RetrofitNY: ICAST Net Zero Energy Retrofit Schematic Design

Final Report | Report Number 19-25 | May 2019

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

RetrofitNY: ICAST
Net Zero Energy Retrofit Schematic Design

Final Report

Prepared for: RetrofitNY

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Notice

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Acronyms and Abbreviations

DHW	domestic hot water
ECM	energy conservation measure
EUI	energy use intensity
ERV	estimated recovery value
ft	feet
kBTU/ft2/year	Kilo-British Thermal Unit per square foot per year
kWh	kilowatt hours
m/s	meters per second
MW	megawatts
NYS	New York State
NYSERDA	New York State Energy Research and Development Authority
NZE	Net Zero Energy
PPA	power purchase agreement
PV	photovoltaic
SHGC	solar heat gain coefficient
THA	Troy Housing Authority

Glossary

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

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

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

Executive Summary

As part of NYSERDA's RetrofitNY program, ICAST and its team were awarded a design project to assist the Troy Housing Authority (THA) and its developer partner, Beacon Communities Inc., in designing a Net Zero Energy (NZE) retrofit to one of the buildings at the Martin Luther King apartment complex in Troy, New York. This report outlines the results of that design project and the recommendations on the project's rehabilitation.

The ICAST RetrofitNY team took the base renovation plans and proposed high-performance design components in lieu of business as usual construction methods to achieve a near net zero property. The project gross floor area is approximately 7,150 ft^2 with six units: two units have two bedrooms, three units have three bedrooms, and one unit has four bedrooms.

The final project design modeled Energy Use Index (EUI) was calculated to be 21.1 kBtu/sf/yr. The base renovation plans and proposed high-performance design components are listed in Table 1.

Table 1. ECMs

ECM	Existing Rehab Plan		Retrofit NY Plan
Shell			
Wall Insulation	Blown (SFS) In R-24.5		No Insulation in cavity (Cost is removal of existing)
Windows	U Value .28/SHGC .27		Passive House /U Value .18 SHGC .5
Doors	Standard Steel Insulated doors with kerf weatherstrip		Standard Doors
Ceiling insulation	Blown In R-55		Blown In R-70
EPDM roof removed- Weather resistive barrier installed			EPDM roof removed- Weather resistive barrier installed
Slab Insulation	None		12" Slab Insulation, excavate + R10
Power Wash and seal Concrete foundation	N/A		
Air Sealing	5 ACH @ 50 Pa		1.5-2.5 ACH @ 50 Pa
Siding			R-24 Wall Assembly + Siding

Table 1 continued

Mechanical			
Heating	95% Combi Boiler		Carrier Cold Climate HP
Cooling	14 SEER A/C		Carrier Cold Climate HP
Ventilation	ASHRAE Bath Fan		Panasonic ERV in Each Unit
DHW	Same Combi boiler		Rheem HPWH in each unit
Heat Recovery	None		Waste Water Heat Recovery
Solar DHW	None		1 Collector System
			Less NYSERDA Solar DHW Rebate
Appliances			
Common Dryer	Electric Dryer		Heat Pump Dryer (with-coin op retrofit)
Range	Conventional Range		Smart Burner Retrofit
Renewable Electric			
Energy Management			
Energy monitoring (M&V)	None		Energy monitoring (M&V)
Control Devices (HEMS)	None		Control Devices (HEMS)
Capital Cost of New Electric Meters	Capital Cost of New Electric Meters		Capital Cost of New Electric Meters
Capital Cost of New Gas Meters	Capital Cost of New Gas Meters		No gas meters

ES.1 Synergy of Components

The design is a whole building approach in which each element of the building was evaluated to minimize the energy use of the building without compromising indoor air quality, tenant safety, or comfort.

The design team was constrained by the fact that this project is one building in a multi-building complex rehab. That meant that the finished building appearance had to closely match the appearance of the other buildings. Because the desire was to add R-value to the building shell (as well as improve the infiltration rate), the developer to agreed to allow covering the existing brick on the first floor with foamboard insulation and then use the same siding on the first floor as is being used on the second floors throughout the rehab. This will make the building look somewhat different from the other buildings, but not so much as to look out of place.

Staengl Engineering ran dozens of permutations of the possible elements of the scope of work and based on the relative value of different approached (cost vs. impact on EUI) the team settled on the final design as presented. The target EUI of 20 kBtu/sf/year was nearly achieved while keeping the budget under the maximum allowed.

The greatest challenge was coming up with a strategy for effective air sealing, which maintains a continuous air barrier. Utilizing the Hunter panels and the Huber Zip sheathing along with utilizing the Aerobarrier aerosol air sealing should achieve a minimum airtightness of at least 1.5 ACH50. This is a close approximation of the Energiesprong approach to building shell, while utilizing current U.S. building practices. It was NYSERDA's goal to find or create a market for panel manufacturers similar to those present in Europe, but our extensive efforts failed to identify a single U.S. manufacturer who actually makes retrofit panels. There were two manufacturers who claimed a willingness to start making panels (Wythe Windows and Funform); however, neither option was deemed viable due to cost.

Critical to the building performance was confidence that the wall assembly would not be prone to surface condensation inside the wall assembly in cold temperatures. In order to devise a safe wall design, several Therm model itineration studies were run to see where condensation might occur using different wall assemblies. Those studies indicated that with installing foamboard exterior sheathing, the existing cavities needed to have no insulation so that the critical temperature level was maintained inside the wall assembly to prevent condensation.

The fenestration installations have been designed to align with the air barrier maintaining a continuous air barrier was possible. The team is planning a training with the installers to maximize the air sealing performance of the installation as well as Aeroseal aerosol air sealing to maximize the infiltration measure. The foundation insulation makes minor improvements to the EUI but will certainly make a definite improvement to the comfort of the units on the first floor.

Using heat pump water heaters create a unique challenge since they dissipate waste cold into the living space. The team will work with the selected mechanical contractor to assess whether it is practical to duct that waste cold outside the envelope or increase the size of the heat pump from 1.0 ton to 1.5 tons to properly heat each apartment. Increasing the heat pump to 1.5 tons will increase the EUI for heating from 8.27-9.85 kbtu/h to 10.152-13.974 kbtu/h. This decision will be made in conjunction with the mechanical contractor selected by the general contractor.

The solar thermal system was originally conceived for the entire building, but due to budget constraints was downsized to only serve the common laundry. Rheem (HPWH manufacturer) will confirm that their unit will operate properly with the solar thermal system.

Regarding ERV and wintertime indoor air vapor management, the challenge of wintertime relative humidity is that the incoming air is very dry—especially as it is warmed to room temperature. The ERV is desirable to retain indoor air humidity, hence the enthalpy performance of the Enthalpy Recovery Ventilator—it is designed to capture that moisture. Heat Recovery Ventilators (HRV) do not recoup the interior humidity during the wintertime, and can create an overly dry interior climate, which is why the ERV was selected.

The HVAC systems (heat pump and ERV) will be connected to the HEMS system (i.e., Smapee), to continuously monitor system operation and performance. This will also be the gateway for measurement and verification (M&V) interaction with the property. The smart burner retrofit makes for small energy savings but contributes greatly to the safety of the residents.

1 Project Narrative

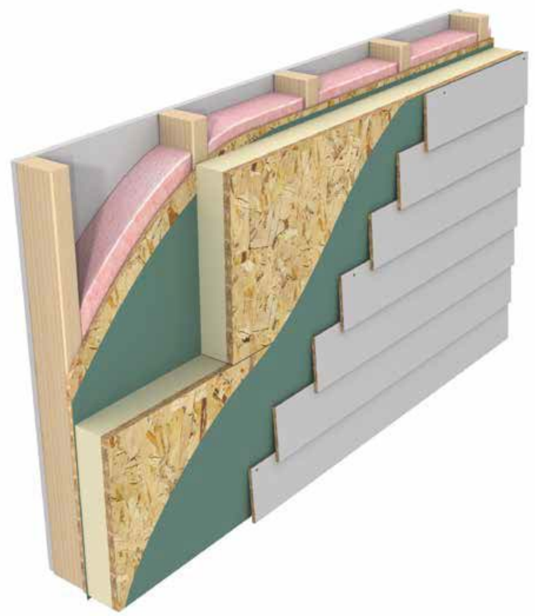
Building Envelope

<table>
<tr><th>Key design criteria to consider</th><th>How does your design address the criteria?</th></tr>
<tr><td>Thermal performance</td><td>R-Value was added to each major component of the shell to reduce heat loss/gain and heating/cooling load.

Wall Assembly: No insulation in wall cavity, min. R-24.8 continuous insulation at exterior walls.

Foundation: R-10 at foundation walls.

Roof: Existing EPDM roof removed, and the underlying EPS- so the team will apply a new air tightness layer onto the existing roof deck and insulate with loose fill cellulose to match the optimized depth per Staengl's evaluation.

</td></tr>
<tr><td>Sealing performance</td><td>A very aggressive air sealing target of 1.5 to 2.5 ACH @50 Pa was established. Integral to that air sealing strategy is adding a Class A fire rated air sealing membrane over the existing flat roof (which will be over framed with a pitched roof as part of the rehab).
Installing a new sheathing layer, which will define the air barrier and be the installation point for fenestrations.
Specified Passive House compliant windows and specified a stringent installation process for fenestration installation.
Defined an air sealing process for the foundation installation and defined an air sealing process for the wall-roof connection where the sheathing meets the roof air barrier.
There is flexibility in the air sealing goals since in retrofits the target can be uncertain. Since the Model EUI is 21.1 kBtu/sf/yr, even if an infiltration rate of only 5 ACH50 is achieved, the EUI would only increase to approximately 23 kBtu/sf/yr, well below our target of 25 kBtu/sf.</td></tr>
</table>

