NYSERDA Market Development Case Study:

Buildings of Excellence

Draft

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NYSERDA Case Study: Buildings of Excellence

Key Results

- Avoided Energy Use. The featured awardee designs have an average of 62% reduction in gross site Energy Use Intensity (EUI) and 100% reduction in net site EUI against their baselines.
- Greenhouse Gas Emissions Avoided. The featured awardee designs have 94% fewer greenhouse gas emissions compared to their baseline designs on average, with decreasing emissions expected as the electric grid gets cleaner.
- Criteria Emissions Avoided. The featured awardee designs reduce annual Nitrogen Oxides (NO_x) emissions by 100% and Sulfur Dioxide (SO_2) by 94% compared to their baseline designs.
- Reduced Embodied Carbon. One featured awardee that made quantifiable efforts to reduce embodied carbon (Solara) was able to lower building envelope embodied carbon by 65% compared to a previous project phase using lessons learned through the multiphase project.
- Improved Thermal Comfort and Indoor Air Quality (AIQ). Designed using Passive House principles with high-performance envelopes and passive solar features, the featured awardees have enhanced thermal comfort throughout the year compared to a code-compliant building. The lack of natural gas use and presence of efficient ventilation systems will create healthier IAQ for the occupants.
- Minimizing First Costs and Return on Investment. The average incremental cost for the featured awardees is $22/ft^2 without incentives and $3/ft^2 with incentives, which represent an 11% and 2% cost premium, respectively. With incentives, the average payback period for the featured awardees is 5.5 years, although the range is wide, and some paybacks are instantaneous.
- Utility Cost Savings. The featured awardee designs result in average annual energy cost savings of $848 per occupant compared to their baseline designs.
- Resiliency. The Passive House designs and general focus on resiliency will increase all the buildings' ability to maintain critical infrastructure and interior livability during extreme events, as well as enhanced everyday performance in a changing climate.
- Replicability. Replicability is addressed in various ways, such as using common building materials and construction techniques, incorporating prefabricated materials, using standard unit designs, and limiting the variation of project exteriors.

1 Introduction

Buildings of Excellence (BOE) is NYSERDA's $58M[1] design competition that recognizes and rewards the design, construction, and operation of design, construction, and operation of clean, resilient, and carbon neutral-ready multifamily buildings that are healthier and more comfortable than conventional construction. The competition funds projects that reduce their energy consumption and per capita carbon emissions and result in positive investments for building owners while improving occupant safety, health, and comfort.

As part of New York State's effort to achieve its carbon-neutral goals, NYSERDA initiated the BOE Design Competition in early 2019. In the 2022 State of the State address, Governor Hochul announced a plan to achieve a minimum of Two Million Climate Friendly Households by 2030, consisting of 1 million

[1] This budget is current as of July 2023 and includes Rounds 1-4. This case study focuses on the first two rounds, which had a $40M budget.

electrified households and up to 1 million electrification-ready households.[2] The 2023 State of the State called for zero-emission new construction, with no on-site fossil fuel combustion (by 2025 for smaller buildings and by 2028 for larger buildings) and a phase out of the sale of new fossil fuel heating equipment.[3]

Under the BOE competition, new buildings and retrofits are eligible for up to $1M to demonstrate beautiful and profitable carbon-neutral buildings that will lead the clean energy transition in New York State. In the first two rounds of the competition there were 42 awardees: 28 in Round 1 and 14 in Round 2.[4] As of July 2023, 14 Round 1 and 2 BOE projects are complete, three more will be complete by the end of the year, and 11 are under construction or in the late design phase. Round 3 of the competition awarded projects in March 2023 and Round 4 is in progress as of this writing.

This case study, featuring four BOE projects, documents the range of benefits of carbon-neutral construction and demonstrates that incremental costs of these designs can be realized at less than a five percent cost premium, while supporting attractive building design. The expected long-term energy and non-energy performance benefits of integrated design, carbon-neutral building practices, and advanced technologies are also documented.

Featured Awardee Selection

This case study focused on several key themes in the four featured projects:

- Workforce development
- low-to-moderate income (LMI) housing and disadvantaged communities (DAC)
- Return on investment and business case
- Adaptive reuse

In consultation with NYSERDA staff, IEc selected four BOE awardees for "deep dive" analysis to cover these themes. The selected projects exemplify key benefits and outcomes of the BOE awardees and had sufficient qualitative and quantitative data available. A summary of the available data can be found in Appendix C: Data Sources.

The four featured projects are:

- West Side Homes – People United for Sustainable Housing, Inc (PUSH Buffalo) is developing the West Side Homes project in Buffalo, which includes 52 units of infill (building on a vacant lot within an established neighborhood) low-to-moderate income (LMI) rental housing built with high-performance ground source heat pumps and passive survivability features. The project team is simultaneously developing a Net-Zero Sustainable Workforce Training Center to train and place workers within the renewable energy sector. The trainings will be offered to low-income

[2] NYSERDA. 2022. "Governor Hochul Announces Plan to Achieve 2 Million Climate-Friendly Homes by 2030." https://www.governor.ny.gov/news/governor-hochul-announces-plan-achieve-2-million-climate-friendly-homes-2030

[3] NYSERDA. 2023. "Governor Hochul Announces Transformative Investments in Energy Affordability, Building Efficiency, and Clean Air and Water." https://www.nyserda.ny.gov/About/Newsroom/2023-Announcements/2023-1-10-Governor-Hochul-Announces-Transformative-Investments-in-Energy-Affordability

[4] BOE Rounds 3 and 4 launched in Q2 2022 and Q3 2023, respectively. The data is this case study focuses on Rounds 1 and 2. There were 14 awardees in Round 3; Round 4 submissions are still under review as of July 2023.

residents, particularly within marginalized communities of color, who are currently under-employed or unemployed.

- Solara Phase II and III – The Solara Apartment Complex is a three-phase development project in Rotterdam of which phases II and III received BOE awards. This project serves as an example of how to design and construct cost-effective net zero energy (NZE) market rate multifamily housing. As a multiphase project, Solara exemplifies how improvements to construction details and building performance can be made between phases. Phase III incorporates material and technological changes to dramatically reduce the embodied carbon compared to Phase II.
- Colonial II – This is an adaptive reuse project in Rome that rehabilitate a facility that has housed low-income senior citizens and adult disabled residents since 1972. The project demonstrates the economic viability and replicability of adaptive reuse projects, specifically existing multifamily building retrofits that integrate advanced clean energy technologies and strategies to optimize health, resiliency, and energy efficiency, while preserving and expanding affordable housing opportunities in New York State.
- Engine 16 – This is an adaptive reuse project that renovates the former Metropolitan Steam Fire Engine Company No. 16 building in Manhattan's Kips Bay neighborhood to a market rate Passive House certified residential building with community spaces on the ground floor. The project emphasizes the building's historic character while providing energy efficient systems for a carbon-neutral urban building.

Key featured awardee information is shown in Table 1. More detailed descriptions can be found in Appendix B: Featured Awardee Descriptions.

Table 1. Buildings of Excellence Featured Awardees

Project Name	Project Theme	Const. Start	Const. End	# Units	# Stories
West Side Homes/Sustainable Workforce Training Center	**Workforce Development/LMI Housing/DAC**	Spring 2022	04/2023	15	3
Solara Phase II+III	**Return on Investment and Business Case**	2018	II: 03/2021 III: 11/2022	248	3
Colonial II Apartments Revitalization	**Adaptive Reuse**	06/2022	11/2023	74	7
Engine 16	**Adaptive Reuse**	01/2021	07/2022	4	5

Awardee Goals and Motivations

All of the BOE buildings are state-of-the-art and high-performance, but each project has a different set of motivations driving the development. For example, some project teams focused on enhancing the lives of the residents while providing affordable housing opportunities whereas others prioritized ease of replicability, minimizing the project's carbon footprint, and designing equally for beauty and performance.

The West Side Homes project focused on creating infill housing to serve as models for resilient and affordable housing elsewhere in the state and country. This project provides safe, healthy, and comfortable housing that enhances the lives of underserved populations in Buffalo's West Side neighborhood. It aligns with PUSH Buffalo's organizational mission to create sustainable housing, community facilities, and living wage jobs for Buffalo's West Side residents.

For the Solara projects, the team had previously worked together to design and construct New York's first ever net zero multifamily development called netZero Village, which was completed in 2016 and located in Rotterdam, NY. The design focused on making net zero buildings possible with common cost-effective construction materials to eliminate the stigma that net zero could not be achieved cost-effectively with familiar technologies. With the success of netZero Village, the team set out to replicate this design but at a larger scale with the Solara Apartment Complex. The Solara Apartment Complex is a model for the net zero energy multifamily housing industry, inspiring other clean energy and green development projects. The development and design team is committed to educating other building professionals about high performance projects. The team's mission is to continuously improve energy efficiency and occupant comfort with each new project through advanced design strategies and technologies. Building upon the achievements and efficiencies of Solara Phase I and II, Phase III emphasized embodied carbon reduction, incorporating New York's Climate Leadership and Community Protection Act (CLCPA) guidelines.

The Colonial II team aimed to demonstrate the viability and replicability of the economic and environmental benefits of multifamily retrofits that integrate advanced clean energy technologies and strategies to optimize health, resiliency, and energy efficiency, while preserving and expanding affordable housing opportunities in New York State. As an existing affordable housing building in need of renovations, the team wanted to enhance the lives of residents while minimizing disruptions to the residents living in the building. The team believes that the Colonial II project can act as a framework for similar low-income residential buildings in need of repair throughout the state. By placing a strong emphasis on green aspects of the building and highlighting the project's energy efficiency, the team hopes to inspire other developers to take on similarly efficient projects.

The Engine 16 team focused on creating a replicable process for adaptive reuse projects and educating others on resilient, energy efficient building strategies. A primary goal was to create solutions for rehabilitating and increasing the efficiency of existing buildings without sacrificing their historic character and design quality. As there are many buildings of a similar scale already in existence in NYC, Engine 16 could become an exemplary project to share a systematic approach to passive retrofits. By producing an efficient and aesthetically pleasing mixed-use historic renovation using Passive House methods, the project team can further promote the benefits of passive construction for tenants, the community, and the planet. Additionally, the team hopes to promote and foster a culture of beautiful, environmentally responsible building practices and socially conscious living. The team targeted no incremental initial cost and reduced operating costs for the lifetime of the building.

2 Benefits of Buildings of Excellence

Table 2 summarizes the benefits and beneficiaries explored in this case study.

Table 2. Buildings of Excellence Benefits

Category	General Benefit	Who Benefits
Environmental	**Avoided energy use**	Homeowner/occupant, society
	GHG emissions avoided	Society
	Criteria emissions avoided	Society
	Reduced embodied carbon	Society

Category	General Benefit	Who Benefits
	Reduced construction waste	Society
Comfort	Improved thermal comfort (temperature, humidity)	Occupant
Health	Improved IAQ and health	Occupant
Economic	Utility cost savings	Owner and/or occupant
	Minimizing first cost	Developer and/or owner
	Cost-effectiveness	Developer and/or owner
Economic/risk reduction	Fault detection / improved quality of service	Owner and/or occupant
Resiliency	Passive survivability	Occupant
Replicability	Replication with others inspired by demonstration project	Society
	Replication with parties directly involved in demonstration project	Developer

The following sections include a summary of the analytical results, an explanation of methods, and a discussion of findings. Design teams reported the qualitative data in their applications, and the IEc team later confirmed this information through interviews for the featured awardees. Applications and energy models submitted by the project teams provided quantitative data. A detailed description of the available data is included in Appendix C: Data Sources.

The majority of this report focuses on project level information for the featured awardees. However, since a rich data set was available for energy, emissions, and cost, the report also includes quantitative data from all of the Round 1 and 2 awardees. For more findings surrounding the larger population of Buildings of Excellence projects, see Appendix A: Buildings of Excellence Awardee Characterization.

Environmental Benefits

The four projects included in this case study were evaluated to identify the environmental benefits associated with their carbon-neutral design and build. The following sections discuss how the projects performed in terms of achieving reductions in site energy use, greenhouse gas and other emissions, and embodied carbon and construction waste.

Avoided Energy Use

To compare building performance across certification paths, this report generally uses site energy use intensity (EUI)—total site energy per year divided by square footage—normalized by gross building area. Appendix D: Energy Use Intensity Determination describes the EUI calculation methodology.

Appendix A: Summary of Buildings of Excellence Awardees, lists all 42 Round 1 and 2 awardees, and indicates their associated categorizations, including building height, and their EUI. Figure 2 shows the EUI performance for the featured awardees. Figure 3 shows that compared to a sample population from Fannie Mae of similar typical construction across the state, which has an average EUI of 81 kBtu/ft^2, the average energy demand of the BOE awardees is much lower.[5]

[5] Fannie Mae. 2012. "Energy and Water Use Survey Database". https://multifamily.fanniemae.com/media/document/xlsx/fannie-mae-energy-and-water-survey-database.

