

Building Segment-Specific Packages of Energy Conservation Measures

Turning Data Into Action



building
energy
exchange

Report Partners:

BRIGHT POWER

sustainable
energy
partnerships

Introduction

These tearsheets have been created to make New York City building energy audit data actionable. The authors have organized the massive dataset of multifamily building energy use and auditor recommendations into digestible packages that will enable building decision makers to better understand their options at critical milestones.

To create these resources New York City's diverse portfolio of multifamily buildings has been divided into 12 major building segments with similar characteristics, such as age, height, and fuel type. A list of energy conservation measure (ECM) opportunities was generated, for each segment, based on the New York City LL87 Energy Audit Data and refined with the input of expert opinion. From this information, the authors developed specific tearsheets for 11 of the segments featuring “packages” of ECMs. Each tearsheet also suggests the optimal time to implement each ECM within a building’s financial lifecycle.

In addition to key touchpoints during a building’s lifecycle, the authors have identified two other important milestones when there is a unique opportunity to implement energy efficiency measures. One is during tenant turnover, when owners have an easier opportunity to address issues within a unit. The second is when a major piece of equipment must be replaced because it has failed or reached the end of its useful life.

The final tearsheet in this package details opportunities available at this time.

The cost, energy savings, and payback of individual ECMs were derived from the LL87 data. In a few rare cases, relevant ECMs not captured in the LL87 data were added to individual tearsheets. In these cases, costs, energy savings, and payback were derived from expert opinion and analysis. Full package costs, savings, and payback have been calculated based on the expectation that an “Anytime/Anywhere” retrofit can deliver 5% energy savings, “Midcycle” retrofits can deliver 10% energy savings, and “Refi” retrofits can deliver 30% energy savings. The authors used these savings assumption as well as fuel costs derived from NYC multifamily building EnergyScoreCards to calculate potential monetary savings and costs of each package of ECMs at each touchpoint.

This resource is designed to guide and inspire building owners and managers in their pursuit of energy efficiency retrofits.

A deeper explanation of these tearsheets, along with additional analysis of LL87 data, can be found in the full-length report, *Turning Data into Action*.

Additional Information

This resource is part of the full length report, *Turning Data into Action*, which can be found on the Building Energy Exchange website.

This report is made possible by the generous support of Energy Efficiency for All and National Grid.

Table of Contents

The tearsheets are ordered from the segment with the greatest potential energy savings opportunity to the segment with the least potential energy savings opportunity.

- Post-war gas low-rise
- Post-war oil
- Pre-war gas low-rise
- Post-war gas high-rise
- Pre-war oil low-rise
- Post-1980 gas high-rise
- Pre-war oil high-rise
- Post-1980 gas low-rise
- Pre-war gas high-rise
- District steam
- All electric
- Equipment replacement

retrofit packages: post-war gas low-rise

This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1947–1979
Height	7 stories or fewer
Facade	Masonry
Heating System	Hydronic or two pipe steam
Heating Fuel	Gas or dual fuel
Ventilation System	Central ventilation and natural ventilation
Cooling	Through-wall or window ACs

Segment Characteristics

Size	1,032 properties; 152,966,300 square feet
Area	9% of all covered multifamily buildings
Potential Savings	12% of all potential GHG reduction



Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$14,560	\$70,000	\$418,000	
Savings	\$5,200	\$10,000	\$31,000	
ROI	2.8	7.0	13.5	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
Install Exhaust Fan Timers	•	•	•		5.0	\$	
Install Submetering		•	•		2.0	\$\$\$	
Install Solar/Photovoltaic			•		17.0	\$\$\$\$	
Upgrade Motors		•	•		5.5	\$\$	
Upgrade Lights		•	•		2.5	\$	
Install Lighting Sensors		•	•		4.0	\$	
Upgrade Burner			•		6.5	\$\$	
Upgrade Boiler			•		>20	\$\$\$\$	
Install TRVs and Zone Control		•	•		6.5	\$\$\$	
Install Heating Controls and Thermostats		•	•		2.5	\$\$	
Insulate Condensate Tank	•	•	•		2.5	\$	
Replace or Repair Steam Traps	•	•	•		3.5	\$\$	
Insulate Pipes	•	•	•		2.0	\$	
Install or Upgrade Master Venting		•	•		3.0	\$\$	
Replace Windows and Glazing			•		>20	\$\$\$\$	
Increase Wall Insulation			•		>20	\$\$\$\$	
Increase Roof Insulation			•		>20	\$\$\$\$	
Complete Air sealing	•	•	•	•	6.0	\$\$	
Separate DHW from Heating			•		6.5	\$\$\$	
Install Low-Flow Showerheads	•	•	•	•	1.0	\$\$	
Install DHW Controls	•	•	•		0.5	\$	
Install Low Flow Aerators	•	•	•	•	1.5	\$\$	
Insulate Pipes and Tank	•	•	•		6.0	\$	

