Chapter 4: Heat Loss
September 6, 2012

Maximum Efficiency

Carnot Engines

Refrigeration and Heat Pumps

Mechanics.....mechanical energy following laws of Motion
Thermodynamics.......Internal energy of systems...thermal energy....Temperature

Heat is the flow of thermal energy......temperature differential
Temperature Scales

- Conversion to Fahrenheit: °F = (1.8 x °C) + 32
- Conversion to Celsius: °C = (°F - 32)/1.8
Specific Heat Capacity

Specific heat capacity
- Quantity of heat needed to raise 1g of a substance by 1 °C (K)

Water
- Highest specific heat
- 1 cal/g °K

Mercury 0.033 cal/g.K

Heat capacity ($C$), is the proportionality between the amount of heat and the change in temperature that this object produces.

$$Q=C(T_{\text{final}} - T_{\text{initial}})$$
Heat is the flow of thermal energy...... temperature differential

- **Conduction**
  - Movement of heat by atomic-scale collision
  - Thermal conductivity

- **Convection**
  - Bulk transfer of molecules
  - Convection cell

- **Radiation**
Infrared Imaging Detects Heat Loss
Why wear black in the desert?

Why do arctic animals have white feathers?/fur?
The First Law of Thermodynamics

The change in internal energy of a system is equal to the heat added to the system minus the work done by the system.

$$\Delta U = Q - W$$

- $\Delta U$: Change in internal energy
- $Q$: Heat added to the system
- $W$: Work done by the system

The Second Law of Thermodynamics

Heat does not flow spontaneously from cold to hot

Can you do it?

Efficiency of an Engine:

Determined by the second law of thermodynamics
Built-in Limitations of the Universe

- The Second Law’s consequences
  - Some things cannot happen
Heat flow in Watts
k conductivity of material
Area
Thickness
Temperature difference

Heat flow = k Area \( (T_{\text{hot}} - T_{\text{cold}}) \)

------------------------
thickness
Energy efficiency over the entire life cycle is the most important single goal of sustainable architecture. Architects use many different techniques to reduce the energy needs of buildings and increase their ability to capture or generate their own energy.
R-Values of Common Building Materials!

The R-value of a material determines how quickly heat is conducted across it. The values below are some of the more common R-factors for surfaces found on buildings in the U.S.

### Exterior Walls with Siding

#### Exterior Walls with Siding

<table>
<thead>
<tr>
<th>Material (8&quot;)</th>
<th>R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete block</td>
<td>2</td>
</tr>
<tr>
<td>with foam insulated cores</td>
<td>20</td>
</tr>
<tr>
<td>with 4&quot; on uninsulated stud wall</td>
<td>4.3</td>
</tr>
<tr>
<td>with 4&quot; insulated stud wall</td>
<td>14</td>
</tr>
</tbody>
</table>

#### Brick (4") R-Value

<table>
<thead>
<tr>
<th>Material</th>
<th>R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>with 4&quot; uninsulated stud wall</td>
<td>4</td>
</tr>
<tr>
<td>with 4&quot; insulated stud wall</td>
<td>14</td>
</tr>
</tbody>
</table>

#### Wooden Frame R-Value

<table>
<thead>
<tr>
<th>Material</th>
<th>R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uninsulated with 2&quot; x 4&quot; construction</td>
<td>4.6</td>
</tr>
<tr>
<td>with 1 1/2&quot; fiberglass</td>
<td>9</td>
</tr>
<tr>
<td>with 3 1/2&quot; fiberglass; studs 16&quot; o.c.</td>
<td>12</td>
</tr>
<tr>
<td>with 3 1/2&quot; fiberglass and 1&quot; foam</td>
<td>20</td>
</tr>
</tbody>
</table>

#### StrongGreenTM Structural Panel R-Value

<table>
<thead>
<tr>
<th>Material</th>
<th>R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 1/2&quot; thick polyurethane panel X 24&quot; Wide</td>
<td>27</td>
</tr>
<tr>
<td>6&quot; thick polyurethane panel</td>
<td>45</td>
</tr>
<tr>
<td>3 1/2&quot; thick polyurethane panel w/ceramic coating</td>
<td>47</td>
</tr>
<tr>
<td>6&quot; thick polyurethane panel W/ceramic coating</td>
<td>65</td>
</tr>
</tbody>
</table>

R value = thickness / k
Calculate the heat transfer for 12 hrs though an insulated window (two glass panes with an air gap of 0.25 in) that measures 4 ft by 7 ft when the outside temperature is 5 degrees F and the inside temperature is 65 degrees F.

