phase, the new triple pane windows, enclosed corridor, and air sealing work included in this scope of work will help the buildings maintain temperature in the event of a power outage. The team also designed the ventilation and domestic hot water system to be centralized in the mechanical shed so that they may be powered by either a generator and/or a battery. The current scope and construction budget do not include a back-up power system, the design allows for its addition in the future. The feasibility of installing a hot water coil in the make-up air ventilation air stream served by the domestic hot water system was evaluated. This would allow a small amount of heat to be delivered to the apartments in the event of a power outage, given that the mechanical shed is supplied with a (future) back-up power source.

RetrofitNY style retrofits greatly improve a project's resiliency. Better-insulated and weatherized buildings are always more resilient due to a slower drop in temperature in winter during power outages, and vice versa in summer. Buildings with lower heating and cooling loads also take much less energy to maintain temperatures, which could be more easily met with a back-up power source. Similarly, lower overall electrical usage will put less stress on the grid and during periods of peak loads, brown or black outs will be less likely as grid tied buildings transition to deep retrofits.

Design choices that improve resiliency can sometimes have a mixed impact on the durability of the solution. For example, if care is not taken when designing an exterior envelope retrofit, water and moisture issues can develop in the wall system that could significantly impact the longevity of the solution. However, if proper detailing is performed, a new wall system may perform much better than the existing wall and/or other business-as-usual approaches. Similarly, adding battery back-up to a project could significantly improve resiliency; however, batteries can be expensive to maintain and replace.

The resilient aspects are intertwined with better building performance and in almost all cases increase occupant comfort and experience, which has a direct impact on the residents' quality of life.

Indicator	Design Solution
Protection: Identify strategies to reduce a building's vulnerability to extreme weather:	
Floodproofing or Flood Control	The property is not located in a flood plain and has not experienced any issues with flooding in the past.
Sewer Backflow Prevention	Unknown. Will evaluate during design development.
Mechanical Equipment Protection and Location	The domestic hot water system and energy recover units are proposed to be housed in equipment 'sheds' attached to the side of the existing building. The sheds will be constructed with wood frame, continuously insulated walls, floors, and roof. The sheds are viewed as being resilient and can be rapidly serviced (outside of apartments) in the event of damage due to a weather event.
Electrical Equipment Protect and Location	Electrical meters and future submeters are contained within an exterior shed. The new subpanel for the mechanical shed will be contained with the shed itself. These areas are well protected from potential weather damage and can be serviced rapidly if they are damaged.
Backup Power Location and Protection	Not applicable, there is no backup power source provided. Future batteries could be added to the mechanical shed. If a generator is to be used to power the mechanical equipment in the mechanical shed, the generator would sit outside. There is currently no plan to provide a generator housing/shed.
Communications	The owner is currently working on an updated communication plan with residents.
Envelope Protection	Triple glazed windows and patio doors are proposed with perimeter air sealing to increase performance against severe wind and temperatures. New enclosed entry corridor reduces thermal envelope area and losses directly from apartments while entering and exiting. These additional envelope weatherization measures create a more resilient building as temperature will be slower to drop in the winter during power outages and vice versa in the summer.
Fire Protection	As part of the business as usual scope of work the fire alarm system will be upgraded. No sprinkler nor plan for sprinkler at this time.
Adaptation: Identify strategies that improve a facility's ability to adapt to changing climate conditions:	
Envelope Design	Blower door testing of the existing building condition was conducted with results showing 4.47 ACH50. Additional air sealing is planned to less than 2.0 ACH50. The existing open-air stairwells will be enclosed with insulated walls and attic to reduce area of exterior walls and buffer the apartment entry doors from the exterior. Triple pane windows and doors are proposed. These installations will improve the ability to maintain comfort and control moisture. Next capital improvement will include full envelope upgrade prior to 2050 (25–30 years).
Mechanical Equipment	Air source heat pumps will be installed for each apartment that can provide both heating/cooling in extreme temperatures. Currently the building only has tenant provided cooling in the living rooms, air conditioning in the bedrooms will be a big improvement especially for temperature and moisture control in the summer. An ERV will be installed for each building which will assist in maintaining humidity control in summer and winter.
Passive Cooling or Ventilation Strategies	Operable windows and patio doors are proposed. The ventilation system is designed with a hot water coil to provide some additional heating as necessary. In the event of a power outage if a generator and/or battery back-up is added to the mechanical shed this ventilation system and hot water coil could help maintain livable conditions in the apartments through extended outages.

