

TOP TEN 2018

Energy Efficiency Technologies for the U.S. Building Sector

The U.S. Department of Energy (DOE) sponsored the Pacific Northwest National Laboratory (PNNL) to develop a Top Ten list to highlight energy savings technologies for the United States' building sector that represent good value for money, are innovative, reliable and widely available. This list covers a broad range of technologies spanning both the residential and commercial sectors, including windows, envelope, sensors and controls, lighting, and HVAC.

Each technology has been weighted using a structured methodology to determine its energy saving potential, technical and financial characteristics, as well as co-benefit characteristics.

How to use the list

Energy consumers, program administrators, developers, designers, and policy makers can use this list to consider the benefits of these technologies, while producers of these technologies can use this list and underlying research to promote their products in the global marketplace.

The United States will partner with other countries that also investigated buildings technologies, including China and Japan. Getting exposure to the Chinese market, for example, can be beneficial for U.S. producers of these technologies and for building energy efficiency in general, as China is one of the largest construction markets in the world.

Top Tens Task Group

The Top Tens Task Group was established in 2013 and is managed through the International Partnership for Energy Efficiency Cooperation (IPEEC). Members include Australia, Canada, China, France, Japan, South Korea, and the United States.

The objective of the task group is to improve energy efficiency globally through better exchange of information about technologies and practices. Members of the task group are developing domestic and international Top Tens lists, with related case studies, to provide practical information for technology users. These will have broad international relevance and provide a range of comparative case studies in different national contexts.

TOP
TEN
S

TOP TEEN S

BEST AVAILABLE ENERGY EFFICIENCY TECHNOLOGIES

These are the technologies that have demonstrated leading energy efficiencies across the U.S. building sector and are innovative or provide other sustainability benefits. The score given is out of 100 possible points.

1

SCORE 77.5

Condensing gas tankless water heaters

Tankless water heaters forgo a storage tank by providing hot water only when needed, thereby eliminating standby losses. The condensing type is able to extract additional heat... [click for more](#)

1

SCORE 77.5

Occupant responsive lighting

Using sensors, management systems, and/or control components, these lighting systems allow facility managers to provide high quality lighting that meet individual preferences... [click for more](#)

3

SCORE 74.5

Heat pump water heaters

Heat pump water heaters work similar to a refrigerator in reverse, moving heat from the surrounding environment into a tank to heat water. They can be 2-3 times more efficient... [click for more](#)

4

SCORE 73

LED downlight luminaires

LED downlight luminaires can deliver significant energy and cost savings as a replacement for incandescent and fluorescent technologies in the residential sector... [click for more](#)

5

SCORE 72

Building energy management and information systems

These systems provide facility managers with the capabilities to monitor, control, adjust, and manage energy... [click for more](#)

6

SCORE 67

Windows attachments (non-adjustable)

Low-e storm windows, high-R window panels, switchable films, and other window attachments are able to provide energy savings from heating, cooling, and even lighting... [click for more](#)

7

SCORE 63.5

Advanced rooftop unit controls

Advanced rooftop unit controls allow facility managers to monitor, control, and adjust heating, cooling, and ventilation services provided by packaged rooftop HVAC systems... [click for more](#)

8

SCORE 63

Plug load control devices

Plug load control devices can reduce energy consumption of both residential and commercial devices through load sensing and/or timer scheduling... [click for more](#)

9

SCORE 61

Comprehensive attic upgrade

A bundled package of attic insulation, attic ventilation, duct sealing, air sealing, and air barriers makes a comprehensive attic upgrade that can significantly reduce... [click for more](#)

10

SCORE 59

Dynamic solar control systems

Window shades, when used effectively, can save energy from heating, cooling, and even lighting. Automating the operation schedule makes savings simple and reliable... [click for more](#)

U.S. Buildings Sector's Best Available Technologies

1 (tied)

SCORE 77.5

Condensing gas tankless water heaters

Condensing gas tankless water heaters forgo a storage tank by providing hot water only when needed, thereby eliminating standby losses. The condensing type is able to achieve efficiencies greater than 90% by also extracting additional heat from the exhaust gases.