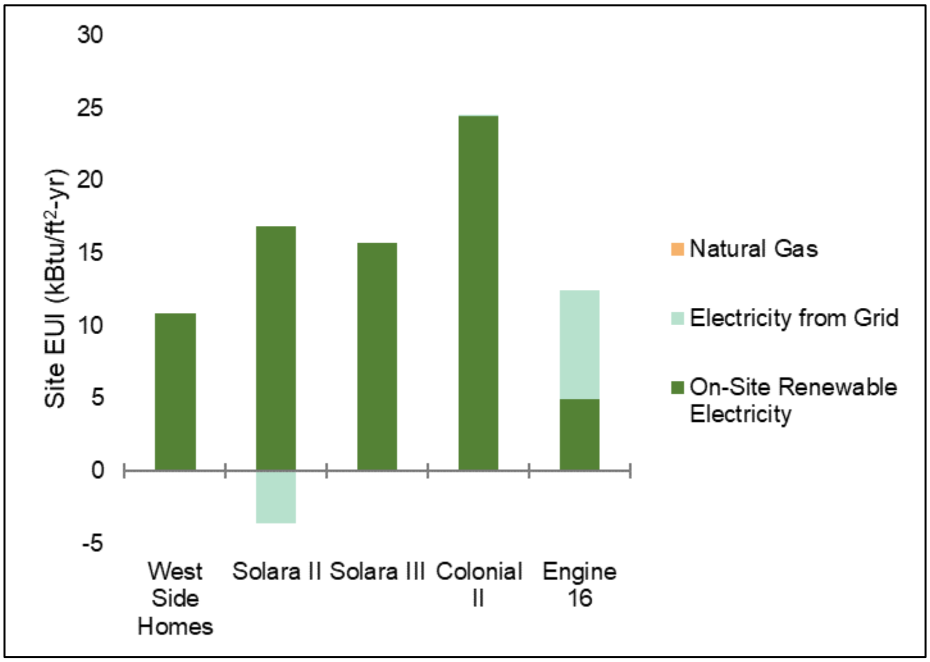

Figure 1: Featured Awardees Site Energy Use Intensity Summary by Fuel Source

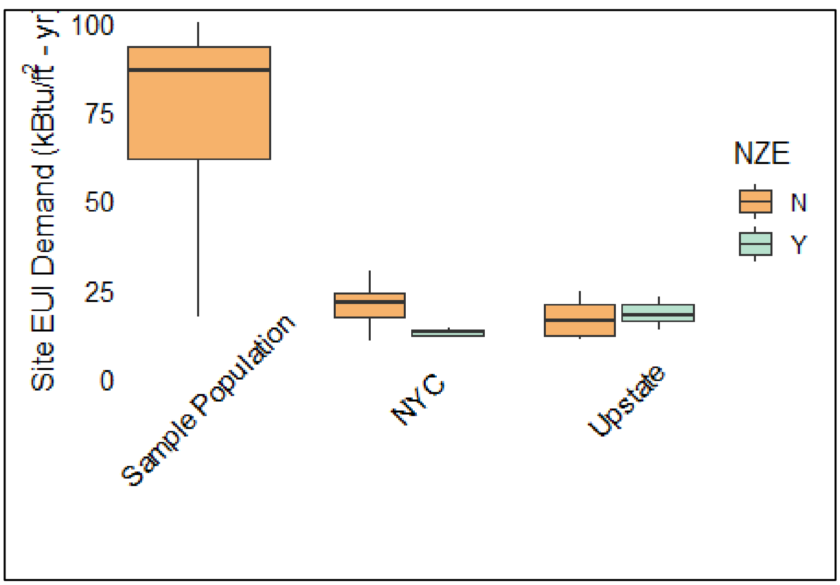

Figure 2. BOE Site Energy Use Intensity Compared to Typical Construction for 42 Round 1 and 2 Awardees

Across all categories, end uses that are not regulated by the energy code—such as appliances, plug loads, etc.—are a substantial portion of the total EUI. In general, high-rise buildings require more energy for domestic hot water (DHW), NYC buildings require more energy for cooling, and upstate buildings require more energy for heating. Figure 5 shows the EUIs by end use for the featured awardees.

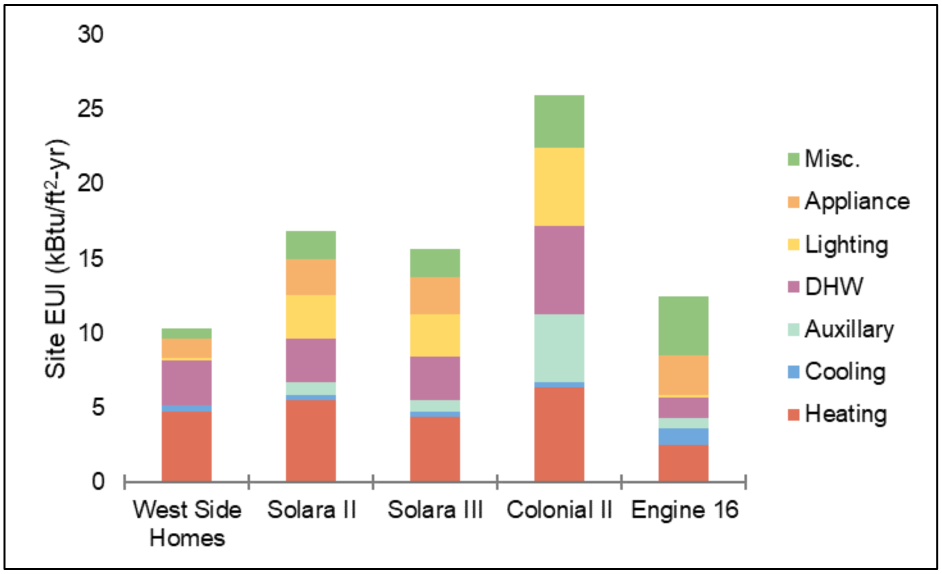

Figure 3: Featured Awardees Site Energy Use Intensity Summary by End Use

Table 3 shows the individual energy results for the featured awardees.[6] The baselines for each project were determined using the methodology shown in Appendix E: Project Baseline Determination.

Table 3. Avoided Energy Summary EUI (kBtu/ft^2-year)

Project	Baseline			Proposed Design			% Savings		
	Electricity	Nat. Gas	Net	Electricity (% Renewable)	Nat. Gas	Net	Electricity	Nat. Gas	Net
West Side Homes	16.8	32.7	49.5	10.8 (100%)	0.0	0.0	35%	100%	100%
Solara II	28.6	0.0	28.6	16.9 (121%)	0.0	-3.6	41%	-	113%
Solara III	28.6	0.0	28.6	15.7 (101%)	0.0	-0.1	45%	-	100%
Colonial II	16.0	62.8	78.8	24.5 (100%)	0.0	0.0	-53%	100%	100%
Engine 16	16.8	32.7	49.5	12.4 (39%)	0.0	7.5	26%	100%	85%

All of the featured case study awardees are all-electric and four have onsite renewables that fully offset the annual electricity demand. While Colonial II shows an increase in electricity EUI over the baseline, this is a remnant of comparing an all-electric design to a mixed fuel baseline, which is specified by the ASHRAE 90.1 standard. When natural gas and electricity are combined, Colonial II does result in overall EUI savings.

Solara II was designed to export additional electricity to the grid from onsite photovoltaics (PV), resulting in a negative EUI. In contrast, Solara III selected a smaller onsite PV system to reduce costs but invested

[6] Solara II and III are different phases of a multiphase project and thus are sometimes grouped together or shown separately depending on the data available.

in envelope improvements to lower demand. Detailed energy information for each awardee is available in Appendix F: Detailed Energy Information by Project.

GHG Emissions Avoided

Figure 7 shows the GHGI of the featured awardees. As noted above, all five sites are all-electric. See Appendix A: Buildings of Excellence Awardee Characterization for GHG intensity by BOE grouping and fuel source for all Round 1 and 2 Awardees.

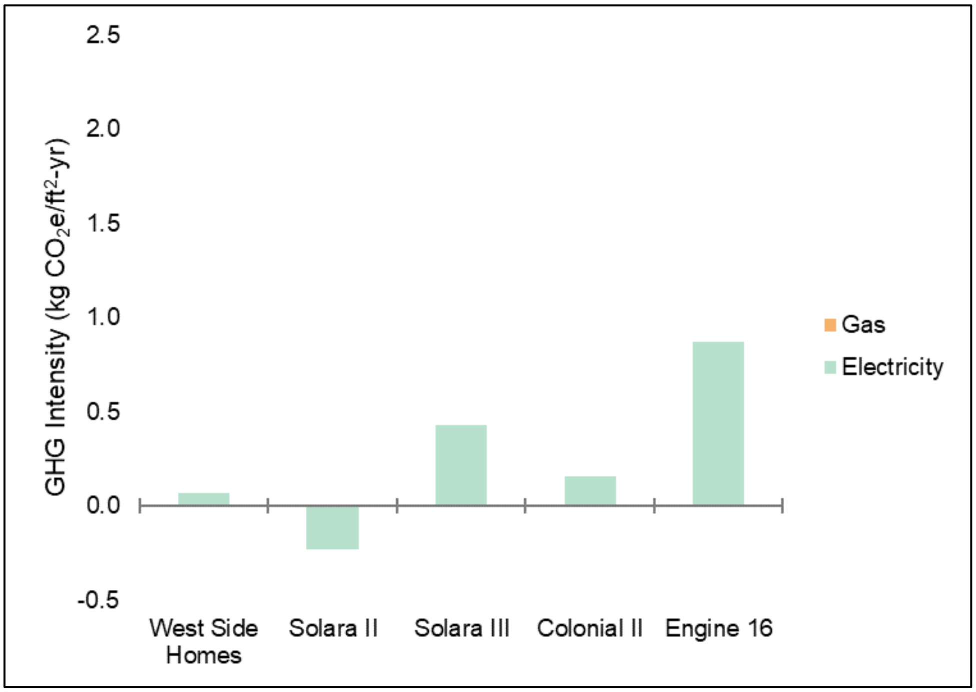

Figure 4: Featured Awardees GHG Intensity by Fuel Source

The GHGIs of the featured awardees are 0.9 kg CO_2e/ft^2-year or less, which is substantially less than their respective project baselines. Table 4 shows the detailed GHG results from the featured awardees in terms of annual tonnes of CO_2 and Table 5 shows the GHGI.

Onsite renewables and all-electric design have the biggest impact on GHG emissions for the featured awardees. Over time, the electric grid is projected to have fewer emissions, so the annual GHGI will decrease throughout the lifetime of these all-electric buildings. Appendix G: Detailed GHG Information by Project has more information about the methodology used and individual project results.

Onsite renewables and all-electric design have the biggest impact on GHG emissions for the featured awardees.

Table 4. Avoided Greenhouse Gas Emissions Summary (tonne CO_2e/year)

Project	Baseline			Proposed Design			Percent Savings		
	Electricity	Nat. Gas	Total	Electricity	Nat. Gas	Total	Electricity	Nat. Gas	Total
West Side Homes	42.5	80.6	123	1.8	0.0	1.8	96%	100%	99%
Solara II	260	0.0	260	-21.6	0.0	-21.6	108%	-	108%
Solara III	260	0.0	260	40.0	0.0	40.0	85%	-	85%
Colonial II	105	399	504	10.5	0.0	10.5	90%	100%	98%
Engine 16	25.3	41.0	66.4	11.5	0.0	11.5	55%	100%	83%

Table 5. Greenhouse Gas Emissions Intensity Summary (kg CO_2e/ft^2-year)

Project	Baseline			Proposed Design		
	Electricity	Nat. Gas	Total	Electricity	Nat. Gas	Total
West Side Homes	1.6	3.1	4.8	0.1	0.0	0.1
Solara II	2.8	0.0	2.8	-0.2	0.0	-0.2
Solara III	2.8	0.0	2.8	0.4	0.0	0.4
Colonial II	1.6	6.0	7.6	0.2	0.0	0.2
Engine 16	1.2	1.7	2.9	0.9	0.0	0.9

Criteria Emissions Avoided

Table 6 summarizes the annual avoided NO_x and SO_2 emissions for the featured awardees. From a tenant health perspective, the onsite emissions avoided are the most important, as they would be more concentrated within the building, but all criteria emissions are important from a societal perspective. Tenant health is covered in the Health Benefits section of the report.

Table 6. Avoided Criteria Emissions Summary (kg/year)

Project Name	Emissions Avoided on Site		Grid Emissions Avoided	
	NOx	SO_2	NOx	SO_2
West Side Homes	34.9	0.2	8.6	2.3
Solara II	0.0	0.0	59.3	15.8
Solara III	0.0	0.0	52.8	14.1
Colonial II	172.7	1.1	21.2	5.7
Engine 16	17.8	0.1	2.4	0.6

Reduced Embodied Carbon

The most common embodied carbon reduction strategies were careful material selection during design, specifying refrigerants with lower greenhouse gas emissions or lower global warming potential (GWP), and using a carbon calculation tool to evaluate embodied carbon more accurately rather than making general assumptions. Table 7 shows the strategies used to reduce the embodied carbon emissions for the featured awardees.

Table 7. Case Study Embodied Carbon Summary

	West Side Homes	Colonial II	Engine 16	Solara
Adaptive reuse		●	●	
Locally sourced materials		●	●	
Concrete mix				●
FSI certified wood	●			
Envelope assemblies (e.g. foam removal)	●			●
Reduced refrigerant GHGs	●	●	●	
Labeling systems (Red List, Declare Labeling, and Environmental Product Declarations)		●		
Tool use (e.g. Embodied Carbon in Construction Calculator tool)	●	●		●

As adaptive reuse projects, Colonial II and Engine 16 have inherently lower embodied carbon than a new construction project. This is achieved through a reduction in the carbon needed for new materials and other construction and demolition activities, such as waste transportation and disposal. The Colonial II project team also selected an air source heat pump (ASHP) with low global warming potential refrigerant, utilized local manufacturing, and measured and quantified carbon emitted during design, construction, and operation through the Skanska EC3 tool. The team further reduced embodied carbon through material specification, with materials selected for durability and low GWP using references such as the Red List,[7] Declare labeling,[8] and Environmental Product Declarations.[9]

The Engine 16 team preserved as much of the historic firehouse character as possible, focusing on salvaging the original structure and finishes. Many components were repurposed and featured throughout the building. The designers relocated railings and tin ceilings, repurposed interior wood windows as partitions, and re-planed existing plank subflooring to reinstall it as the new finished flooring.

West Side Homes and Solara Phase III focused primarily on material selection to reduce the embodied carbon in the building. For example, the West Side Homes team removed foam insulation from a portion of the building envelope and replaced it with an alternative insulation. Through lessons learned in Phases I and II, the Solara team reduced embodied carbon in Phase III. Phase III has an innovative envelope assembly that performs better and reduces the embodied carbon in the wall and foundation, while maintaining a similar cost to previous iterations. Overall, from Phase II to III, the Solara team reduced the embodied carbon in the building's envelope by 65% and increased the use of carbon sequestering materials in the project by 56%.

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[7] https://living-future.org/lbc/red-list/
[8] https://declare.living-future.org/
[9] https://www.environdec.com/home

Reduced Construction Waste

As adaptive reuse projects, Colonial II and Engine 16 already have reduced waste streams through the reuse of existing building components, but these teams also incorporated demolition material recycling.