In-unit	Heating and Air conditioning provided in all living spaces, continuous energy recovery ventilation.
Site	Limited tree removal will be performed to increase the performance of the photovoltaic system. Any landscaping will utilize local species which do not require irrigation once established. No additional storm water management is planned. Buildings currently utilize simple rainwater management released back to local water table.
Backup: Identify strategies that provide critical needs for when a facility loses power or other services:	
Critical Systems with Backup	Mechanical shed and associated sub panel will be designed with transfer switch so that small generator can run the ventilation and DHW systems during power outages. For this project battery back-up will not be provided by could be integrated at a later date.
Backup Power Type	None, but mechanical shed and common subpanel will be designed with a transfer switch for operation with a generator and/or battery system.
Access to Potable Water and Sanitary Services	The property is on municipal water. The DHW (and ERV) system could be utilized if a generator and/or back-up power is provided.
Safety Precautions for Mechanical Equipment Operations	Central systems and breakers held within mechanical shed not accessible to tenants, along with PV inverters and associated equipment. Ducts and piping inaccessible and unable to be tampered with.
Community: Identify strategies that encourage behavior which enhances resilience:	
Emergency Management Awareness for Residents	Rock Property Management Company regularly communicates with local Fire and Police officials to ensure they have proper and sufficient access. Rock PMC is also building their phone and email database to reach tenants in an emergency.
Access to Manuals, Emergency Event Guidelines	Rock Property Management Company maintains an on-site office with regularly posted hours. Tenants are also aware how to contact maintenance and or management in the event staff is not on site.

11 Resident Health Impact Summary

The goal of our RetrofitNY scope is to both reduce energy usage and improve indoor air quality and health and comfort of the residents. To achieve this, we are performing select envelop improvements, replacing the heating and cooling systems and providing continuous ventilation.

We will be adding air conditioning to all apartments including the bedrooms. The bedrooms did not previously have air conditioning and it was only available via tenant purchase of through-wall A/C units in the living rooms. Refer to Architectural Drawings for infill and air sealing notes. This will be a substantial improvement to resident comfort. The addition of air conditioning throughout the apartments will also help control humidity levels in the summer, reducing the potential for mold growth.

Continuous exhaust in the bathroom and kitchens will provide source control of moisture and contaminants, while fresh air will be provided to the living rooms and all bedrooms. This will greatly improve the indoor air quality within the apartments, which do not currently have a source of continuous mechanical ventilation. Low-VOC materials into our design during design development and construction documents will also be incorporated, including both the RetrofitNY and business-as-usual scope of work.

The central ERV system, running continuously, will balance out humidity throughout the entire building. Given the occupancy type, mostly seniors and low density (~430 sqft/ person), there is not an excessive amount of moisture to deal with. With an ERV with a latent recovery effectiveness of approximately 55% to 60% some of the moisture in the exhaust air stream will be rejected from the building. As a result, we do not anticipate humidity levels to rise above safe levels.

RetrofitNY style projects provide several health and comfort benefits to the residents. An improved thermal envelope provides, a more comfortable living environment, reduced draughts, and reduced potential for mold growth. Continuous and balanced ventilation, both exhaust and supply, provides a healthier environment by removing indoor stale air, toxins and providing fresh air to each individual living and sleeping space. Air sealing and balanced, energy recovery ventilation reduce potential for contamination between apartments and from the outdoors by balancing pressure differentials, while supplying constant, measured, and tempered outdoor air.

Indicator	Location	Intervention	
		Design Solution	Maintenance Plan
Mold	Units - Kitchens	Existing apartments do not have adequate ventilation. A new central ventilation system will be installed with an energy recovery ventilator. The system will provide 25 CFM and 30 CFM continuous exhaust in the one-bedroom and two-bedroom apartment kitchens respectively. The ERV will be fitted with MERV 13 air filters to remove contaminants.	The central ventilation systems will need to have filters checked and changed on a bi-annual basis. The constant air flow regulators will need to be checked for dust/dirt build up every three years and cleaned as necessary. The constant air flow regulators settings will need to be adjusted in the two-bedroom apartments if more than (3) occupants are living in the apartment.
	Units - Bathrooms	Existing apartments do not have adequate ventilation. A new central ventilation system will be installed with an energy recovery ventilator. The system will provide 20 CFM and 25 CFM continuous exhaust in the one-bedroom and two-bedroom apartment bathrooms respectively.	See ‘Units – Kitchens’ description above.
	Units - Windows and Exterior Doors	Existing windows are old, have broken seals, and are metal-framed. They are reported to be a source of condensation and mold/mildew build-up. The new windows will be triple-paned with low conductivity thermally broken frames, which will result in warmer surface temperatures and prevent mold/mildew growth.	Yearly condition assessment by maintenance staff to address any damage. Exterior caulk joints reviewed and replaced as necessary.
	Units - Mechanical Rooms	Domestic hot water and energy recovery ventilation systems will be housed in a new mechanical ‘shed’ addition, attached to the side of the existing building.	Typical exterior envelope and roof maintenance similar to existing buildings.
	Common Areas - Windows and Exterior Doors	See ‘Units Windows and Doors’ description above.	See ‘Units Windows and Doors’ description above.
	Common Areas - Mechanical Rooms	See ‘Units – Mechanical Rooms’ description above.	See ‘Units – Mechanical Rooms’ description above.
	Below Grade	N.A.	N.A.