R value for this type of window is 1.54 ft².hr.F/Btu

\[ \text{Heat flow} = k \frac{\text{Area} \ (T_{\text{hot}} - T_{\text{cold}})}{\text{thickness}} \]

\[ R \text{ value} = \frac{\text{thickness}}{k} \]

\[ \text{Heat flow} = \frac{(1/R) \text{Area} \ (T_{\text{hot}} - T_{\text{cold}})}{} \]

Area = 4 ft x 7 ft = 28 ft²

Temperature difference is 65-5 = 60 degrees F

Heat flow = 12 hrs x 28 ft² x 50 F x 1/1.54 ft².hr.F/Btu = 13,100 Btu
Typically exterior walls of houses are made up of several materials...combination of materials Cellulose fiber + fiberglass + pine wood + brick

\[ R_{\text{total}} = R_{\text{cellulose fiber}} + R_{\text{fiberglass}} + R_{\text{wood}} + R_{\text{brick}} \]
Example:

Consider an exterior wall that consists of $\frac{1}{2}$ in of plasterboard, 3.5 inches of fiberglass insulation, $\frac{3}{4}$ in plywood, and $\frac{1}{2}$ in lapped wood siding....

a) What is the effective R value?

b) What is the hourly heat loss from a house in which all the exterior surfaces have this R value when the inside temperature is 65 F and the outside temperature is 15 F. The dimensions of the house are 30 ft x 50 ft x 10 ft.
The First Law of Thermodynamics

The change in internal energy of a system is equal to the heat added to the system minus the work done by the system.

$$\Delta U = Q - W$$

- $\Delta U$: Change in internal energy
- $Q$: Heat added to the system
- $W$: Work done by the system

The Second Law of Thermodynamics

Heat does not flow spontaneously from cold to hot

Can you do it?

Efficiency of an Engine:

Determined by the second law of thermodynamics
What is the problem????????

Efficiency

Engines:

Efficiency = work done/energy put into the system

= What you got out/What you put in

100% efficiency not possible....
friction, viscosity
insulation
other

A heat engine is a physical or theoretical device that converts thermal energy to mechanical output. The mechanical output is called work, and the thermal energy input is called heat.
All fossil fuels and biomasses consist of carbon and hydrogen atoms. When these fuels are burned, or "combusted," carbon atoms unite with oxygen in the air to form carbon dioxide.
Think of an engine as operating between two thermal reservoirs...
One at High Temperature...engine takes the heat ($Q_H$ from hot reservoir)
does work with it and returns the rest to the cooler reservoir...

Energy Conservation.......................... $Q_H = \text{Work} + Q_C$

If you want engine to operate you must provide $Q_H$

Efficiency = $W/Q_H$
No perfect engines............
We can only convert some of the heat to work not all of it........

2\textsuperscript{nd} Law of Thermodynamics............... Entropy
.............. Time Travel
............... “Beam me up Scotty”

\[ \Delta S = \frac{Q}{T}, \]
Example: In the US, 85% of the electricity is generated by burning fossil fuels to produce steam, which in turn drives alternators that produce electricity. Power plants can produce steam with a temperature as high as 600°C by pressurizing the steam. The resulting waste heat must be exhausted into the environment at a temperature of 20°C.

\[
(1 - \frac{T_{\text{cold}}}{T_{\text{hot}}}) \times 100\% = \text{maximum efficiency}
\]

600 + 273 = 873 degree Kelvin
20 + 273 = 293
1 - (293/873) \times 100\% = 66.4\%

Real power plants ............... 40\%
Maximum Efficiency...