Table 8 summarizes the construction waste reduction measures in the featured awardees. The Engine 16 team was inventive with recycling demolition materials to further reduce waste. During demolition at the Engine 16 site, the team salvaged every removed brick to either be reused on the project or donated to a local brickyard. Other building fixtures such as sinks were also donated for reuse. The West Side Homes envelope is constructed with a panelized ZIP System® R-sheathing wall, which is pre-manufactured and uses roughly 26% less wood than traditional framing techniques. Panelized construction reduces the amount of energy, waste, emissions, and cost that typically arises from fabrication and construction.

Table 8. Reduced Construction Waste Summary

	West Side Homes	Colonial II	Engine 16	Solara
Recycling all non-hazardous demolition materials		●	●	
Adaptive reuse		●	●	
Prefabricated components (e.g. panelized walls)	●	●		

3 Comfort Benefits – Improved Thermal Comfort

Improved thermal comfort for building occupants involves consistently maintaining temperature and humidity within the thermal comfort range during all outdoor conditions. By pursuing high-performance and Passive House envelopes with higher insulation values and airtight construction, all the featured awardees reduced the thermal load from the exterior environment, and therefore reduced the impact that exterior temperature has on interior spaces. Airtight construction also reduces air infiltration through the building envelope, effectively eliminating uncomfortable drafts. Table 9 shows the different comfort strategies employed by the featured awardees.

Table 9. Comfort Benefits Summary

	West Side Homes	Colonial II	Engine 16	Solara
Envelope measures to improve thermal comfort	●	●	●	●
Enhanced HVAC design	●	●		
Individual HVAC controls	●	●	●	●
Temperature and/or humidity tracking	●			
Reduced draftiness	●	●	●	●

4 Health Benefits – Improved Indoor Air Quality

Designed with Passive House principles, all of the featured awardee teams incorporated enhanced ventilation into the projects, which is essential when designing an airtight envelope. While only two teams self-reported the reduced risk of mold/mildew formation, it is known that Passive House projects reduced the risk of mold /mildew formation along the exterior walls and envelope through the proper detailing and placement of vapor and air barriers in conjunction with higher levels of insulation. The complete list of strategies each awardee used for improved health and IAQ are shown in .

Designed with Passive House principles, all of the featured awardee teams incorporated enhanced ventilation into the projects, which is essential when designing an airtight envelope.

Table 10. Improved Health and IAQ Summary

	West Side Homes	Colonial II	Engine 16	Solara
EPA Indoor airPLUS certification	●			●
Low-VOC-laden finishes, adhesives, furniture	●	●	●	●
Reduced contaminants (e.g. lead, radon mitigation)		●		
No combustion	●	●	●	●
IAQ monitoring (e.g. BMS tracking temp, humidity, CO2)	●			●
Reduced risk of mold/mildew formation			●	●
Enhanced ventilation (e.g. ERV)	●	●	●	●
Enhanced filtration	●	●	●	
Compartmentalization	●	●	●	●

A key component to increasing indoor air quality is eliminating combustion equipment within conditioned spaces. All the featured awardee designs are all-electric, so there is no combustion of any kind inside the buildings. Most projects also use low- or no-volatile organic compound (VOC) materials and low- or no-formaldehyde emitting wood products.

As an adaptive reuse project, Colonial II incorporated existing contaminant removal and mitigation in the demolition and construction phases. The project team followed the New York State Homes and Community Renewal (HCR) Green Building and Energy Efficiency Practices that guides teams with indoor air quality and health strategies. All materials and finishes installed are certified for healthy indoor air quality with low or no VOCs. The project also included radon mitigation and limited lead exposure through safe work practices and removal of contaminated materials. This was especially important for this project since residents were living in the building during demolition and re-construction.

5 Economic Benefits

The BOE awardees show that resilient, carbon-neutral, passive design can be delivered for a similar price as standard buildings with ongoing health, wellness, and operational benefits. To ensure a return on investment, project teams focused on both minimizing first incremental costs and reducing ongoing operational costs.

Return on Investment

Project designers kept cost premiums small by making informed, cost-effective package tradeoffs without sacrificing performance. While most projects have an incremental cost compared to their baselines, the expected operational cost savings will offset and additional upfront costs. Key cost reducing strategies reported include:

- Integrated, experienced teams.
- Shortening learning curves.
- Simple, replicable designs using standard construction methods.
- Cost effective systems.
- Quality installation and commissioning.

Project designers kept cost premiums small by making informed, cost-effective package tradeoffs without sacrificing performance.

Projects with negative incremental costs like Solara II and Engine 16 receive an instantaneous payback. shows the results of the cost-benefit analyses for the featured awardees. None are above 20 years with incentives, which is much less than the lifetime of a building, and typically similar to or less than the lifetime of most of the mechanical equipment and PV systems.

Table 11. Cost-Benefit Analysis Summary

Project Name	Incremental Cost ($)		Annual Energy Savings ($/year)	Payback (years)	
	No Incentives	Incentives		No Incentives	Incentives
West Side Homes	$1,130,236	$623,919	$32,191	35.1	19.4
Solara II	$974,226	-$629,859	$136,133	7.2	Instant
Solara III	$2,741,139	$1,233,089	$136,133	20.1	9.1
Colonial II	$2,000,000	$690,100	$38,156	52.4	18.1
Engine 16	$0	-$203,410	$14,168	Instant	Instant

Minimizing First Cost

Project teams provided estimates and information on project costs, including total and incremental costs for the whole project and individual components, as well as anticipated incentives. Incremental costs mostly stem from a combination of additional generation, a state-of-the-art envelope, and efficient HVAC technology and appliances.

Incremental costs mostly stem from a combination of additional generation, a state-of-the-art envelope, and efficient HVAC technology and appliances.

Building envelope costs are substantial for most of the featured awardees. Project designers' emphasis on building resilience and ensuring low energy costs for tenants were key factors driving envelope costs. High efficiency HVAC, lighting, and controls equipment have a slight cost premium but also provide energy savings over time. Interestingly, DHW is not a reported driver of incremental cost in any projects, even those with all-electric designs. DHW remains a technical challenge in the electrification of high-rise buildings, but the BOE awardees demonstrate that it is feasible.

The low-rise and NZE projects have higher incremental renewable generation costs per square foot because enough PV has been included to offset the demand, whereas the baseline case does not include any renewable generation.

Table 12 shows the summary of project costs (with and without incentives) for the featured awardees, along with the comparison to the baseline costs. Across all awardees, West Side Homes has the highest incremental cost: 12% increase over the baseline. This is primarily due to the inclusion of an envelope that performs much better than the code compliant baseline and accounts for a $16/ft^2 incremental cost before incentives. Solara II has a less expensive design cost compared to baseline after incentives. Comparatively Solara III's 3% incremental cost from baseline is driven by the project's $11/ft^2 in non-energy benefit costs related to embodied carbon improvements. Additional information on incremental costs is shown in Appendix H: Detailed Cost Information By Project.

Table 12. Project Cost Summary

Project Name	Proposed Design Cost		% Above Baseline	
	($)	($/ft^2)	w/o Incentives	w/ Incentives
West Side Homes	$6,236,624	$242	22%	12%
Solara II	$10,894,446	$157	10%	-6%
Solara III	$13,141,379	$142	17%	3%
Colonial II	$27,842,074	$419	8%	3%
Engine 16	$8,400,000	$640	0%	-2%

Utility Cost Savings

Each BOE project team reported predicted annual energy costs based on the modeled annual energy use and the assumed utility rates for the building that were submitted as part of project teams' proposals and updated as required by the competition agreement. Energy costs can be normalized in a few different ways; the IEc team normalized energy costs by total building floor area and by the estimated number of occupants for this study.[10] Table 13 shows the annual energy cost savings of each featured awardee.[11]

LMI projects have higher energy costs by building area compared to market rate projects but have lower costs by occupant. This suggests that the market rate projects have more space per occupant, but occupants in LMI may have lower utility costs, depending on the billing structure. Nine of the 34 LMI projects awarded in Round 1 and 2 have all-in rental models, meaning utilities are fully paid by the owner, and nearly all of the projects have some energy costs covered by the owner, so the average tenant-paid energy cost per occupant is even lower than the value shown. Solara II and III energy costs are assumed to be fully offset by renewable generation.

West Side Homes and Colonial II, which are both LMI projects, have all-in rental models. All-in utility models provide residents with constant, predictable housing costs, which is especially important for LMI populations. They also allow the owner to accrue savings over the lifetime of the building, which incentivizes investment in energy efficiency and renewables. Alternatively, tenant-paid utilities can incentivize occupants to pay closer attention to their behavior changes that can reduce consumption. Mixed owner/tenant paid utilities allow both parties to see energy bill savings.

Solara II & III pass the cost from the efficient and low-carbon design to tenant rents by adding a fixed monthly fee above market rate: $1.80/year-ft^2 charge for offsetting any utility costs and $0.24/year-ft^2 charge for the high-performance design. While this appears to be more than the $1.47/year-ft^2 of energy cost savings previously shown in Table 11, the cost savings per residential unit floor area will be higher than the fixed monthly fee.

Table 13. Energy Cost Summary

Project Name	Baseline			Proposed Design			Savings		
	$/year	$/year-ft^2	$/year-occupant	$/year	$/year-ft^2	$/year-occupant	$/year	$/year-ft^2	$/year-occupant
West Side Homes	$33,435	$1.30	$857	$1,244	$0.05	$32	$32,191	$1.25	$825
Solara II	$136,133	$1.47	$1,134	$0	$0.00	$0	$136,133	$1.47	$1,134
Solara III	$136,133	$1.47	$732	$0	$0.00	$0	$136,133	$1.47	$732
Colonial II	$45,538	$0.68	$308	$7,382	$0.11	$50	$38,156	$0.57	$258
Engine 16	$31,117	$2.37	$2,829	$16,949	$1.29	$1,541	$14,168	$1.08	$1,288

[10] The IEc team estimated occupancy as a function of the number of bedrooms in each unit, which may not reflect the actual number of occupants at any given time.

[11] Where baseline energy costs were not provided, the study assumes an average residential rate for the region based on New York natural gas utility rate schedules and average electric rates by region from EIA and multiplies the rate by the baseline energy consumption for an annual energy cost. As applicable (may be different for MF), NYSERDA's website does have electric data for NYS at the state level: https://www.nyserda.ny.gov/Researchers-and-Policymakers/Energy-Prices/Electricity

6 Risk Reduction Benefits

In addition to environmental benefits and managing building costs, the four projects were also reviewed for fault detection, as ensuring building systems are performing properly is key to maintaining the benefits of their design.

Fault Detection & Improved Quality of Service

All featured awardees reported having some strategy for fault detection, allowing for more timely maintenance with the goal of preventing issues from becoming more severe. All of the featured awardees included some form of building management system (BMS) monitoring or alarms to ensure the building operates as designed. These BMS systems are coupled with energy use monitoring devices to provide feedback to residents regarding their energy usage. Table 14 shows the summary of risk reduction strategies.

As an example, Colonial II will use Base BMS and Wegowise Utility Tracking Software to ensure continued energy efficiency and early detection of any leaks or building system issues and to provide analysis and oversight for building operations. The BMS will track energy use, while water use will be tracked through utility bill review. The team also has the opportunity to compare Colonial II with its sister building (a similar building adjacent to Colonial II completed prior to the BOE competition) to compare energy use data at the two sites. The Colonial II development team will create resident training and informational handouts, providing tenants with explanations of the building's upgraded systems, sustainability goals, tenant behavior requirements, and related maintenance tasks. The team hopes this will ensure the proper use and care of the building systems and equipment in conjunction with the incorporated monitoring systems.

Table 14. Risk Reduction Strategy Summary

	West Side Homes	Colonial II	Engine 16	Solara
Leak detection		•		
Monitoring of HVAC and other system malfunctioning		•	•	•
Monitoring of general overuse of energy and/or water (e.g. behavior change potential)	•	•	•	•

7 Resiliency Benefits

Resiliency is a key focus of the BOE competition. **Table 15** summarizes the wide array of resilience considerations covered by the project teams.

With climate change, extreme weather events are expected to happen more frequently, requiring preparation for increased strain of the power grid in both winter and summer. In general, passive and carbon-neutral design, resiliency, and passive survivability are naturally aligned through tight, durable

Passive and carbon-neutral design, resiliency, and passive survivability are naturally aligned through tight, durable envelopes.

envelopes, which are included in all featured awardees. In extreme weather events or extended grid outages, high-performance envelopes minimize indoor temperature swings to maintain safe interior temperatures. During normal operation, the enhanced envelope design paired with high-performance HVAC systems provides occupants with enhanced thermal comfort and IAQ.

Table 15. Resiliency Summary

	West Side Homes	Colonial II	Engine 16	Solara
Passive survivability / Ability for building to maintain temperatures during power outages (e.g., envelope tightness, passive solar design)	●	●	●	●
Emergency generation		●		
Battery			●	
Critical equipment support (e.g., surge suppression, UPS)		●	●	●
Maintaining access to potable water during outages	●	●		●
Reduced mold risk	●	●	●	●
Pest management		●		
Storm water management	●			●
Urban heat island reduction (e.g., low albedo roof)			●	●
Critical systems above flood plain	N/A	●	N/A	N/A
Food security	●			

The increased potential for heavy precipitation during storms comes with increased risk of flooding. West Side Homes includes rain gardens and underground detention systems to manage stormwater on site and prevent overflows, while Colonial II is sited entirely outside of the 500-year floodplain. To be resilient, projects also need to consider how buildings will service critical infrastructure during power surges and outages. The Solara projects have an uninterruptible power supply to critical infrastructure such as elevators and internet networks. Engine 16 has a battery storage system that can be used in an outage and Colonial II has an emergency dual-fuel generator. Another resiliency strategy found in some of the 42 Round 1 and 2 BOE awardees was designing wind protection. However, the four featured awardees did not specifically note this as an included strategy. Detailed descriptions of resiliency features for each of the featured awardees are also included in Appendix I: Detailed Resilience Information By Project.

8 Replicability Benefits

NYSERDA demonstration programs like Buildings of Excellence, serve as a tool to show the wider marketplace the feasibility and benefits of high performance building projects. The four case study projects were reviewed to identify the ways in which they contribute to this goal.