Pests	Units	Blower door tests were performed by our team and we have identified areas where air sealing is proposed (electrical boxes, pipes, duct to drywall connections, remove AC sleeves). This air sealing will further prevent pests from entering the units.	Yearly condition assessment by maintenance staff to address any damage. Visible caulk joints reviewed and replaced where necessary.
	Common Areas	See ‘Units’ description above.	See ‘Units’ description above.
	Below Grade	N.A.	N.A.
	Exterior	See ‘Units’ description above.	See ‘Units’ description above.
VOCs (enter level of VOCs in products: conventional, low- or no-VOC)	Units - Paints	No-VOC.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance
	Units - Coatings	N.A.	N.A.
	Units - Primers	No-VOC.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance.
	Units - Adhesives and Sealants	No-VOC.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance.
	Units - Flooring Materials	No-VOC.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance.
	Common Areas - Paints	No-VOC.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance.
	Common Areas - Coatings	N.A.	N.A.
	Common Areas - Primers	No-VOC.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance.
	Common Areas - Adhesives and Sealants	No-VOC.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance.
	Common Areas - Flooring Materials	No-VOC.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance.
Other Contaminants	Units	Composite wood: No-VOC or urea formaldehyde.	Typical product specifications provided to maintenance staff so that materials purchased for future maintenance.
	Common Areas		

12 Overall Rehab Proposal

The design team acquired a previously determined business-as-usual renovation scope of work and incorporated the determined retrofit scope into these planned improvements to establish the full project scope.

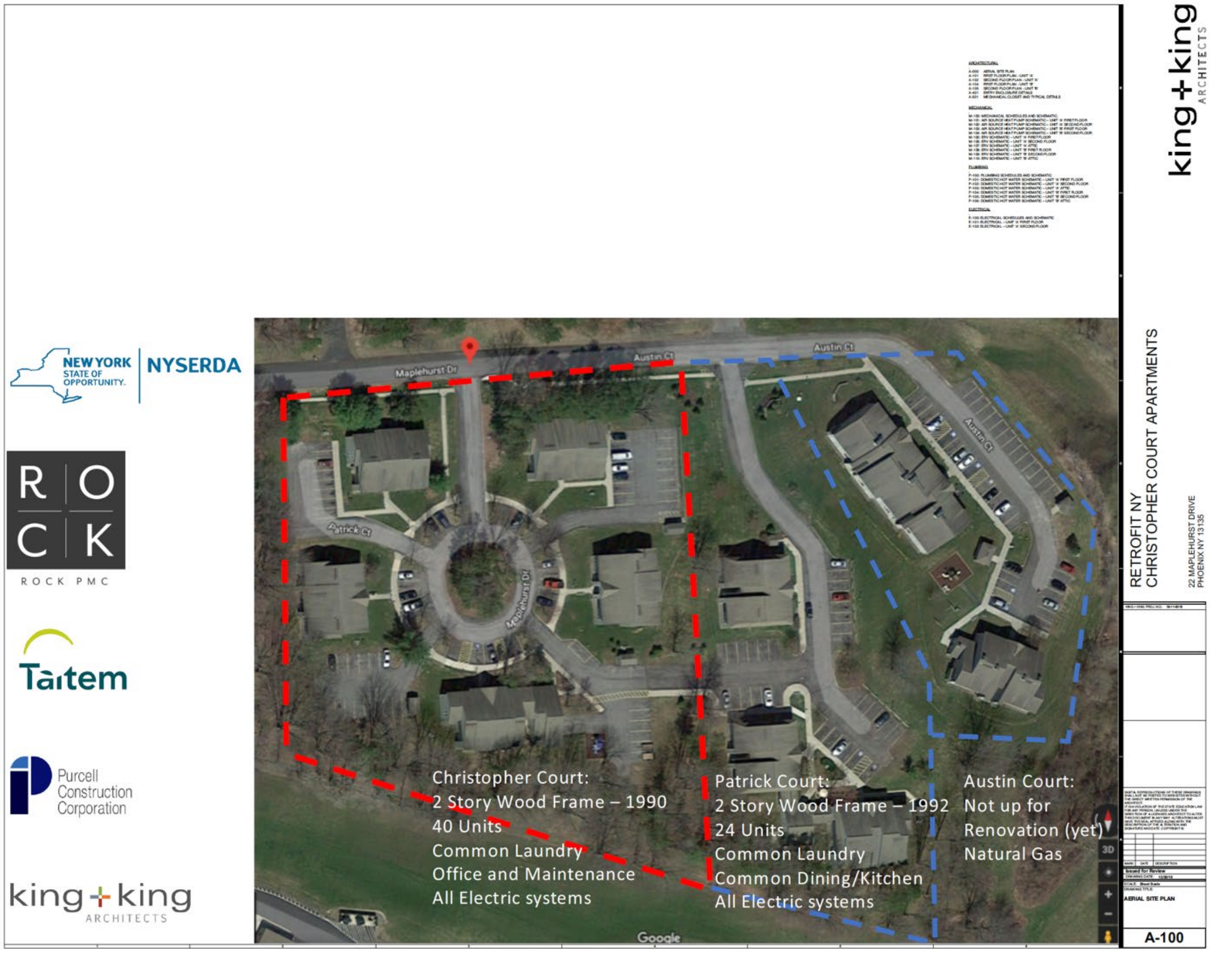
Rock Property Management is the property Owner and Manager. King + King Architects will act as design project lead and provide architectural services. Taitem Engineers will provide all MEP engineering, structural engineering, blower door testing, and other energy design services. Keplinger Freeman Associates will provide site and landscape design. Purcell Construction will provide both preconstruction and construction general contractor services. Together all firms plan to team and provide an integrated design and construction approach.