	Air sealing will be with a continuous zip board wall sheathing attached to second floor studs and installed over the existing brick and taped to the foundation. The existing EPDM membrane and underlying EPS insulation will be removed per the design architect's direction, and Zip board with taped joints or a Class A air barrier with taped joints will be installed over the existing plywood deck. The vertical Zip board will be taped to the new roof deck air barrier for continuous air tightness from foundation to roof. The new pitched roof truss assembly will be installed over this, with raised heels to permit required insulation depth.
Moisture performance	Exterior: The Buildings will have a much more robust ability to resist exterior moisture sources due to the new envelope construction. Ceilings will be protected by a new over framed roof structure, weather resistive barrier and Zip roof panels acting as the new floor of the attic. Walls will have a comprehensive air sealing/moisture plane, and foundations will have a 2" Geoform EPS (treated to protect structure from termite infestation) with cap flashing and stucco finish to 6" below grade and grading corrected so bulk moisture is not sitting against the foundation. Interior: A key component of the retrofit is installing continuously operating Enthalpy Recovery Ventilators (ERV) in each unit, so that they each meet the ASHRAE 62.2 residential ventilation requirements. These should mitigate much excessive moisture accumulating in the apartments, thus stunting mold/mildew growth and promoting indoor air quality.
Structural performance and long-term integrity of materials	The proposed modifications call for the addition of continuous sheathing from foundation to roof, increasing the shear strength and wind uplift resistance of the structures. Planned corrective work at existing overhang conditions will strengthen bearing walls. Together, these improvements will greatly increase the structural integrity of the wall assemblies. The proposed over framed truss roofs will bear on these exterior walls, consistent with preceding phases of work completed by architect of record. Exterior insulation panels, Zip sheathing, and weather resistive barrier will add approximately four pounds per sf to the wall system. While this adds some weight to the structure it is not excessive and as long as the assemblies are installed according to manufacturer's instructions, they should have no impact on durability. Additional attic insulation and house wrap adds negligible weight to the structure. Foundation insulation contributes to protecting the foundation from bulk water intrusion. Included in the rehab is adding plywood to interior walls to add sheer strength to the exterior walls inherently protecting the integrity of the RetrofitNY proposed upgrades.
How will the new design affect resident life? Are there custom/atypical design features that require careful consideration?	The main ways would be improved indoor air quality due to managed ventilation, much better thermal comfort due to installation of foundation insulation, and right sized HVAC, which will have longer run times at slower fan speeds promoting destratification of air and more even temperatures with less noise. New windows and doors will be draft free and should add considerable thermal comfort to the residents' experience. Replacing the electric resistance stoves with either induction cooktops or temperature-controlled replacement coils will reduce the risk of fire and injury from hot cooktops. Improved kitchen ventilation will reduce the amount of indoor air contaminants, improving the air quality for residents.

Maintenance of solution	The systems will typically require less maintenance than the system they are replacing except for the solar thermal for the laundry. Existing DHW for example are tankless type demand appliances, which require annual maintenance to prevent mineral deposits. Heat pump hot water (HPWH) heaters heat water much slower and do not tend to precipitate out minerals nearly as much and as such require less maintenance. Existing space heaters are pancake style air handlers that derive their heat from the same demand appliance that provides DHW, and like most hydronic systems require regular maintenance/service. These will be replaced by conventional dx type cold climate air source heat pumps. These will require a similar (if not less) maintenance cycle.
Sustainability of solution	Since the carbon footprint is being reduced by 75%, the team is implementing a very sustainable path in terms of resource usage. The life cycles of the shell measures should be at least 25 years, if not longer. The life cycles of the solar thermal should be 25 to 30 years. The life cycle of the HVAC (including the ERV) should be 15 to 20 years. The all electric solution that the team has proposed allows the use of on-site distributed or stored energy resources.
Replication potential at scale	Additional sheathing and insulation are very familiar US-specific building methods and so will be easily adopted by construction crews. Very replicable. The windows and doors use similar installation to most fenestrations, with the additional air sealing techniques being a necessary training element as part of any rollout. Very replicable. The air sealing process we propose is very familiar to construction crews today, involving the installation of Zip sheathing with their proprietary tapes is common practice today. The added care required to seal penetrations and terminations to the foundation walls and roof are newer concepts but are basic and easily taught. Very replicable. The HVAC systems specified are very conventional, readily available, very familiar to mechanical contractors. Very replicable. The heat pump water heaters are a newer technology in the U.S., but the installation is very similar to conventional heat pumps and water heaters. Any mechanical contractor can install easily, and service is very similar to other refrigeration systems. Units are well suited to individual residences. Very replicable. ERV installation is increasingly common in conventional construction but will still be unfamiliar to many crews. The installation process for ERVs, however, is very simple, and the kit of parts that most manufacturers supply is typically “click together” with little need for extra taping or other means of air sealing. Very replicable. The solar thermal is not common and unfamiliar to most mechanical contractors; however, it is simple in its operation and so easily serviceable. It is a poor solution for a single residence system, however when a central plant is serving multiple homes it is very advantageous. Sometimes replicable.

Other Questions	Team Response
What challenges have you encountered in designing an envelope solution that meets the RFP requirements? How are you addressing them?	The major challenge is in sourcing any exterior panel manufacturers. Our attempts to mimic the Energiesprong approach will be greatly limited until such time as American manufacturers embrace this modular approach and make cost effective panels.
Are there any unresolved major issues? What would it take to resolve them?	Since we met most of the design criteria in a cost-effective way, we think being able to add the panelized system will just be a bonus in the future.
Other comments (optional)	

Ventilation and Indoor Air Quality

Key design criteria to consider	How does your design address the criteria?
RFP requirement of greater of 20 cfm / bathroom + 25 cfm / kitchen and 18 cfm / person	The installation of the energy recovery ventilator (ERV) system in each apartment achieves this design goal in a very energy-efficient manner. This solution includes, for each apartment and the laundry room, an ERV running continuously to provide the required ventilation air while recovering sensible and latent heat (82% sensible effectiveness, 60% latent effectiveness) from the exhaust air. This tempered ventilation air is then mixed with the supply air from an air handler that distributes air that is heated and cooled by a mini-split heat pump.
Prevention of mold, mildew, pests and other environmental triggers of respiratory or other ailments	The regular air changes provided by the dedicated ventilation system and its integral filters should greatly improve indoor air quality and mitigate indoor pollutants. The design will incorporate filtration systems, integrated with the air handling systems, which provide a minimum efficiency of MERV 8 for the ventilation systems and MERV 8 for the space conditioning systems (established using ASHRAE Standard 52-1994). Filter return grilles shall be used instead of the filter bank in the ducted indoor unit for ease of filter changing. Heat pumps will be equipped with dry mode for additional humidity control.
Active ventilation to reduce volatile organic compounds and other potential internal air contaminants	The regular air changes provided by the dedicated ventilation system and its integral filters should greatly improve indoor air quality and mitigate indoor pollutants.
Maintenance of solution	Since there are disposable filters integral to this solution, regular filter changes will be required.
Sustainability of solution	As long as there is fresh air outside, the very small energy penalty associated with these systems seems like a reasonable tradeoff for better indoor air quality.
Replication potential at scale	Easily replicable at scale.

Question	Team Response
What challenges have you encountered in designing an IAQ solution that meets the RFP requirements? How are you addressing them?	Very straightforward solution.
Are there any unresolved major issues? What would it take to resolve them?	None
Other comments (optional)	

Space Heating/Cooling

Key design criteria to consider	How does your design address the criteria?
Space heating/cooling EUI of not more than 11 kBtu/ft^2/year	We crush this metric. EUI for heating and cooling, including fan energy, is 5.0 kbtu/sf/year. Heating: 1.9 Cooling: 2.4 Fans: 0.7 The ICAST team analyzed several heating and cooling systems, including central systems and individual systems. The other buildings in the rehab plan (non-RetrofitNY) included gas fired combi-boiler type systems. Due to the goals of this project all gas systems were eliminated from consideration. We evaluated electric resistance, air source heat pump, air to water heat pump and hybrid systems utilizing multiple technologies. We determined that cold climate air source heat pumps were the best mix of cost effectiveness, serviceability, efficiency and simplicity. There are more efficient types of equipment available like the Chilltrix air to water heat pump for example; these are not currently a widely used type of equipment and lack a track record for local installation and service.
Maintaining heating and cooling comfort (including humidity)	Since these are variable speed units, they will run at lower speeds providing mostly continuous air circulation, de-stratifying the air on a regular basis, leading to more even space temperatures. The ERVs will help maintain humidity during dry winter months, and the heat pumps can provide dehumidification during humid summer months.
Innovative ways to improve system efficiency	
Required sensors and controls	Will use a smart thermostat
Maintenance of solution	Regular filter changes
Sustainability of solution	Super-efficient equipment lowers carbon footprint
Replication potential at scale	Very standard equipment makes this approach very replicable

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?	Finding equipment with sufficient cold temperature performance such that we do not require back-up resistance electric would have been impossible 10 years ago. Now they are readily available.
Are there any unresolved major issues? What would it take to resolve them?	None
Other comments	

Domestic Hot Water

Key design criteria to consider	How does your design address the criteria?
DHW system design and sizing	While we feel the demand criteria are high, the system was designed to meet the 21-gallon/person/day requirement. The system consists of seven Rheem heat pump water heaters.
Innovative ways to improve system efficiency (i.e., heat recovery)	We were proposing drain waste heat recovery units be installed in each apartment until budget constraints eliminated that option. Since there is only one shower in each apartment that helps lower cost. These were modeled to account for approximately 29% of the DHW energy usage and would have been a nice feature to incorporate.
Required sensors and controls	The systems are each self-contained and independent of each other. The solar thermal will act as an energy battery and simply provide heated water (when its sunny) to the input of the Rheem water heater in the laundry.
Maintenance of solution	The Rheem water heaters will have similar maintenance requirements as the heat pumps. The tanks should not have most of the problems associated with high delta/t water heaters that tend to precipitate out minerals as sediment, so should require less maintenance than most water heaters. Solar thermal systems require regular maintenance (especially of circulation pumps), which should be added to regular maintenance schedules.
Sustainability of solution	No natural gas, lower GHG emissions, 35% electric, 35% Solar, and 30% Recovered energy, about as sustainable as it gets
Replication potential at scale	As replicable as any DHW system.