Replication with Parties Directly Involved in Demonstration Project

As part of the proposal process, project teams described the project's viability and replicability, as demonstrated by expected ease or efficiency of construction, economic viability for the market served, unique financing solutions, or other factors that would make the project a model for future projects. Replicability is addressed in several different ways including using common building materials and construction techniques, including prefabricated materials, using standard unit designs, and limiting the variation of project exteriors, and is shown in Table 16.

Table 16. Replicable Strategies with Parties Directly Involved in Demonstration Project Summary

	West Side Homes	Colonial II	Engine 16	Solara
Constructability: Using common building materials and construction techniques (e.g. prefabricated materials, standard unit designs)	•	•		•
Economics: Cost reductions (e.g. efficient pipe runs, right-sized equipment, design tradeoffs, lower operating costs), utility models / leasing structure	•	•	•	•
Planning / approach: Experienced team, integrated design	•	•	•	•
Multiphase: Team working on multiple phases or projects demonstrating iterative improvements	•	•	•	•

In the West Side Homes project, the team incorporated modern and simple details to reduce labor costs related to more intricate designs. They also selected materials and systems that are readily available in the marketplace to increase ease of repair and familiarity with advanced products for future projects. They implemented trades training to ensure that the project is built to the design intent and that the skills are widely available to complete similar work on future projects. During operations the project will have an energy management specialist employed by the developer, whose role will include energy management at West Side Home. This individual is critical to post occupancy operations and, will be focused on better understanding building's performance, be experienced in troubleshooting MEP system problems, and be able to learn and share best practices for future projects.

Project teams with multiple phases or projects have successfully incorporated lessons learned to make iterative improvements. Between Phase II and III of the Solara projects, the team transitioned from just focusing on operational carbon to incorporating embodied carbon reduction strategies. By simply swapping out less carbon intensive insulation materials and right sizing concrete foundations, the team successfully reduced embodied carbon from the Phase III building envelope in a way that is expected to have a 50% reduction in total carbon footprint (including operation and embodied carbon) compared to a 2020 Code Scenario.

Replication with Others Inspired by Demonstration Project

All the BOE awardees actively share information to educate and inspire others in high-performance design, as shown in Table 17. Project teams have invited guests for tours and spoken about their projects at conferences. Many project teams reported that they were aware of another project or team being inspired by their project.

Table 17. Replicability with Others Inspired by Demonstration Project Summary

	West Side Homes	Colonial II	Engine 16	Solara
Knowledge transfer: Sharing project information / education	●	●	●	●
Model: Act as a model for future projects	●	●		●

The West Side Homes team is also working on the design of a 3,000 square foot Net-Zero Sustainable Workforce Training Center. This will serve to demonstrate sustainable technologies and construction methods and provide space for their workforce development programs. These programs work to train and place workers within the renewable energy sector, matching trainees with contractors and supporting long term workforce development. The trainings will be offered to low-income residents, particularly within marginalized communities of color, who are currently under-employed or unemployed in the Buffalo area.

The Colonial II development will develop a simple online platform to provide information about the project and its significance to the area. The Engine 16 team created a replicable process for adaptive reuse projects and educates others on resilient, energy efficient building strategies. With many existing buildings of a similar scale in NYC, Engine 16 is an exemplary project that illustrates a systematic approach to passive retrofits. By producing an efficient and aesthetically pleasing mixed-use historic renovation using Passive House methods, the project team can further promote the benefits of passive construction for tenants, the community, and the planet.

The Solara development team is eager to both promote the work and educate other building professionals. They provide tours, open houses, press conferences, and local presentations. Promotional content that focuses on educating potential renters about low-carbon, net zero housing and energy efficient living is posted to the development company's website and social media pages.

Appendix A: Characterization of All Buildings of Excellence Round 1 and 2 Awardees

The following table summarizes all Round 1 and Round 2 Buildings of Excellence awardees and highlights the projects featured in this case study.

Table 18. Summary of the Round 1 and Round 2 BOE Awardees

Featured awardees are indicated in bold text.

#	Project	City	NYC / Upstate	NZE	All-Electric	# Stories	Category	Performance Path	LMI (partial or all units)	Completed (as of 12/2022)
1	Linden Boulevard	Brooklyn	NYC		✓	8	Mid	ASHRAE	✓	
2	1182 Woodycrest Development	Bronx	NYC			9	Mid	PHIUS	✓	✓
3	Bushwick Alliance	Brooklyn	NYC	✓	✓	4	Mid	PHIUS	✓	
4	Street Smart	Brooklyn	NYC		✓	4	Mid	PHI		
5	Tree of Life	Jamaica	NYC			12	High	PHIUS	✓	✓
6	Rheingold Senior Housing	Brooklyn	NYC		✓	8	Mid	ASHRAE	✓	
7	Park Haven	Bronx	NYC			10	Mid	ASHRAE	✓	✓
8	Flow Chelsea	New York	NYC			24	High	PHI		✓
9	**Solara Apartment Phase II**	**Rotterdam**	**Upstate**	✓	✓	**3**	**Low**	**PHIUS**		✓
10	Linden Grove	Brooklyn	NYC			9	Mid	PHIUS	✓	
11	2050 Grand Concourse	Bronx	NYC			13	High	ASHRAE	✓	✓
12	Creekview Apartments Phase II	Canandaigua	Upstate	✓	✓	2	Low	ERI	✓	
13	The Seventy-Six Phase 1	Albany	Upstate	✓	✓	8	Mid	PHI	✓	
14	Geneva Solar Village	Geneva	Upstate	✓	✓	3	Low	ERI	✓	
15	Sendero Verde Building A	New York	NYC			34	High	PHI	✓	
16	425 Grand Concourse	Bronx	NYC			26	High	PHIUS	✓	✓
17	75 North Seventh Street	Hudson	Upstate	✓	✓	5	Mid	PHIUS	✓	
18	St. Marks Passive House	Brooklyn	NYC	✓	✓	5	Mid	PHI		
19	North Miller Passive House	Newburgh	Upstate	✓	✓	3	Low	PHIUS	✓	✓
20	Park Avenue Green	Bronx	NYC			15	High	PHIUS	✓	✓
21	Perdita Flats	Ithaca	Upstate	✓	✓	3	Low	ERI		✓
22	515 East 86th Street	New York	NYC			22	High	PHI	✓	✓
23	La Central	Bronx	NYC		✓	13	High	PHI	✓	
24	**Engine 16**	**New York**	**NYC**		✓	**4**	**Mid**	**PHI**		✓
25	Zero Place	New Paltz	Upstate	✓	✓	4	Mid	ERI	✓	✓
26	HELP One	Brooklyn	NYC			10	Mid	ASHRAE	✓	✓
27	Village Grove	Trumansburg	Upstate	✓	✓	2	Low	PHIUS	✓	
28	Westgate Apartments	Rochester	Upstate	✓	✓	4	Mid	PHIUS	✓	
29	Bethany Terraces Senior Homes	Brooklyn	NYC	✓	✓	4	Mid	PHIUS	✓	
30	Cooper Park Commons - Building 2	Brooklyn	NYC		✓	18	High	PHI	✓	
31	**Colonial II Apartments Revitalization**	**Rome**	**Upstate**		✓	**7**	**Mid**	**ASHRAE**	✓	
32	Johnson Park Green Community Apartments (JPA VII)	Utica	Upstate		✓	3	Low	PHIUS	✓	
33	Great Oaks Mixed Use Eco-Park: Building 150	Albany	Upstate	✓	✓	5	Mid	PHIUS		
34	The Rise	Brooklyn	NYC		✓	7	Mid	PHI	✓	
35	**Solara Apartments Phase III**	**Rotterdam**	**Upstate**	✓	✓	**3**	**Low**	**ERI**		✓
36	The Seventy Six Building C	Albany	Upstate	✓	✓	7	Mid	PHIUS	✓	
37	Hudson Green/Hudson Hill	Yonkers	Upstate		✓	6	Mid	ASHRAE	✓	
38	Baird Road Apartments R2	Fairport	Upstate	✓	✓	2	Low	PHIUS	✓	
39	Dekalb Commons	Brooklyn	NYC		✓	7	Mid	PHIUS	✓	
40	Linden Boulevard Phase III BOE	Brooklyn	NYC		✓	8	Mid	ASHRAE	✓	
41	Court Square Sustainable Luxury Re-Imagined	Long Island City	NYC		✓	52	High	ASHRAE		
42	**West Side Homes**	**Buffalo**	**Upstate**		✓	**3**	**Low**	**PHIUS**	✓	

This report categorizes the 42 awardees as follows:

- Location and height
    - Upstate low-rise (n=10)
    - Upstate mid-rise (n=8)
    - NYC mid-rise (n=12)

    - NYC high-rise (n=12)
- All-electric vs. net zero energy (NZE)
    - All-electric (n=31)
    - NZE (n=17)
- Market
    - Low-to-moderate income (LMI) (n=34)
    - Market rate (n=8)

Energy Use Intensity of All Round 1 and 2 Awardees

Figure 1 shows the average site EUI by category for all 42 Round 1 and 2 awardees. In this set, low-rise buildings have lower EUIs and a higher proportion of renewable energy consumption. Natural gas is only used in some mid- and high-rise Round 1 NYC buildings; all of the buildings from Round 2 are fully electric. The average EUI demand (which does not include renewable generation) for all BOE awardees is 17.3 kBtu/ft^2-year. The average net EUI is 9.6 kBtu/ft^2-year.

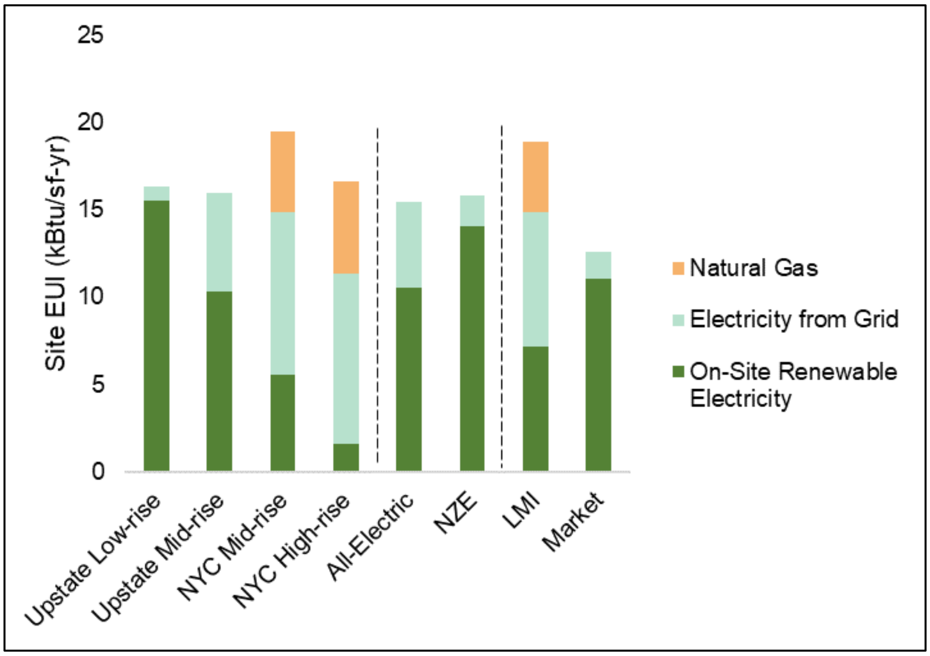

Figure 5. BOE Site Energy Use Intensity Summary by Fuel Source for 42 Round 1 and 2 Awardees

Figure 4 shows the EUIs of all 42 Round 1 and Round 2 BOE awardees by building category broken out by end use demand. These data were gathered from individual project teams and not all teams provided end use data. The report team included either self-reported data, energy modeling results, or extrapolation from end use percentages, so the EUIs differ between Figure 1 and Figure 4.

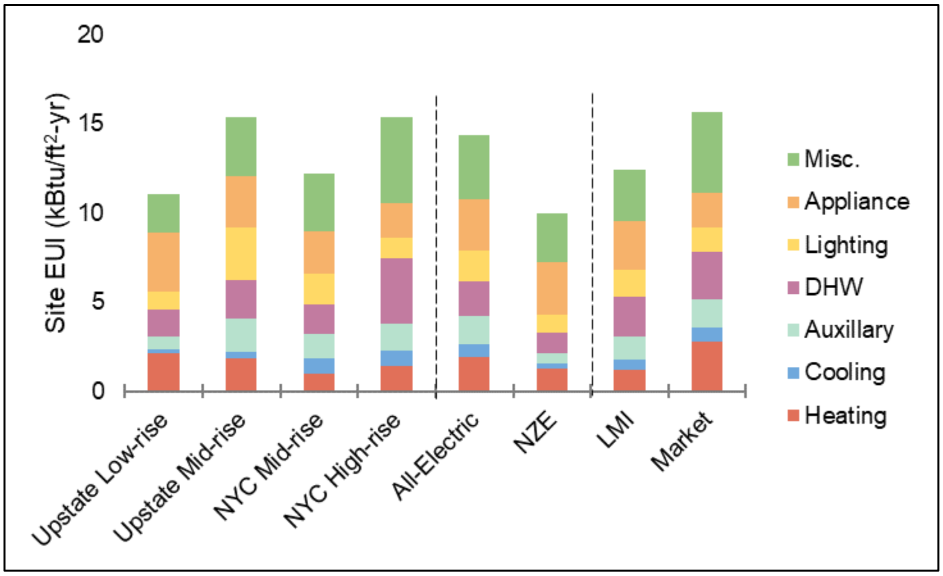

Figure 6. BOE Site Energy Use Intensity Summary by End Use for 42 Round 1 and 2 Awardees

Greenhouse Gas Intensity (GHGI) of All Round 1 and 2 Awardees

Figure 6 shows the GHG Intensity (GHGI) of each building type separated by fuel source. Upstate low-rise buildings consistently achieved carbon-neutral design using high-performance envelopes, efficient and creative mechanical system design, and onsite PV.