Few challenges integrating the business-as-usual and retrofit scopes are foreseen, as both scopes of work will be incorporated into a single set of construction documents. If the business-as-usual scope and retrofit scope were handled by separate design entities, more challenges and coordination issues would be likely to arise. Relatively small teams and associated project experts will have an advantage, with less consultant management and coordination required, limiting mistakes and omissions between consultant documents.

The team is relatively compressed as it stands, with all engineering under one consultant, overall project design and coordination falling to a single entity, and remaining cost estimating and construction services to a third. We see disadvantages to adding numerous team members and consultants to fit predetermined requirements. This may have negative impact on project cost, timeline, and coordination though design, and during construction.

Appendix A. Schematic Design Documents

(Click on image to access the Rendering)



(Click on image to access the Design Documents)

NEW YORK STATE OF OPPORTUNITY. NYSERDA

1 Preliminary Specifications

The following specifications apply to new work proposed as part of the RetrofitNY project.

1.1 Division 6 – Wood, Plastics, Composites

1.1.1 061600 – Insulated Wall Sheathing:

2.0 inch thick ZIP composite insulation system (R=9.6) with integral air/water barrier, tape joints per system instructions.

1.1.2 062015 - Exterior Finish Carpentry:

Provide fiber cement trim and clapboard in size and dimensional exposure to match existing. James Hardie, or equal.

1.2 Division 7 – Thermal and Moisture Protection

1.2.1 072100 - Thermal Insulation

Foil Faced Polyisocyanurate Rigid Board Insulation: Dow or Owens Corning. Locations: Attic Plenum. Thickness: 2 inches.

Mineral-Wool Blanket: Unfaced, Rockwood or equal. Locations: New exterior entrance wall, exterior walls of mechanical shed, A/C sleeve infill. Thickness: Full depth of framing, refer to drawings.

Cellulose Loose-Fill Insulation: US Greenfiber, Greenfiber Cellulose Insulation or equal. Locations: Attics above common hallway, garage attic, locations in attics where insulation is disturbed through other work, mechanical shed attic. Total settled depth = 18" (R-Value 62.5 min).

1.2.2 072700 – Air Barriers

Air seal apartments to reduce total leakage to outdoors to less than 2.0 ACH50. Air sealing must be confirmed through whole building blower door test. Locations to seal include duct-to-drywall connections, outlet/switch/cable box to drywall connections, all holes within outlet/switch/cable boxes, pipe to drywall connections, through-the-wall AC sleeves, and window rough openings.

Air seal office by sealing duct-to-drywall connections, outlet/switch/cable box to drywall connections, all holes within outlet/switch/cable boxes, pipe to drywall connections, through-the-wall AC sleeve, and window rough openings.

(Click on image to access the Preliminary Specifications)

Appendix B. Scalability Strategy

NYSERDA RetrofitNY – Schematic Design
Scalability Strategy
Team: Christopher Court

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	We opted to go with a central ventilation system for this project so as to reduce the amount of ductwork/soffits in the apartment and to reduce maintenance requirements (only one system per bundling not eight). We believe that continuing to develop this solution will be helpful for other buildings, specifically by developing ductwork installation strategies (pre-fab standard lengths and pre-insulated) and the pre-fabricated mechanical shed.	See comments below on Minotair Pentacare unit. We believe there is a market for a mid-size ERV (~250 CFM – 1000 CFM) range that includes dx coils connected to a heat pump. This would prevent the need to install a hot water coil in the air stream and would reduce the load requirements on the DHW air to water heat pump system.
Space Heating/Cooling	Air source heat pumps are already a very common technology in the market place. The biggest areas for improvement in order for installing this solution at scale are the following: • Incentivize manufacturers to produce multi-split systems with better turn down ratios for proper use in low-load buildings • Development of interior line set covers that are attractive, efficient to install, and low cost. This may not dramatically reduce full cost but would be helpful in providing a quick and easy installation which may simplify location of the indoor heads (since line set is easily covered may be able to locate in areas where you may otherwise not have). • Working with manufacturers to bring the price down for floor mounted indoor units, which as of schematic design we have decided not to use on our project due to the increased cost. • Development of a sleeve for installation of line set through exterior walls that is air sealed, efficient to install, and aesthetically pleasing.	We looked closely at the MINOTAIR PENTACARE-V12 compact air treatment system. For a variety of reasons, we did not select this equipment for our project. However, if improvements are made to the equipment and ductwork/soffit installation it may provide a solution that is better able to scale. Improvements to consider would be: • Variable speed compressor to help regulate supply air temperatures better (so not cycling between compressor on and off) • Removal of electric resistance heat by improving cold weather performance and/or integration of hot water coil served by DHW system (which would in turn need to be served by an air to water heat pump). Since new ductwork would likely need to be run in the apartments, the cost and time to install this ductwork is a big driver for cost and scalability of this solution. Improvements in ductwork may include pre-insulated fabricated sections. And pre-fabricated soffits with special mounting clips to make installation quick and efficient.

