

Decarbonization Roadmap for Multifamily Affordable Housing



April 21, 2023
31 Chambers Street
New York, NY

Decarbonization Roadmap for Multifamily Affordable Housing

Welcome & Opening Remarks

- Richard C. Yancey, Executive Director, Building Energy Exchange
- William Xia, Director, Multifamily Residential Programs, NYSERDA
- Adolfo Carrión Jr., Housing Commissioner, NYC HPD

Presentation

- Jennifer Leone, Chief Sustainability Officer, NYC HPD
- James Henshaw, Manager, Sustainability Services, Bright Power
- Katie Schwamb, Director, Educational Resources, Building Energy Exchange



Agenda

- Welcome & Opening Remarks
- Presentation
- Q & A
- Closing Remarks
- Adjourn for Happy Hour

Project Overview

Context

NYC Climate Mobilization Act

- LL97 emissions limits start in 2024, but affordable housing is treated differently.
 - Prescriptive Pathway for most HPD affordable housing
 - 2035 Pathway (delayed compliance) for income restricted housing

NYS Climate Leadership and Community Protection Act

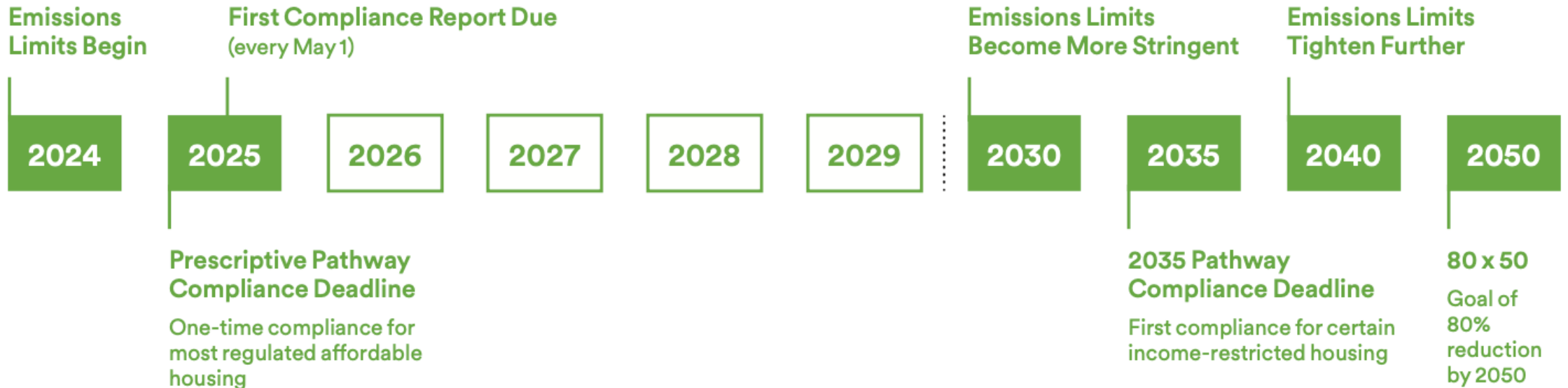
- GHG emissions reductions 85% by 2050
- Clean energy grid by 2040

Fossil fuel bans for existing buildings are under consideration by NYC and NYS.



Project Goals

To understand how affordable housing *could* comply with LL97's short- and long-term limits and to inform project scopes and policy decisions.

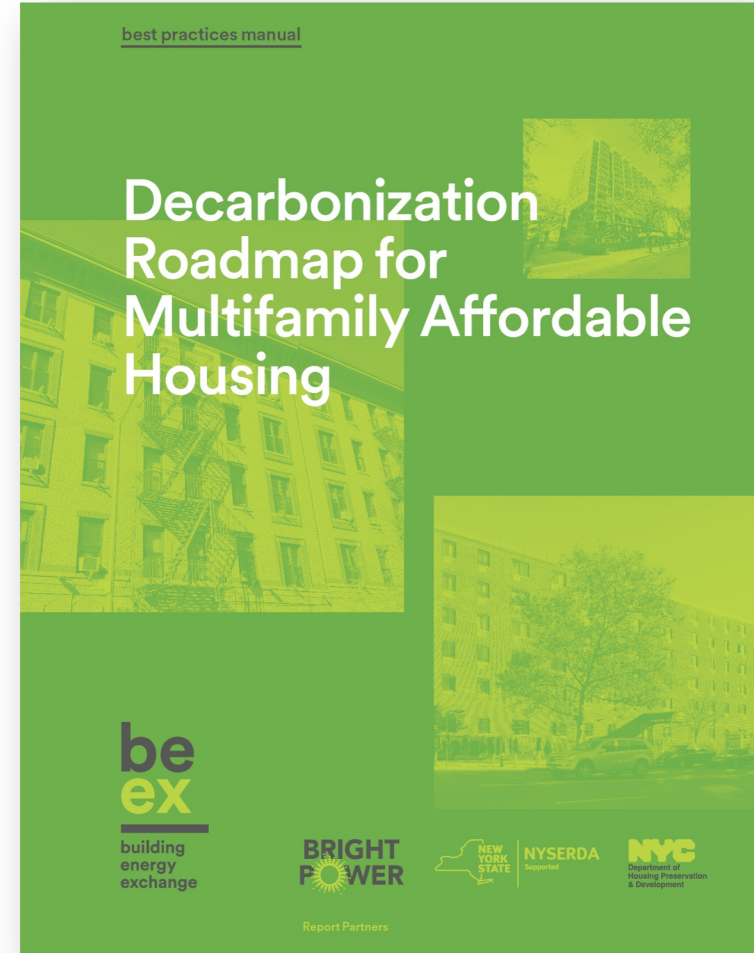


Tools

Tear Sheets



Best Practices Manual



Unpacking the Process

Building Typologies



post-1980 mid-rise senior rental

year built: 1988
size: 99 units · 70,460 sq. ft.
heating system: hydronic baseboard
LL97 path: Prescriptive Pathway



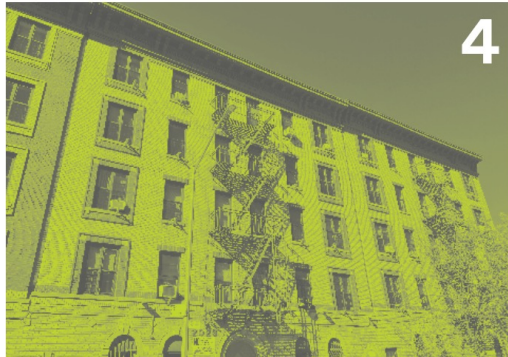
post-war high-rise Mitchell-Lama

year built: 1975
size: 182 units · 127,009 sq. ft.
heating system: two pipe steam w/baseboard
LL97 path: 2035 Pathway



pre-war low-rise rent stabilized rental

year built: 1927
size: 52 units · 44,250 sq. ft.
heating system: hydronic convectors
LL97 path: Prescriptive Pathway



pre-war low-rise HDFC co-op

year built: 1913
size: 40 units · 40,850 sq. ft.
heating system: one-pipe steam radiators
LL97 path: Prescriptive Pathway