Other Questions	Team Response
What challenges have you encountered in designing a DHW solution that meets the RFP requirements? How are you addressing them?	The DHW was the most challenging element of the EUI to reduce. It required all three elements to get us below a EUI of 20 kBtu/sf. Where cost constraints limit your choices to just the DHW plant (no solar, no recovery), reducing the impact of DHW to the overall EUI will be quite challenging. The 21 gal/person/day design standard proved to be a challenge.
Are there any unresolved major issues? What would it take to resolve them?	None
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 main way we are reducing electric loads is with the smart burner retrofit of the electric ranges. These thermostatically controlled burners do not allow the burner temperature to exceed 650°F (below the flash point of most oils). So, they are both a health and safety measure as well as an energy saver.
Variation in consumption between occupants	
Maintenance of solution	None
Sustainability of solution	Very
Replication potential at scale	Very

Other Questions	Team Response
What challenges have you encountered in designing a MELs solution that meets the RFP requirements? How are you addressing them?	MEL's is such a black box, that it will always be a challenge. How do you control misc. usage without really annoying your tenants?
Are there any unresolved major issues? What would it take to resolve them?	Yet to find really good MEL's solutions other than the smart burner
Other comments (optional)	

Distributed Energy Resources (DER)

Key design criteria to consider	How does your design address the criteria?
DER relevant to/included in the retrofit design	Our design did not include any of the work associated with the on-site solar PV plant. The implementation of the on-site solar PV plant is being conducted by the developer and Troy Housing Authority.
Onsite DER capacity vs. offsite	N/A
How to integrate DER into HVAC and other major end uses	N/A
Structural performance	N/A
Efficiency degradation	N/A
Required sensors and controls	N/A
Maintenance of solution	N/A
Sustainability of solution	N/A
Replication potential at scale	N/A

Other Questions	Team Response
What challenges have you encountered in designing a DER solution? How are you addressing them?	N/A
Are there any unresolved major issues? What would it take to resolve them?	N/A
Other comments (optional)	N/A

Building Performance + Modeling & Life Cycle Cost Analysis

Key design criteria to consider	How does your design address the criteria?
Overall site EUI of not more than 25 kBtu/ft2/year	Staengl Engineering conducted energy analysis of potential retrofit solutions for Martin Luther King Apartments, Building #10. The goal of the retrofit design is to achieve a site energy use intensity (EUI) of 20 kBtu/sf/year or less, excluding energy offset by the planned photovoltaic system. We used the energy modeling software IES-VE 2018 to estimate the energy consumption throughout three rounds of analysis: 1. There are 24 different design solutions, plus a baseline case based on the Phase II retrofit being implemented for the other buildings in the apartment complex (this first round of simulations is described in the attached Energy Simulation Report dated August 1, 2018) 2. Various configurations of slab insulation, wall insulation, heat pump and solar thermal DHW, and air-to-water heat pumps for DHW and space conditioning. 3. A narrowed-down list of specific envelope enhancements (including high-performance windows and doors, exterior wall insulation) drain-water heat recovery, and solar thermal DHW. Through these iterative energy studies, the team arrived at the conceptual design for the project, which as an estimated EUI of 16.3 kBtu/sf/year. The PHASE II retrofit baseline has an estimated EUI of 54.5 kBtu/sf/year. Utility bills show that the pre-retrofit baseline has an estimated EUI of 61.9 kBtu/sf/year. The final project Schematic design modeled Energy Use Index (EUI) was calculated to be: **21.4 kBtu/ft2/yr.**

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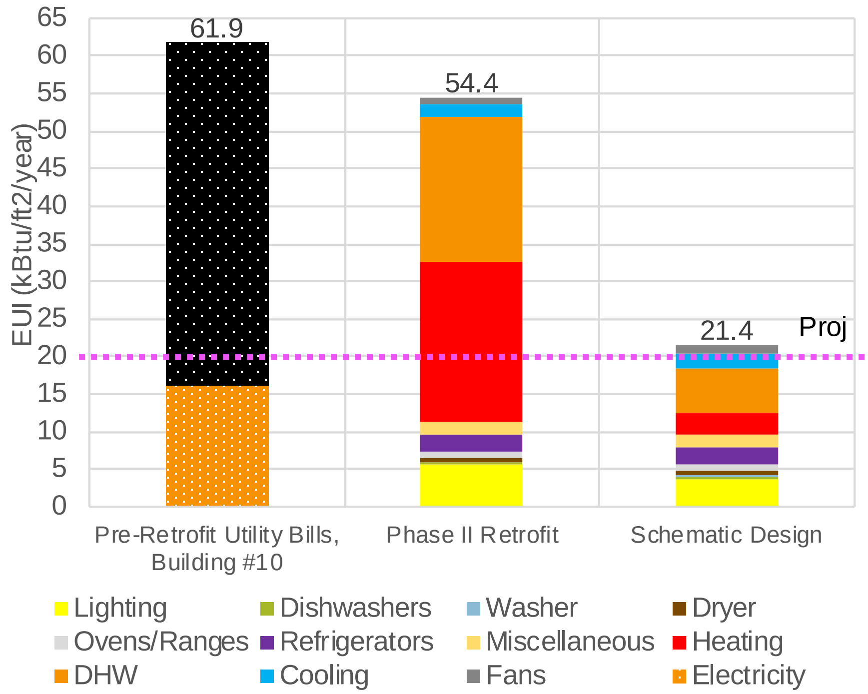
Figure 1 shows the EUI for the existing, pre-retrofit building (based on utility bills), the Phase II retrofit baseline, and the schematic design.



Heating EUI: 3.0 kBtu/ft^2/yr
Cooling EUI: 1.8 kBtu/ft^2/yr
Fans EUI: 1.1 kBtu/ft^2/yr

Infiltration rate assumed: 1.6 ACH50
In the **Schematic** Design the modeled Energy Use Index (EUI) was calculated to be **21.4 kBtu/ft2/yr.**

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<tr>
<td>Determination of operational assumptions (schedules, people densities, etc.)</td>
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The project RFP lists the following required “levels of comfort and service”:

1. Minimum heating season space temperature: 68° F (daytime: 6am-10pm), 62° F (nighttime: 10pm-6am)
2. Maximum cooling season space temperature: 77° F
3. Domestic hot water service: 21 gallons/person/day delivered at 120°F
4. Apartment ventilation: the greater of:
    - 20 cfm per bathroom + 25 cfm per kitchen
    - 18 cfm per person
5. Solutions must account for a reasonable level of apartment-level electrical consumption (lighting, appliances and plug loads) expected to be at least 5 kBtu/ft^2/yr

Items one through four from this list have been included in the model. Item number five has been accounted for by entering inputs for lighting, appliances, and plug loads based on reasonable assumptions and schedules, as described in the next sub-section.

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Occupancy-Based Parameters

Table 2: Occupancy, ventilation, and DHW

Unit	Bath	Bedroom	Kitchen	OA cfm bathroom + kitchen	OA cfm people	OA req'd	# people	DHW peak gal/hr	
A	1	3	1	45	72	**72**	4	6.72	
B	1	3	1	45	72	**72**	4	6.72	
C	1	2	1	45	54	**54**	3	5.04	
D	1	2	1	45	54	**54**	3	5.04	
E	2	4	1	65	90	**90**	5	8.4	
F	1	3	1	45	72	**72**	4	6.72	
TOTAL	**6**	**17**	**6**	**270**	**414**	**414**	**23**	**21**	**gal/person/day**
								1.68	peak gal/hr/person
								483	gal/day HW

Peak Consumption and Heat Gains

The peak electricity consumption and heat gains (sensible and latent) for appliances, miscellaneous plug loads, and lights are described in the following tables.

Table 3: Peak consumption and heat gains for appliances, plug loads, and lighting

	Peak elecricity consumption (Btu/h)	Peak sensible heat gain (Btu/h)	Peak latent heat gain (Btu/h)
Dishwasher	135	81	20
Washer*	207	166	0
Dryer*	1653	744	248
Oven/Range	399	160	120
Refrigerator	365	365	0
Miscellaneous	517	481	0
Lights	997	997	0

*This appliance is per site. All others are per apartment unit.

These peaks are then multiplied by the hourly fractions shown in the Schedules sub-section on the next page. The lighting power is estimated to be 0.6 W/ft^2 for the laundry room and 0.4 W/ft^2 for the apartment units. The appliance consumption and hourly schedules are based on the *2014 Building America House Simulation Protocols* published by NREL. The dryer is based on an average of 3 loads/day using a 7.4 cu. ft. Energy Star rated Whirlpool heat pump dryer (model WED9290).

Peak Consumption and Heat Gains

The peak electricity consumption and heat gains (sensible and latent) for appliances, miscellaneous plug loads, and lights are described in the following tables.

Table 4. Peak consumption and heat gains for appliances, plug loads, and lighting

	Peak electricity consumption (Btu/h)	Peak sensible heat gain (Btu/h)	Peak latent heat gain (Btu/h)
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*This appliance is per site. All others are per apartment unit.

Schedules

Table 5. Hourly schedules

Time of Day	Dish-washer	Washer	Dryer	Occup-ancy	Oven/ Range	Refrig-erator	Miscel-laneous	Lights	DHW
:00	0.28	0.28	0.33	1.00	0.07	0.82	0.73	0.16	0.29
:00	0.15	0.05	0.28	1.00	0.04	0.80	0.60	0.06	0.09
:00	0.06	0.05	0.05	1.00	0.04	0.78	0.56	0.06	0.04
:00	0.05	0.03	0.05	1.00	0.03	0.75	0.55	0.06	0.01
:00	0.03	0.05	0.03	1.00	0.03	0.73	0.55	0.06	0.01
:00	0.03	0.06	0.05	1.00	0.06	0.71	0.52	0.19	0.04
:00	0.09	0.13	0.06	1.00	0.07	0.71	0.58	0.39	0.25
:00	0.16	0.25	0.13	1.00	0.16	0.73	0.68	0.44	0.94
:00	0.28	0.45	0.25	0.85	0.28	0.80	0.71	0.39	1.00
:00	0.54	0.60	0.45	0.39	0.31	0.81	0.60	0.17	0.98
0:00	0.56	0.66	0.60	0.23	0.33	0.84	0.52	0.12	0.84
1:00	0.51	0.66	0.66	0.23	0.28	0.80	0.53	0.12	0.76
2:00	0.45	0.75	0.66	0.23	0.33	0.80	0.53	0.12	0.61
3:00	0.36	0.73	0.75	0.23	0.39	0.84	0.52	0.12	0.53
4:00	0.38	0.74	0.73	0.23	0.29	0.84	0.53	0.12	0.48
5:00	0.34	0.71	0.74	0.23	0.28	0.81	0.60	0.20	0.41
6:00	0.34	0.68	0.71	0.23	0.39	0.84	0.56	0.12	0.48
7:00	0.34	0.75	0.68	0.30	0.64	0.90	0.71	0.44	0.54
8:00	0.45	0.90	0.75	0.56	1.00	0.95	0.85	0.61	0.74
9:00	0.75	0.88	0.90	0.90	0.79	1.00	0.94	0.82	0.86
0:00	1.00	0.84	0.88	0.90	0.40	0.95	0.97	0.98	0.81
1:00	0.82	0.60	0.84	0.90	0.25	0.93	1.00	1.00	0.74
2:00	0.57	0.54	0.60	1.00	0.17	0.91	0.97	0.69	0.61
3:00	0.38	0.33	0.54	1.00	0.11	0.90	0.84	0.38	0.53

Note: See *2014 Building America House Simulation Protocols* published by NREL, Section 4.5: Appliances and Miscellaneous Electric Loads.