Energy Conservation Measure	Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
Ventilation & Cooling	\$ <\$.05	0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
Other	\$ \$ \$0.05-\$0.25	3.1-8	
Lighting	\$ \$ \$ \$0.26-\$1.00	8.1-12	
Heating Equipment	\$ \$ \$ \$ >\$1.00	>12	

retrofit packages: post-war oil

This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1947-present
Height	Any height
Façade	Masonry
Heating System	Hydronic or two-pipe steam
Heating Fuel	Oil or dual fuel
Ventilation System	Central ventilation and natural ventilation
Cooling	Through-wall or window ACs

Segment Characteristics

Size	892 properties; 165,298,145 square feet
Area	10% of all covered multifamily buildings
Potential Savings	13% of all potential GHG reduction



Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$18,260	\$85,000	\$525,000	
Savings	\$8,300	\$17,000	\$50,000	
ROI	2.2	5.0	10.5	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
Upgrade Exhaust Fans			•		9.5	\$\$\$	
Install Exhaust Fan Timers	•	•	•		1.0	\$	
Install Submetering		•	•		4.0	\$\$\$	
Install Solar/Photovoltaic			•		18.0	\$\$\$	
Upgrade Motors		•	•		4.5	\$	
Install VFDs		•	•		4.0	\$\$	
Upgrade Lights		•	•		3.0	\$	
Install Lighting Sensors		•	•		4.0	\$\$	
Upgrade Burner			•		4.5	\$\$\$\$	
Upgrade Boiler			•		6.5	\$\$\$\$	
Install TRVs and Zone Control		•	•		3.5	\$\$\$	
Install Heating Controls and Thermostats		•	•		1.5	\$\$	
Insulate Condensate Tank	•	•	•		2.5	\$	
Replace or Repair Steam Traps	•	•	•		3.5	\$\$	
Repair Leaks	•	•	•		0.5	\$	
Insulate Pipes	•	•	•		2.0	\$	
Replace Windows and Glazing			•		>20	\$\$\$\$	
Increase Roof Insulation		•	•		7.5	\$\$\$	
Complete Air sealing	•	•	•	•	3.0	\$	
Upgrade DHW Boiler		•	•		11.5	\$\$\$	
Separate DHW from Heating			•		3.5	\$\$\$	
Install Low Flow Showerheads	•	•	•	•	2.5	\$\$	
Install DHW Controls	•	•	•		1.0	\$	
Install Low Flow Aerators	•	•	•	•	0.5	\$\$	
Insulate Pipes and Tank	•	•	•		4.0	\$	

Energy Conservation Measure		Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
Ventilation & Cooling	Heating Distribution	\$ <\$.05	0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
Other	Envelope	\$\$ \$0.05-\$0.25	3.1-8	
Lighting	Domestic Hot Water	\$\$\$ \$0.26-\$1.00	8.1-12	
Heating Equipment		\$\$\$\$ >\$1.00	>12	

retrofit packages: pre-war gas low-rise



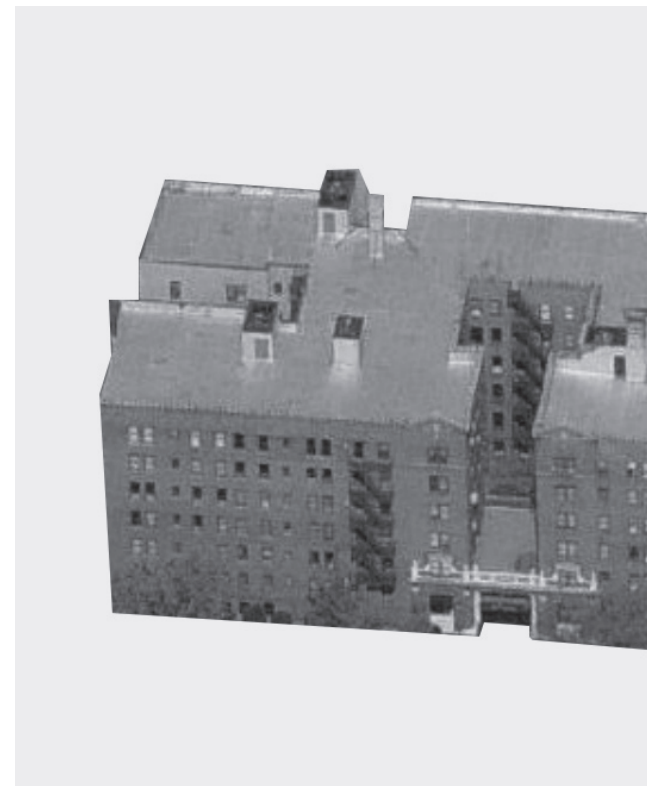
This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1947 or earlier
Height	7 stories or fewer
Size	100-500 units, up to 500,000 SF
Façade	Masonry
Construction	Masonry
Heating System	Steam (one or two pipe) or hydronic (if renovated)
Heating Fuel	Gas or dual fuel
Ventilation System	Natural
Cooling	Window ACs

Segment Characteristics















































Size	1,644 properties; 171,654,600 square feet
Area	9% of all covered multifamily buildings
Potential Savings	11% of all potential GHG reduction














Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$13,720	\$70,000	\$391,000	
Savings	\$4,900	\$10,000	\$29,000	
ROI	2.8	7.0	13.5	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
 Upgrade Exhaust Fans			•		6.5	\$	
 Install VFDs		•	•		3.5	\$\$	
 Upgrade Motors		•	•		7.5	\$\$	
 Install Solar/Photovoltaic			•		19.5	\$\$\$\$	
 Install Lighting Sensors		•	•		5.0	\$\$	
 Upgrade Lights		•	•		3.0	\$\$	
 Upgrade Burner			•		5.5	\$\$\$	
 Upgrade Boiler			•		4.5	\$	
 Insulate Condensate Tank	•	•	•		4.5	\$	
 Install or Upgrade Master Venting	•	•	•		1.0	\$\$	
 Install TRVs and Zone Control		•	•		7.0	\$\$\$	
 Install Heating Controls and Thermostats		•	•		2.5	\$\$	
 Insulate Pipes	•	•	•		2.0	\$	
 Replace Exterior Door			•		4.5	\$	
 Increase Wall Insulation			•		>20	\$\$\$\$	
 Replace Windows and Glazing			•		>20	\$\$\$\$	
 Increase Roof Insulation			•		>20	\$\$\$\$	
 Complete Air Sealing	•	•	•	•	4.0	\$\$	
 Insulate Pipes and Tank	•	•	•		4.0	\$	
 Install DHW Controls	•	•	•		0.5	\$	
 Install Low Flow Showerheads	•	•	•	•	1.5	\$	
 Separate DHW from Heating			•		6.5	\$\$\$	
 Install Low Flow Aerators	•	•	•	•	1.5	\$\$	

Energy Conservation Measure		Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
 Ventilation & Cooling	 Heating Distribution	\$ <\$.05	 0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
 Other	 Envelope	\$\$ \$0.05-\$0.25	 3.1-8	
 Lighting	 Domestic Hot Water	\$\$\$ \$0.26-\$1.00	 8.1-12	
 Heating Equipment		\$\$\$\$ >\$1.00	 >12	

retrofit packages: post-war gas high-rise



This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1947-1979
Height	8 stories or greater
Size	100-500 units, up to 500,000 SF
Façade	Masonry
Construction	Steel frame
Heating System	Hydronic or two-pipe steam
Heating Fuel	Gas or dual fuel
Ventilation System	Central ventilation and natural ventilation
Cooling	Through-wall or window ACs

Segment Characteristics

Size	425 properties; 121,987,481 square feet
Area	7% of all covered multifamily buildings
Potential Savings	9% of all potential GHG reduction



Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$14,500	\$72,000	\$420,000	
Savings	\$5,800	\$12,000	\$35,000	
ROI	2.5	6.0	12.0	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
Install Exhaust Fan Timers	•	•	•		2.0	\$	
Install CAR Dampers			•		5.5	\$	
Replace Washing Machines		•			10.0	\$	
Install VFDs	•	•	•		1.5	\$\$	
Upgrade Motors			•		18.5	\$\$	
Install Lighting Sensors		•	•		3.0	\$\$	
Upgrade Lights		•	•		5.0	\$\$	
Upgrade Burner			•		5.0	\$\$\$	
Upgrade Boiler			•		13.5	\$\$\$\$	
Install TRVs and Zone Control			•		6.0	\$\$\$	
Install Heating Controls and Thermostats		•	•		4.0	\$\$	
Insulate Pipes	•	•	•		1.5	\$	
Replace or Repair Steam Traps	•	•	•		3.5	\$\$	
Replace Windows and Glazing			•		>20	\$\$\$\$	
Increase Roof Insulation		•	•		9.5	\$\$	
Complete Air Sealing		•	•	•	5.0	\$\$	
Insulate Pipes and Tank	•	•	•		2.0	\$	
Install DHW Controls	•	•	•		0.5	\$	
Install Low Flow Aerators	•	•	•	•	2.0	\$\$	
Separate DHW from Heating			•		5.5	\$\$\$	
Install Low Flow Showerheads	•	•	•	•	1.5	\$	

Energy Conservation Measure	Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
Ventilation & Cooling	\$ <\$.05	0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
Other	\$ \$ \$0.05-\$0.25	3.1-8	
Lighting	\$ \$ \$ \$0.26-\$1.00	8.1-12	
Heating Equipment	\$ \$ \$ \$ >\$1.00	>12	

retrofit packages: pre-war oil low-rise



This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1947 or earlier
Height	7 stories or fewer
Size	100-500 units, up to 500,000 SF
Façade	Masonry
Construction	Masonry
Heating System	Steam (one or two pipe) or hydronic (if renovated)
Heating Fuel	Oil or dual fuel
Ventilation System	Natural
Cooling	Window ACs in unit

Segment Characteristics

Size	1123 properties; 109,938,745 square feet
Area	7% of all covered multifamily buildings
Potential Savings	11% of all potential GHG reduction



Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$19,580	\$90,000	\$567,000	
Savings	\$8,900	\$18,000	\$54,000	
ROI	2.2	5.0	10.5	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
○ Upgrade Motors			●		4.0	\$\$	■
○ Replace Washing Machines		●			5.5	\$	■
○ Install Solar/Photovoltaic			●		>20	\$\$\$\$	■
☀️ Install Lighting Sensors		●	●		4.5	\$	■
☀️ Upgrade Lights		●	●		3.0	\$	■
🔧 Upgrade Burner			●		2.0	\$\$\$	■
🔧 Upgrade Boiler			●		8.0	\$\$\$\$	■
Insulate Condensate Tank	●	●	●		1.5	\$\$\$	■
Install TRVs and Zone Control		●	●		2.5	\$\$\$	■
Install Heating Controls and Thermostats		●	●		1.5	\$\$\$	■
Insulate Pipes	●	●	●		1.0	\$	■
🏠 Replace Exterior Door			●		6.0	\$	■
🏠 Increase Wall Insulation			●		14.0	\$\$\$\$	■
🏠 Increase Roof Insulation		●	●		15.0	\$\$\$	■
🏠 Replace Windows and Glazing			●		>20	\$\$\$\$	■
🏠 Complete Air sealing		●	●	●	2.0	\$	■
💧 Install Low Flow Showerheads	●	●	●	●	1.5	\$\$	■
💧 Insulate Pipes and Tank	●	●	●		2.0	\$	■
💧 Install DHW Controls	●	●	●		1.0	\$	■
💧 Separate DHW from Heating			●		4.0	\$\$\$	■
💧 Install Low Flow Aerators	●	●	●	●	1.0	\$\$	■

Energy Conservation Measure

- 🌀 Ventilation & Cooling
- Other
- ☀️ Lighting
- 🔧 Heating Equipment

- |||| Heating Distribution
- 🏠 Envelope
- 💧 Domestic Hot Water

Cost per Square Foot

\$	<\$.05
\$\$	\$0.05-\$0.25
\$\$\$	\$0.26-\$1.00
\$\$\$\$	>\$1.00

Energy Savings per SF (kBtu)

■	0-3
■	3.1-8
■	8.1-12
■	>12

Notes

This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.

retrofit packages: post-1980 gas high-rise



This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1980 or later
Height	8 stories or greater
Size	30-500 units, up to 500,000 SF
Façade	Masonry or glass curtain wall
Construction	Steel frame
Heating System	Hydronic or two-pipe steam
Heating Fuel	Gas or dual fuel
Ventilation System	Central ventilation and natural ventilation
Cooling	Through-wall or window ACs

Segment Characteristics

Size	695 properties; 135,392,326 square feet
Area	8% of all covered multifamily buildings
Potential Savings	6% of all potential GHG reduction



Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$15,120	\$77,000	\$432,000	
Savings	\$5,400	\$11,000	\$32,000	
ROI	2.8	7.0	13.5	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
🌀 Install CAR Dampers		•	•		3.0	\$\$	█
🌀 Replace/Upgrade Packaged Units			•		>20	\$\$\$	█
🌀 Install Exhaust Fan Timers	•	•	•		0.5	\$	█
🌀 Install Cogeneration Plant		•	•		8.5	\$\$\$\$	█
🌀 Install VFDs		•	•		6.0	\$\$\$	█
🌟 Upgrade Exterior Lighting		•	•		1.5	\$	█
🌟 Install Lighting Sensors		•	•		2.5	\$	█
🌟 Upgrade Lights		•	•		3.5	\$\$	█
🏠 Upgrade Boiler			•		>20	\$\$\$\$	█
🔥 Install TRVs and Zone Control		•	•		11.5	\$\$\$	█
🔥 Upgrade Pumps		•	•		4.0	\$\$	█
🔥 Replace or Repair Steam Traps	•	•	•		3.5	\$\$	█
🔥 Insulate Pipes	•	•	•		2.0	\$	█
🔥 Install Heating Controls and Thermostats		•	•		2.5	\$\$\$	█
🏠 Replace Windows and Glazing			•		>20	\$\$\$\$	█
🏠 Complete Air sealing		•	•	•	3.5	\$\$	█
💧 Insulate Pipes and Tank	•	•	•		3.5	\$	█
💧 Separate DHW from Heating			•		18.5	\$\$\$	█
💧 Install DHW Controls	•	•	•		1.0	\$	█
💧 Upgrade DHW Boiler			•		16.5	\$\$\$	█
💧 Install Low Flow Aerators	•	•	•	•	1.0	\$\$	█
💧 Install Low Flow Showerheads	•	•	•	•	4.5	\$	█

Energy Conservation Measure	Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
🌀 Ventilation & Cooling	\$ <\$.05	█ 0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
🌀 Other	\$\$ \$0.05-\$0.25	█ 3.1-8	
🌟 Lighting	\$\$\$ \$0.26-\$1.00	█ 8.1-12	
🏠 Heating Equipment	\$\$\$\$ >\$1.00	█ >12	
🔥 Heating Distribution			
🏠 Envelope			
💧 Domestic Hot Water			

retrofit packages: pre-war oil high-rise



This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1947 or earlier
Height	8 stories or greater
Façade	Masonry
Heating System	Steam (one or two pipe) or hydronic (if renovated)
Heating Fuel	Oil or dual fuel
Ventilation System	Natural
Cooling	Window ACs in unit