post-1980 high-rise rental

year built: 1995
size: 198 units · 182,828 sq. ft.
heating system: steam PTACs
LL97 path: Prescriptive Pathway

see pages 4-5
of the Manual

Scoping for Compliance

Low Carbon Retrofit

No Carbon Retrofit

Enhancing Efficiency

baseline building conditions		low carbon retrofit package		GHG savings	no carbon retrofit package		GHG savings			
		<p>This post-war high-rise building has a brick masonry assembly, balconies, and no insulation. No connecting buildings makes it ideal for full envelope upgrades, especially insulated over-cladding. Natural gas heating and thru-wall ACs for cooling provide an opportunity for central VRF heat pumps. Master metered electric also makes the building a good candidate for solar on the roof.</p>		<p>Low Carbon improvements include new steam boilers and thru-wall ACs, an electric air source heat pump DHW system, rooftop post & rail solar PV, and LED lighting. Envelope upgrades include new roof insulation, windows and doors, air sealing measures, and optional above grade wall R-15 EIFS over-cladding that also covers the underside of the balconies. GHG savings for this scope of work are based on the 2030 emissions factor.</p>		<p>RELATIVE TO BASELINE BUILDING AND BASED ON THE 2030 EMISSIONS FACTOR</p>	<p>No Carbon improvements include all 2030 measures plus additional upgrades which may supersede some 2030 measures. These include central VRF heat pumps, electric stoves and dryers, and energy recovery ventilation resulting in whole building electrification. New high-performance windows and doors and optional above grade wall R-15 EIFS over-cladding upgrade the envelope. GHG savings for this scope of work are based on the 2050 emissions factor.</p>		<p>RELATIVE TO BASELINE BUILDING AND BASED ON THE 2050 EMISSIONS FACTOR</p>	
BUILDING SYSTEM	% OF GHG EMISSIONS	SYSTEM COMPONENTS	DESCRIPTION	ENERGY CONSERVATION MEASURES (ECMs)	ESTIMATED COST/DU*		ENERGY CONSERVATION MEASURES (ECMs)	ESTIMATED COST/DU*	ESTIMATED TOTAL COST/DU*	
envelope	n/a	Roof Insulation	Concrete deck, 2" rigid insulation	■ R-49 blown-in insulation	\$1,250	2%			\$1,250	0% ***
		Windows/Glazing	Aluminum, double hung	■ New aluminum, double hung, double pane, low-e, argon filled ■ New storefront/entry doors	\$6,650		■ New uPVC, thermally broken, casement windows & ENERGY STAR balcony doors	\$10,850	\$10,850	
		Air Sealing & Weatherization	Leaky windows & doors	■ Door & window weatherstripping	\$1,000			\$1,000		
		Above Grade Walls	Uninsulated brick wall assembly	+ Optional R-15 EIFS over-cladding, including underside of balconies	\$17,250		+ Optional R-15 EIFS over-cladding, including underside of balconies	\$17,250	\$17,250	
heating	63%	Heating	(2) Scotch Marine steam boilers with baseboards, outdoor air reset and pressure controls	■ New steam boilers with east/west zone valves ■ Heat Timer boiler controls with indoor temp feedback ■ Real Time Energy Management (RTEM)	\$3,350 \$500 \$2,000	24% +8% WITH R-15 EIFS OVER-CLADDING	■ Central VRF with rooftop units ♯ †	\$10,050	\$10,050	67% *** +0% *** WITH R-15 EIFS OVER-CLADDING
		Cooling	Thru-wall ACs	■ New thru-wall ENERGY STAR ACs	\$2,000		(see above) VRFs also provide cooling			
		Pumps	0.75 hp single speed pump	■ No additional measures	\$0					
		Pipe Insulation	Piping mostly insulated	■ New pipe insulation	\$300					
		Ventilation	Common Areas: passive Apartment, Bath, Kitchen; central exhaust fans	■ Direct drive, variable speed EC motor central exhaust fans with timers & CAR dampers	\$1,300		■ Central ERVs serving corridors ♯ † ■ Central ERVs serving apartments ♯ †	\$4,750	\$4,750	
domestic hot water	17%	DHW	Tankless coils in steam boilers	■ Central air source heat pump (ASHP) with storage ♯ †	\$6,450	16%	No additional recommended measures	\$6,450	\$6,450	20% ***
		Plumbing Fixtures	Standard flow fixtures	■ Low flow fixtures (WaterSense where applicable)	\$300			\$300		
lighting	6%	Common Area	Fluorescent/CFL/Incandescent	■ LEDs with occupancy/vacancy sensors	\$800	1%	No additional recommended measures	\$800	\$800	4% ***
		Exterior	Fluorescent/CFL/Incandescent	■ LEDs with photocells & timeclock	(see above)			(see above)		
		In-unit	Fluorescent circline	■ LEDs	\$1,000			\$1,000		
appliances	14%	Appliances	Non-ENERGY STAR refrigerators Gas stoves	■ ENERGY STAR refrigerators	\$1,350	1%	■ Electric stoves ♯ †	\$950	\$2,300	9%
		Central Laundry	(4) Non-ENERGY STAR washers (4) Electric dryers	■ (4) ENERGY STAR washers	\$0 (per equipment lease agreement)		■ (4) Heat pump dryers ♯ †	\$0 (per equipment lease agreement)	\$0	
renewables		None		■ 65KW post & rail rooftop solar PV system	\$1,700	2%	No additional recommended measures	\$1,700	\$1,700	0%
				<p>♯ electrical service and distribution upgrades † structural/finish upgrades including dunnage, patching, & sealing</p>	\$1,600 \$10		<p>♯ electrical service and distribution upgrade † structural/finish upgrades including dunnage, patching, & sealing</p>	\$6,750 \$4,200	\$8,350 \$4,210	
				<p>2030 Emissions Factor The 2030 emissions factor reflects an electric grid powered 70% by renewable energy.</p>	\$31,560	46%	<p>2050 Emissions Factor The 2050 emissions factor reflects a zero-emissions electric grid powered 100% by renewable energy.</p>	\$55,010	\$55,010	100%
				<p>ESTIMATED TOTAL COST/DU WITH R-15 EIFS OVER-CLADDING</p>	\$48,810	54%	<p>ESTIMATED TOTAL COST/DU WITH R-15 EIFS OVER-CLADDING</p>	\$72,260	\$72,260	100%

Low Carbon Retrofit Package

Provides moderate emissions reductions and meets near-term LL97 limits through strategic system upgrades and partial electrification.