(Click on image to access the Scalability Strategy)

Appendix C. Budget and Financing Plan

LINE ITEM	NET ZERO ENERGY (NZE) BUDGET Unit Cost	Notes (as Needed)	Total $	INCREMENTAL COST/(SAVINGS) Total	INCREMENTAL COST/(SAVINGS) Per NZE Unit
HARD COSTS					
General Requirements	-		-	-	-
Existing Cond. / Site work in HC Basis	-		168,557	-	-
Concrete	-		19,230	6,250	156
Masonry	-		-	-	-
Metals	-		1,674	1,674	42
Wood, Plastics and Composites	-		296,415	260,765	6,519
Thermal/Moisture Protection - Façade Insulation	-		155,490	-	-
Thermal/Moisture Protection - Roof Insulation	-		45,100	8,850	221
Thermal/Moisture Protection - All Other	-		337,352	67,390	1,685
Openings - Windows	-	*Applied EAU to NZE budget*	147,500	13,300	333
Openings - Doors	-	*Applied EAU to NZE budget*	171,927	131,261	3,282
Openings - All Other	-		75,660	-	-
Finishes	-		121,130	66,750	1,669
Specialties	-		975	975	24
Equipment	-		28,000	7,500	188
Furnishings	-		303,990	-	-
Conveying Equipment	-		-	-	-
Fire Suppression	-		30,982	-	-
Plumbing - DHW System	-	*Applied EAU to NZE budget*	168,000	134,400	3,360
Plumbing - All Other	-		1,500	-	-
HVAC - Heating/Cooling System	-	*Applied EAU to NZE budget*	316,000	266,500	6,663
HVAC - Ventilation System	-		114,500	105,300	2,633
HVAC - All Other	-		-	-	-
Electrical	-		87,300	63,700	1,593
Communications	-		-	-	-
Electronic Safety and Security	-		2,750	-	-
Earthwork	-	*includes tree removal for solar*	60,800	60,800	1,520
Exterior Improvements	-		5,500	-	-
Utilities	-		-	-	-
Electrical Power Generation	-		-	-	-
General Conditions	-		209,531	106,987	2,675
GC Overhead	-		124,012	65,415	
GC Profit	-		316,570	170,078	4,252
GC Insurance	-		10,690	10,690	267
Performance Bond	-		11,215	11,215	280
Escalation Factor	-		-	-	-
Overhead	-		-	-	-
Selective Demolition	-		25,000	25,000	625
(Reserved)	-		-	-	-
(Reserved)	-			-	-
(Reserved)					

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

Appendix D. Projected Construction Schedule

Work Package	Task	Start	Days	Completion
PRECONSTRUCTION	CDs Complete	M 4/1/19	32	W 5/15/19
	Permits Pulled	W 5/15/19	5	S 6/01/19
	Construction Contract Finalized	M 4/1/19	22	W 5/01/19
	Project Closing Date	W 5/1/19	0	W 5/01/19
PROCUREMENT	Procurement Period	M 4/1/19	58	F 6/21/19
CONSTRUCTION	Site Prep and Demolition	M 6/24/19	13	F 7/12/19
	-Building Envelope	M 6/24/19	13	F 7/12/19
	-Mechanical Systems	M 6/24/19	13	F 7/12/19
	Exterior Renovation	M 6/24/19	38	F 8/16/19
	-Building Envelope	M 6/24/19	38	F 8/16/19
	-Mechanical Systems	M 6/24/19	38	F 8/16/19
	Interior Renovation	M 6/24/19	38	F 8/16/19
	-Building Envelope	M 6/24/19	38	F 8/16/19
	-Mechanical Systems	M 6/24/19	38	F 8/16/19
	Installation Onsite Renewables	M 6/24/19	67	F 9/27/19
CLOSEOUT	Equipment Start up and Testing	M 9/30/19	13	F 10/18/19
	Commissioning of Systems	M 10/21/19	27	F 11/29/19
	Punchlist Inspection	M 10/21/19	1	T 10/22/19
	Correction of Punchlist Items	T 10/22/19	8	F 11/01/19
	Final Inspection	M 11/4/19	2	W 11/06/19
	Project Complete	R 11/28/19	0	F 11/29/19

(Click on image to access the Projected Construction Schedule)

Appendix E. Building Performance Summary

Utility Savings and Cost Savings:		*over baseline	*over baseline	*over baseline
	Existing Condition	BAU Renovation	Deep Energy Retrofit	Deep Energy Retrofit + Solar
Utility Cost Savings ($/yr)		$ 3,635	$ 17,104	$ 37,023
Utility Cost Savings (%)		7%	31%	67%
Energy Savings (%)		7%	38%	93%
Energy Cost Savings (%)		7%	40%	94%
Energy Savings (kBTU/yr)		81,932	451,116	1,094,971
Energy Cost Savings ($/yr)		$ 15,169	$ 15,169	$ 35,088.26
Water Savings (%)		6.3%	11%	11%
Water Cost Savings (%)		6.3%	11%	11%
Water Savings (gal/yr)		68,133	119,817	119,817
Water Cost Savings ($/yr)		$ 1,100	$ 1,935	$ 1,935