Segment Characteristics





















































Size	629 properties; 99,504,093 square feet
Area	6% of all covered multifamily buildings
Potential Savings	7% of all potential GHG reduction














Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$18,250	\$90,000	\$528,000	
Savings	\$7,300	\$15,000	\$44,000	
ROI	2.5	6.0	12.0	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
 Install Exhaust Fan Timers	•	•	•		1.5	\$	
 Install CAR Dampers			•		10.5	\$\$	
 Replace/Upgrade Packaged Units		•	•		9.5	\$\$	
 Install Submetering		•	•		3.0	\$\$\$	
 Install VDFs		•	•		4.5	\$\$	
 Install Solar/Photovoltaic		•	•		17.5	\$\$\$	
 Upgrade Motors			•		5.0	\$\$	
 Upgrade Exterior Lighting		•	•		3.5	\$	
 Install Lighting Sensors		•	•		3.5	\$	
 Upgrade Lights		•	•		3.0	\$\$	
 Upgrade Burner			•		6.5	\$\$\$	
 Upgrade Boiler			•		9.0	\$\$\$\$	
 Replace or Repair Steam Traps	•	•	•		4.5	\$\$	
 Insulate Condensate Tank	•	•	•		2.0	\$	
 Install TRVs and Zone Control		•	•		4.0	\$\$\$	
 Install Heating Controls and Thermostats		•	•		2.0	\$\$	
 Insulate Pipes	•	•	•		2.5	\$	
 Increase Wall Insulation			•		12.5	\$\$\$	
 Increase Roof Insulation			•		16.5	\$\$\$	
 Replace Windows and Glazing			•		>20	\$\$\$\$	
 Complete Air sealing		•	•	•	9.0	\$\$	
 Install Low Flow Showerheads	•	•	•	•	2.0	\$\$	
 Install DHW Controls	•	•	•		1.0	\$	
 Insulate Pipes and Tank	•	•	•		3.0	\$	
 Install Low Flow Aerators	•	•	•	•	1.5	\$\$	
 Separate DHW from Heating			•		4.5	\$\$\$	

Energy Conservation Measure		Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
 Ventilation & Cooling	 Heating Distribution	\$ <\$0.05	 0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
 Other	 Envelope	\$\$ \$0.05-\$0.25	 3.1-8	
 Lighting	 Domestic Hot Water	\$\$\$ \$0.26-\$1.00	 8.1-12	
 Heating Equipment		\$\$\$\$ >\$1.00	 >12	

retrofit packages: post-1980 gas low-rise



This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1980 or later
Height	7 stories or fewer
Façade	Masonry or glass curtain wall
Construction	Concrete block, plans, or poured
Heating System	Hydronic, heat pump, or PTAC
Heating Fuel	Gas or dual fuel
Ventilation System	Central ventilation
Cooling	Central chiller, heat pumps with common area cooling, window ACs, or through wall ACs

Segment Characteristics

Size	474 properties; 5,955,4267 square feet
Area	4% of all covered multifamily buildings
Potential Savings	3% of all potential GHG reduction



Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$14,280	\$70,000	\$418,000	
Savings	\$5,100	\$10,000	\$31,000	
ROI	2.8	7.0	13.5	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
🌀 Replace/Upgrade AC Units		•	•		6.0	\$\$\$	■
○ Install Solar/Photovoltaic			•		15.0	\$\$\$\$	■
○ Install VFDs		•	•		3.0	\$\$	■
☀️ Install Lighting Sensors		•	•		3.0	\$	■
☀️ Upgrade Exterior Lighting		•	•		4.0	\$	■
☀️ Upgrade Lights		•	•		3.0	\$\$	■
🔧 Upgrade Boiler			•		>20	\$\$\$\$	■
🔧 Install TRVs and Zone Control		•	•		6.5	\$\$	■
🔧 Install Heating Controls and Thermostats		•	•		1.5	\$\$	■
🔧 Insulate Pipes	•	•	•		2.5	\$	■
🏠 Add Window Films		•	•		>20	\$\$\$	■
🏠 Increase Wall Insulation			•		>20	\$\$\$\$	■
🏠 Increase Roof Insulation			•		>20	\$\$\$	■
🏠 Replace Windows and Glazing			•		>20	\$\$\$\$	■
🏠 Complete Air Sealing		•	•	•	6.5	\$\$	■
🔧 Separate DHW from Heating			•		15.5	\$\$\$	■
🔧 Insulate Pipes and Tank		•	•		11.5	\$	■
🔧 Install DHW Controls	•	•	•		0.5	\$	■
🔧 Install Low-Flow Showerheads	•	•	•	•	4.0	\$\$	■
🔧 Install Low Flow Aerators	•	•	•	•	1.5	\$\$	■