baseline building conditions		low carbon retrofit package		GHG savings	no carbon retrofit package		GHG savings				
		<p>This post-war high-rise building has a brick masonry assembly, balconies, and no insulation. No connecting buildings makes it ideal for full envelope upgrades, especially insulated over-cladding. Natural gas heating and thru-wall ACs for cooling provide an opportunity for central VRF heat pumps. Master metered electric also makes the building a good candidate for solar on the roof.</p>		<p>Low Carbon improvements include new steam boilers and thru-wall ACs, an electric air source heat pump DHW system, rooftop post & rail solar PV, and LED lighting. Envelope upgrades include new roof insulation, windows and doors, air sealing measures, and optional above grade wall R-15 EIFS over-cladding that also covers the underside of the balconies. GHG savings for this scope of work are based on the 2030 emissions factor.</p>		<p>RELATIVE TO BASELINE BUILDING AND BASED ON THE 2030 EMISSIONS FACTOR</p>	<p>No Carbon improvements include all 2030 measures plus additional upgrades which may supersede some 2030 measures. These include central VRF heat pumps, electric stoves and dryers, and energy recovery ventilation resulting in whole building electrification. New high-performance windows and doors and optional above grade wall R-15 EIFS over-cladding upgrade the envelope. GHG savings for this scope of work are based on the 2050 emissions factor.</p>		<p>RELATIVE TO BASELINE BUILDING AND BASED ON THE 2050 EMISSIONS FACTOR</p>		
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envelope	n/a	Roof Insulation	Concrete deck, 2" rigid insulation	■ R-49 blown-in insulation	\$1,250	2%			\$1,250	0% ***	
		Windows/Glazing	Aluminum, double hung	■ New aluminum, double hung, double pane, low-e, argon filled ■ New storefront/entry doors	\$6,650			■ New uPVC, thermally broken, casement windows & ENERGY STAR balcony doors	\$10,850		\$10,850
		Air Sealing & Weatherization	Leaky windows & doors	■ Door & window weatherstripping	\$1,000				\$1,000		
		Above Grade Walls	Uninsulated brick wall assembly	+ Optional R-15 EIFS over-cladding, including underside of balconies	\$17,250			+ Optional R-15 EIFS over-cladding, including underside of balconies	\$17,250		\$17,250
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		Cooling	Thru-wall ACs	■ New thru-wall ENERGY STAR ACs	\$2,000		(see above) VRFs also provide cooling				
		Pumps	0.75 hp single speed pump	■ No additional measures	\$0						
		Pipe Insulation	Piping mostly insulated	■ New pipe insulation	\$300						
		Ventilation	Common Area: passive Apartment, Bath, Kitchen; central exhaust fans	■ Direct drive, variable speed EC motor central exhaust fans with timers & CAR dampers	\$1,300			■ Central ERVs serving corridors # T ■ Central ERVs serving apartments # T	\$4,750		\$4,750
ductwork	In-unit leaky	■ Clean & seal ducts; conduct testing, adjusting, & balancing	(see above)								
domestic hot water	17%	DHW	Tankless coils in steam boilers	■ Central air source heat pump (ASHP) with storage # T	\$6,450	16%	No additional recommended measures		\$6,450	20% ***	
		Plumbing Fixtures	Standard flow fixtures	■ Low flow fixtures (WaterSense where applicable)	\$300				\$300		
lighting	6%	Common Area	Fluorescent/CFL/Incandescent	■ LEDs with occupancy/vacancy sensors	\$800	1%	No additional recommended measures		\$800	4% ***	
		Exterior	Fluorescent/CFL/Incandescent	■ LEDs with photocells & timeclock	(see above)				(see above)		
		In-unit	Fluorescent circline	■ LEDs	\$1,000				\$1,000		
appliances	14%	Appliances	Non-ENERGY STAR refrigerators Gas stoves	■ ENERGY STAR refrigerators	\$1,350	1%	■ Electric stoves # T	\$950	\$2,300	9%	
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renewables	None			■ 65KW post & rail rooftop solar PV system	\$1,700	2%	No additional recommended measures		\$1,700	0%	
		ASSOCIATED UPGRADES		# electrical service and distribution upgrades † structural/finish upgrades including dunnage, patching, & sealing	\$1,600 \$10		# electrical service and distribution upgrade † structural/finish upgrades including dunnage, patching, & sealing	\$6,750 \$4,200	\$8,350 \$4,210		
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Low Carbon Retrofit Package

Strategic Upgrades + Partial Electrification



Air Sealing & Roof Insulation



Electric DHW



Solar PV



see pages 8-15
of the Manual

No Carbon Retrofit Package

Provides **deep** emissions reductions and meets **long-term LL97 limits**, through more robust system upgrades and **full building electrification**.

baseline building conditions		low carbon retrofit package		GHG savings	no carbon retrofit package		GHG savings			
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envelope	n/a	Roof Insulation	Concrete deck, 2" rigid insulation	■ R-49 blown-in insulation	\$1,250	2%			\$1,250	
		Windows/Glazing	Aluminum, double hung	■ New aluminum, double hung, double pane, low-e, argon filled ■ New storefront/entry doors	\$6,650			■ New uPVC, thermally broken, casement windows & ENERGY STAR balcony doors	\$10,850	\$10,850
		Air Sealing & Weatherization	Leaky windows & doors	■ Door & window weatherstripping	\$1,000				\$1,000	
		Above Grade Walls	Uninsulated brick wall assembly	+ Optional R-15 EIFS over-cladding, including underside of balconies	\$17,250			+ Optional R-15 EIFS over-cladding, including underside of balconies	\$17,250	\$17,250
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		Pumps	0.75 hp single speed pump	■ No additional measures	\$0					
		Pipe Insulation	Piping mostly insulated	■ New pipe insulation	\$300					
		Ventilation	Common Areas: passive Apartment, Bath, Kitchen; central exhaust fans	■ Direct drive, variable speed EC motor central exhaust fans with timers & CAR dampers	\$1,300		■ Central ERVs serving corridors # T ■ Central ERVs serving apartments # T	\$4,750	\$4,750 (see above)	
ductwork	In-unit leaky	■ Clean & seal ducts; conduct testing, adjusting, & balancing	(see above)							
domestic hot water	17%	DHW	Tankless coils in steam boilers	■ Central air source heat pump (ASHP) with storage # T	\$6,450	16%	No additional recommended measures		\$6,450	20% ^{***}
		Plumbing Fixtures	Standard flow fixtures	■ Low flow fixtures (WaterSense where applicable)	\$300			\$300		
lighting	6%	Common Area	Fluorescent/CFL/Incandescent	■ LEDs with occupancy/vacancy sensors	\$800	1%	No additional recommended measures		\$800	4% ^{***}
		Exterior	Fluorescent/CFL/Incandescent	■ LEDs with photocells & timeclock	(see above)			(see above)		
		In-unit	Fluorescent circline	■ LEDs	\$1,000			\$1,000		
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				# electrical service and distribution upgrades	\$1,600		# electrical service and distribution upgrade		\$6,750	\$8,350
				T structural/finish upgrades including dunnage, patching, & sealing	\$10		T structural/finish upgrades including dunnage, patching, & sealing		\$4,200	\$4,210
				2030 Emissions Factor The 2030 emissions factor reflects an electric grid powered 70% by renewable energy.	\$31,560	46%	2050 Emissions Factor The 2050 emissions factor reflects a zero-emissions electric grid powered 100% by renewable energy.		\$55,010	100%
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No Carbon Retrofit Package

Robust Upgrades + Full Electrification



High Performance Windows



Electric Heating



Energy Recovery Ventilation (ERV)



Electric Cooking



see pages 8-15
of the Manual

Enhancing Efficiency

Each retrofit package includes an **optional over-cladding** scope to show how more **comprehensive envelope upgrades** provide additional benefits and savings.