The model, with these peak values and hourly fractional multipliers, results in monthly consumption for cooling, appliances, plug loads, and lighting that is in reasonable agreement with measured pre-retrofit electricity consumption after accounting for upgrading the lighting to LED from a pre-retrofit mix of incandescent and fluorescent.

Figure 1. Measured electricity consumption vs. adjusted model

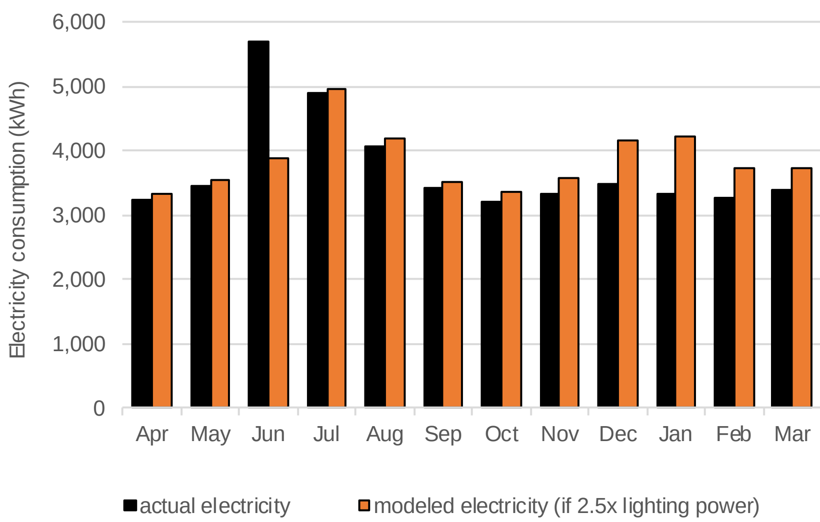
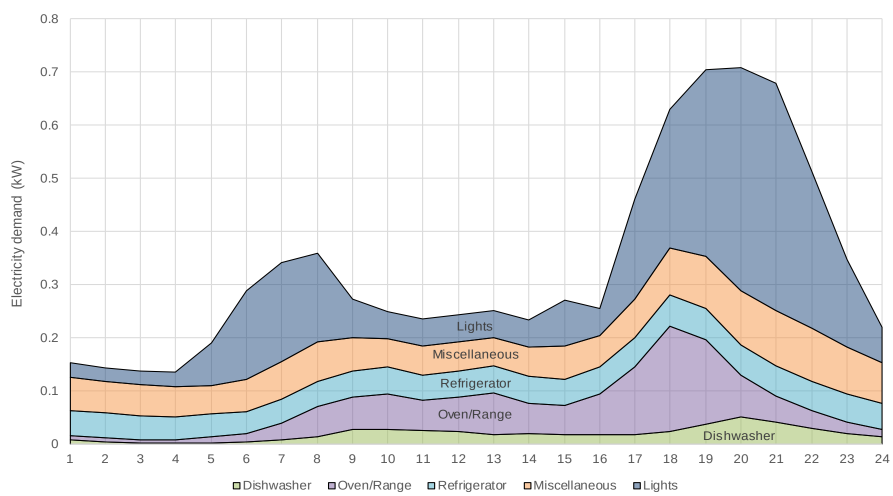


Figure 3. shows the hourly profile for all appliances, miscellaneous plug loads, and lights for one apartment.

The peak demand (kW) for each end use has been calibrated to force the annual consumption to match the Building America consumption.



Design Solution Parameters

The previous round of energy modeling (documented in the attached Energy Simulation Report dated August 1, 2018) identified the following influential design pieces which may be mixed in several ways to form a solution meeting the energy target:

- Envelope enhancements (windows, doors, walls, roof, slab edge)
- Solar thermal domestic hot water system
- Drain-water heat recovery
- Air-sealing for infiltration reduction
- Air-to-air or air-to-water heat pumps for space conditioning and/or DHW

Note that many of the items relate to domestic hot water, which is the single largest energy end-use for this project.

The following design solution parameters were held constant for all solutions:

- Lighting: all LED
- Shared dryer: Heat pump type
- Exhaust air energy recovery: passive ERV

The second round of energy modeling, presented in this report, analyzed the impact of slab insulation, wall insulation, heat pump and solar thermal DHW, and air-to-water heat pumps for DHW and space conditioning.

The third round of energy modeling assumed ERVs plus mini-split heat pumps for space conditioning and explored the impact of specific envelope enhancements (including high-performance windows and doors, exterior wall insulation) drain-water heat recovery, and solar thermal DHW.

The Schematic design for the project is based on implanting all the analyzed Energy efficiency measures:

- Walls: No Cavity batt insulation + R-24 sheathing exterior insulation
- Slab insulation: R-10, 1' deep vertical foam board from the slab edge down along the foundation wall
- Roof: R-70 loose fill insulation above the existing roof
- Windows: U-factor 0.18, SHGC 0.5
- Doors: R-2.5
- Infiltration: 1.5 to 2.5 ACH at 50 Pa (0.05 ACH at atmospheric pressure)
- 19 SEER ducted mini-split heat pump per apartment
- ERV per apartment (82% sensible effectiveness, 60% latent effectiveness)
- Solar DHW system comprising 1 30-tube collector (evacuated tube type)
- 7 Rheem heat pump water heaters to meet the DHW load

In addition to the design solutions, we have simulated the Phase II retrofit baseline to allow comparison of the design solutions to the “business as usual” case.

The EUI associated with the baseline case is 54.4 kBtu/ft^2/year.

Operation and maintenance costs	

Anticipated costs savings for 30 years relative to “business as usual” normal retrofit intervention

Energy Cost Analysis for MLK Before and After (Best Case Analysis)

Bldg. Square Feet	7150

Utility	Monthly Service Fee	Utility Rate	*Delivery*	*Supply*
Utility Rate for gas ($/Therm)	$20.35	$0.74	*$0.27*	*0.46673*
Utility Residential Rate for Electric ($/kWh)	$17.50	$0.092	$0.0565	*$0.0357*
Utility Demand rate for Electric ($/kwh)	$52.52	$0.049	$0.0063	*$0.0425*
Peak/Demand Charge ($/KW)	$0.00	$10.94		

Base (BAU) Building	Bldg. EUI	Annual kBtu	Annual kWh Usage
	54.4	388960	28986

	Gas Service Fees	Therms usage	Therm Charge	Electric Service Fees	Demand (kW)	Demand Charge	Kwh Usage	kWh Charge
Jan	$142	241.16	$178	$158	8	$88	2415	$223
Feb	$142	241.16	$178	$158	8	$88	2415	$223
Mar	$142	241.16	$178	$158	8	$88	2415	$223
Apr	$142	241.16	$178	$158	8	$88	2415	$223
May	$142	241.16	$178	$158	8	$88	2415	$223
June	$142	241.16	$178	$158	8	$88	2415	$223
July	$142	241.16	$178	$158	8	$88	2415	$223
Aug	$142	241.16	$178	$158	8	$88	2415	$223
Sept	$142	241.16	$178	$158	8	$88	2415	$223
Oct	$142	241.16	$178	$158	8	$88	2415	$223
Nov	$142	241.16	$178	$158	8	$88	2415	$223
Dec	$142	241.16	$178	$158	8	$88	2415	$223
TOTAL	**$1,709**		**$2,137**	**$1,890**		**$1,051**		**$2,671**
							Grand Total	**$9,459**

1 Demand Meter	Bldg. EUI	Annual kBtu	Annual kWh Usage
Retrofit NY Bldg.	16.3	116545	34156

	Electric Service	Demand (kW)	Demand Charge	Kwh Usage	kWh Charge
Jan	$53	28	$306	2846	$139
Feb	$53	28	$306	2846	$139
Mar	$53	28	$306	2846	$139
Apr	$53	28	$306	2846	$139
May	$53	28	$306	2846	$139
June	$53	28	$306	2846	$139
July	$53	28	$306	2846	$139
Aug	$53	28	$306	2846	$139
Sept	$53	28	$306	2846	$139
Oct	$53	28	$306	2846	$139
Nov	$53	28	$306	2846	$139
Dec	$53	28	$306	2846	$139
TOTAL	**$630**		**$3,677**		**$1,668**
		Grand Total			**$5,975**

7 Meters (6 residential and 1 demand)	Bldg. EUI	Annual kBtu	Annual kWh Usage
Retrofit NY Bldg.	16.3	116545	34156

	Electric Service	Demand (kW)	Demand Charge	Kwh Usage	kWh Charge
Jan	$157.52	4.8	$52.53	2846	$262.37
Feb	$157.52	4.8	$52.53	2846	$262.37
Mar	$157.52	4.8	$52.53	2846	$262.37
Apr	$157.52	4.8	$52.53	2846	$262.37
May	$157.52	4.8	$52.53	2846	$262.37
June	$157.52	4.8	$52.53	2846	$262.37
July	$157.52	4.8	$52.53	2846	$262.37
Aug	$157.52	4.8	$52.53	2846	$262.37
Sept	$157.52	4.8	$52.53	2846	$262.37
Oct	$157.52	4.8	$52.53	2846	$262.37
Nov	$157.52	4.8	$52.53	2846	$262.37
Dec	$157.52	4.8	$52.53	2846	$262.37
TOTAL	**$1,890.24**		**$630.36**		**$3,148.44**
Grand Total					**$ 5,669**

$5,612	**One Demand Meter Annual Savings over BAU**	**$3,484**
	7 Meters Annual Savings over BAU	**$3,789**
	Difference between the two options (over BAU)	***$306***

Retrofit business model + sustainability and scalability of solution	Several challenges are evident from our utility cost analysis. For example, even though the design reduces the EUI for the building by approx. 70% from 56 to 16 kbtu/sf/yr, the annual cost of energy (ignoring the presence of solar PV), is only reduced by 30%, due to the dramatic difference in the cost of natural gas vs. electric. That will continue to be a major economic hindrance to the adoption of all electric solutions.