Energy Conservation Measure

- 🌀 Ventilation & Cooling
- Other
- ☀️ Lighting
- 🔧 Heating Equipment

- 🔧 Heating Distribution
- 🏠 Envelope
- 🔧 Domestic Hot Water

Cost per Square Foot

- \$ <\$.05
- \$\$ \$0.05-\$0.25
- \$\$\$ \$0.26-\$1.00
- \$\$\$\$ >\$1.00

Energy Savings per SF (kBtu)

- 0-3
- 3.1-8
- 8.1-12
- >12

Notes

This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.

retrofit packages: pre-war gas high-rise



This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	1947 or earlier
Height	8 stories or greater
Façade	Masonry
Heating System	Steam (one or two pipe) or hydronic (if renovated)
Heating Fuel	Gas or dual fuel
Ventilation System	Natural
Cooling	Window ACs

Segment Characteristics

Size	404 properties; 65,699,959 square feet
Area	4% of all covered multifamily buildings
Potential Savings	3% of all potential GHG reduction


























































Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$13,720	\$70,000	\$391,500	
Savings	\$4,900	\$10,000	\$29,000	
ROI	2.8	7.0	13.5	

All costs and savings reflect a 100 unit, 100,000 SF building

Building Touchpoint

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
 Install Exhaust Fan Timers	•	•	•		0.5	\$	
 Install CAR Dampers			•		5.0	\$\$\$	
 Upgrade Motors			•		11.5	\$\$	
 Install VFDs		•	•		3.0	\$\$	
 Upgrade Exterior Lighting		•	•		5.5	\$	
 Install Lighting Sensors		•	•		3.5	\$\$	
 Upgrade Lights		•	•		4.0	\$\$	
 Upgrade Burner			•		2.0	\$\$\$	
 Upgrade Boiler			•		17.5	\$\$\$\$	
 Replace or Repair Steam Traps		•	•		1.5	\$\$	
 Insulate Condensate Tank	•	•	•		3.0	\$	
 Install TRVs and Zone Control		•	•		6.0	\$\$\$	
 Install Heating Controls and Thermostats		•	•		2.5	\$\$	
 Insulate Pipes	•	•	•		3.0	\$	
 Increase Roof Insulation			•		>20	\$\$\$	
 Replace Windows and Glazing			•		>20	\$\$\$\$	
 Complete Air sealing		•	•	•	4.0	\$	
 Install Low Flow Showerheads	•	•	•	•	0.5	\$	
 Install DHW Controls	•	•	•		0.5	\$	
 Insulate Pipes and Tank	•	•	•		7.0	\$	
 Separate DHW from Heating			•		6.5	\$\$\$	
 Install Low Flow Aerators	•	•	•	•	1.5	\$\$	

Energy Conservation Measure		Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
 Ventilation & Cooling	 Heating Distribution	\$ <\$.05	 0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
 Other	 Envelope	\$\$ \$0.05-\$0.25	 3.1-8	
 Lighting	 Domestic Hot Water	\$\$\$ \$0.26-\$1.00	 8.1-12	
 Heating Equipment		\$\$\$\$ >\$1.00	 >12	

retrofit packages: district steam

This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	Anytime, generally pre- or post war
Height	Any height
Façade	Masonry or curtain wall
Heating System	Two-pipe steam or hydronic with steam-to-water heat exchanger
Heating Fuel	District steam
Ventilation System	Central ventilation
Cooling	Natural or central ventilation systems

Segment Characteristics

Size	272 properties; 66,781,990 square feet
Area	4% of all covered multifamily buildings
Potential Savings	2% of all potential GHG reduction



Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$19,800	\$80,000	\$531,000	
Savings	\$9,900	\$20,000	\$59,000	
ROI	2.0	4.0	9.0	

All costs and savings reflect a 100 unit, 100,000 SF building

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
☰ Install Exhaust Fan Timers	•	•	•		1.5	\$	■
○ Install Submetering		•	•		1.5	\$\$	■
○ Replace Washing Machines	•	•			2.5	\$	■
○ Upgrade Motors		•	•		5.0	\$\$	■
○ Install VFDs		•	•		3.0	\$\$	■
☀ Upgrade Exterior Lighting		•	•		3.5	\$	■
☀ Install Sensors		•	•		2.5	\$	■
☀ Upgrade Lights		•	•		2.5	\$\$	■
☑ Convert Off District Steam			•		6.0	\$\$\$\$	■
Replace or repair Steam Traps		•	•		6.0	\$\$	■
Install TRVs and Zone Control		•	•		4.5	\$\$	■
Install Heating Controls and Thermostats		•	•		1.5	\$\$	■
Insulate Pipes	•	•	•		3.0	\$	■
🏠 Replace Windows and Glazing			•		>20	\$\$\$	■
🏠 Complete Air sealing	•	•	•	•	3.0	\$	■
💧 Install DHW Controls	•	•	•		0.5	\$	■
💧 Recover Heat from Utility Steam			•		1.5	\$\$	■
💧 Separate DHW from Heating			•		2.5	\$\$\$	■
💧 Insulate Pipes and Tank	•	•	•		1.0	\$\$	■
💧 Install Low Flow Aerators	•	•	•	•	1.5	\$\$	■
💧 Install Low Flow Showerheads	•	•	•	•	1.5	\$\$	■