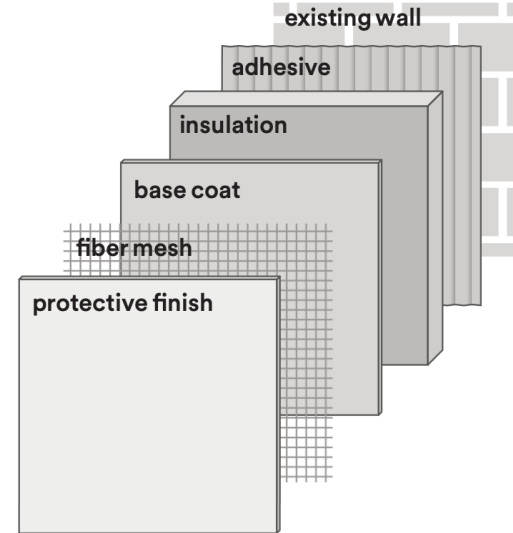
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Enhancing Efficiency

Optional Over-cladding



Exterior Insulation Finishing System (EIFS)

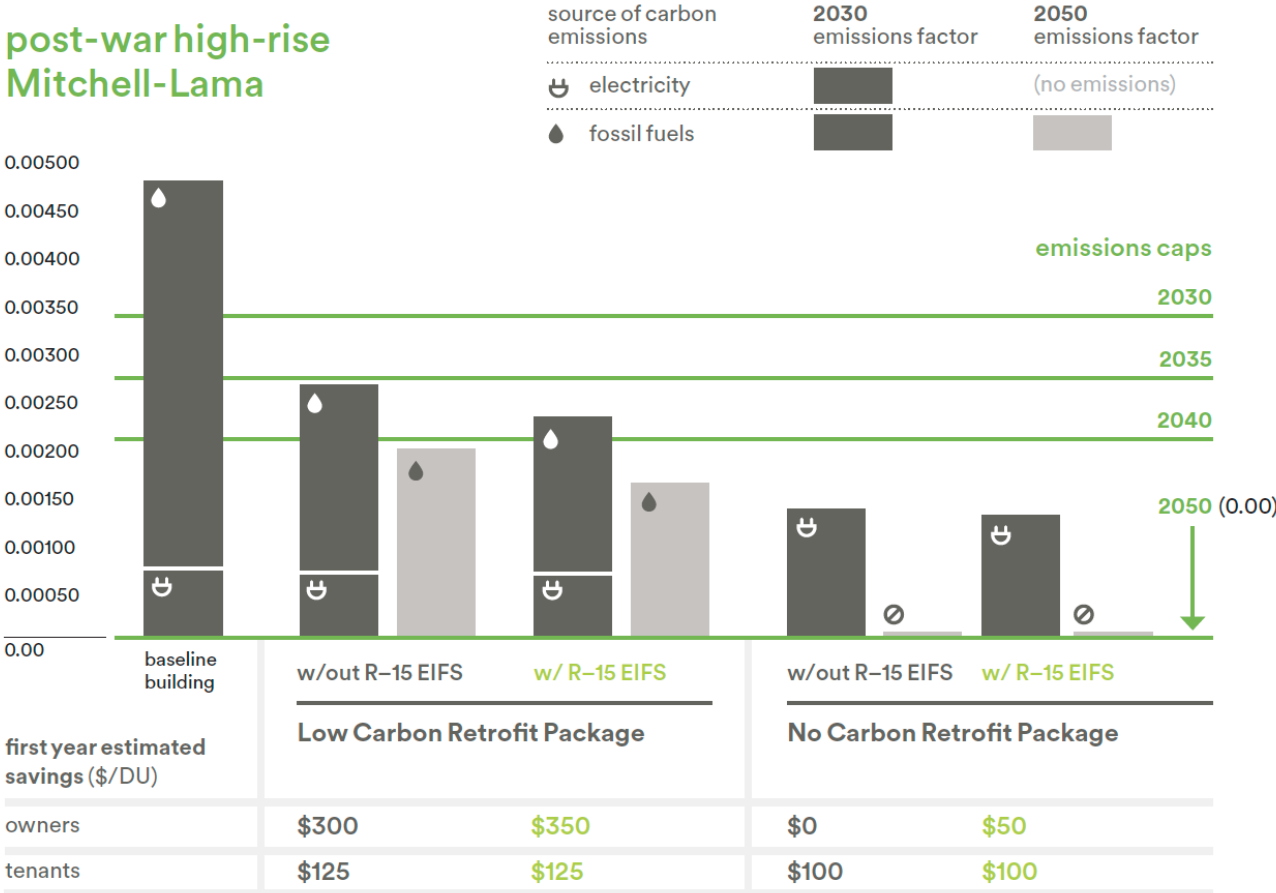


see pages 8-15
of the Manual

Assessing for Compliance

Each retrofit package is compared to LL97 emissions caps using the 2030 and 2050 emissions factors to demonstrate compliance as the grid also transitions to clean energy sources.

post-war high-rise Mitchell-Lama



The Tear Sheets

How to Use the Tear Sheets

Building typology is based on age, size, and rental/ownership structure.

Baseline building conditions describe the system components comprising the existing building.

The Low Carbon retrofit package provides moderate emissions reductions through key system upgrades and strategic electrification.

The No Carbon retrofit package provides deep emissions reductions through more robust system upgrades and full building electrification, eliminating onsite fossil fuel use.

GHG savings show the percentage reduction associated with implementing the ECMs within each building system category.

Decarbonization Roadmap diagram lists key steps to developing a decarbonization retrofit plan.

Key Takeaways provide insight and rationale into the retrofit packages developed for that specific building typology.

Decarbonization Roadmap for Multifamily Affordable Housing

tear sheet 1/5

post-1980 mid-rise senior rental housing

Based on the Mar's Island affordable housing project

be ex building energy exchange

BRIGHT POWER

NYSERDA

NYS

April 2022

typology: post-1980, mid-rise, senior rental housing

baseline building conditions		low carbon retrofit package		GHG savings	no carbon retrofit package		GHG savings
Roof insulation	Commercial, no insulation	R-19 blown attic	\$5,100	19%	High performance, R-19 blown attic, no insulation	\$4,100	0%
Exterior walling	Exterior walling, no insulation	Exterior walling, double-pane, low-e argon-filled, double-pane	\$4,100		High performance, R-19 blown attic, no insulation	\$4,100	
Windows	Single-pane, wood-framed	Double-pane, wood-framed	\$10,000	5%	High performance, R-19 blown attic, no insulation	\$10,000	52%
Doors	Single-pane, wood-framed	Double-pane, wood-framed	\$10,000		High performance, R-19 blown attic, no insulation	\$10,000	
Lighting	Incandescent	LED	\$10,000	1%	High performance, R-19 blown attic, no insulation	\$10,000	13%
Plumbing	Standard	Low-flow	\$10,000		High performance, R-19 blown attic, no insulation	\$10,000	
HVAC	Standard	High-efficiency	\$10,000	23%	High performance, R-19 blown attic, no insulation	\$10,000	30%
Electrical	Standard	High-efficiency	\$10,000		High performance, R-19 blown attic, no insulation	\$10,000	
Water	Standard	High-efficiency	\$10,000	4%	High performance, R-19 blown attic, no insulation	\$10,000	0%
Other	Standard	High-efficiency	\$10,000		High performance, R-19 blown attic, no insulation	\$10,000	
Total			\$41,900	53%			100%
Total			\$61,900	65%			100%

Decarbonization Roadmap for Multifamily Affordable Housing

- calculate
- compare
- develop
- implement

carbon emissions intensity: post-1980 mid-rise

Key Takeaways:

- Each scope of work is evaluated against the 2030 and 2050 emissions factors and different cost (LCOE) scenarios.
- The 2030 emissions factor reflects an electric grid powered 75% by renewable energy.
- The 2050 emissions factor reflects a more emissions-intensive grid powered 100% by renewable energy.
- The grid LCOE ranges from 2000 to 10000.
- Systems associated with a scope of work are subject to financial limits.