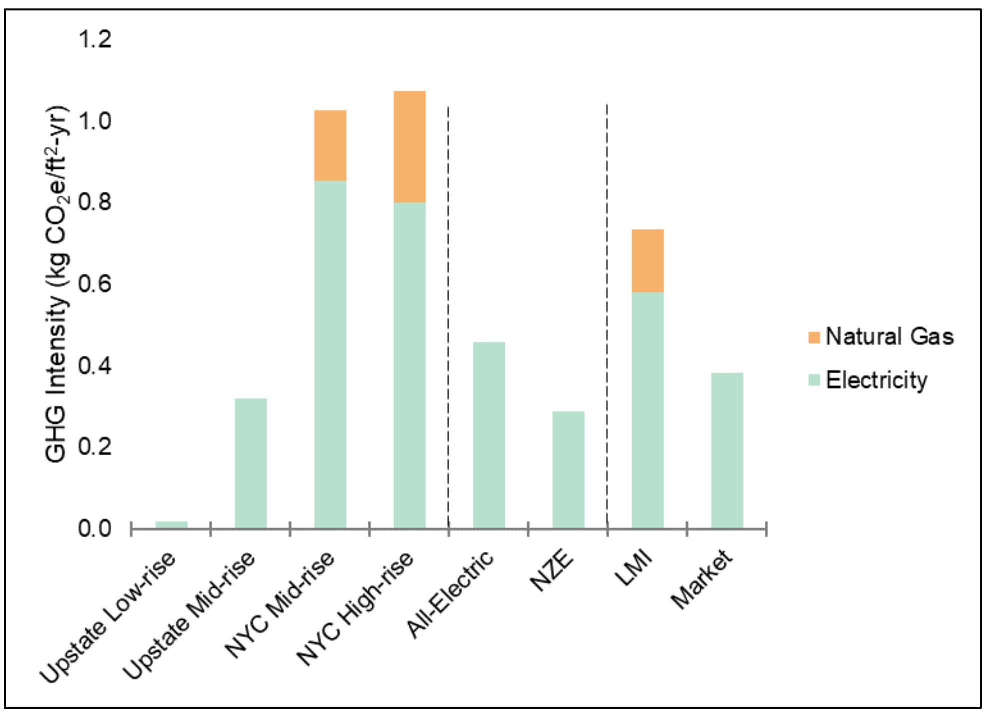

Figure 7. GHG Intensity by BOE Grouping and Fuel Source for 42 Round 1 and 2 Awardees

Figure 8 shows the breakdown of incremental costs by component for all BOE Awardees.

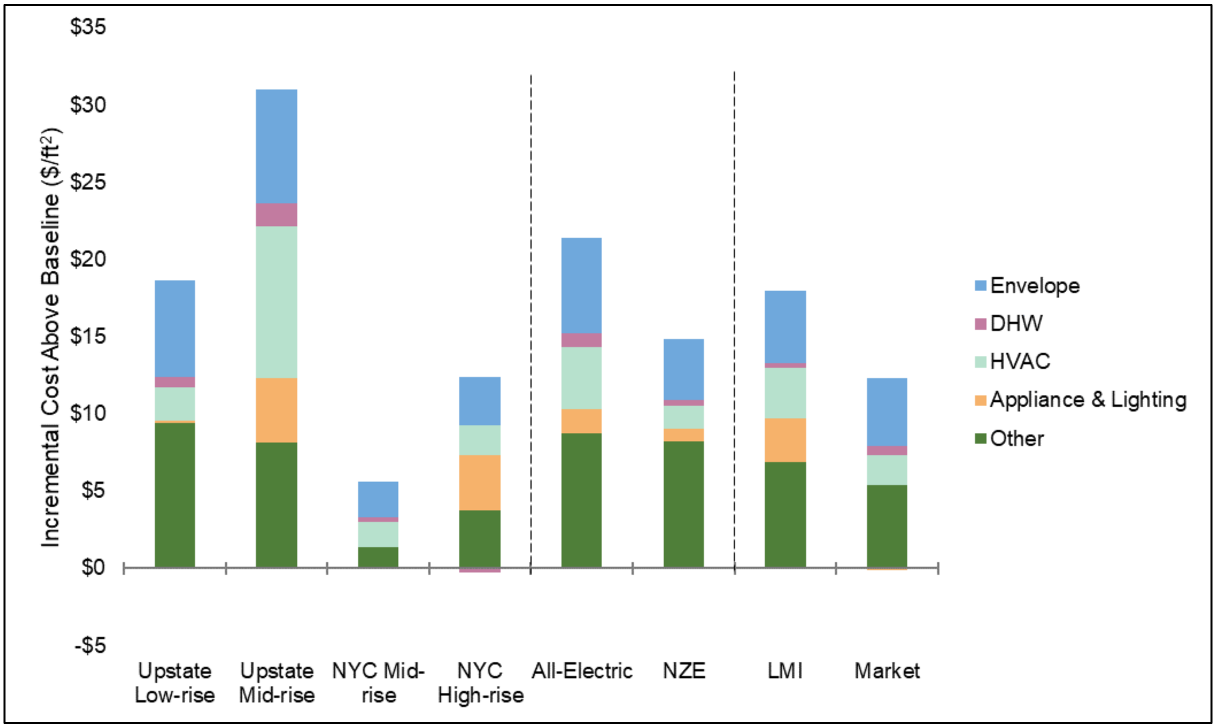

Figure 8. BOE Incremental Component Cost Summary

Incremental Costs of All Round 1 and 2 Awardees

Figure 9 shows the incremental costs for all Round 1 and 2 Awardees without and with incentives. Low-rise and NZE buildings result in negative incremental costs on average, meaning the BOE buildings are less expensive to build than the estimated baseline after factoring in incentives. On average, market rate projects also have negative incremental costs after incentives. LMI projects are still $21/ft^2 above the baseline pre-incentives and $8/ft^2 after, which indicates that the incentives are useful and likely necessary for these early adopters. However, it should be noted that the LMI buildings had higher occupant densities than the market rate projects. Market rate projects had lower total costs by area, but higher per occupant as compared to the LMI set.

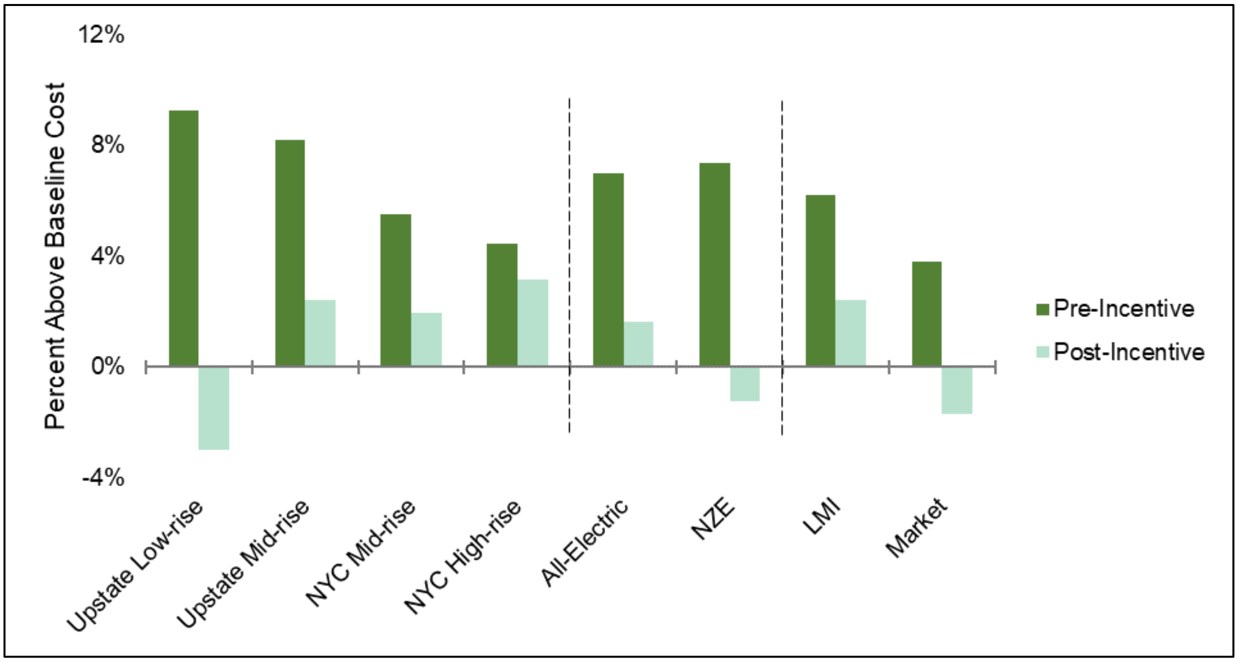

Figure 9. BOE Incremental Cost without and with Incentives Summary

Energy Costs of All Round 1 and 2 Awardees

Figure 10 shows normalized annual energy costs for both floor area and occupants for Round 1 and 2 BOE awardees. Costs in NYC are higher, due to both higher design energy use and higher utility rates as compared to upstate. NZE buildings have the lowest energy costs, around $100/year-occupant on average.

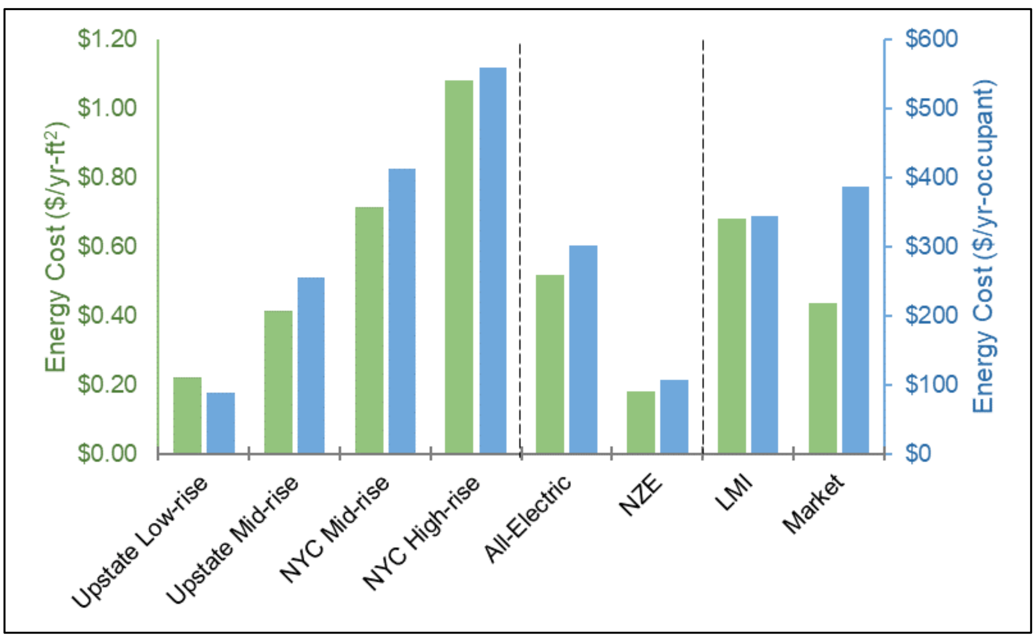

Figure 10. BOE Energy Cost Summary

Appendix B: Featured Awardee Descriptions

Workforce Development, LMI Housing, and DAC

This deep dive pairs the Round 2 PUSH Buffalo BOE awardee and the Sustainable Workforce Development Center when discussing the West Side Homes project. PUSH Buffalo is building a training center that will provide green jobs training for local low-income residents, which will help the organization continue low-income housing redevelopment in the Buffalo region.

- The Buffalo Neighborhood Stabilization Company Inc (BNSC), the housing development arm of PUSH Buffalo, is developing 52 units of housing on Buffalo's West Side that is targeting certification with Passive House Institute US (PHIUS) and pursuing the NYSERDA Low Rise New Construction Program Tier III Net Zero certification, 2020 Enterprise Green Communities, and WELL Building Certification. By coordinating housing and sustainability work, West Side Homes addresses both human and ecosystem health, while building a resilient project that addresses future heat, precipitation, and drought events, and uses renewable energy sources and avoids GHG emissions.
    - Technical attribute summary: all electric, panelized walls w/zip sheathing, polyiso & cellulose, ground source heat pump (GSHP), energy recovery ventilation (ERV), solar photovoltaic (PV), battery storage, net zero energy, electric dryers and stoves, smart buildings energy management
- BNSC is also developing a 3,000 square foot Sustainable Workforce Training Center (SWTC). This will serve to demonstrate sustainable technologies and construction methods and provide space for BNSC's workforce development programs. These programs work to train and place workers within the renewable energy sector, matching trainees with contractors and working towards long term workforce development. The trainings will be offered to low-income residents, particularly within marginalized communities of color, who are currently under employed or unemployed in the Buffalo area. The SWTC will be a net-zero facility with classrooms, offices, and meeting space that demonstrate sustainable technologies and construction methods, catalyzing PUSH Buffalo's established workforce development program in the rapidly growing clean energy and green construction trades. This will be the region's first green jobs training facility, with flexibility to expand as the field develops.

Return on Investment and Business Case

This deep dive highlights developer expertise and performance in reducing costs while simultaneously building better buildings. It covers the Solara Phase II and III projects by David Bruns Realty in Rotterdam, NY. The Solara Apartment Complex is a three-phase project that serves as an example of how to design and construct a multi-family building project with superior return on investment that achieves net zero energy (NZE) level of performance. Phases II and III of the Solar Apartment Complex received BOE awards in Round 1 and Round 2, respectively. According to the project team, Solara will be the largest market rate NZE complex in the US upon completion. The project utilized an integrated design process, involving all stakeholders early on. This integrated team worked together on netZero Village and through all three phases of Solara's development, and is now a BOE demonstration project winner for its next multifamily project, called EcoFlats at Log City. Building upon iterations of design from one project or phase to the next allows for progressive increases in efficiency and decarbonization.

- Solara Phase II: A leading example of market rate NZE housing using conventional materials and technologies. The apartments are designed to radically reduce energy use through extensive air sealing, continuous exterior insulation, air source heat pumps for heating and cooling, energy recovery ventilation, premium windows, and solar hot water. Photovoltaic solar panels will produce 100% of Solara's energy. The apartments feature attractive, "all-inclusive" living with all utilities included in the monthly rent. Solara demonstrates that market-rate green multifamily buildings are superior to conventional multifamily buildings and provide an enhanced living environment without sacrificing comfort and convenience.

