Decarbonization Roadmap for Multifamily Affordable Housing

1. **calculate**
carbon emissions
   Calculate the building’s annual estimated GHG emissions using the BE-Ex Carbon Calculator: www.be-exchange.org/calculator

2. **compare**
carbon emissions intensity:
The following graph illustrates the carbon emissions intensity associated with the Low Carbon and No Carbon retrofit packages outlined on the previous page.

3. **develop**
   a retrofit master plan
   Develop a scope of energy conservation measures (ECMs) that are selected and phased to align with building operational and system needs, and financing cycles.

4. **implement**
   building decarbonization measures
   Depending on the 2030 and 2050 emissions factors as defined under LL97:
   - The 2030 emissions factor reflects an electric grid powered 70% by renewable energy.
   - The 2050 emissions factor reflects a zero emissions electric grid powered 100% by renewable energy.
   - The Baseline Building shows emissions from the existing building conditions based on the 2030 emissions factor.

**Emissions Factors**
Each scope of work is evaluated against the 2030 and 2050 emissions factors as defined under LL97:
- The 2030 emissions factor reflects an electric grid powered 70% by renewable energy.
- The 2050 emissions factor reflects a zero emissions electric grid powered 100% by renewable energy.

The Baseline Building shows emissions from the existing building conditions based on the 2030 emissions factor.

**Emissions per Fuel Type**
The graph distinguishes between the carbon emissions associated with each fuel type:
- electricity or fossil fuels.
- In 2050, when the electric grid is powered by 100% renewable energy sources, the emissions from electric equipment will be zero. The No Carbon scopes have zero emissions as a result.

**Emissions Caps**
The graph includes carbon emissions caps for the LL97 reporting periods. Note the emissions cap for 2050 is at zero.
When the emissions associated with a scope of work exceed a specific emissions cap, the building may be subject to financial penalties.

**key takeaway**
Low-rise co-ops are often a good fit for resident-paid, multi-split heat pumps; 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.

**Based on the 2023 Monterey Ave. affordable housing project**

---

4 / 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**: Bronx, NY
- **dwelling units**: 40
- **building area**: 40,850 sq. ft
- **metering**:
  - gas: master
  - electricity: direct
- **heating fuel**: natural gas
- **heating system**: one-pipe steam radiators
- **cooling system**: window ACs
- **ventilation system**: passive via windows
- **utility payment structure**: heating: owner-paid; cooling: tenant-paid

**Local Law 97 2030 emissions limits not compliant**

---

**2030 emissions factor**
- source of carbon emissions
  - electricity
  - fossil fuels

**2050 (0 emissions)**
- **emissions caps**
  - 2030
  - 2035
  - 2040

**pre-war low-rise HDFC co-op**

---

**Emissions Factors**
Each scope of work is evaluated against the 2030 and 2050 emissions factors as defined under LL97:
- The 2030 emissions factor reflects an electric grid powered 70% by renewable energy.
- The 2050 emissions factor reflects a zero emissions electric grid powered 100% by renewable energy.

The Baseline Building shows emissions from the existing building conditions based on the 2030 emissions factor.

**Emissions per Fuel Type**
The graph distinguishes between the carbon emissions associated with each fuel type:
- electricity or fossil fuels.
- In 2050, when the electric grid is powered by 100% renewable energy sources, the emissions from electric equipment will be zero. The No Carbon scopes have zero emissions as a result.

**Emissions Caps**
The graph includes carbon emissions caps for the LL97 reporting periods. Note the emissions cap for 2050 is at zero.
When the emissions associated with a scope of work exceed a specific emissions cap, the building may be subject to financial penalties.

**key takeaway**
Low-rise co-ops are often a good fit for resident-paid, multi-split heat pumps; 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.
### Baseline Building Conditions

This pre-war low-rise building has a brick masonry assembly, no insulation in the walls, and minimal insulation in the roof. An attached building to one side partially limits opportunities for over-cladding, but envelope upgrades are possible, especially to windows. Lack of ventilation lends the building to the use of unitized ERV. Natural gas for heating and window ACs for cooling make Monterey a strong candidate for mini-split heat pumps.

<table>
<thead>
<tr>
<th>BUILDING SYSTEM</th>
<th>% OF GHG EMISSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>envelope</td>
<td>63%</td>
</tr>
<tr>
<td>heating</td>
<td>17%</td>
</tr>
<tr>
<td>cooling</td>
<td>6%</td>
</tr>
<tr>
<td>ventilation</td>
<td>14%</td>
</tr>
<tr>
<td>DHW</td>
<td>14%</td>
</tr>
<tr>
<td>lighting</td>
<td>14%</td>
</tr>
<tr>
<td>appliances</td>
<td>14%</td>
</tr>
</tbody>
</table>

### Low Carbon Retrofit Package

Low Carbon improvements include a new scotch marine steam boiler, air source heat pump for DHW, LED lighting, ballasted rooftop solar PV, and new ENERGY STAR refrigerators. Envelope upgrades include new roof insulation, double pane windows, air sealing measures, and optional above grade wall R-15 EIFS over-cladding. GHG savings for this scope of work are based on the 2030 emissions factor.

#### GHG Savings

No Carbon improvements include all 2030 measures plus additional upgrades which may supersede some 2030 measures. These include split air source heat pumps for heating and cooling, energy recovery for active ventilation, and electric stoves for cooking resulting in whole building electrification. Envelope upgrades include new high-performance windows and optional above grade wall R-16 EIFS over-cladding. GHG savings for this scope of work are based on the 2050 emissions factor.