Energy Conservation Measure		Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
☰ Ventilation & Cooling	Heating Distribution	\$ <\$.05	■ 0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
○ Other	🏠 Envelope	\$\$ \$0.05-\$0.25	■ 3.1-8	
☀ Lighting	💧 Domestic Hot Water	\$\$\$ \$0.26-\$1.00	■ 8.1-12	
☑ Heating Equipment		\$\$\$\$ >\$1.00	■ >12	

retrofit packages: all electric

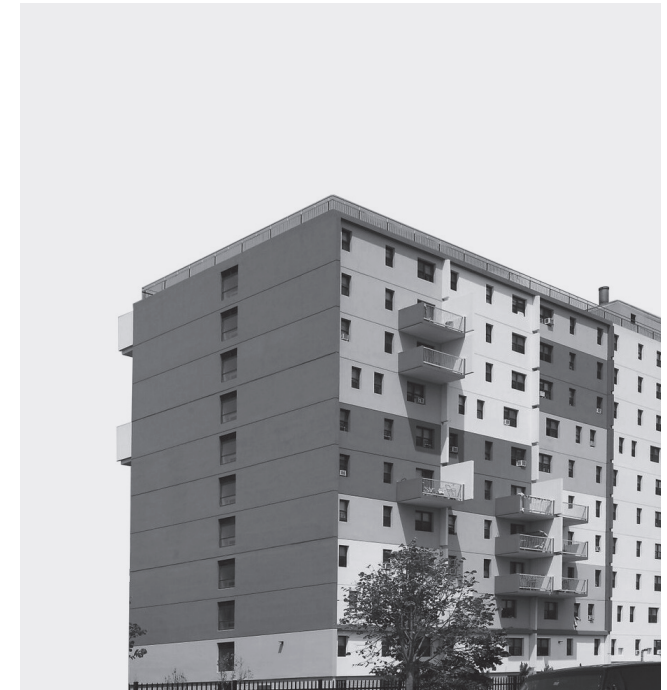
This tearsheet shows packages of energy conservation measures at key milestones in a building's lifecycle that can reduce utility bills, maximize energy savings, and improve value and performance.

Typical Building Characteristics

Age	Anytime, generally post war
Height	Any height
Façade	Masonry or curtain wall
Heating System	Electric baseboard, PTAC or heat
Heating Fuel	Electric
Ventilation System	Central ventilation
Cooling	PTACs, heat pumps, through-wall ACs, window ACs

Segment Characteristics

Size	199 properties; 31,191,784 square feet
Area	2% of all covered multifamily buildings
Potential Savings	1% of all potential GHG reduction












































Typical Retrofit Costs

Touchpoint	Anytime/Anywhere	Midcycle Retrofit	Refinance	Tenant Turnover
Description	Lower cost; simple measures	Low to medium cost; mid-level measures	Long-term investment; deeper saving	Requires tenant unit access
Cost	\$14,250	\$66,000	\$408,000	
Savings	\$5,700	\$11,000	\$34,000	
ROI	2.5	6.0	12.0	

All costs and savings reflect a 100 unit, 100,000 SF building

Building Touchpoint

Energy Conservation Measure	Anytime/ Anywhere	Midcycle Retrofit	Refinancing/ Substantial Retrofit	Tenant Turnover	Payback (years)	Cost per SF	Energy Savings per SF
 Install Exhaust Fan Timers	•	•	•		1.5	\$	
 Install CAR Dampers		•	•		2.5	\$\$\$	
 Install Cogeneration Plant			•		7.0	\$\$\$\$	
 Install VFDs		•	•		0.5	\$\$\$	
 Upgrade Exterior Lighting		•	•		3.0	\$\$	
 Install Lighting Sensors		•	•		2.0	\$	
 Upgrade Lights		•	•		3.0	\$\$	
 Install Heating Controls and Thermostats		•	•		2.0	\$\$	
 Replace Windows and Glazing			•		17.0	\$\$\$\$	
 Increase Roof Insulation		•	•		4.0	\$\$\$	
 Complete Air sealing	•	•	•	•	1.5	\$\$	
 Install Low Flow Aerators	•	•	•	•	3.5	\$\$\$	
 Install DHW Controls	•	•	•		7.0	\$\$	
 Insulate Pipes and Tank	•	•	•		3.5	\$\$	
 Install Low-Flow Showerheads	•	•	•	•	0.5	\$	