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 major challenge was reducing the energy requirements of the DHW load. That was addressed by adding solar thermal and heat recovery systems.
What challenges have you encountered in modeling the solution's performance? How are you addressing them?	The biggest challenge has been the basic strategy of leaving in place the existing brick veneer and being confident that we are not creating an assembly that will have the potential to allow condensation inside the wall cavity at low temperatures. We have modeled dew point analysis using several scenarios to have confidence in our design.
What challenges have you encountered in completing an LCCA? How are you addressing them?	Getting accurate costs for some measures has been challenging
Are there any unresolved major issues? What would it take to resolve them?	None
Other comments (optional)	

Construction Budget

Key criteria to consider	How does your budget address the criteria?
Cost compression due to anticipated innovation	Very little cost compression expected. Typical site-based construction is very hard to squeeze dollars out of.
Cost compression at scale	Very little cost compression expected. Typical site-based construction is very hard to squeeze dollars out of.
Current availability of required products	All materials specified are readily available on standard construction delivery schedules.
Anticipated future availability of required products	All materials specified are readily available on standard construction delivery schedule.
Transportation of products/systems to project site	Transportation will be as standard as most construction materials.
On-site vs. off-site labor	We don't expect there to be any off-site labor.

Other Questions	Team Response
What challenges have you encountered in producing a construction budget? How are you addressing them?	Local construction costs are quite high due to tight labor market and very busy subcontractors
Are there any unresolved major issues? What would it take to resolve them?	Project is currently cost-prohibitive without major subsidies on the order of $60k per unit or more.
Other comments (optional)	

Construction Schedule

Key criteria to consider	How does your schedule address the criteria?
Schedule compression due to anticipated innovation	Scheduling issues really aren't applicable on this project since it is a subset of a greater rehab project. Only element of project that might affect construction schedule is the more involved sheathing installation/ air sealing, which will require additional training of installer staff.
Schedule compression at scale	As these methods become more standard construction schedules should be able to be compressed slightly.
Current availability and lead time of required products	All materials specified are readily available on standard construction delivery schedules.
Anticipated future availability and lead time of required products	All materials specified are readily available on standard construction delivery schedules.
Transportation of products/systems to project site	
On-site vs. off-site labor	If any U.S. manufacturers start making cost-effective panel systems, the offsite labor savings should kick in.

Other Questions	Team Response
What challenges have you encountered in producing a construction schedule? How are you addressing them?	We have no say in schedule.
Are there any unresolved major issues? What would it take to resolve them?	Not our purview.
Other comments (optional)	

2 Schematic Design Documents

- Combined specifications
- Design specification
- Schematic design documents
- Revitalization phase plans
- 00_RetrofitNY_CONCEPT SKETCHES - 2018-09-15
- 00_RetrofitNY_EXISTING - 2018-09-15
- 01_RetrofitNY_CRITICAL CUSTOM DETAILS - Perimeter Insulation Change_2018-10-04
- 2018-09-17_THERM MODEL SLIDES_REVISED
- 2018-10-04_THERM DIAGRAMS_Full Wall Section_PERIMETER INSULATION CHANGE
- 223300 - electric water heaters
- 223450 - solar hot water heating system
- 237200 - air-to-air energy recovery equipment
- 238130 - air-to-air heat pumps
- 38MAR Sizes 09-12
- 40MBDQ Sizes 09-48
- 40MPHA Sizes 09-12
- 40VM900006-C-1SD
- Architectural Specs
- Eurotek-Flyer-Updated-01192018
- Hot Water Schematic 12_14_18 each apartment
- HP Dryer installation-instructions-W10679043-RevA
- HP Dryer warranty-W10678945-W
- Hunter-Xci-CG-Submittal
- Hunter-XCI-NB
- Hunter-Xci-Ply-Submittal
- MLK Building 10 Elevation
- Panasonic ERV FV-10VEC1_Sell Sheet
- Panasonic ERV FV-10VEC1_Submittal
- Performance Data eurotek windows
- Pioneer SmartBurner Spec Sheet
- RetrofitNY Combined Specifications
- Rheem HPWH THD-PPEH4_Rev6_THD_Gen_4_Hybrid+15_amp
- Smappee Pro Installation and Product Manual_EN - US Version

3 Scalability Strategy

The design was started by thinking in terms of how buildings are currently built and rehabbed. Recognizing that since this project is a subset of an ongoing rehab of the existing property, any approach needed to be easily delivered by the same contractors that were doing the conventional rehab. While that was limiting, it was also useful in the sense that the approach should be readily repeatable by your typical residential construction crew.

Everything proposed as an energy saving element is very familiar and repeatable by typical construction firms. The major barrier to scalability is payback on these improvements. Barring a dramatic rise in utility costs or the imposition of a carbon tax, the industry will need to develop retrofit solutions that are far more cost-effective to achieve viable payback periods. Regarding the Energiesprong notion of a panelized system, manufacturing companies should take the lead in developing an inexpensive system so significant adoption can take place.

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	Since ERVs are being installed commonly in buildings today, solution is readily scalable as add on to HVAC System	CERV is a terrific unit https://www.buildequinox.com/ but cost was prohibitive
Space Heating/Cooling	Cold Climate Heat pumps are quickly being adopted throughout the country. Rigorous M&V will prove actual energy savings which will help adoption	Ground Source heat pumps are always an interesting choice, especially where bodies of water are available
Domestic Hot Water	HPWH is a simple modification of refrigeration systems that have been in use for 100 years. While only around for a few years in this form, technology is very proven	Europe and Asia have a HP HVAC unit that also does the DHW job. Introducing that technology into the U.S. will reduce costs further and drive scalability
Miscellaneous Electric Loads	Plug load monitoring for MEL	Home automation systems, as they get cheaper and more prevalent will drive scale in this segment
Façade	Since there is still no actual manufacturer of panels currently selling in the USA, adding foam insulation to existing façade or adding SIPS or sheathing solutions over the insulation is readily scalable and easily adopted by U.S. builders	Perhaps blown-in insulation with residents in place, a solution in place for decades, is a cost-effective and scalable option
Roof	More ceiling insulation is readily scalable and adopted	
Distributed Energy Resources	Solar PV is an established solution	

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	2500	2400	2000	2000	2000
Space Heating/Cooling	7000	6750	6000	5000	5000
Domestic Hot Water	2000	2000	1750	1500	1400
Miscellaneous Electric Loads	1000	1000	1000	750	500
Façade	n/a	n/a	n/a	n/a	n/a
Roof	n/a	n/a	n/a	n/a	n/a
Distributed Energy Resources	n/a	n/a	n/a	n/a	n/a

4 Budget and Financing Plan

The approach was to evaluate each potential improvement using the cost per kWh saved as a yardstick for improvements made the most sense. The team then had an easily understood rubric for evaluating each measure as compared to every other measure. As a result, it became abundantly clear the high cost of insulated wall panels or other envelop treatments made pursuing heat pumps or heat pump water heaters instead a more cost-effective route toward achieving the same performance levels.

The team worked with National Grid to try to maximize utility incentives, but that was determined not feasible because they amounted to less than $10,000. The cost-effectiveness of this project is difficult. Utility costs will need to greatly increase and retrofit costs will need to greatly decrease before projects like this will be cost-effective in terms of payback. The retrofit scope should slightly improve building's durability due to better moisture management.

5 Projected Construction Schedule

The team had no input on Construction Schedules. The project is being run by a developer and general contractor who, at the time of this report's completion, were still determining a construction schedule for Phase II of the overall campus renovation. The project will not be a tenant in place rehab, so that element cannot currently be commented on.

6 Building Performance Summary

Mechanical equipment from major manufacturers with a long history of high-quality manufacturing and product support were selected.

The design was able to reduce energy consumption by approximately 70%, which is quite impressive. At this point any more efficiency would result in an exponential increase in costs. Because the project has a community wide solar array, NZE was the desired end result, and it was felt that mix of 70% efficiency and 30% renewables seems like the sweet spot for a NZE rehab project.

At least 10 different approaches to increasing the wall insulation and air sealing were evaluated. Discussions occurred on the difficulties of installation, and the cost of approach with architect, engineer, and potential general contractor. Based on those conversations, all but two were eliminated based on practical considerations such as cost and availability of materials. Those two remaining were a simple adding of foam to the existing shell in conventional manner, and the theoretical wall panel system, which were evaluated based on NYSERDA's interest in that option. Ultimately, an affordable panelized approach was not identified.

6.1 Distributed Energy Resources Summary

The solar array onsite is completely outside the scope of the project. It will simply provide electricity to the site at approx. .10 per kWh.

6.2 Supplemental Renewables Plan

This was not applicable due to the project developer introducing a community solar array to serve the campus.

7 Resident Management Plan

The Troy Housing Authority will spearhead these efforts, since their staff is present onsite. They have expertise and enthusiasm for helping tenants reduce energy usage.

Resident Management Plan

Goals

To educate tenants on opportunities for saving energy and making facility more sustainable.

Length of construction phase

06/2019 to 12/2019

Length of resident management plan

TBD

Plan for resident notifications and communication

Residents in the homes to be renovated are already relocated. These are major renovation projects.

Resident liaison or resident groups

No one named in particular. There is a program to establish a community ‘club house’ where these types of relationships are to be addressed and engaged in.

In-unit construction plan

As scheduled—building will not be occupied

Exterior construction plan

As scheduled

Parking impacts

Limited, as building will be unoccupied

Plan for special needs

Not applicable

Expected areas of pushback

None

Residents' Meeting Plan

Plan for initial resident outreach

Will be scheduled two months prior to commencement of construction or perhaps occupancy.

Kickoff event

This is an ongoing project with multiple renovations already completed. No kick-off event is likely.

Resident update meetings

None Planned

Trainings

To be determined

Other resident activities

Community Clubhouse; Interaction with other communities in North Troy in terms of developing critical mass for various activities and community development; Community Gardens are in the exploration stages.

ICAST has a resident engagement app, available on the android and iPhone platforms, called ICAST, which it will offer to THA and others involved in the program, at no cost. The app allows for resident education of EE and other sustainable behaviors and offers challenges as a means for resident engagement that can be offered to the NZE building occupants in competition with occupants from business as usual buildings.

Method to gauge resident participation and track achievements

Not determined.

Residents' Guidelines

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

Operations and maintenance guidelines

To be determined in the future.

Health and safety guidelines

To be determined in the future.

Residents' guide to understanding the utility bill

To be determined in the future.

Schedule of routine in-unit maintenance

To be determined in the future.