  - Technical attribute summary: PV, solar thermal domestic hot water (DHW), air source heat pump (ASHP), ERV, heat pump (HP) clothes dryers, electrical vehicle (EV) charging stations, advanced controls/monitoring strategy for energy, humidity, indoor air quality (IAQ), all-in rental model
- Solara Phase III: Represents an evolution of market rate, low-carbon, net zero energy housing, using conventional materials and technologies. The design reduces embodied carbon through responsible and climate resilient material and assembly specifications such as cellulose insulation, concrete with a high percentage of fly ash, and low-carbon wallboard. The design radically reduces operational energy use through extensive air sealing, air source heat pumps for heating and cooling, energy recovery ventilation, and solar hot water. Photovoltaic solar panels offset 100% of Solara's electric use on an annual basis.
  - Technical attribute summary: all electric, ASHP, solar thermal DHW + ASHP backup, ERV, solar PV, smart buildings controls, HP clothes dryers, electric ENERGY STAR appliances, EV charging stations.

Adaptive Reuse

This deep dive illustrates that the decarbonization of adaptive reuse projects is feasible and cost-effective, while providing superior comfort and health for occupants. It focus on two BOE awardees:

- Engine 16: This adaptive reuse project rehabilitates the former Metropolitan Steam Fire Engine Company No. 16 building in Manhattan's Kips Bay neighborhood. The space will be brought back to life through a full scale, Passive House certified renovation and conversion into a four-unit multifamily residence, plus a community facility on the ground floor. Through open collaboration between the development and design teams, the general contractors, engineers, consultants, and Passive House certifiers, the Engine 16 project respects, celebrates, and extends upon the building's historical character while creating an energy efficient, carbon-neutral building. The design and development team aims to create a replicable process for adaptive reuse projects and educate others on resilient, energy efficient building strategies. The developers hope that Engine 16 can become a model for Passive House certified retrofits of existing NYC buildings by demonstrating the possibilities of energy efficiency and carbon-neutrality in a city setting.
  - Technical attribute summary: exceptional design of an adaptive re-use / gut rehab, ASHP for HVAC, ERV, HP for DHW, solar PV, induction cooktop, smart buildings controls, market-rate
- Colonial II Apartments Revitalization: The Colonial II Senior Housing facility has housed low-income senior citizens and adult disabled residents since 1972. However, the existing building façade has fallen into severe disrepair and the outdated building systems lack energy efficiency, resulting in higher and more costly energy usage than updated or newly constructed local buildings of similar size and use. The renovation of the Colonial II building will create a tighter thermal envelope, add light emitting diode (LED) light fixtures, install high efficiency equipment, and upgrade the thermostats in each apartment.

- Technical attribute summary: all electric, gut rehab, GSHP, solar PV, ERV, CO_2 HP for DHW, electric ENERGY STAR appliances.

Appendix C: Data Sources

To develop the case study, the IEc Team analyzed energy and emissions data for all of the BOE awardees. For the five featured awardees, the Team analyzed construction costs to-date and non-energy benefits. To fill data gaps and provide richer information on the awardees, the IEc Team conducted interviews across stakeholder groups (i.e., building owners, project A&E leads, and construction managers) to gather additional or updated information on other potential benefit areas identified in Exhibit 3. The budget included a maximum of four interviews per project and 20 interviews total.

Over the past few years, NYSERDA and its contractors have gathered a rich set of data on the Round 1 and 2 BOE buildings. Application packets included a project summary and proposal, renderings and diagrams, drawing set, and energy models and calculation spreadsheets. Each project submitted an "Attachment A" Excel data collection form containing the following tabs: Project Data, Building Energy Performance, Carbon-neutral, Advanced Clean Energy, Replicability, Design Quality, and Bonus Categories.

Some project teams also submitted updated information for milestone and deliverable approval on Salesforce (the availability of this data depends on the stage that each project is in and what documents have been submitted by project teams). When available, this included an updated Attachment A with post-award data. Some projects also provided:

- One-page summary of project changes, if applicable
- Construction schedule
- One-page summary of lessons learned
- Updated and/or as-built energy model files
- Photographs of project construction
- Photographs of final project

NYSERDA staff collects building cost data in a "New Construction Building Cost Data" spreadsheet, which is updated monthly and includes:

1. Total, specific (per ft^2), and component (heating, ventilation, and air-conditioning (HVAC), envelope, etc.) building costs.
2. Total and component incremental costs as compared to typical code compliant building (estimated by the design teams).
3. Incentives and tax credits.
4. Projected energy costs of the building as designed and, if available, as improved.

Performance validation data is only available for the select buildings that are already occupied, including monthly billing data and sub metered unit and equipment daily, hourly, or per minute energy data.

Appendix D: Energy Use Intensity Determination

For each building, Resource Refocus determined the site EUI (kBtu/sf-yr) for grid electricity, solar electricity, natural gas, and total energy use for gross building area. This was challenging for some awardees, as Round 1 applicants were only required to submit source energy demand while later applicants were also required to submit site energy demand; different modeling softwares use different site-to-source ratios for each fuel type along with different calculations for the floor area in the site EUI denominator, and some do not report source energy use by fuel type at all. Additionally, information in the submitted energy models often differed from information in additional data forms submitted by the project teams. The following sections describe the methodology for determining site EUI from the energy models or data attachments.

Plan A: Site Energy Reported

When available, the team first reviewed reported site energy reported in the additional data form submitted by the project teams. This was only available for Round 2 and small selection of Round 1 awardees. This was then divided by the gross floor area, which was also reported in the additional data form.

Plan B: Energy Models

If site energy was not reported or did not align with submitted modeling results, the results of the energy models were used to determine site energy. Energy demand is listed in different ways for different software, so for models that did not report total site energy for each fuel type, the report team derived the site energy by either summing up energy demand for all end uses and/or dividing source energy values by site-to-source ratios provided by the modeling software. Project teams used WUFI, PHPP, eQUEST, and HERS software. The site energy was then divided by the gross floor area, which was also reported in the additional data form.

Plan C: Source Energy Reported

If site EUI could not be determined through energy models, the report team referenced the source energy submitted in the data form by project teams. The team assumed source energy factors of 2.6 (kBtu source/1 kBtu site) for grid electricity, 1 for PV electricity, and 1.1 for natural gas. An issue related to accounting for solar in the source energy is that it was sometimes treated as avoided grid electricity (conversion factor of 2.6 applied) and sometimes as energy produced on site (conversion factor of 1), so best judgement was used to determine onsite solar generation.

Source Multipliers

As noted, different energy models—and different references—use different source energy factors. The NYC Energy Conservation Code uses 2.55 for all electricity and 1.05 for all other fuels.[12] The PHIUS+ 2018 standard notes a default source energy factor for grid electricity of 3.16, but suggests using 2.8 for the United States, along with 1.07 for natural gas but 1.1 for natural gas used for boilers.[13] PHIUS 2021

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[12] https://up.codes/viewer/new_york_city/nyc-energy-conservation-code-2020/chapter/R4/residential-energy-efficiency#R405.3

[13] https://www.phius.org/PHIUS+2018/PHIUS+%20Certification%20Guidebook%20v2.0_final.pdf

has shifted to a source energy factor for the United States of 1.8.[14] According to the PHPP tool used for BOE buildings seeking PHI certification, PHI uses a source energy factor of 2.6 for all grid electricity, 1 for on-site electricity generation, and 1.1 for natural gas and heating oil[15]. For the sake of consistency, the report team used the source energy factors listed in Plan C above unless otherwise noted in an energy model or proposal.

Appendix E: Project Baseline Determination

Baselines were not provided by every project team and the methodologies differed when baselines were available. The West Side Homes and Engine 16 teams did not provide baseline models. Instead, the IEc team estimated a baseline building based on energy models in the same climate zone created using a standard low-rise multifamily prototype from the Department of Energy with inputs based on the 2020 Energy Conservation Construction Code of New York State (2020 ECCCNYS).[16] The baseline was aggregated across models with different fuel types for heating and water heating, resulting in a mixed fuel baseline. Scaled by gross floor area, the baseline EUI is 49.5 kBtu/ft^2-year. For the Solara projects, the project team provided a baseline based on the 2020 ECCCNYS, but unlike the other baselines, they chose to assume an all-electric baseline. The methodology for the creation of the baseline model was not provided. Colonial II used the ASHRAE 90.1 path, which includes a standard mixed fuel baseline model with natural gas space heating and water heating.[17]

Appendix F: Detailed Energy Information by Project

West Side Homes

West Side Homes, which will be certified through Phius+ 2018 and will employ an efficient ground source heat pump (GSHP) for space conditioning and water heating, has a modeled site EUI demand of 10.8 kBtu/ft^2-year and has a photovoltaic (PV) system designed to offset the annual energy demand.

The energy model created for the Phius certification did not have a comparable code-minimum baseline model, so the baseline described in the section above was used, resulting in an EUI of 49.5 kBtu/ft^2-year.

Figure 11 shows the improvement over the baseline by end use and by fuel type. It is assumed that all electricity for the baseline building comes from the grid, not onsite renewables. The results show the largest savings in miscellaneous energy use, although the exact performance will likely vary by occupant due to behavioral differences. The baseline model is an aggregation of different fuel sources used for

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[14] https://www.phius.org/Tools-Resources/TechCorner/phius%202021%20Future%20Electricity%20Source%20Energy%20Factor%20-%20L.%20White.pdf

[15] https://passivehouse.com/04_phpp/04_phpp.htm

[16] This analysis uses the same EnergyPlus prototype models and fuel type aggregation as the "Energy Savings and Cost-Effectiveness Analysis of the Residential Provisions of the 2018 International Energy Conservation Code, as Modified for the Provisions of the 2020 Energy Conservation Construction Code of New York State."

[17] ASHRAE 90.1-2016 Appendix G, which is a compliance option for the 2020 ECCCNYS commercial code, uses natural gas storage water heating and PTAC w/ fossil fuel boiler as the default systems for the baseline. https://up.codes/viewer/new_york/ashrae-90.1-2016/chapter/normative_appendix_g_/normative-appendix-g-performance-rating-method#G3.1.1

water and space heating, but the improvement in energy use of the GSHP system over a code-minimum system of any fuel type is clear.

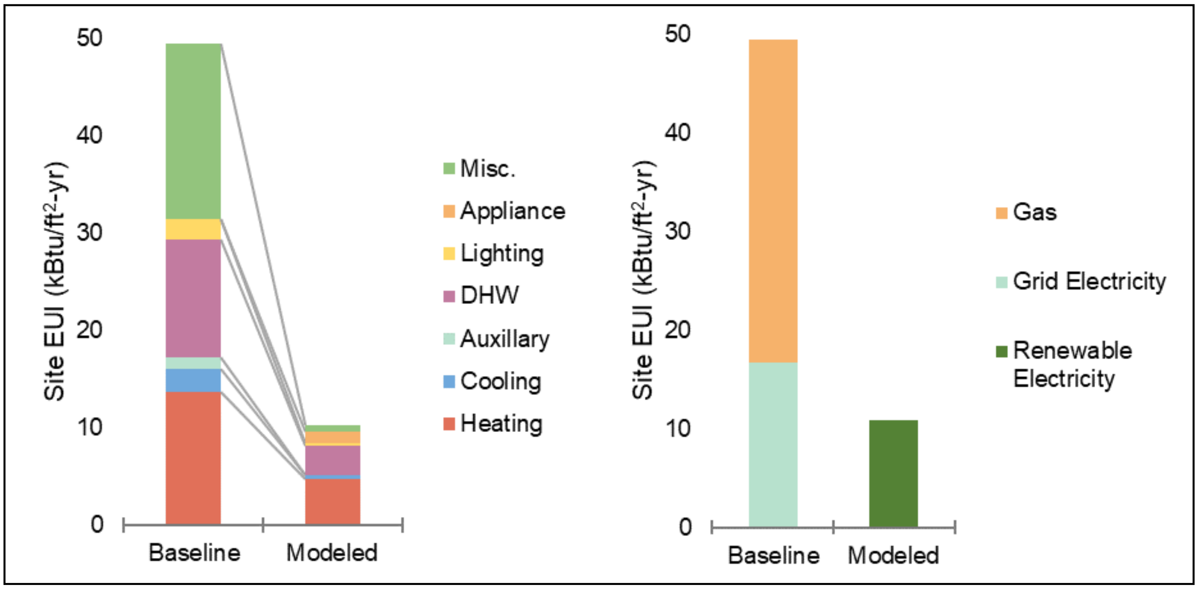

Figure 11. West Side Homes Site EUI by End Use and Fuel Source Compared to Baseline

Solara

Solara Phase II and III are part of a three-phase project and both included mini-split HPs for space conditioning and a combination of solar thermal and heat pump water heaters (HPWH) for domestic hot water. Solara Phase II has a modeled site EUI demand of 16.9 kBtu/ft^2-year and a PV system designed to produce 20.5 kBtu/ft^2-year, resulting in a projected 3.6 kBtu/ft^2-year of electricity that will be exported to the grid. Solara Phase III has slightly improved wall and roof insulation levels, and thus has a lower modeled site EUI demand of 15.8 kBtu/ft^2-year, but the PV system has been designed to only offset the demand and not export electricity to the grid.

The design team created their own baseline model based on the 2020 ECCCNYS, and it is assumed to use all-electric minimum efficiency mechanical equipment. Figure 12 shows the improvement for the Solara buildings over the baseline; the biggest impact of the high-performance design of the Solara buildings is on space conditioning energy.