Energy Conservation Measure		Cost per Square Foot	Energy Savings per SF (kBtu)	Notes
 Ventilation & Cooling	 Heating Distribution	\$ <\$.05	 0-3	This list of Energy Conservation Measures (ECM) is based on LL87 audit data and therefore may be incomplete. Suggested ECMs for each Building Touchpoint are representative, and not necessarily applicable to every building. Variety in specific building systems and condition of equipment must be considered in determining the appropriate packages of ECMs for individual buildings. The first step of any upgrade should be to work with a qualified service provider to develop a scope of work appropriate for your building.
 Other	 Envelope	\$ \$ \$0.05-\$0.25	 3.1-8	
 Lighting	 Domestic Hot Water	\$ \$ \$ \$0.26-\$1.00	 8.1-12	
 Heating Equipment		\$ \$ \$ \$ >\$1.00	 >12	

equipment replacement

Replacing a major piece of equipment in a building system when it reaches the end of its useful life can be a crucial opportunity for energy efficiency improvements. While a simple code compliant, like-for-like replacement may net some savings, with additional planning and investment, a comprehensive system upgrade can maximize lifecycle savings and improve performance. Below are potential related system upgrades for several major building systems, featuring measures identified through analysis of the LL87 Energy Audit data, combined with expert review.

boiler

Most of NYC large multifamily buildings have boilers that provide heat and hot water to the building, either distributing the heat through steam or circulated hot water. Often, when the boiler fails, much of the auxiliary equipment connected to the boiler can also be upgraded to deliver substantial additional savings and faster payback.


	Baseline Measure	Potential Related Upgrades*	Total
	Replace boiler	Upgrade burner Insulate condensate tank Upgrade master venting Upgrade/Install heating controls and sensors Install TRVs Insulate pipes and condensate tank	
Cost	\$160,000	+ \$120,000	\$280,000
Annual Savings	\$11,000	+ \$19,000	\$30,000
Simple Payback	15		9

The package estimates are for a 100,000 SF, gas-heated 1-pipe steam building.

*Potential related upgrade cost reflects all measures listed. However, please note that not every measure will apply to every situation.

domestic hot water system


After space heating, domestic water heating (for showers, baths, dishwashing, etc.) is usually the largest energy consumer in multifamily buildings, often representing 26% of the total common area consumption. Additionally, in many buildings, the same boiler provides for water and space heating, which requires firing up a much larger boiler. During summer and shoulder months, buildings have dramatically higher energy losses from oversized boilers. In some cases, installing a smaller, separate boiler for domestic water heating in summer can be very cost-effective. However, the authors, in consultation with members of the advisory committee, believe that this measure is over-recommended in the LL87 audits, and often does not have the savings that some auditors project.

	Baseline Measure	Potential Related Upgrades*	Total
	Replace DHW boiler	Install new DHW controls Insulate pipes and condensate tank	
Cost	\$46,000	+ \$7,000	\$53,000
Annual Savings	\$8,000	+ \$4,000	\$12,000
Simple Payback	6		4

The package estimates are for a 100,000 SF, gas-heated 1-pipe steam building; domestic hot water tied to the boiler.

window

Building management and occupants often find that it eventually becomes imperative to replace all of the windows in a building, or at least across one or two facades. There are many different window replacement options, usually with very different energy characteristics. Going beyond the lowest cost window options, to include several other related envelope sealing measures, can provide significant energy savings and improvements in tenant comfort.


	Baseline Measure	Potential Related Upgrades*	Total
	Replace Windows	Weather stripping Air sealing	
Cost	\$290,000	+ \$10,000	\$300,000
Annual Savings	\$7,000	+ \$3,000	\$10,000
Simple Payback	40		30 year

The package estimates are for a 100,000 SF, gas-heated building.

*Potential related upgrade cost reflects all measures listed. However, please note that not every measure will apply to every situation.

roof

When a roof has passed the end of its useful life, and simple repairs are no longer possible or cost-effective, a major capital investment must be made to replace the roof. Accompanying this replacement with additional measures could improve the lifecycle economics of this replacement.

	Baseline Measure	Potential Related Upgrades*	Total
	Replace roof	Add roof/ceiling insulation	
Cost	\$140,000	+ \$71,000	\$211,000
Annual Savings	\$0	+ \$5,000	\$5,000
Simple Payback		14	

The package estimates are for a 100,000 sf, gas-heated building.
Payback only relevant for incremental cost of related upgrade.

about this resource

Authors

Richard Yancey

Building Energy Exchange

Talia Kula

Building Energy Exchange

Adam Hinge

Sustainable Energy Partnerships

Jeffrey Perlman

Bright Power, Inc.

David Sachs

Bright Power, Inc.

Sarah Newman

Pacific Northwest National Laboratory

Sponsors



Disclaimer

While every effort has been made to contain correct information, neither Building Energy Exchange nor the authors or project advisors make any warranty, express or implied, or assume any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, or process disclosed or represents that its use would not infringe privately owned rights. None of the parties involved in the funding or creation of this resource assume any liability or responsibility to the user of any third party for the accuracy, completeness, or use or reliance on any information contained in these tearsheets, or for any injuries, losses, or damages arising from such use or reliance.

©Building Energy Exchange

All Rights Reserved

August 2018

be-exchange.org

BE-Ex: the building energy exchange connects New York City real estate and design communities to energy and lighting efficiency solutions through exhibitions, education, technology demonstrations, and research. We identify opportunities, navigate barriers to adoption, broker relationships, and showcase best practices at our resource center in the Surrogate's Courthouse.

be-exchange.org