8 Performance Guarantee Pathway

It does not seem as though there is a precedence in the U.S. for guaranteeing performance of residential buildings regarding to energy usage. This may be because of the many variables that can adversely affect energy usage, especially in instances when tenants are not paying utilities.

The understanding is that contractors, developers, and landlords alike have expressed little interest in a performance guarantee, though this might interest the insurance industry should a market develop, and the economics prove out. Designing a building for high-performance is often an excellent marketing opportunity, though this is often only verified as part of the construction process or simply assumed given the additional construction processes and costs. M&V might assist in demonstrating performance, but the widespread adoption of a performance guarantee would represent a significant change to the current state of the industry, especially when new and unproven technologies are involved.

Given the disparity, the analysis revealed between energy savings and retrofit cost does not show an easy pathway to financing a project by guaranteeing those savings. Compounding the challenge is that the infrastructure needed for such a guarantee (third-party verification, established energy savings standards, predictable energy costs, financial vehicles to support or insure performance) is not yet present in this country. Additionally, the risk of legal liability may also prove a deterrent.

Providing legislative safeguards to the guarantor might facilitate adoption, but given these obstacles, ICAST as an organization could not foresee providing a comprehensive performance guarantee at this time.

Maintenance and Warranties

Which 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)

None of the systems offer an energy savings performance guarantee. Most have one-year labor warranty. The equipment warranties are provided in the following table. The solar PV solution is on a PPA basis and is a pay-for-performance contract.

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

Typical contractor warranties are one year for parts and labor, and that would be part of the contracting process for this project. In terms of the actual equipment specified, the warranties are as follows.

Component	Manufacturer	Parts Warranty	Labor Warranty
Cold Climate Heat Pump	Carrier	10 Years	n/a
Cold climate ERV	Panasonic	3 years	6 years motor
Heat Pump Water Heater	RHEEM	10 years	n/a
Windows	Eurotek	10 Years	n/a
Doors	Jeld-Wen	10 Years	n/a
Heat Pump Dryer	Whirlpool	1 year	1 year

List the schedule of high-level maintenance needs through the 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.

System	Component	Expected intervention needed
Wall Insulation	Wall Insulation	None
Windows		None
Doors		Occasional weather-strip maintenance
Ceiling Insulation		None
Weather resistive barrier		None
Slab Insulation		None
Air Sealing		None
Siding		Regular Painting
HVAC	Compressor	Replace 10% before life cycle ends
HVAC	Fan (Condenser side)	Replace 10% before life cycle ends
HVAC	Fan (Evaporator side)	Replace 10% before life cycle ends
HVAC	Filter	Change regularly
Ventilation	Motor	Replace 10% before life cycle ends
Ventilation	Filter	Change regularly
DHW	System	Tri-annual servicing
Solar DHW	Major Components	Bi-annual servicing of key components
HP Dryer		Annual service maintenance
Range		None

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

Most extended warranties are not cost-effective. A service contract could be negotiated with the mechanical contractor to provide extended warranty service for the mechanical systems, but after discussing with most multifamily owners, they never purchase extended warranties.

System	Is an extended warranty available?	Would such warranty be beneficial
Wall Insulation	No	n/a
Windows	No	n/a
Doors	No	n/a
Ceiling Insulation	No	n/a
Weather resistive barrier	No	n/a
Slab Insulation	No	n/a
Air Sealing	No	n/a
Siding	No	n/a
HVAC- Heat Pump	Yes	Second most likely to have failures, might benefit from service contract
Ventilation- ERV	Maybe	Very unlikely to fail
DHW	Maybe	Very unlikely to fail
Solar DHW	Maybe	Most likely system to fail- Most benefit from service contract
HP Dryer	Yes- Might not qualify in commercial application	Would benefit from extended warranty
Range	no	No

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

System	Is an extended warranty available?	Who would do work
Wall Insulation	No	n/a
Windows	No	n/a
Doors	No	n/a
Ceiling Insulation	No	n/a
Weather resistive barrier	No	n/a
Slab Insulation	No	n/a
Air Sealing	No	n/a
Siding	No	n/a
HVAC- Heat Pump	Yes	Installing mechanical contractor
Ventilation- ERV	Maybe	Installing mechanical contractor
DHW	Maybe	Installing mechanical contractor
Solar DHW	Maybe	Installing Solar Contractor
HP Dryer	Yes- Might not qualify in commercial application	Appliance service company of owners' choice
Range	no	Appliance service company of owners' choice

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

There isn't a contractor, manufacturer, or engineer in the country who will guarantee the energy performance of their components. There are way too many variables, especially in a MF building, which can affect energy performance.

Perhaps if a single entity is controlling every aspect of the retrofit, they may provide a performance guarantee.

System	Is there a performance guarantee available	What is the cost
Wall Insulation	No	n/a
Window s	No	n/a
Doors	No	n/a
Ceiling Insulation	No	n/a
Weather resistive barrier	No	n/a
Slab Insulation	No	n/a
Air Sealing	No	n/a
Siding	No	n/a
HVAC- Heat Pump	No	n/a
Ventilation- ERV	No	n/a
DHW	No	n/a
Solar DHW	No	n/a
HP Dryer	No	n/a
Range	no	n/a
		n/a

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

Currently uncertain.

M&V

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

M&V subcontractor

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

System	Is there value to monitoring	How will system be monitored
Wall Insulation	No	n/a
Windows	No	n/a
Doors	No	n/a
Ceiling Insulation	No	n/a
Weather resistive barrier	No	n/a
Slab Insulation	No	n/a
Air Sealing	No	n/a
Siding	No	n/a
HVAC- Heat Pump	Yes	HEMS
Ventilation- ERV	Yes	HEMS
DHW	Yes	HEMS
Solar DHW	Yes	HEMS
HP Dryer	Yes	HEMS
Range	Yes	HEMS

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

SMAPEE home energy monitoring service will provide dashboard feedback on component specific energy usage for both tenant and management and provide reporting basis for M&V.

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

Approximately $1,000 per unit (apt of laundry) in materials and $500 in labor (electrician).

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

M&V subcontractor will charge $7,000 per year for compiling and reporting usage data per building.

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

System	kWh usage	kW demand	Coincident peak demand
Wall Insulation	No	No	n/a
Windows	No	No	n/a
Doors	No	No	n/a
Ceiling Insulation	No	No	n/a
Weather resistive barrier	No	No	n/a
Slab Insulation	No	No	n/a
Air Sealing	No	No	n/a
Siding	No	No	n/a
HVAC- Heat Pump	Yes	Yes	Yes
Ventilation- ERV	Yes	Yes	Yes
DHW	Yes	Yes	Yes
Solar DHW	Yes	Yes	Yes
HP Dryer	Yes	Yes	Yes
Range	Yes	Yes	Yes

List the sampling rate for each KPI

Every 60 seconds.

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

This team did not go into these details—the M&V contractor, hired for the job may have insights. ICAST believes access to performance data will assist the property in not only ensuring energy consumption is within design parameters but can also help improve operational efficiencies by tagging when energy consumption goes off expected values so that someone can conduct some analysis and perhaps a site visit to evaluate the reason for the change and in that process, perhaps identify malfunctioning equipment sooner, rather than later.

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

ICAST is unsure at this juncture—the theory is the pilot project will help determine at the end of Phase II. Also, since there are no offers for a performance guarantee, the question will remain unanswered until someone can offer such a guarantee and does the necessary analysis.

9 Regulatory Barrier Summary

Regulatory barriers were a minor concern in the design. There were a few potential code issues that did not rise to the level of consulting any code official because the architect of record devised solutions that made this unnecessary. Issues were not typical or likely to be common.

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
		Fire Code regarding existing EPDM Roofing	Removing existing membrane roof increased cost of project, but was a minor cost increase	Discussed with Architect of record and he required removal of existing roof. Never got to the level of Building official	Yes		

10 Resiliency Summary

Building resiliency was not a primary area of attention given the focus on energy savings, deferring instead to the overall rehab team on this matter. Though resiliency was not central to the project's scope, some elements of our design will enhance resiliency by their implementation.

HVAC and DHW will require less wattage and thus a smaller back up system if one is present. The ERV will be more effectively managed inside shell moisture. Additionally, the new exterior shell will better manage moisture migration through walls.

Indicator	Design Solution
Protection: Identify strategies to reduce a building's vulnerability to extreme weather:	
Floodproofing or Flood Control	None
Sewer Backflow Prevention	None
Mechanical Equipment Protection and Location	None
Electrical Equipment Protect and Location	None
Backup Power Location and Protection	None
Communications	None
Envelope Protection	Buildings will be wrapped with moisture resistive barrier
Fire Protection	None
Adaptation: Identify strategies that improve a facility's ability to adapt to changing climate conditions	
Envelope Design	Tight efficient building has much slower response to changing conditions, is able to maintain consistent temperature even as conditions quickly change
Mechanical Equipment	Properly sized equipment provides adequate heating and cooling, so as climate conditions change system will still be able to provide comfort temperatures
Passive Cooling or Ventilation Strategies	Operable Windows
In-unit	Energy awareness, CO2 control on ERV
Site	Outside of our scope
Backup: Identify strategies that provide critical needs for when a facility loses power or other services:	

Critical Systems with Backup	Mechanical systems will be all electric and facility will have PV Solar, so systems will have ability to operate when solar resource is available. If Battery systems are added later then systems could operate during power outages
Backup Power Type	Solar PV array for site. No Battery reserve
Access to Potable Water and Sanitary Services	None
Safety Precautions for Mechanical Equipment Operations	No Systems in the design are subject to severe damage by sudden power loss
Community: Identify strategies that encourage behavior, which enhances resilience:	
Emergency Management Awareness for Residents	Outside of the scope
Access to Manuals, Emergency Event Guidelines	Maintenance staff will be trained on Emergency Event guidance

11 Resident Health Impact Summary

Having an active 24/7 ventilation system in place will support the promotion of indoor air quality. That will include reducing the chance for mold growth etc. Active ventilation will also allow VOC to be exhausted from the building.