Utility Uses and Costs:				
	Existing Condition	BAU Renovation	Deep Energy Retrofit	Deep Energy Retrofit + Solar
	Energy + Water			
Utility Cost without Solar ($/yr)	$ 54,903	$ 51,268	$ 37,799	$ 17,880
Utility Cost with Solar ($/yr)				
	Energy			
Heating (kBTU/sq ft/yr)	18.1	15.9	5.1	5.1
Cooling (kBTU/sq ft/yr)	1.3	0.8	0.7	0.7
Ventilation (kBTU/sq ft/yr)				
Domestic Hot Water (kBTU/sq ft/yr)	9.6	9.6	5.3	5.3
In-unit Lighting (kBTU/sq ft/yr) Common Area Lighting (kBTU/sf/yr) Appliances (kBTU/sq ft/yr) Miscellaneous Eletric Load (kBTU/sq ft/yr) Fans (kBTU/sq ft/yr) Pumps (kBTU/sq ft/yr)	10.5	10.4	11.6	11.6
Total BTU/sq ft (without Solar)	39.4	36.7	22.7	22.7
Total BTU/sq ft (with Solar)				2.5
Energy Use (without solar) (kBTU/yr)	1,173,503	1,091,571	722,387	722,387
Energy Cost (without Solar) ($/yr)	$ 37,518	$ 34,983.08	$ 22,349	$ 22,349
Energy Use (with solar) (kBTU/yr)				78,532
Energy Cost (with Solar) ($/yr)				$ 2,429.57
	Water			
Use (Gal/yr)	1,076,645	1,008,512	956,828	956,828
Water Cost ($/yr)	$ 17,385	$ 16,285	$ 15,450	$ 15,450

Assumptions:	
Building sq ft pre-retrofit	29,764
Building sq ft post-retrofit	31,856
Water Cost ($/kGal)	$ 16.15
Electric Cost ($/kWh)	$ 0.106
Propane Cost ($/Gal)	$ 5.74

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

Appendix F. Resident Management Plan

NYSERDA RetrofitNY – Schematic Design
Resident Management Plan
Team: Christopher Court

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Please use this template to complete the Resident Management Plan. Click on the text boxes below each heading to find additional instructions.

Management Plan

Goals

- Ensure safety of our Employees, Owner, Owner's Representative and Tenants throughout the renovation project.
- Provide an acceptable work environment for Employees and Tenants.
- Minimize disturbance to Owner and Tenants.
- Perform quality workmanship.
- Complete work on time.
- Complete work within budget.

Length of construction phase

June 21, 2019 - October 10, 2019

Length of resident management plan

June 21, 2019 - November 28, 2019

Plan for resident notifications and communication

The General Contractor will coordinate with the Owner for access to each individual apartment unit. The Owner's Representative shall communicate and schedule work times with each tenant. A pre-construction meeting with the Owner's Representative, Tenants and Construction Manager will be scheduled to present the construction management plan and inform all parties of the schedule, scope of work to be performed and provide time for Tenants to ask questions. At this meeting, explanation of the safety plan shall be presented. The on-site Superintendent will manage the safety of tenants and employees. The Superintendent shall ensure adequate signage is posted and pathways are kept clear at all times. The Superintendent will have a comprehensive checklist and ensure safety standards are being met.

Resident liaison or resident groups

The Owner shall appoint an individual to act as the Liaison between the Tenants and the Contractor. This individual shall coordinate access to each apartment for work to be performed.

In-unit construction plan

The renovation inside the apartment will consist of the installation of new heating/cooling units, new windows, doors, installation of ductwork and air sealing, and related work (thermostats, wiring, piping, etc.). The estimated time of construction will be approximately two weeks per apartment. Work shall be performed in multiple apartments at the same time. Installation of doors and windows will be performed immediately after the removal of the old door or window and will cause minimal disturbance. The majority of the ductwork will be installed in the attic and will come down through chases to feed the first floor. Miscellaneous air sealing will be performed at each apartment. Clean-up will be performed on a daily basis. Care will be taken as work is performed to minimize dust and dirt.

(Click on image to access the Resident Management Plan)

Appendix G. Performance Guarantee Pathway

NYSERDA RetrofitNY – Schematic Design
Performance Guarantee Pathway
Team: Christopher Court

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Please complete both the Maintenance and Warranties section as well as the M&V section below.

Maintenance and Warranties

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

The following energy performance parameters could fall under a performance guarantee:

1. Heating slope (Btu/SF/HDD)
   a. This performance guarantee supports the analysis of the total heat load (envelope/air leakage/ventilation rates) and the performance of the installed heating system. While there may be some variation in heating usage between apartments due to occupancy, the overall project will have a fairly consistent weather-normalized heating usage on a yearly basis that could be guaranteed.
2. Solar PV production (kWh/yr)
   a. Production is guaranteed for a set timeframe by the designer/installer in a typical solar PV contract. We expect this to be the case once the regulatory barriers are overcome and PV is feasible to install.