Sectors and end-use applications

Residential water heating

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>12/15</u>
<u>1.2 Technical potential</u>	<u>5/10</u>
<u>1.3 Maximum adoption potential</u>	<u>7.5/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>3/5</u>
<u>2.2 Innovative nature</u>	<u>3/5</u>
<u>2.2 Reliability</u>	<u>10/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>25/25</u>
<u>3.2 Payback period</u>	<u>10/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>2/10</u>
TOTAL	<u>77.5/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

1 (tied)

SCORE 77.5

Occupant responsive lighting

Lighting systems including sensors, management systems, and/or control components allow facility managers to provide high quality lighting that meet individual preferences and light needs while reducing energy demand and costs. Control methods include occupancy sensing, timer scheduling, and dimming.

Sectors and end-use applications

Commercial lighting

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>15/15</u>
<u>1.2 Technical potential</u>	<u>10/10</u>
<u>1.3 Maximum adoption potential</u>	<u>7.5/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>5/5</u>
<u>2.2 Innovative nature</u>	<u>3/5</u>
<u>2.2 Reliability</u>	<u>10/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>15/25</u>
<u>3.2 Payback period</u>	<u>4/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>8/10</u>
TOTAL	<u>77.5/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

3

SCORE 74.5

Heat pump water heaters

Heat pump water heaters work similarly to a refrigerator in reverse. A heat pump moves heat from the surrounding environment into a tank to heat water. Since heat pump water heaters move heat rather than generating it, they are 2-3 times more energy efficient compared to traditional electric resistance water heaters. We investigated heat pump water heaters in the residential sector only, although this technology also has commercial applications such as the food services industry while providing spot cooling in kitchens.

Sectors and end-use applications

Residential water heating

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>15/15</u>
<u>1.2 Technical potential</u>	<u>10/10</u>
<u>1.3 Maximum adoption potential</u>	<u>7.5/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>5/5</u>
<u>2.2 Innovative nature</u>	<u>3/5</u>
<u>2.2 Reliability</u>	<u>6/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>20/25</u>
<u>3.2 Payback period</u>	<u>6/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>2/10</u>
TOTAL	74.5/100

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

4

SCORE 73

LED downlight luminaires

LED downlight luminaires can deliver significant energy and cost savings as a replacement for incandescent and fluorescent technologies in the residential sector. We also investigated the technology's application in the commercial sector, but the high baseline efficacy in our model made the energy savings and economic characteristics poor in comparison to the residential sector. Because the characteristics for downlighting are substantially different between the two sectors, we consider only its residential application herein.

Sectors and end-use applications

Residential lighting (downlighting – ceiling light directed downwards)

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>15/15</u>
<u>1.2 Technical potential</u>	<u>2.5/10</u>
<u>1.3 Maximum adoption potential</u>	<u>2.5/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>5/5</u>
<u>2.2 Innovative nature</u>	<u>3/5</u>
<u>2.2 Reliability</u>	<u>10/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>25/25</u>
<u>3.2 Payback period</u>	<u>6/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>4/10</u>
TOTAL	<u>73/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

5

SCORE 72

Building energy management and information systems

These systems provide facility managers with the capabilities to monitor, control, adjust, and manage energy performance of various systems such as HVAC and lighting. In this study, we accounted for total project costs, including hardware, software, implementation, and personnel time.

Sectors and common applications

Commercial heating, cooling, ventilation, and lighting

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>6/15</u>
<u>1.2 Technical potential</u>	<u>10/10</u>
<u>1.3 Maximum adoption potential</u>	<u>10/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>3/5</u>
<u>2.2 Innovative nature</u>	<u>3/5</u>
<u>2.2 Reliability</u>	<u>6/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>20/25</u>
<u>3.2 Payback period</u>	<u>6/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>8/10</u>
TOTAL	<u>72/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

6

SCORE 67

Window attachments (non-adjustable)

Windows are a main contributor to heating and cooling loads in U.S. buildings. Low-e storm windows, high-R window panels, switchable films, and other window attachments are able to save energy from heating, cooling, and even lighting. For this study, we differentiated between adjustable and non-adjustable window attachments, since the former depends significantly on user behavior or operation.