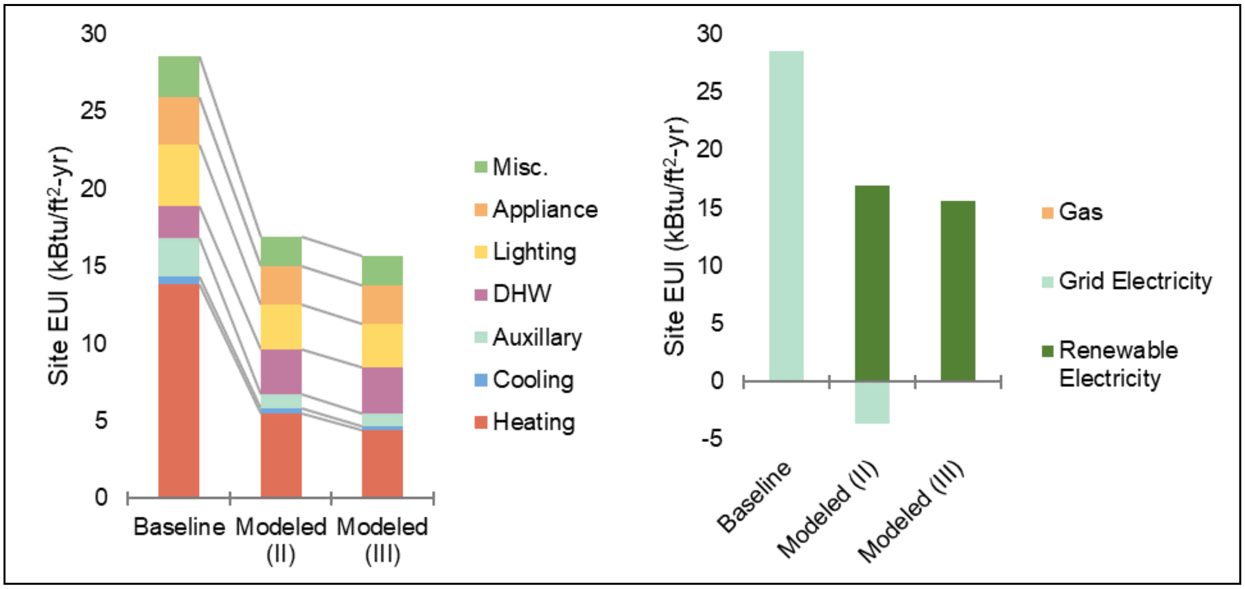

Figure 12. Solara Site EUI by End Use and Fuel Source Compared to Baseline

Colonial II

The Colonial II retrofit includes efficient GSHPs and HPWHs as well as improved insulation. The predicted site EUI demand is 24.5 kBtu/ft^2-year, and the PV system will be sized to offset all the demand.

The building was modeled with eQUEST using an ASHRAE 90.1 2016 baseline to determine performance, so there was a standard code-minimum baseline model to compare against. The baseline model assumed natural gas space and water heating systems. Figure 13 shows the improvement of the building over the ASHRAE 90.1 baseline. The biggest improvements are in space and water heating.

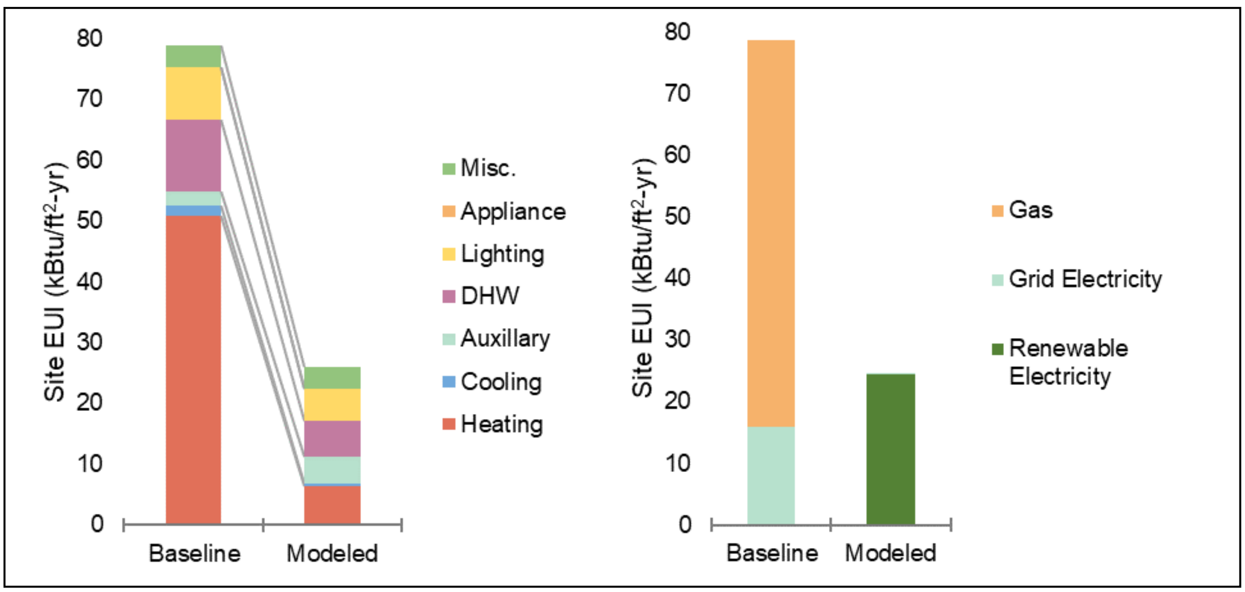

Figure 13. Colonial II Site EUI by End Use and Fuel Source Compared to Baseline

Engine 16

The Engine 16 retrofit will be certified through the Passive House renovation program. The retrofit includes mini-split HPs for space conditioning, HPWH for water heating, and enhanced envelope insultation. The predicted site EUI demand is 12.4 kBtu/ft^2-year, and the onsite PV system will be sized to offset 4.9 kBtu/ft^2-year, leaving a net EUI of 7.5 kBtu/ft^2-year from the electric grid.

Like West Side Homes, Engine 16 did not have a code-compliant baseline model for comparison, only a PHPP baseline model, so a baseline EUI of 49.5 kBtu/ft^2-year was used.

Figure 14 shows the improvement of Engine 16 over the approximated code-compliant model. The miscellaneous and appliance demand improvements do not represent an accurate estimate, as the generic baseline model is not fitted with the same number of bedrooms or units, which could skew the comparison. However, Engine 16 has markedly more efficient hot water and space conditioning systems than a code-compliant building, which are end uses that tend to scale more linearly with building area.

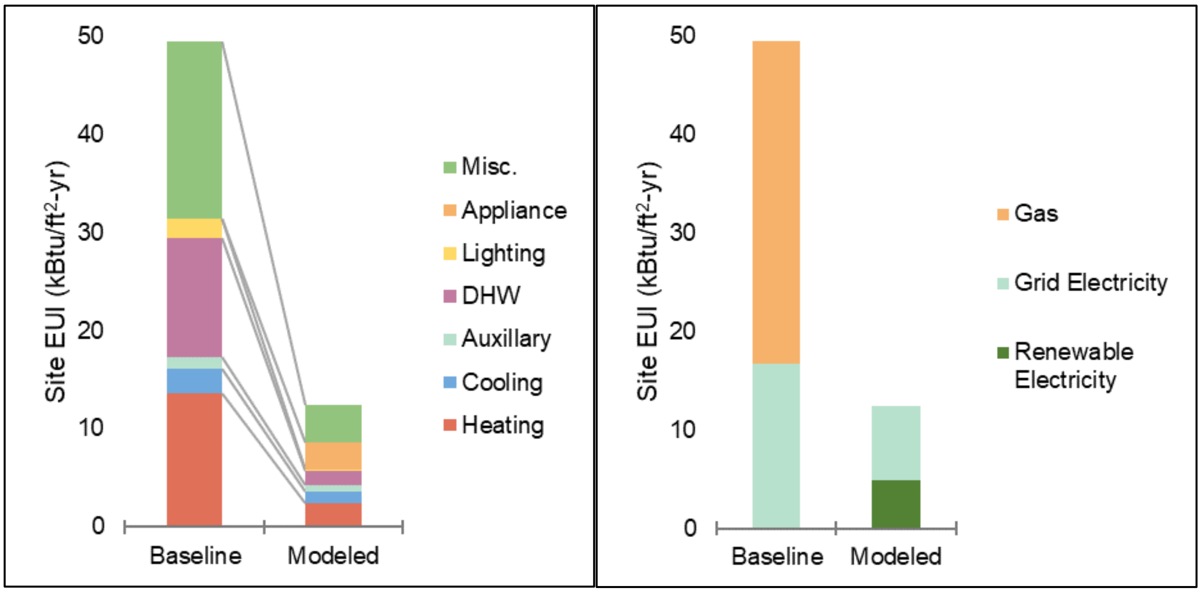

Figure 14. Engine 16 Site EUI by End Use and Fuel Source Compared to Baseline

Appendix G: Detailed GHG Information by Project

To calculate the estimated greenhouse gas (GHG) emissions from electricity demand in the first two rounds of BOE awardees, the IEc team used 2022 long-run marginal hourly CO_2-equivalent (CO_2e) emissions factors—which include CO_2, CH_4, and N_2O emissions—from NYSERDA's Projected Emissions Factors white paper.[18] The hourly emissions factors were multiplied by a generic building load shape scaled to each building's annual electricity consumption.[19]

[18] Projected Emission Factors for New York State Grid Electricity. NYSERDA. 2022. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-18-Projected-Emission-Factors-for-New-York-Grid-Electricity.pdf

[19] The generic load shape was generated from a completed BOE project with hourly energy monitoring as part of the "NYSERDA Buildings of Excellence – Performance Validation of Round 1 & 2 Projects: Trend Analysis."

To account for avoided emissions from PV systems, the IEc team used hourly PV load shapes from NREL's PVWatts for a standard PV layout in each building's ZIP code and scaled to each building's annual PV production.[20] This was then subtracted from the hourly electricity consumption data.

Natural gas emissions were estimated using emission factors from NYSERDA's Fossil Fuel GHG Emission Factors white paper, which shows a factor of 95.5 kg CO_2e/MBtu of natural gas combusted in residential and commercial buildings.[21]

West Side Homes

The West Side Homes design reduces emissions by 78% as compared to a code compliant building before adding on the PV system. The PV system directly offsets 93% of the remaining emissions, resulting in a nearly carbon-neutral building. The results are shown in Figure 15.

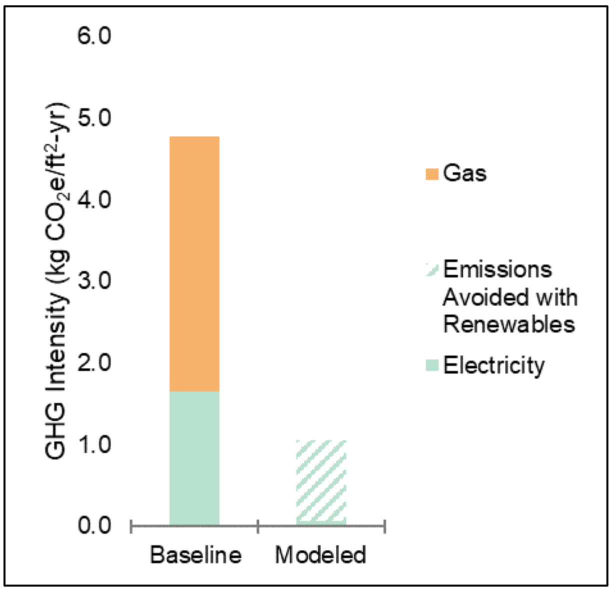

Figure 15. West Side Homes GHG Intensity

Solara

The Solara II design reduces emissions by 41% before adding on the PV system, which offsets 11% of the Solara II emissions from electricity demand. The Solara III design has a 45% emissions reduction before adding on the PV system, which offsets 72% of the Solara III emissions from electricity demand. The results are shown in Figure 16.

[20] PVWatts 2022. NREL. https://pvwatts.nrel.gov/version_6_3.php

[21] Fossil and Biogenic Fuel Greenhouse Gas Emission Factors. NYSERDA. 2022. https://www.nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-23-Fossil-and-Biogenic-Fuel-Greenhouse-Gas-Emission-Factors.pdf

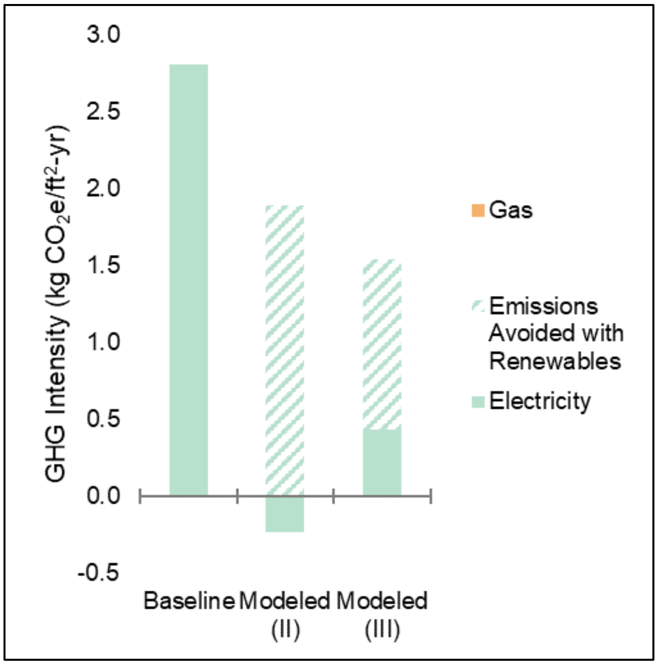

Figure 16. Solara GHG Intensity

Colonial II

Colonial II design reduces emissions by 68% before adding on the PV system, which offsets 93% of the Colonial II emissions from electricity demand. The results are shown in Figure 17.

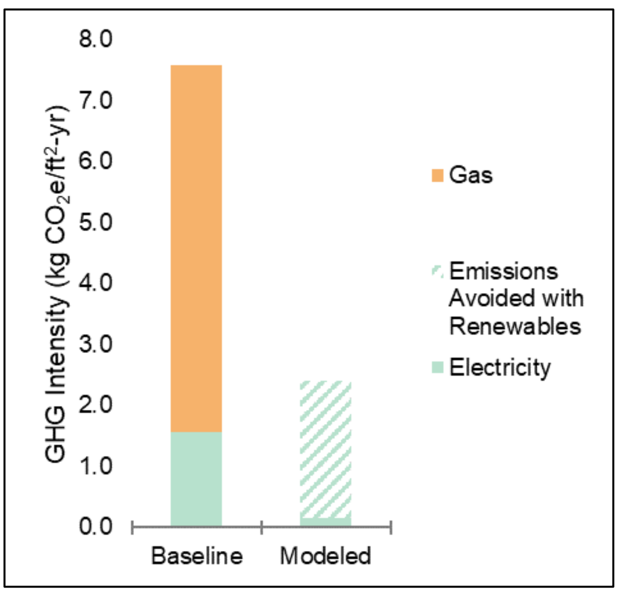

Figure 17. Colonial II GHG Intensity

Engine 16

The Engine 16 reduces emissions by 72% before adding on the PV system, which offsets 39% of the Engine 16 emissions from electricity demand. The results are shown in Figure 18.