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

The entire project will have a one-year construction warranty provided by the General Contractor. Additional manufacturer warranties are listed below:

Air source heat pumps – Daikin: 12-year warranty on compressor and parts

Ventilation – RenewAire: 10-year warranty on ERV core and 5-year warranty on all other components

Windows – Zola Windows: 5-year warranty on materials

Domestic Hot Water – Sanden SanCO2 air to water heat pump: 3-year labor, 10-year heat pump parts, 15-year tank warranty. Circulation Pump (TBD): Manufacturer warranty expected to be 2-year

Solar PV – SunPower: 25-year warranty on products (labor, parts, shipping, etc…)

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

Air source heat pumps:

- Indoor filter cleaning bi-annual.
- Outdoor coil cleaning – once every three years

(Click on image to access the Performance Guarantee Pathway)

Appendix H. Regulatory Barrier Summary

NYSERDA RetrofitNY – Schematic Design
Regulatory Barrier Summary
Team:

Regulation			Impediment	Action
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?**
NY		No building/fire code regulatory barriers identified at this time.		
USDA		USDA Rural Development Financing	NYSERDA solutions/incentives need to coordinate and be compatible with USDA program. Based on this current metering configuration savings from energy efficiency improvements would be realized by the tenants in the short term. However, because of the utility allowance/income-based rent structure, these savings would be charged back in the form of rent once annual rent/UA adjustment is made. Since savings do not go to the owner, financing the energy retrofit becomes more difficult as the energy savings cannot help off-set any upfront costs/loan payments (see Metering section below for other metering options). In summary, neither the owner nor the tenant sees the long-term direct benefit of energy efficiency measures.	USDA has been engaged early on this project, and they are actively involved in meetings and discussions.
USDA		USDA Rural Development Competitive Bid Requirements.	USDA typically requires competitive bidding (traditional "design-bid-build" process) above rehab of $12,000/apt. Waiver request per RD instruction 1924.13 (e) (1) (VII) necessary. General Contractor/CM is part of current RetrofitNY concept design team as integral team member.	Will GC/CM soliciting subcontractor bids from all trades be acceptable within USDA framework? How would competitive bid requirements be handled and/or waived for a future solution provider that does work in house and therefore would not be soliciting subcontractor pricing?

(Click on image to access the Regulatory Barrier Summary)

Appendix I. Resiliency Summary

NYSERDA RetrofitNY – Schematic Design
Resiliency Summary
Team: Christopher Court

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

Indicator	Design Solution
Protection: Identify strategies to reduce a building's vulnerability to extreme weather:	
Floodproofing or Flood Control	The property is not located in a flood plain and has not experienced any issues with flooding in the past.
Sewer Backflow Prevention	Unknown. Will evaluate during design development.
Mechanical Equipment Protection and Location	The domestic hot water system and energy recover units are proposed to be housed in equipment 'sheds' attached to the side of the existing building. The 'sheds' will be constructed with wood frame, continuously insulated walls, floors, and roof. The sheds are viewed as being resilient and can be rapidly serviced (outside of apartments) in the event of damage due to a weather event.
Electrical Equipment Protect and Location	Electrical meters and future submeters are contained within an exterior shed. The new subpanel for the mechanical shed will be contained with the shed itself. These areas are well protected from potential weather damage and can be serviced rapidly if they are damaged.
Backup Power Location and Protection	Not applicable, there is no backup power source provided. Future batteries could be added to the mechanical shed. If a generator is to be used to power the mechanical equipment in the mechanical shed, the generator would sit outside. There is currently no plan to provide a generator housing/shed.
Communications	The owner is currently working on an updated communication plan with residents.
Envelope Protection	Triple glazed windows and patio doors are proposed with perimeter air sealing to increase performance against severe wind and temperatures. New enclosed entry corridor reduces losses directly from apartments while entering and exiting.
Fire Protection	As part of the business as usual scope of work the fire alarm system will be upgraded. No sprinkler nor plan for sprinkler at this time.
Adaptation: Identify strategies that improve a facility's ability to adapt to changing climate conditions:	
Envelope Design	Blower door testing of the existing building condition was conducted with results showing 4.47 ACH50. Additional air sealing is planned to less than 2.0 ACH50. The existing open-air stairwells will be enclosed with insulated walls and attic to reduce area of exterior walls and buffer the apartment entry doors from the exterior. Triple pane windows and doors are proposed. These installations will improve the ability to maintain comfort and control moisture. Next capital improvement will include full envelope upgrade prior to 2050 (25-30 years).
Mechanical Equipment	Air source heat pumps will be installed for each apartment that can provide both heating/cooling in extreme temperatures. Currently the building only has tenant provided cooling in the living rooms, air conditioning in the bedrooms will be a big improvement especially for temperature and moisture control in the summer. An ERV will be installed for each building which will assist in maintaining humidity control in summer and winter.
Passive Cooling or Ventilation Strategies	Operable windows and patio doors are proposed. The ventilation system is designed with a hot water coil to provide some additional heating as necessary. In the event of a power outage if a generator and/or battery back-