Existing building overview provides a more detailed snapshot of the baseline building conditions.

Percentage of GHG emissions for the baseline building shows the portion of total emissions attributed to each building system.

ECMs are organized by specific building system categories.

Estimated cost per dwelling unit for individual ECMs and the total scope of work show the price associated with implementing each retrofit package.

Total GHG savings shows the percentage reduction of the baseline building emissions that results from implementing each retrofit package including the additional savings from the optional R-15 EIFS over-cladding.

Carbon Emissions Intensity graph depicts the emissions per square foot of the baseline building, the Low Carbon, and No Carbon retrofit packages.

Both retrofit packages are evaluated using the 2030 and 2050 emissions factors to show how emissions will reduce over time as the grid transitions towards clean energy sources.

LL97 emission caps are indicated in the graph to show how emissions from each scope of work compares to the increasingly stringent limits.

Tear Sheets | Existing Building Overview

Building typology is based on age, size, and rental/ownership structure.

A detailed snapshot of the baseline building conditions.

Decarbonization Roadmap for Multifamily Affordable Housing

post-war high-rise Mitchell-Lama

Based on the Marien Heim affordable housing project



tear sheet
2 / 5

This tear sheet shows packages of energy conservation measures that reduce a building's greenhouse gas emissions in an effort to achieve anticipated LL97 emissions limits and to move towards carbon neutrality.

existing building overview

location
Brooklyn, NY

dwelling units
182

building area
127,009 sq. ft

metering
gas: master
electricity: submetered

heating fuel
natural gas

heating system
two pipe steam with baseboards

cooling system
thru-wall A/Cs

ventilation system
rooftop exhaust fans

utility payment structure
heating: owner-paid
cooling: tenant-paid

Local Law 97
2030 emissions limits not compliant

be ex
building energy exchange

BRIGHT POWER

NEW YORK STATE
Supported

NYC
Department of Housing Preservation & Development

April 2023

Tear Sheets | Retrofit Packages

Details about the specific scope items, including costs and savings.

baseline building conditions		low carbon retrofit package		GHG savings	no carbon retrofit package		GHG savings					
<p>This post-war high-rise building has a brick masonry assembly, balconies, and no insulation. No connecting buildings makes it ideal for full envelope upgrades, especially insulated over-cladding. Natural gas heating and thru-wall ACs for cooling provide an opportunity for central VRF heat pumps. Master metered electric also makes the building a good candidate for solar on the roof.</p>		<p>Low Carbon improvements include new steam boilers and thru-wall ACs, an electric air source heat pump DHW system, rooftop post & rail solar PV, and LED lighting. Envelope upgrades include new roof insulation, windows and doors, air sealing measures, and optional above grade wall R-15 EIFS over-cladding that also covers the underside of the balconies. GHG savings for this scope of work are based on the 2030 emissions factor.</p>		<p>RELATIVE TO BASELINE BUILDING AND BASED ON THE 2030 EMISSIONS FACTOR</p>	<p>No Carbon improvements include all 2030 measures plus additional upgrades that may supersede some 2030 measures. These include central VRF heat pumps, stoves and dryers, and energy recovery ventilation resulting in whole building electrification. New high-performance windows and doors and optional above grade wall R-15 EIFS over-cladding upgrade the envelope. GHG savings for this scope of work are based on the 2050 emissions factor.</p>		<p>RELATIVE TO BASELINE BUILDING AND BASED ON THE 2050 EMISSIONS FACTOR</p>					
BUILDING SYSTEM	% OF GHG EMISSIONS	SYSTEM COMPONENTS	DESCRIPTION	ENERGY CONSERVATION MEASURES (ECMs)	ESTIMATED COST/DU*		ENERGY CONSERVATION MEASURES (ECMs)	ESTIMATED COST/DU*	ESTIMATED TOTAL COST/DU**	ESTIMATED TOTAL COST/DU**	ESTIMATED TOTAL COST/DU**	ESTIMATED TOTAL COST/DU**
envelope	n/a	Roof Insulation	Concrete deck, 2" rigid insulation	■ R-49 blown-in insulation	\$1,250	2%			\$1,250	0%***		
		Windows/Glazing	Aluminum, double hung	■ New aluminum, double hung, double pane, low-e, argon filled ■ New storefront/entry doors	\$6,650			■ New uPVC, thermally broken, casement windows & ENERGY STAR balcony doors	\$10,850		\$10,850	
		Air Sealing & Weatherization	Leaky windows & doors	■ Door & window weatherstripping	\$1,000				\$1,000			
		Above Grade Walls	Uninsulated brick wall assembly	+ Optional R-15 EIFS over-cladding, including underside of balconies	\$17,250			+ Optional R-15 EIFS over-cladding, including underside of balconies	\$17,250		\$17,250	
heating	63%	Heating	(2) Scotch Marine steam boilers with baseboards, outdoor air reset and pressure controls	■ New steam boilers with east/west zone valves ■ Heat Timer boiler controls with indoor temp feedback ■ Real Time Energy Management (RTEM)	\$3,350 \$500 \$2,000	24% +8% WITH R-15 EIFS OVER-CLADDING	■ Central VRF with rooftop units # T ■ RTEM via programmable thermostat	\$10,050 \$2,000	\$10,050 \$2,000	67%*** +0%*** WITH R-15 EIFS OVER-CLADDING		
		Cooling	Thru-wall ACs	■ New thru-wall ENERGY STAR ACs	\$2,000		(see above) VRFs also provide cooling					
		Pumps	0.75 hp single speed pump	■ No additional measures	\$0							
		Pipe Insulation	Piping mostly insulated	■ New pipe insulation	\$300							
		Ventilation	Common Area: passive Apartment, Bath, Kitchen; central exhaust fans	■ Direct drive, variable speed EC motor central exhaust fans with timers & CAR dampers	\$1,300		■ Central ERVs serving corridors # T ■ Central ERVs serving apartments # T	\$4,750	\$4,750		(see above)	
ductwork	17%	Ductwork	In-unit: leaky	■ Clean & seal ducts; conduct testing, adjusting, & balancing	(see above)							
		DHW	Tankless coils in steam boilers	■ Central air source heat pump (ASHP) with storage # T	\$6,450	16%	No additional recommended measures		\$6,450	20%***		
lighting	6%	Plumbing Fixtures	Standard flow fixtures	■ Low flow fixtures (WaterSense where applicable)	\$300				\$300			
		Common Area	Fluorescent/CFL/Incandescent	■ LEDs with occupancy/vacancy sensors	\$800	1%	No additional recommended measures		\$800	4%***		
		Exterior	Fluorescent/CFL/Incandescent	■ LEDs with photocells & timeclock	(see above)			(see above)				
In-unit	Fluorescent circline	■ LEDs	\$1,000		\$1,000							
appliances	14%	Appliances	Non-ENERGY STAR refrigerators Gas stoves	■ ENERGY STAR refrigerators	\$1,350	1%	■ Electric stoves # T	\$950	\$2,300	9%		
		Central Laundry	(4) Non-ENERGY STAR washers (4) Electric dryers	■ (4) ENERGY STAR washers	\$0 (per equipment lease agreement)		■ (4) Heat pump dryers # T	\$0	\$0		(per equipment lease agreement)	
renewables		None		■ 65kW post & rail rooftop solar PV system	\$1,700	2%	No additional recommended measures		\$1,700	0%		
		ASSOCIATED UPGRADES		⚡ electrical service and distribution upgrades ⚙ structural/finish upgrades including dunnage, patching, & sealing	\$1,600 \$10		⚡ electrical service and distribution upgrade ⚙ structural/finish upgrades including dunnage, patching, & sealing	\$6,750 \$4,200	\$8,350 \$4,210			
				2030 Emissions Factor The 2030 emissions factor reflects an electric grid powered 70% by renewable energy.	ESTIMATED TOTAL COST/DU \$31,560	46%	2050 Emissions Factor The 2050 emissions factor reflects a zero-emissions electric grid powered 100% by renewable energy.	ESTIMATED TOTAL COST/DU \$55,010	100%			
				ESTIMATED TOTAL COST/DU WITH R-15 EIFS OVER-CLADDING	\$48,810	54%	ESTIMATED TOTAL COST/DU WITH R-15 EIFS OVER-CLADDING	\$72,260	100%			