<table>
<thead>
<tr>
<th>SYSTEM COMPONENTS</th>
<th>DESCRIPTION</th>
<th>ENERGY CONSERVATION MEASURES (ECM)</th>
<th>ESTIMATED COST/DU*</th>
<th>TOTAL COST/DU*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Insulation</td>
<td>No insulation</td>
<td>R-39 roof insulation</td>
<td>$3,950</td>
<td>$3,950</td>
</tr>
<tr>
<td>Windows/Glazing</td>
<td>Aluminum, double hung</td>
<td>New aluminum, double pane, low-e, argon filled, double hung</td>
<td>$7,700</td>
<td>$9,650</td>
</tr>
<tr>
<td>Air Sealing &amp; Weatherization</td>
<td>Unknown</td>
<td>Door &amp; window weatherstripping</td>
<td>$1,200</td>
<td>$1,200</td>
</tr>
<tr>
<td>Above Grade Walls</td>
<td>Brick wall assembly with interior cavity insulation</td>
<td>Optional R-15 EIFS over-cladding</td>
<td>$33,350</td>
<td>$33,350</td>
</tr>
<tr>
<td>Heating</td>
<td>Scotch marine steam boiler with one-pipe distribution</td>
<td>New scotch marine steam boiler</td>
<td>$6,750</td>
<td>$6,750</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat Timer boiler controls with indoor temp feedback</td>
<td>$800</td>
<td>$800</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Real-Time Energy Management (RTEM)</td>
<td>$1,600</td>
<td>$1,600</td>
</tr>
<tr>
<td>Cooling</td>
<td>Thru-wall ACs</td>
<td>New thru-wall ENERGY STAR ACs</td>
<td>$2,700</td>
<td>$2,700</td>
</tr>
<tr>
<td>Pumps</td>
<td>None</td>
<td>New pipe insulation</td>
<td>$300</td>
<td>$300</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Common Area: passive Apartment: passive</td>
<td>No additional recommended measures</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Ductwork</td>
<td>No ductwork</td>
<td>No additional recommended measures</td>
<td>$0</td>
<td>$0</td>
</tr>
</tbody>
</table>

### Renewables

- Rough order of magnitude estimated costs based on current information at the time of publication, subject to material, labor, and mark-up. For more information, see the Decarbonization Roadmap for Multifamily Affordable Housing Best Practices Manual.
- Due to the interactivity of the energy model, the GHG savings for envelope are attributed to the HVAC category for the 2050 scope.
- Full-weatherized systems in 2030 show a GHG savings increase in 2050 because of New York’s electrical grid transitioning to more clean energy sources.

**GHG savings from envelope upgrades fail to zero once all related building systems are electrified and the electric grid is fully de-carbonized. However, improvements to the building envelope will reduce the need for heating and cooling, which saves energy and minimizes operating costs.**
Decarbonization Roadmap for Multifamily Affordable Housing

1. calculate carbon emissions
   Calculate the building’s annual estimated GHG emissions using the BE-Ex Carbon Calculator: www.be-exchange.org/calculator

2. compare carbon emissions intensity
   The following graph illustrates the carbon emissions intensity associated with the Low Carbon and No Carbon retrofit packages outlined on the previous pages.

3. develop a retrofit master plan
   Develop a scope of energy conservation measures (ECMs) that are selected and phased to align with building operational and system needs, and financing cycles.

4. implement building decarbonization measures
   Based on the 2023 Monterey Ave. affordable housing project

Decarbonization Roadmap for Multifamily Affordable Housing

Based on the 2023 Monterey Ave. affordable housing project

**Low-rise HDFC co-op**

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.

- **Location**: Bronx, NY
- **Existing building overview**
  - **Building area**: 40,850 sq. ft
  - **Metering**: Gas: master, electricity: direct
  - **Heating fuel**: Natural gas
  - **Heating system**: One-pipe steam radiators
  - **Cooling system**: Window ACs
  - **Ventilation system**: Passive via windows

Carbon Emissions Intensity:

<table>
<thead>
<tr>
<th>source of carbon emissions</th>
<th>2030 emissions factor</th>
<th>2050 emissions factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>(emissions)</td>
<td>(emissions)</td>
</tr>
<tr>
<td>Fossil fuels</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Emissions Factors:

- **2030 emissions factor** reflects an electric grid powered 70% by renewable energy.
- **2050 emissions factor** reflects a zero emissions electric grid powered 100% by renewable energy.

Baseline Building:

- **First year estimated savings ($/DU)**
  - **Owners**: $225, $250
  - **Tenants**: $150, $150

Low Carbon Retrofit Package:

- **Electricity savings ($/DU)**
  - **Owners**: $200, $250
  - **Tenants**: $150, $200

No Carbon Retrofit Package:

- **Electricity savings ($/DU)**
  - **Owners**: $125, $200
  - **Tenants**: $200, $200

**Emissions Caps**

- The graph includes carbon emissions caps for the LL97 reporting periods. Note the emissions cap for 2050 is at zero.
- When the emissions associated with a scope of work exceeds a specific emissions cap, the building may be subject to financial penalties.

**Emissions per Fuel Type**

- The graph distinguishes between the carbon emissions associated with each fuel type: electricity or fossil fuels.

**Key takeaway**

Low-rise co-ops are often a good fit for resident-paid, multi-split heat pumps; 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.