Sectors and common applications

Residential and commercial heating and cooling

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>12/15</u>
<u>1.2 Technical potential</u>	<u>10/10</u>
<u>1.3 Maximum adoption potential</u>	<u>10/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>3/5</u>
<u>2.2 Innovative nature</u>	<u>5/5</u>
<u>2.2 Reliability</u>	<u>10/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>5/25</u>
<u>3.2 Payback period</u>	<u>2/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>10/10</u>
TOTAL	<u>67/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

7

SCORE 63.5

Advanced rooftop unit controls

Advanced rooftop unit (ARU) controls allow facility managers to monitor and control heating, cooling and ventilation services provided by packaged rooftop HVAC systems. Specifically, ARU controls allow regulating (e.g., remotely) the supply fan to meet ventilation demands, which allows the fan to run at lower speeds and therefore save energy.

Sectors and common applications

Commercial heating, cooling, and ventilation

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>15/15</u>
<u>1.2 Technical potential</u>	<u>7.5/10</u>
<u>1.3 Maximum adoption potential</u>	<u>5/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>3/5</u>
<u>2.2 Innovative nature</u>	<u>5/5</u>
<u>2.2 Reliability</u>	<u>6/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>10/25</u>
<u>3.2 Payback period</u>	<u>2/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>10/10</u>
TOTAL	<u>63.5/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

8

SCORE 63

Plug load control devices

Plug load control devices, such as a power strip, can reduce energy consumption of both residential and commercial devices through load sensing and/or timer schedule controls.

Sectors and common applications

Residential and commercial plug load devices, such as televisions, computers, and other office equipment

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>9/15</u>
<u>1.2 Technical potential</u>	<u>10/10</u>
<u>1.3 Maximum adoption potential</u>	<u>10/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>5/5</u>
<u>2.2 Innovative nature</u>	<u>5/5</u>
<u>2.2 Reliability</u>	<u>6/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>10/25</u>
<u>3.2 Payback period</u>	<u>4/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>4/10</u>
TOTAL	<u>63/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

9

SCORE 61

Comprehensive attic update

A bundled package of attic insulation, attic ventilation, duct sealing, air sealing, and air barriers makes a comprehensive attic update that can significantly reduce the heating and cooling load of residential buildings. In our modeling, we assumed that existing residential houses upgrade their attic to meet the requirements of the 2012 International Energy Conservation Code.

Demand sectors and common applications

Residential heating and cooling

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>6/15</u>
<u>1.2 Technical potential</u>	<u>2.5/10</u>
<u>1.3 Maximum adoption potential</u>	<u>2.5/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>5/5</u>
<u>2.2 Innovative nature</u>	<u>3/5</u>
<u>2.2 Reliability</u>	<u>10/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>20/25</u>
<u>3.2 Payback period</u>	<u>4/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>8/10</u>
TOTAL	<u>61/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)

U.S. Buildings Sector's Best Available Technologies

10

SCORE 59

Dynamic solar control systems

Window shades, when used effectively, can save energy from heating, cooling, and even lighting. Shades can reduce unwanted solar heat gain in the cooling season without affecting useful solar heat gain in the heating season. Insulated shades can also reduce heat transfer through the window. Automating the operation schedule is a simple and reliable way to capture the energy savings while also meeting other needs of the user.

Sectors and common applications

Residential and commercial heating, cooling, and lighting

Score and weighting

Indicator	Score
1. Energy saving potential	
<u>1.1 Level of energy efficiency</u>	<u>6/15</u>
<u>1.2 Technical potential</u>	<u>10/10</u>
<u>1.3 Maximum adoption potential</u>	<u>10/10</u>
2. Technical practicality	
<u>2.1 Advanced nature</u>	<u>3/5</u>
<u>2.2 Innovative nature</u>	<u>5/5</u>
<u>2.2 Reliability</u>	<u>10/10</u>
3. Economic characteristics:	
<u>3.1 Internal rate of return</u>	<u>5/25</u>
<u>3.2 Payback period</u>	<u>2/10</u>
4. Social characteristics	
<u>4.1 Co-benefits</u>	<u>8/10</u>
TOTAL	<u>59/100</u>

[Back to UNITED STATES' TOP TEN TECHNOLOGIES list](#)