(Click on image to access the Resiliency Summary)

Appendix J. Resident Health Impact Summary

NYSERDA RetrofitNY – Schematic Design
Resident Health Impact Summary
Team: Christopher Court

Indicator	Location	Intervention	
		Design Solution	Maintenance
Mold	Units - Kitchens	Existing apartments do not have adequate ventilation. A new central ventilation system will be installed with an energy recovery ventilator. The system will provide 25 CFM and 30 CFM continuous exhaust in the 1-bedroom and 2-bedroom apartment kitchens respectively. The ERV will be fitted with MERV 13 air filters to remove contaminants.	The central ventilation systems will ne changed on a bi-annual basis. The constant air flow regulators will ne build up every three years and cleanec The constant air flow regulators settin the 2-bedroom apartments if more tha the apartment.
	Units - Bathrooms	Existing apartments do not have adequate ventilation. A new central ventilation system will be installed with an energy recovery ventilator. The system will provide 20 CFM and 25 CFM continuous exhaust in the 1-bedroom and 2-bedroom apartment bathrooms respectively.	See 'Units – Kitchens' description abov
	Units - Windows and Exterior Doors	Existing windows are old, have broken seals, and are metal-framed. They are reported to be a source of condensation and mold/mildew build-up. The new windows will be triple-paned with low conductivity thermally broken frames, which will result in warmer surface temperatures and prevent mold/mildew growth.	Yearly condition assessment by mainte damage. Exterior caulk joints reviewe
	Units - Mechanical Rooms	Domestic hot water and energy recovery ventilation systems will be housed in a new mechanical 'shed' addition, attached to the side of the existing building.	Typical exterior envelope and roof mai buildings.
	Common Areas - Windows and Exterior Doors	See 'Units Windows and Doors' description above.	See 'Units Windows and Doors' descri
	Common Areas - Mechanical Rooms	See 'Units – Mechanical Rooms' description above.	See 'Units – Mechanical Rooms' descr
	Below Grade	N.A.	N.A.
Pests	Units	Blower door tests were performed by our team and we have identified areas where air sealing is proposed (electrical boxes, pipes, duct to drywall connections, remove AC sleeves). This air sealing will further prevent pests from entering the units.	Yearly condition assessment by mainte damage. Visible caulk joints reviewed necessary.
	Common Areas	See 'Units' description above.	See 'Units' description above.
	Below Grade	N.A.	N.A.

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

Appendix K. Overall Rehab Proposal

king+king ARCHITECTS

3/8/19

Christopher Court – Professional Design Services Description

Professional design services scope shall consist of architectural, site, structural, mechanical, electrical, and plumbing (MEP) design services to complete the construction scope illustrated in both the Business as Usual (BAU) and Retrofit incremental cost summaries. Design phases include right-to-build, and design development through construction administration for the scope of work. The team members are as follows:

Architectural: King + King Architects, LLP
MEP Engineering and Structural Engineering: Taitem Engineering, P.C.
Site Design/Landscape Architecture: Keplinger Freeman Associates, LLC

Professional Design Service Fees:

Our fees for the above services shall be a lump sum fee as follows:

Architectural (King + King):	$ 120,300
MEP / Structural Engineering (Taitem):	$ 60,000
Site / Landscape: (Keplinger Freeman):	$ 9,700
Total:	$ 190,000.

Reimbursable expenses are included in the above fees and include expenditures made by the Architect, their employees and/or their professional consultants in the interest of the project for expenses of transportation (mileage) in connection with the project, long distance communications, expenses of reproductions, blueprinting and copying, photographic production techniques and postage for the project.

Other Soft and Hard Costs:

Refer to Template #4 – 'Budget and Financing Plan' which includes hard and soft costs, including profession design service fees listed above and construction scope.

Assumptions:

We have made the following assumptions.

1. Environmental and hazardous material testing, design and abatement is not required as part of K+K's design services.
2. It is assumed that current utility services to building are adequate (electric, water, fire protection water, gas) and new service design beyond 5'-0" from building is not required.
3. All data/IT systems, building security, access control systems, loose fixtures, furniture and equipment will be specified and provided by Owner's vendors. K+K will coordinate with vendors where power, data or pathways are required.
4. The project is not seeking LEED, or other design certification.
5. A sprinkler (fire protection) system is not required.

Jason Benedict, AIA David Johnson, AIA Jim King, AIA Peter King, AIA Kirk Narburgh, AIA, ASLA Chad Rogers, AIA Kerry Tarolli, AIA
358 West Jefferson Street Syracuse, NY 13202 PHONE 315 • 682 • 6180 FAX 315 • 682 • 7891 www.kingarch.com

(Click on image to access the Overall Rehab Proposal)

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New York State Energy Research and Development Authority

17 Columbia Circle
Albany, NY 12203-6399

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

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

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Richard L. Kauffman, Chair | Alicia Barton, President and CEO