Indicator	Location	Intervention	
		Design Solution	Maintenance Plan
Mold	Units – Kitchens	Continuous Ventilation using ERV	Change filters regularly
	Units – Bathrooms	Continuous Ventilation using ERV	Change filters regularly
	Units – Windows and Exterior Doors	Continuous Ventilation using ERV	Change filters regularly
	Units – Mechanical Rooms	Continuous Ventilation using ERV	Change filters regularly
	Common Areas – Windows and Exterior Doors	Laundry is only common area.	Staff regularly cleans
	Common Areas – Mechanical Rooms		
	Below Grade	N/A	
Pests	Units	Effective air sealing will limit infiltration opportunities	
	Common Areas		
	Below Grade	N/A	
	Exterior		

VOCs (enter level of VOCs in products: conventional, low - or no-VOC)	Units - Paints	Low-Voc	
	Units - Coatings	Low-Voc	
	Units - Primers	Low-Voc	
	Units - Adhesives and Sealants	Low-Voc	
	Units - Flooring Materials	Low-Voc	
	Common Areas - Paints	Low-Voc	
	Common Areas – Coatings	Low-Voc	
	Common Areas – Primers	Low-Voc	
	Common Areas - Adhesives and Sealants	Low-Voc	
	Common Areas - Flooring Materials	Low-Voc	
Other Contaminants	Units		
	Common Areas		

12 Overall Rehab Proposal

The proposal only relates to the energy component of the project, which was then to be incorporated into the overall renovation scope of the entire campus. While the project developer, architect, engineer and contractor collaborated closely with the team, ultimately there was little input on the conventional aspects of the remaining rehab and there is no meaningfully comment on the integration of the proposal into that larger scope. The team's role in the rehab was to define the scope of work to deliver an NZE building (including renewables) as part of a larger rehab project and, once completed, this was handed over to the developer.

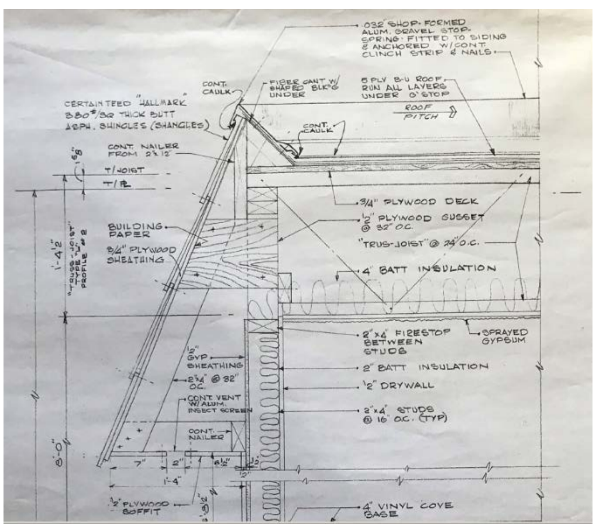
Given current project funding and the added cost to supervise the rehab work, the team does not foresee playing a role in the implementation of the design. When trying to develop new construction processes, the first few projects are not likely economically viable, and without grant funding, many organizations may not be willing to absorb these initial losses while developing new processes.

Appendix A. Schematic Design Documents

Rendering

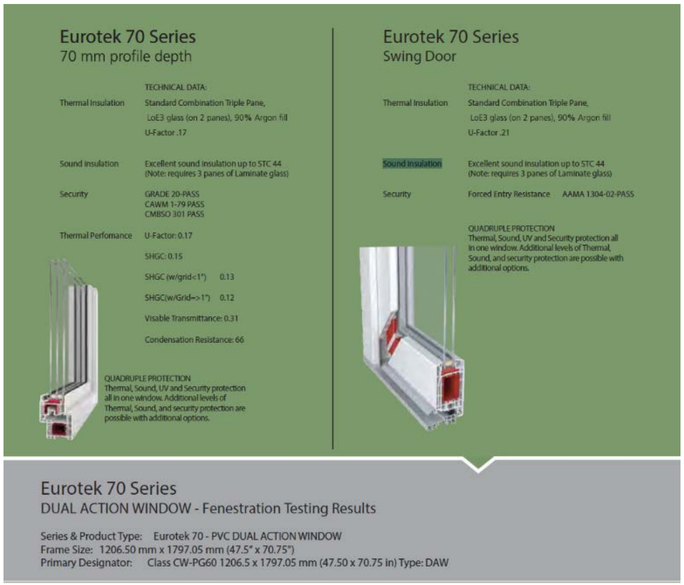
(Click on image to access the Rendering)

Design Documents



(Click on image to access the Design Documents)

Preliminary Specifications



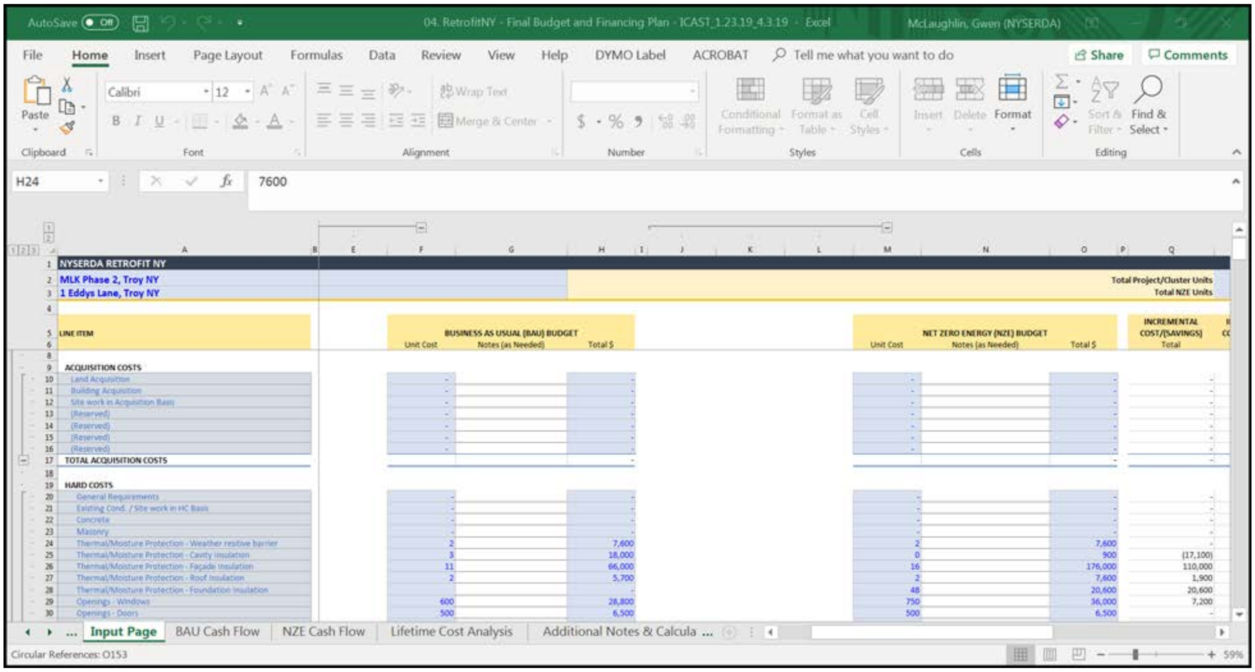
(Click on image to access the Preliminary Specifications)

Appendix B. Scalability Strategy

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	Since ERV's are being installed commonly in building today, solution is readily scalable as add on to HVAC System	CERV is a terrific unit https://www.buildequinox.com/ But cost was prohibitive
Space Heating/Cooling	Cold Climate Heat pumps are quickly being adopted throughout the country. Rigorous M&V will prove actual energy savings which will help adoption.	Ground Source heat pumps are always an interesting choice, especially where bodies of water are available
Domestic Hot Water	HPWH is a simple modification of refrigeration systems that have been in use for 100 years. While only around for a few years in this form technology is very proven	Europe and Asia have a HP HVAC unit that also does the DHW job. Introducing that technology into the US will reduce costs further and drive scalability.
Miscellaneous Electric Loads	Plug load monitoring for MEL	Home automation systems, as they get cheaper and more prevalent will drive scale in this segment
Façade	Since there is still no actual manufacturer of panels currently selling in the USA, adding foam insulation to existing façade or adding SIPS or sheathing solutions over the insulation is readily scalable and easily adopted by US Builders.	Perhaps blown-in insulation with residents in place, a solution in place for decades, is a cost-effective and scalable option.
Roof	More ceiling insulation is readily scalable and adopted	
Distributed Energy Resources	Solar PV is an established solution	

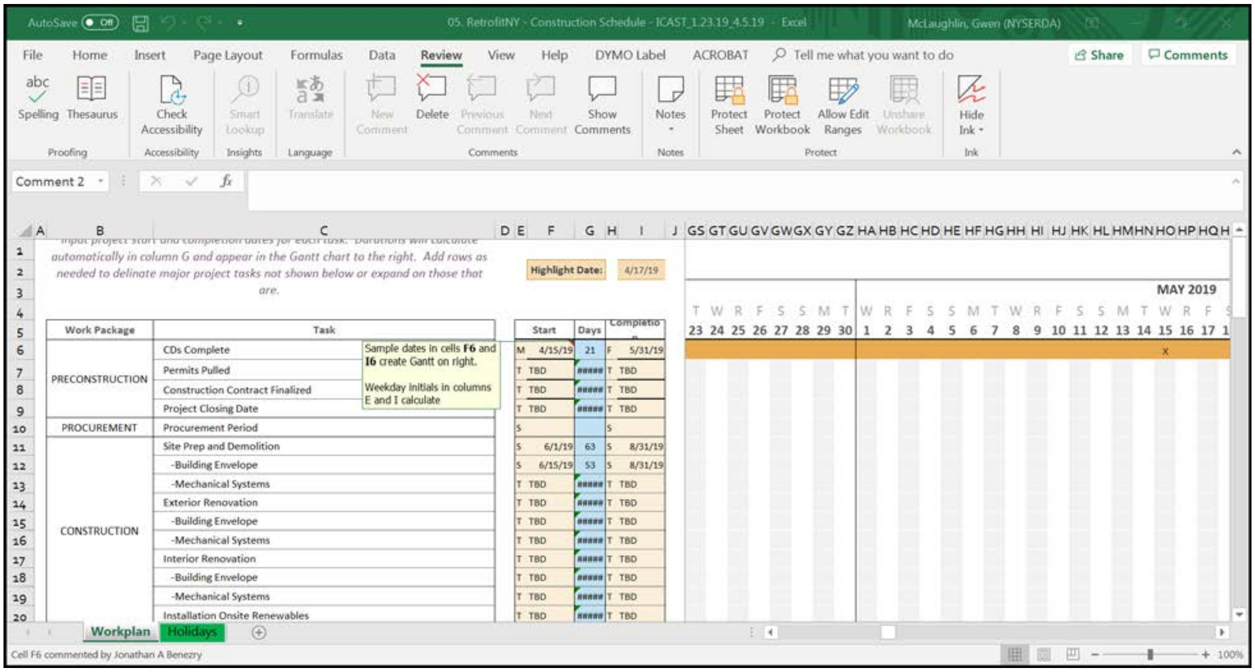
(Click on image to access the Scalability Strategy)

