Appendix B

Estimated Cumulative Energy Savings From Packages of Retrofits for Thirteen Different Building Types

This appendix illustrates the effect of forming three packages of retrofits for each of the 13 building types for which retrofit options were presented in appendix A. One package contains a set of nonoverlapping retrofits of low capital cost; a second package includes a set of retrofits of moderate capital cost compared to savings; and a third package contains retrofits of high capital cost compared to savings.

For each building type there is a graph that shows cumulative energy savings as low, moderate, and high capital cost retrofit packages are added to that building. The cost per million Btu of each package is shown on the vertical axis of each graph. Because of interactive effects the cost per annual million Btu saved may fall outside the capital cost thresholds established by OTA for individual retrofits even though all the individual retrofits in the package would fall within the threshold if installed separately. This happens occasionally for the low capital cost package, more frequently for the moderate cost package, and very frequently for the high cost package.

For example, when combined into a package the low capital cost retrofits to a clad wall commercial building with an air system will cost $26 per annual million Btu saved ("fuel-adjusted") even though each of the retrofits in the package will cost no more than $14 per annual million Btu saved if done individually. For the rest of the building types, however, the cost per annual million Btu of the low cost retrofit package lies within the low capital cost threshold.

Similarly, for several of the commercial buildings the cost per annual million Btu saved of the moderate cost package is somewhat higher than the moderate capital cost threshold of $49 per annual million Btu saved even though individual retrofits in the package cost less than that. Several of the high capital cost retrofit packages cost substantially more than the high capital cost threshold. The rest cost a little more. These results indicate that high capital cost retrofits would not be cost effective if done after all low capital cost and all moderate capital cost retrofits had been installed.

For convenience the list of retrofits included in each retrofit package is given at the right of each graph. There are a few differences between these lists and those shown in appendix A. In most cases this is because some interactive effects among retrofits were anticipated in assigning individual retrofits to retrofit packages.

Figure B-1.—Small Frame House: Air System
V: Retrofit cost—$/million Btu saved
H: Annual million Btu saved

Retrofits included in Low, Moderate, and High Cost Packages for Analysis of Cumulative Savings

Small Frame House With an Air System

<table>
<thead>
<tr>
<th>Low*</th>
<th>Moderate*</th>
<th>High*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall insulation</td>
<td>Roof insulation</td>
<td>Window insulation</td>
</tr>
<tr>
<td>Weatherstripping</td>
<td>Storm windows</td>
<td>Vent damper</td>
</tr>
<tr>
<td>Thermostats</td>
<td>Insulate ducts</td>
<td>DHW vent damper</td>
</tr>
<tr>
<td>2-speed fan motor</td>
<td>Insulate DHW</td>
<td></td>
</tr>
<tr>
<td>Flow controls</td>
<td>DHW vent damper</td>
<td></td>
</tr>
</tbody>
</table>

*Capital cost compared to savings.  

Base annual energy use = 575 million Btu "fuel-adjusted."
Figure B-2.—Small Frame House: Water System*

Retrofits Included in Low, Moderate, and High Cost Packages for Analysis of Cumulative savings

Small Frame House With a Water System

Low*: Roof insulation, Wall insulation, Weatherstripping, Thermostats, Flow controls, Insulate DHW storage

Moderate*: Storm windows, Vent damper, Modular aquastat, Replace room AC, DHW vent damper

High*: Window insulation, Replace burner

Base annual energy use = 628 million Btu “fuel-adjusted.”

Figure B-3.—Small Frame House: Decentralized System*

Small Frame House With a Decentralized System

Low*: Roof insulation, Storm windows, Electric heat pump, Wall insulation, Weatherstripping, Replace room AC, Flow controls, Insulate storage

Moderate*: Window insulation, Modular aquastat, Replace room AC

High*: Replace burner

Base annual energy use = 705 million Btu “fuel-adjusted.”
Figure B-4.—Small Masonry Rowhouse: Air System*

Retrofits Included in Low, Moderate, and High Cost Packages for Analysis of Cumulative Savings

*Base annual energy use = 404 million Btu "fuel-adjusted."

Figure B-5.—Small Masonry Rowhouse: Water System*

*Base annual energy use = 436 million Btu "fuel-adjusted."

*Low*  Moderate  High
Weatherstripping  Roof insulation  Wall insulation
Thermostats  Storm windows  Window insulation
2-speed fan motor  Vent damper  Insulate ducts
Flow controls  Insulate storage  Insulate storage
DHW vent damper  Modular aquastat  Replace room AC

● Capital cost compared to savings.