Tear Sheets | Carbon Emissions & Key Takeaways

For this Typology:

The Low Carbon retrofit package meets the 2035 limits but not 2040.

Phasing in electric heating before 2040 might be necessary.

Full electrification and comprehensive envelope upgrades would be needed to meet 2050 limits.

post-war high-rise Mitchell-Lama






source of carbon emissions	2030 emissions factor	2050 emissions factor
☹ electricity	█	(no emissions)
● fossil fuels	█	█



The Best Practices Manual







Summary | Performance of the Case Studies

The Low Carbon retrofit package helps all buildings meet 2035 limits and three buildings meet 2040 limits.

building typology	key takeaways	low carbon retrofit		no carbon retrofit		
		W/OUT EIFS	W/ EIFS	W/OUT EIFS	W/ EIFS	
1 post-1980 mid-rise senior rental  <p>LL97 path Prescriptive Pathway existing heating system gas-hydronic baseboards proposed heating system Packaged cold climate heat pump (PTHP)</p>	<p>Simple, freestanding, low-rise buildings can be a good fit for prefabricated Deep Energy Retrofit projects like RetrofitNY, but the high costs are an impediment; whereas the Low Carbon retrofit package would comply with LL97 2030 emissions limits. Adding PTHPs into existing AC sleeves, while retaining the existing gas/hydronic heating system, can provide cooling to vulnerable seniors while enabling a future cost-effective phase-out of fossil-fuels when the building is overclad and/or the boiler is converted to a heat pump.</p>	GHG Emissions Reductions	53%	65%	100%	100%
		Meets 2030 GHG limits?	✓	✓	✓	✓
		Meets 2035 GHG limits?	✓	✓	✓	✓
		Meets 2040 GHG limits*	✓	✓	✓	✓
		Estimated Cost per dwelling unit	\$38,360	\$48,360	\$56,050	\$66,050
		Estimated Savings per dwelling unit Owner / Tenant	\$320 / \$10	\$400 / \$50	\$95 / \$0	\$200 / \$10
		2 post-war high-rise Mitchell-Lama  <p>LL97 path 2035 Pathway existing heating system two-pipe steam with baseboards proposed heating system central VRF</p>	<p>Many Mitchell-Lamas (ML) have poorly performing steam systems and building envelopes, so the Low Carbon retrofit package, which would meet the 2035 emissions limits, may not meet the 2040 limits, leading to penalties within a 15-year financing cycle. However, by phasing in electric heating, after 2035, penalties could be avoided. Leaving the steam system in place provides a temporary backup, until the building can be fully electrified and insulated, before the 2050 deadline. As a master-metered building, this wouldn't cause a shift in heating costs to the tenants.</p>	GHG Emissions Reductions	46%	54%
Meets 2030 GHG limits?	✓			✓	✓	✓
Meets 2035 GHG limits?	✓			✓	✓	✓
Meets 2040 GHG limits*	■			■	✓	✓
Estimated Cost per dwelling unit**	\$31,560			\$48,810	\$55,010	\$72,260
Estimated Savings per dwelling unit Owner / Tenant	\$300 / \$125			\$350 / \$125	\$0 / \$100	\$50 / \$100
3 pre-war low-rise rent stabilized rental  <p>LL97 path Prescriptive Pathway existing heating system gas-hydronic convectors proposed heating system central ASHP & WSHP</p>	<p>Many low-rise rentals can electrify hydronic heating systems without significant tenant disruption. Because the Low Carbon retrofit package would comply with 2030 emissions limits, and electrifying heating will increase utility costs, these buildings should typically focus on insulation and air sealing to improve comfort and reduce utility costs. They should also consider electrifying cooking and/or installing mechanical ventilation to improve comfort and air quality in the near term and convert to electric heating when the boiler fails.</p>			GHG Emissions Reductions	59%	62%
		Meets 2030 GHG limits?	✓	✓	✓	✓
		Meets 2035 GHG limits?	✓	✓	✓	✓
		Meets 2040 GHG limits*	✓	✓	✓	✓
		Estimated Cost per dwelling unit**	\$42,050	\$55,850	\$82,650	\$96,450
		Estimated Savings per dwelling unit Owner / Tenant	\$425 / \$10	\$450 / \$25	-\$45 / \$80	\$25 / \$80
		4 pre-war low-rise HDFC co-op  <p>LL97 path Prescriptive Pathway existing heating system one-pipe steam radiators proposed heating system mini-split heat pumps</p>	<p>Low-rise co-ops are often a good fit for resident-paid, multi-split heat pumps because utility cost-shifting is not an issue for them; however, the Low Carbon retrofit package complies with 2030 emissions limits without electrifying heating, which would increase utility costs. Focusing on envelope improvements, ventilation, and electrification of cooking now can reduce utility costs while improving comfort and air quality. These buildings should develop a plan for future electrification, anticipating laws that will phase out fossil-fuel equipment.</p>	GHG Emissions Reductions	52%	57%
Meets 2030 GHG limits?	✓			✓	✓	✓
Meets 2035 GHG limits?	✓			✓	✓	✓
Meets 2040 GHG limits*	■			■	✓	✓
Estimated Cost per dwelling unit**	\$48,050			\$81,900	\$107,300	\$141,150
Estimated Savings per dwelling unit Owner / Tenant	\$225 / \$150			\$250 / \$150	-\$200 / \$200	-\$125 / \$200
5 post-1980 high-rise rental  <p>LL97 path Prescriptive Pathway existing heating system steam PTACs proposed heating system packaged cold climate heat pumps (PTHPs)</p>	<p>The Low Carbon retrofit package for high rise buildings complies with 2030 emissions limits, because improvements to the envelope and ventilation system can significantly reduce their energy use. Replacing steam PTACs with cold-climate PTHPs is a simple future retrofit project. Over-cladding, especially if it can offset LL11 costs, can yield additional savings and allow for conversions from exhaust-only ventilation to ERVs within the cavity behind the cladding.</p>			GHG Emissions Reductions	56%	58%
		Meets 2030 GHG limits?	✓	✓	✓	✓
		Meets 2035 GHG limits?	✓	✓	✓	✓
		Meets 2040 GHG limits*	✓	✓	✓	✓
		Estimated Cost per dwelling unit**	\$26,800	\$43,600	\$74,600	\$91,400
		Estimated Savings per dwelling unit Owner / Tenant	\$450 / \$400	\$475 / \$450	\$250 / \$300	\$275 / \$325