Appendix C. Budget and Financing Plan



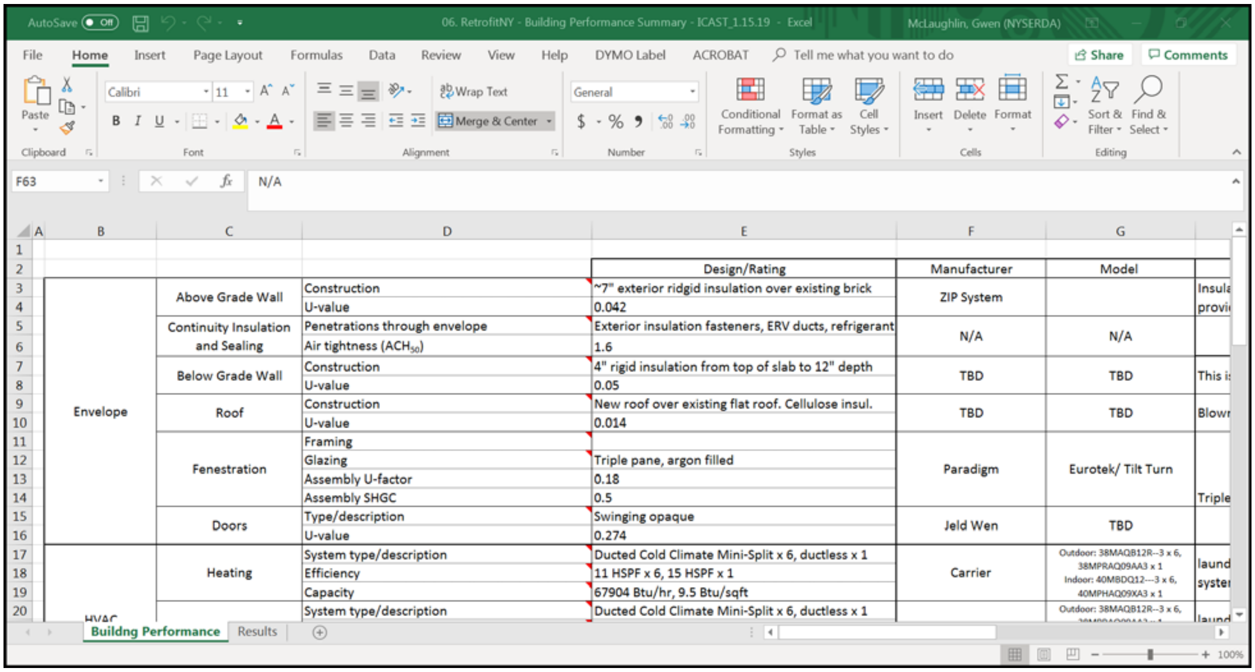
(Click on image to access the Budget and Financing Plan)

Appendix D. Projected Construction Schedule



(Click on image to access the Projected Construction Schedule)

Appendix E. Building Performance Summary



			Design/Rating	Manufacturer	Model
Envelope	Above Grade Wall	Construction	~7" exterior ridgid insulation over existing brick	ZIP System	
		U-value	0.042		
	Continuity Insulation and Sealing	Penetrations through envelope	Exterior insulation fasteners, ERV ducts, refrigerant	N/A	N/A
		Air tightness (ACH_{50})	1.6		
	Below Grade Wall	Construction	4" rigid insulation from top of slab to 12" depth	TBD	TBD
		U-value	0.05		
	Roof	Construction	New roof over existing flat roof. Cellulose insul.	TBD	TBD
		U-value	0.014		
	Fenestration	Framing		Paradigm	Eurotek/ Tilt Turn
		Glazing	Triple pane, argon filled		
		Assembly U-factor	0.18		
		Assembly SHGC	0.5		
	Doors	Type/description	Swinging opaque	Jeld Wen	TBD
		U-value	0.274		
HVAC	Heating	System type/description	Ducted Cold Climate Mini-Split x 6, ductless x 1	Carrier	Outdoor: 38MAQB12R--3 x 6, 38MPRAQ09AA3 x 1 Indoor: 40MBDQ12---3 x 6, 40MPHAQ09XA3 x 1
		Efficiency	11 HSPF x 6, 15 HSPF x 1		
		Capacity	67904 Btu/hr, 9.5 Btu/sqft		
		System type/description	Ducted Cold Climate Mini-Split x 6, ductless x 1		Outdoor: 38MAQB12R--3 x 6,

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

Appendix F. Resident Management Plan

Resident Management Plan

Goals

To educate tenants on opportunities for saving energy, and making facility more sustainable.

Length of construction phase

06/2019 to 12/2019

Length of resident management plan

TBD

Plan for resident notifications and communication

Residents in the homes to be renovated are already relocated. These are major renovation projects.

Resident liaison or resident groups

No one named in particular. There is a program to establish a community 'club house' where these types of relationships are to be addressed and engaged in.

In-unit construction plan

As scheduled- Building will not be occupied

Exterior construction plan

As scheduled

Parking impacts

Limited, as building will be unoccupied

Plan for special needs

Not applicable

Expected areas of pushback

None

Residents' Meeting Plan

Plan for initial resident outreach

Will be scheduled 2 (?) months prior to commencement of construction or perhaps occupancy?

(Click on image to access the Resident Management Plan)

Appendix G. Performance Guarantee Pathway

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)

None of the systems offer an energy savings performance guarantee. Most have one year labor warranty. The equip. warranties are provided below. The solar PV solution is on a PPA basis and as such is a pay-for-performance contract.

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

Typical contractor warranties are 1 year for parts and labor, and that would be part of the contracting process for this project. In terms of the actual equipment specified the warranties are as follows.

Component	Manufacturer	Parts Warranty	Labor Warranty
Cold Climate Heat Pump	Carrier	10 Years	n/a
Cold climate ERV	Panasonic	3 years	6 years motor
Heat Pump Water Heater	RHEEM	10 years	n/a
Windows	Eurotek	10 Years	n/a
Doors	Jeld-Wen	10 Years	n/a
Heat Pump Dryer	Whirlpool	1 year	1 year

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

Text

System	Component	Expected intervention needed
Wall Insulation	Wall Insulation	None

(Click on image to access the Performance Guarantee Pathway)

Appendix H. Regulatory Barrier Summary

Regulation			Impediment	Action	Resolution		
Code	Section	Description	Explain how this regulation impedes your ability to achieve the RetrofitNY criteria.	What action has the team taken to date to resolve this barrier?	Resolved	Resolution in Progress	Seeking Assistance with Resolution
		Fire Code regarding existing EPDM Roofing	Removing existing membrane roof increased cost of project, but was a minor cost increase	Discussed with Architect of record and he required removal of existing roof. Never got to the level of Building official	Yes		

(Click on image to access the Regulatory Barrier Summary)

Appendix I. Resiliency Summary

Indicator	Design Solution
Protection: Identify strategies to reduce a building's vulnerability to extreme weather:	
Floodproofing or Flood Control	None
Sewer Backflow Prevention	None
Mechanical Equipment Protection and Location	None
Electrical Equipment Protect and Location	None
Backup Power Location and Protection	None
Communications	None
Envelope Protection	Buildings will be wrapped with moisture resistive barrier ()
Fire Protection	none
Adaptation: Identify strategies that improve a facility's ability to adapt to changing climate conditions:	
Envelope Design	Tight efficient building has much slower response to changing conditions, is able to maintain even temperature even as conditions quickly change
Mechanical Equipment	Properly size equipment provides adequate Heating and Cooling, so as climate conditions change system will still be able to provide comfort temperatures
Passive Cooling or Ventilation Strategies	Operable Windows
In-unit	Energy awareness, CO_2 control on ERV
Site	Outside of our scope
Backup: Identify strategies that provide critical needs for when a facility loses power or other services:	
Critical Systems with Backup	Mechanical systems will be all electric, and facility will have PV Solar, so systems will have ability to operate when solar resource is available. If Battery systems are added later then then systems could operate during power outages
Backup Power Type	Solar PV array for site. No Battery reserve
Access to Potable Water and Sanitary Services	None
Safety Precautions for	No Systems in the design are subject to severe damage by sudden power loss.

(Click on image to access the Resiliency Summary)

Appendix J. Resident Health Impact Summary

Indicator	Location	Intervention	
		Design Solution	Maintenance Plan
Mold	Units - Kitchens	Continuous Ventilation using ERV	Change filters regularly
	Units - Bathrooms	Continuous Ventilation using ERV	Change filters regularly
	Units - Windows and Exterior Doors	Continuous Ventilation using ERV	Change filters regularly
	Units - Mechanical Rooms	Continuous Ventilation using ERV	Change filters regularly
	Common Areas - Windows and Exterior Doors	Laundry is only common area.	Staff regularly cleans
	Common Areas - Mechanical Rooms		
	Below Grade	N/A	
Pests	Units	Effective air sealing will limit infiltration opprtunities	
	Common Areas		
	Below Grade	N/A	
	Exterior		
VOCs (enter level of VOCs in products: conventional, low- or no- VOC)	Units - Paints	Low-Voc	
	Units - Coatings	Low-Voc	
	Units - Primers	Low-Voc	
	Units - Adhesives and Sealants	Low-Voc	
	Units - Flooring Materials	Low-Voc	
	Common Areas - Paints	Low-Voc	
	Common Areas - Coatings	Low-Voc	
	Common Areas - Primers	Low-Voc	
	Common Areas - Adhesives and Sealants	Low-Voc	
	Common Areas - Flooring Materials	Low-Voc	
Other Contaminants	Units		
	Common Areas		

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

Appendix K. Overall Rehab Proposal

NYSERDA RetrofitNY
Overall Rehab
Proposal

Martin Luther King – Building #10

(Click on image to access the Overall Rehab Proposal)

Appendix L. RetrofitNY Energy Simulation Report


RetrofitNY High-Performance Retrofit Solutions Design

Energy Simulation Report - Draft

August 1, 2018

Prepared by:

STAENGL ENGINEERING

DRAFT

(Click on image to access the RetrofitNY Energy Simulation Report)

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

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New York State Energy Research and Development Authority

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