Figure B-6.—Small Masonry Rowhouse: Decentralized System*

Retrofits Included in Low, Moderate, and High Cost Packages for Analysis of Cumulative Savings

Small Masonry Rowhouse With a Decentralized System

Low* Moderate* High*
Weatherstripping Roof insulation Wall insulation
Thermostats Storm windows Electric heat pump
Flow controls Window insulation
Insulate storage Replace room AC

DHW heat pump

*Base annual energy use = 466 million Btu “fuel-adjusted.”

Figure B-7.—Large Multifamily Building: Air System*

Large Multifamily Building With an Air System

Low* Moderate* High*
Roof spray Window Insulation Roof insulation
Vent damper Water-cooled Wall Insulation
Thermostats Condenser Weatherstripping
Enthalpy control Insulate ducts
Vary CHW temp
2-speed fan motor
Flow controls
DHW vent damper
Hybrid lamps

*Capital coat compared to savings.

*Base annual energy use = 12,985 million Btu “fuel-adjusted.”
Retrofits included in Low, Moderate, and High Cost Packages for Analysis of Cumulative Savings

**Large Multifamily Building With a Water System**

- **Low**
  - Roof spray
  - Vent damper
  - Modular aquastat
  - Thermostats
  - Flow controls
  - DHW vent damper

- **Moderate**
  - Roof insulation
  - Weatherstripping

- **High**
  - Wall insulation
  - Boiler turbolator

- **Base annual energy use = 13,950 million Btu “fuel-adjusted.”**

**Large Multifamily Building With a Decentralized System**

- **Low**
  - Roof spray
  - Thermostats
  - Flow controls
  - Window insulation
  - Insulate storage
  - Hybrid lamps

- **Moderate**
  - Roof insulation

- **High**
  - Window insulation
  - Electric heat pump
  - Replace room AC

- **Base annual energy use = 14,923 million Btu “fuel-adjusted.”**

"Capital cost compared to savings."
Figure B-10.—Large Commercial Building: 
Air System* 

Retrofit Cost: $ per annual MMBTU's saved 

Large Commercial Building With an Air System 

Low* 
- Roof spray 
- Vent damper 
- Thermostats 
- Enthalpy control 
- Vary CHW temp 
- Reduce ventilation 
- 2-speed fan motor 
- Flow controls 
- Insulate storage 
- DHW vent damper 
- Task lighting 
- High-efficiency fluorescent 

Moderate* 
- Weatherstripping 
- Shading devices 
- Replace burner 
- Insulate ducts 

High* 
- Roof insulation 
- Wall insulation 
- Window insulation 
- Water-cooled condenser 

*Base annual energy use = 10,545 million Btu "fuel-adjusted."

Figure B-11.—Large Commercial Building: 
Water System* 

Retrofit Cost: $ per annual MMBTU's saved 

Large Commercial Building With a Water System 

Low* 
- Roof spray 
- Vent damper 
- Modular aquastat 
- Thermostats 
- Flow controls 
- Insulate storage 
- DHW vent damper 
- High-efficiency fluorescent 

Moderate* 
- Weatherstripping 
- Shading devices 
- Replace burner 
- Replace room AC 
- Task lighting 

High* 
- Roof insulation 
- Wall insulation 
- Window insulation 

*Capital cost compared to savings. 

*Base annual energy use = 10,579 million Btu "fuel-adjusted."
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Figure B-12.—Large Commercial Building: Decentralized System

Retrofits Included in Low, Moderate, and High Cost Packages for Analysis of Cumulative Savings

Large Commercial Building With a Decentralized System

- Low*: Shading devices, Roof spray, Thermostats, Flow controls, Insulate storage, High-efficiency fluorescent
- Moderate: Roof insulation, Weatherstripping, Window insulation, Replace room AC, Task lighting
- High: Wall insulation

*Base annual energy use = 10,882 million Btu "fuel-adjusted."

Figure B-13.—Large Commercial Building: Reheat System

Large Commercial Building With a Complex Reheat System

- Low*: Roof spray, Replace burner, Vent damper, Thermostats, Reheat to VAV, Flow controls, DHW vent damper, High-efficiency fluorescent
- Moderate: Weatherstripping, Shading devices, Boiler turbolator, Insulate ducts, Insulate storage, Task lighting
- High: Window insulation, Water-cooled condenser

*Capital cost compared to savings.