see pages 16-17 of the Manual

Building Systems | Benefits & Impacts

BUILDING SYSTEM	SYSTEM COMPONENT ¹	benefits				impacts				when to implement		
		GHG SAVINGS	COMFORT	HEALTH/IAQ	ENERGY COST SAVINGS	COSTS	LIFESPAN (YRS) ⁴	MAINTENANCE	TENANT DISRUPTION	NOW	MID-CYCLE	FUTURE REFI
 envelope	Roof Insulation	☆☆☆☆☆	low	low	\$\$\$\$\$	\$\$\$\$\$	20	medium	low	as needed	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Windows/Doors	☆☆☆☆☆	high	medium	\$\$\$\$\$	\$\$\$\$\$	20	medium	high	as needed	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Air Sealing & Weatherization ²	☆☆☆☆☆	high	medium	\$\$\$\$\$	\$\$\$\$\$	15	medium	low	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Exterior Wall Insulation	☆☆☆☆☆	high	medium	\$\$\$\$\$	\$\$\$\$\$	20	low	medium	if feasible	<input type="checkbox"/>	<input checked="" type="checkbox"/>
 HVAC	Heating System Upgrades ²	☆☆☆☆☆	medium	medium	\$\$\$\$\$	\$\$\$\$\$	10–20	medium	low	per HPD guidelines ⁵	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Electrify Heating	☆☆☆☆☆	high	high	\$\$\$\$\$	\$\$\$\$\$	15	medium	high	per HPD guidelines ⁵	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Pipe Insulation ²	☆☆☆☆☆	medium	low	\$\$\$\$\$	\$\$\$\$\$	15	low	low	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Ventilation Upgrades	☆☆☆☆☆	medium	high	\$/\$\$\$\$\$ (ERV)	\$\$\$\$\$	15	medium/ high (ERV)	high	per HPD guidelines ⁵	<input type="checkbox"/>	<input checked="" type="checkbox"/>
 domestic hot water	Electrify Hot Water Heating	☆☆☆☆☆	low	high	\$\$\$\$\$	\$\$\$\$\$	10	medium	low	per HPD guidelines ⁵	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Plumbing Fixture Upgrades	☆☆☆☆☆	low	low	\$\$\$\$\$	\$\$\$\$\$	10	low	low	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 lighting	Common Area & Exterior Upgrades ²	☆☆☆☆☆	low	medium	\$\$\$\$\$	\$\$\$\$\$	15–20	low	low	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	In-Unit Upgrades	☆☆☆☆☆	low	medium	\$\$\$\$\$	\$\$\$\$\$	15–20	low	medium	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 plug loads	Appliance Upgrades	☆☆☆☆☆	low	low	\$\$\$\$\$	\$\$\$\$\$	15	low	medium	as needed	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Electrify Cooking	☆☆☆☆☆	medium	high	\$\$\$\$\$	\$\$\$\$\$	10	low	high	per HPD guidelines ⁵	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	Electrify Laundry	☆☆☆☆☆	low	medium	\$\$\$\$\$	\$\$\$\$\$	10	medium	low	as needed	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
 renewables	Solar PV ³	☆☆☆☆☆	low	low	\$\$\$\$\$	\$\$\$\$\$	20–25	low	low	per HPD SWF ³	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

see pages 6-7
of the Manual

Key Considerations | Costs

Costs are high compared to “business as usual.”

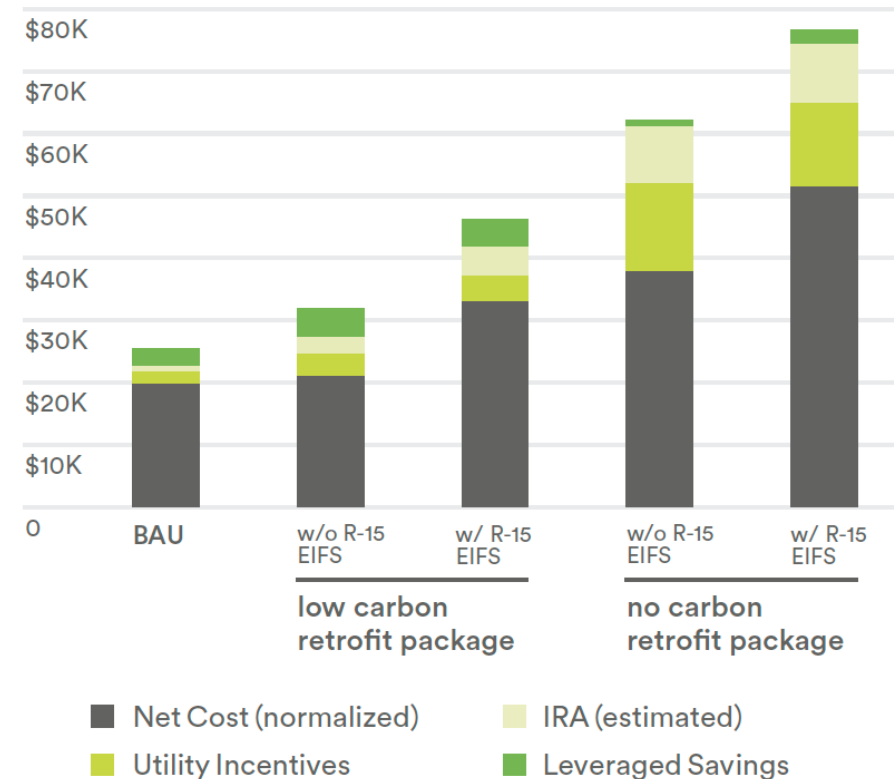
Energy savings alone do not make up the difference.