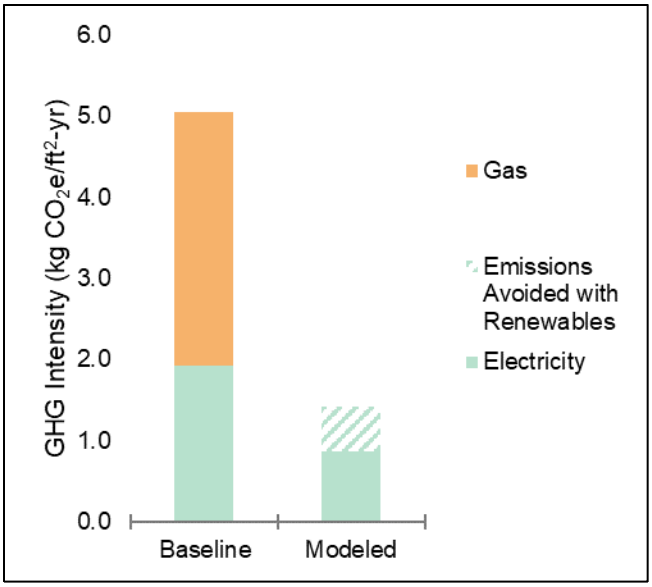

Figure 18. Engine 16 GHG Intensity

Appendix H: Detailed Cost Information By Project

Project teams provided estimates and information on upfront project costs, including total and incremental costs for the whole project and individual components, as well as anticipated incentives. Incremental costs require baseline costs, which have been estimated by the project teams based on either a business-as-usual case or code-compliant building. While no standard method for estimating the baseline or incremental costs was required for these projects, they still provide useful insight into project team decision making.

West Side Homes

After $20/ft^2 of incentives, the West Side Homes incremental cost is $24/ft^2, which is a 12% increase from baseline. The incremental cost associated with the improved envelope accounts for 53% of the total incremental cost, while the improved HVAC system accounts for 25% of the total incremental cost. Results are shown in Figure 19.

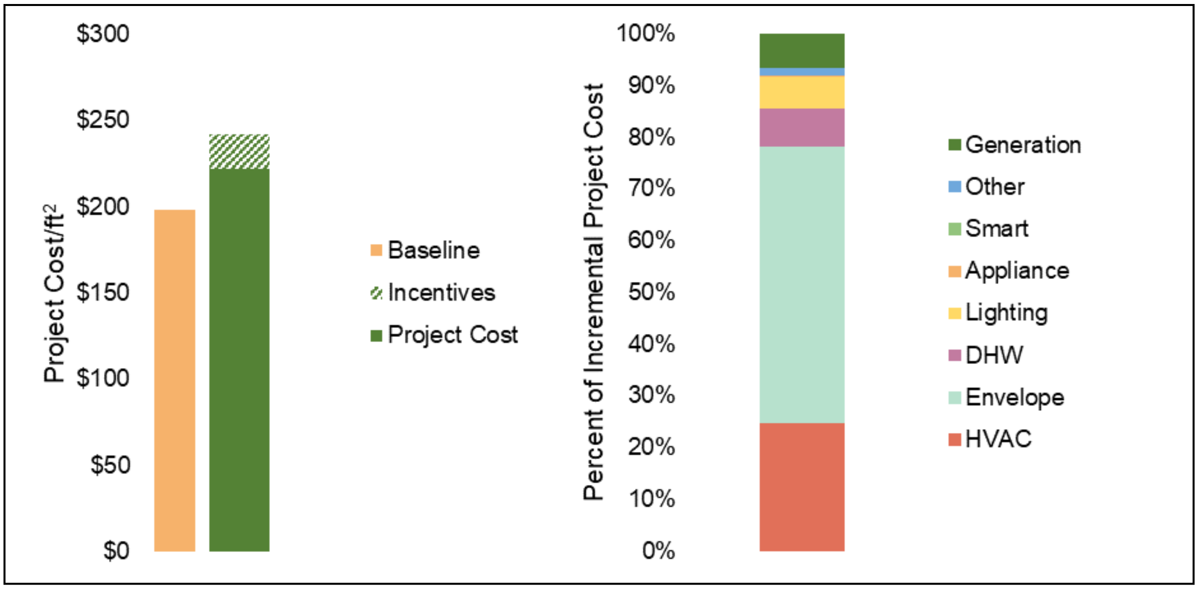

Figure 19. West Side Home Project Cost Compared to Baseline and Incremental Cost by Component

Solara

After incentives, the Solara II total project cost is $9/ft^2 lower than the baseline (6% reduction), while Solara III has a $4/ft^2 incremental cost (3% increase). Without incentives, the incremental cost associated with the improved envelope accounts for 21% of the total incremental cost of Solara II and 26% of Solara III, while the PV system accounts for 71% of the total incremental cost for Solara II and 86% for Solara III. Solara III also has non-performance cost savings that represent a 21% reduction of the incremental cost. Results are shown in Figure 20.

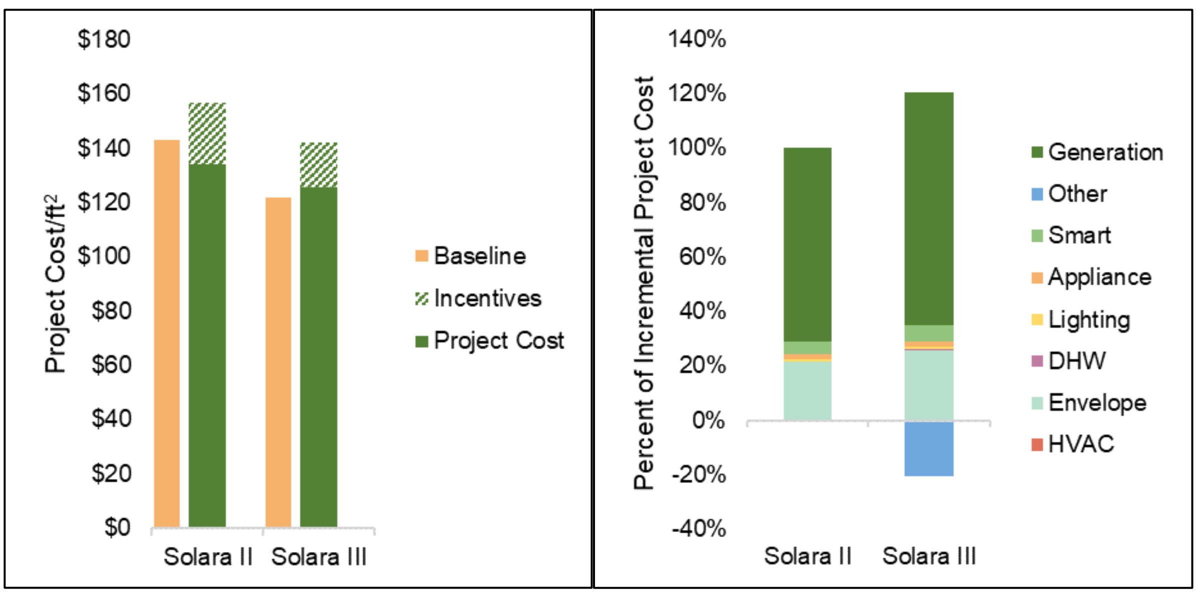

Figure 20. Solara Project Cost Compared to Baseline and Incremental Cost by Component

Colonial II

Colonial II has a total cost of $10/ft^2$ more than the baseline cost of $388/ft^2$ after receiving $20/ft^2$ of incentives, a 3% increase. Individual component incremental costs were not available at the time this study was conducted. Results are shown in Figure 21.

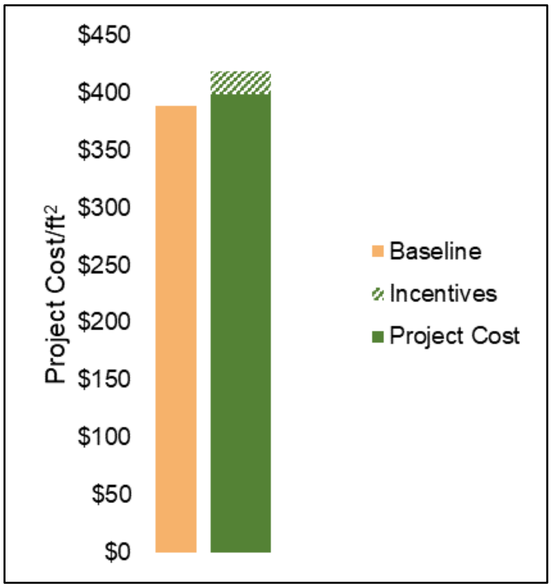

Figure 21. Colonial II Project Cost Compared to Baseline

Engine 16

Engine 16 has a total cost of $15/ft^2$ less than the baseline cost of $640/ft^2$ after receiving $15/ft^2$ of incentives, a 2% decrease. Individual component incremental costs were not available at the time this study was conducted. Results are shown in Figure 22.

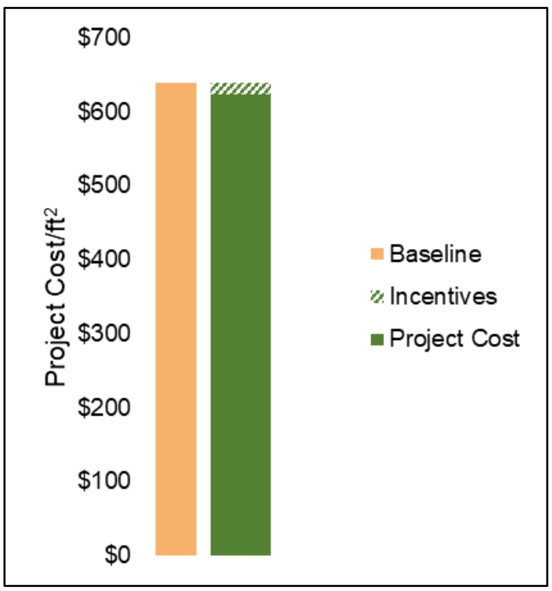

Figure 22. Engine 16 Project Cost Compared to Baseline

Appendix I: Detailed Resilience Information By Project

West Side Homes

The West Side Homes team partnered with the University at Buffalo School of Architecture and Planning's Resilient Buildings Laboratory to understand the impacts of climate change on buildings as well as creating strategies for addressing them. The project incorporated many strategies to ensure resiliency for the buildings, residents, and neighborhood, such as:

- *Passive survivability:* Designing and building to Phius certification standards will increase the project's ability to maintain safe interior temperatures during grid failures or extreme climate events.
- *Green infrastructure and stormwater management:* Like many older cities, Buffalo has a combined sewer system that overflows after moderate and extreme precipitation events, including rain and snow melts, which are anticipated to increase in Buffalo's future climate. The project includes both green infrastructure and underground detention systems to manage stormwater on site and prevent overflows. Landscaping at all sites will include rain gardens to help absorb and collect water. Some parts of the development will also include an underground piping system to retain water. These efforts comply with the City of Buffalo Green Code and the Buffalo Sewer Authority's Rain Check program. Additionally, BNSC operates an eco-landscaping social enterprise business – PUSH Blue – that installs and maintains green infrastructure systems, ensuring that these resiliency efforts will perform throughout the life of the building.
- *Food security:* Changing climates will impact secure and safe access to food. To improve resident's food security and resiliency, BNSC currently maintains two large community gardens with a third planned, all near to West Side Homes apartments. West Side Home residents will be prioritized for garden plots when they became available and BNSC will explore opportunities to create new garden plots on site or near to the West Side Homes apartments that will be reserved for West Side Homes residents.

They also commissioned a feasibility study of battery storage from American Microgrid Solutions to better understand storage options, which found that given current technology costs and available capital, a PV-only strategy was more financially feasible. As both technology and project financing evolves, the development team will continue to strongly consider incorporating battery storage and evaluate available technologies and financing opportunities.

Solara

Solara's airtight envelope and continuous insulation allow the building to remain at a stable and safe interior temperature in the event of a prolonged power outage. During heat waves, the white roofing membrane and exterior shading design will passively prevent solar gain. In the winter outages, the envelope provides protection against freezing. The solar shades that block summer heat gain, allow for solar gains in the winter when the sun is lower in the sky. The airtight strategy combined with dense-pack cellulose will prevent infiltration of cold air and mitigate against plumbing freezing, generally keeping the building warm for extended periods. The 1,200 gallon solar hot water thermal storage tank can provide hot water for extended outages.

Sensitive components of Solara's electrical infrastructure like the elevator, internet network, EV charging equipment, BMS, etc. are protected with a surge suppression system. The BMS also has a dedicated circuit with an uninterruptible power supply (UPS) to ensure that it remains functional during power surges and outages. All stormwater is managed on site, reducing runoff and runoff pollution and increasing groundwater infiltration. In both phases, careful attention to the vapor barrier assemblies reduces the risk of moisture and mold growth.

Colonial II

The Colonial II project team paid careful attention to design and material choices that ensure the longevity of the building and the safety of its occupants. The entire building, including the basement, sits outside of both the 100-yr and 500-yr flood plains, minimizing the risk of flood damage. The design includes redundant power supply systems, utilizing a dual fuel back-up system, and connections to renewable energy production sources to provide continual power service. This ensures resiliency during prolonged grid failures and power outages. The back-up system will provide adequate energy to ensure the use of elevators, hallway lighting and plugs, space heating and hot water system, as well as community room lighting, plugs, and refrigeration of medicine. In line with goals for passive survivability, the improved building envelope increases the duration of comfortable and survivable interior temperatures during extreme weather and/or extended periods without power. Additionally, the project team will employ future climate data sets through energy modeling to estimate the potential duration of passive survivability.

Engine 16

The project team performed in-depth existing masonry testing to evaluate the moisture durability with interior insulation. The project team thoroughly waterproofed all existing below grade surfaces using the highest rated materials available and carefully installed interior-side vapor and moisture control materials. Thermal bridge analysis for construction junctions, windows, and doors minimizes condensation concerns. Air tightness compartmentalization prevents air quality contamination between each apartment unit. During grid outages, limited electricity will be supplied by the battery system, which will be supplied by PV generation in the future.