Costs can be partially offset by leveraging:

- incentives
- energy savings
- other life cycle costs

The net costs are not that different from business as usual.

Scope Cost Comparison: Full Cost vs. Net Cost (per apt.)



see pages 20-21 of the Manual

Key Considerations | Utility Policies

HPD is working through these barriers with the Retrofit Electrification Pilot.

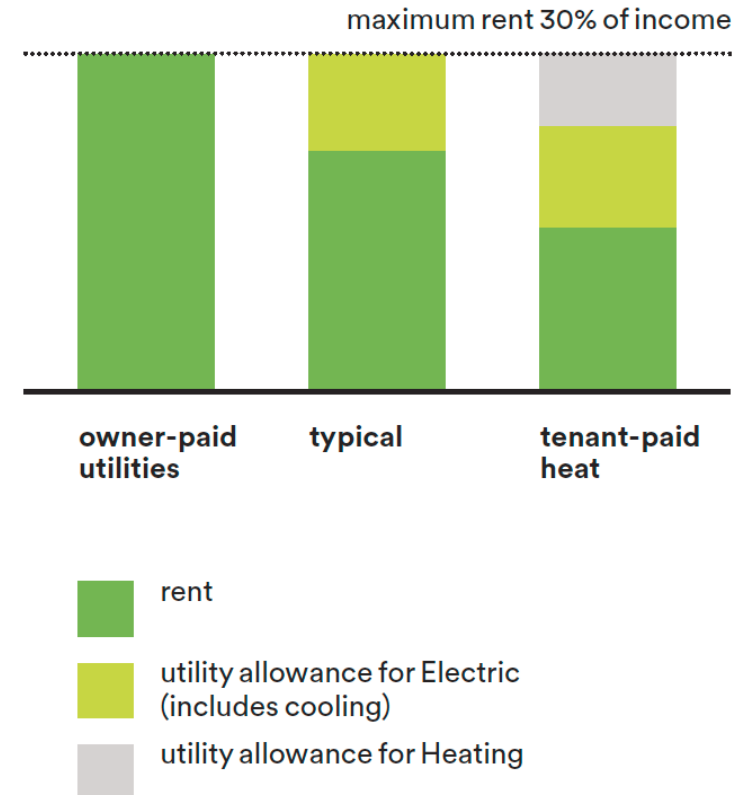
Utility Challenges:

- Rates are high, especially for electricity
- “The Split Incentive Problem”
- Difficulty around cost shifting

What HPD is doing:

- Electric Heating Policy
- Utility allowances to support electrification
- M&O Standards for electrification

Rent and Utility Allowances



see pages 18-19 of the Manual

Key Considerations | Phasing

This assumes all buildings will ultimately need to be fossil fuel free.

Example Phased Scenarios

The following scenarios demonstrate how different buildings may consider phasing based on LL97 requirements, heating system type, or other capital needs:

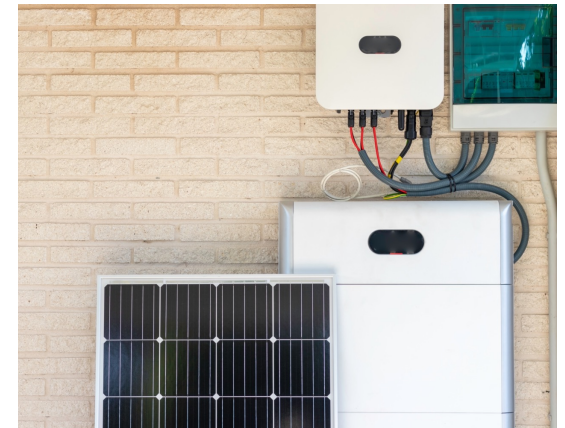
	What to do now: →	What to do next: →	What to do at refinancing:
Project subject to the 2035 Pathway where electrification isn't financially viable	Implement a Low Carbon Retrofit Package	Phase in or partially electrify heating ahead of the 2040 compliance deadline	Insulate and ventilate building, and decommission (remove) existing fossil fuel system before 2050 compliance deadline.
Buildings with oil or electric resistance heat	Implement a No Carbon Retrofit Package	Replace electric equipment in kind as needed	Replace systems as needed and overclad if economics allow
Buildings with gas-hydraulic heating where electrification isn't financially viable	Implement a Low Carbon Retrofit Package	If boiler fails, replace with minimally disruptive central heat pump to comply with new laws	Insulate building & add ventilation
Buildings needing significant facade work, e.g. to comply with LL11	Implement a Low Carbon w/ EIFS Retrofit Package	Maintain boiler until refinancing	At system end of life: Refinance and electrify heating system

see pages 20-21 of the Manual

Looking Forward

Innovation – in the form of **better hardware, better software, and integrated solutions** – is needed to achieve these goals at scale.

NYCHA has been piloting innovative technologies such as window heat pumps.



see pages 22
of the Manual

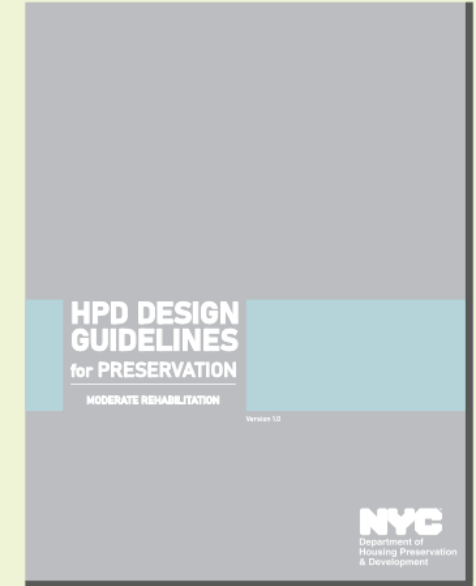
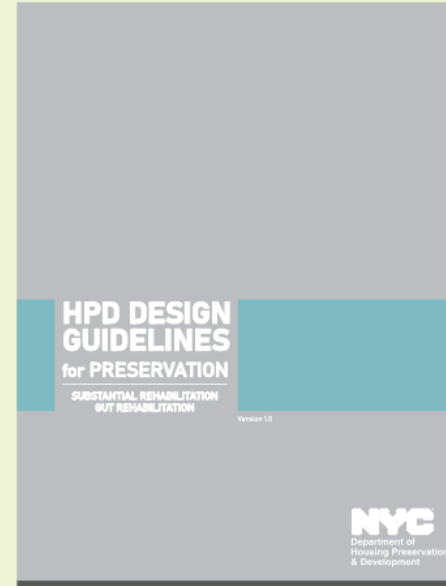
Taking Action

Taking Action | Beyond Carbon

In addition to meeting New York's ambitious climate goals, building decarbonization has many benefits:

- Improves local air quality
- Contributes to safety and comfort
- Reduces utility costs
- Increases the resiliency of both building and grid

HPD's new Design Guidelines address LL97 compliance as well as health, safety, and resiliency.



see pages 23
of the Manual

Taking Action | A Roadmap for Decarbonization



see pages 23
of the Manual

Questions?



<https://be-exchange.org/report/hpd-ll97-decarbonization-roadmap/>