Equatorial lake is 10,000 m$^2$ in surface area... Sun deposits 0.500 kW/m$^2$ into the lake. What is the maximum conceivable amount of electric power such a power plant on the lake could generate?

If lake was a perfect collector (solar):
Power = 0.500 kW/m$^2$ x 10,000 m$^2$ = 5.000 MW
Efficiency of an ideal engine (Carnot):

\[
(1 - \frac{T_{\text{cold}}}{T_{\text{hot}}}) \times 100\% = (1 - \frac{288}{303}) \times 100\% = 4.95\%
\]

If you then build a solar powered electric plant on the lake which operates by using the temperature difference between the top \(30^\circ C\) and bottom \(15^\circ C\) water layers of the lake what is the maximum power that you can get out of this plant?

Temperature in Kelvin....
1 Celsius = 273.15 + 1 = 274 K

**Efficiency of an ideal engine (Carnot):**

\[
(1 - \frac{T_{\text{cold}}}{T_{\text{hot}}}) \times 100\% = (1 - \frac{288}{303}) \times 100\% = 4.95\%
\]

From earlier part ....
If lake was a perfect collector (solar):
Power = 0.500 kW/m\(^2\) \times 10,000 m\(^2\) = 5.000 MW

5.00 MW \times 0.0495 = 247.5 kWatt
What is cogeneration?
## Efficiency

**Conservation**

### TABLE 5.1 Panel Estimate of the Potential for Cost-Effective Annual U.S. Energy Savings (in quads) Achievable with Energy Efficiency Technologies in 2020 and 2030

<table>
<thead>
<tr>
<th>Sector</th>
<th>Conservative Estimate</th>
<th>Optimistic Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
<td>2030</td>
</tr>
<tr>
<td>Buildings, primary (source)</td>
<td>9.4</td>
<td>14.4</td>
</tr>
<tr>
<td>Residential electricity</td>
<td>4.4</td>
<td>6.4</td>
</tr>
<tr>
<td>Commercial</td>
<td>5.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Buildings, natural gas</td>
<td>2.4</td>
<td>3.0</td>
</tr>
<tr>
<td>Residential electricity</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Commercial</td>
<td>0.9</td>
<td>1.5</td>
</tr>
<tr>
<td>Transportation, light-duty</td>
<td>2.0</td>
<td>8.2</td>
</tr>
<tr>
<td>Industry, manufacturing</td>
<td>4.9</td>
<td>4.9</td>
</tr>
<tr>
<td>Total</td>
<td>18.6</td>
<td>30.5</td>
</tr>
</tbody>
</table>

|                               | 2020                  | 2030                |
|                               | 9.4                   | 14.4                |
| Residential electricity       | 4.4                   | 6.4                 |
| Commercial                    | 5.0                   | 8.0                 |
| Buildings, natural gas        | 2.4                   | 3.0                 |
| Residential electricity       | 1.5                   | 1.5                 |
| Commercial                    | 0.9                   | 1.5                 |
| Transportation, light-duty    | 2.0                   | 8.2                 |
| Industry, manufacturing       | 4.9                   | 4.9                 |
| Total                         | 18.6                  | 30.5                |

**Note:** Savings are relative to the reference scenario of the EIA’s *Annual Energy Outlook 2008* (EIA, 2008) or, for transportation, a similar scenario developed by the panel. See *Table 1.2* for more information on the baselines used in the panel’s analysis of the buildings, transportation, and industry sectors.

2010
OVERARCHING FINDINGS

Overarching Finding 1

Energy-efficient technologies for residences and commercial buildings, transportation, and industry exist today, or are expected to be developed in the normal course of business, that could potentially save 30 percent of the energy used in the U.S. economy while also saving money. If energy prices are high enough to motivate investment in energy efficiency, or if public policies are put in place that have the same effect, U.S. energy use could be lower than business-as-usual projections by 19–22 quadrillion Btu (17–20 percent) in 2020 and by 30–36 quadrillion Btu (25–31 percent) in 2030.\textsuperscript{2,3}

The transportation fraction would be higher if heavy-duty vehicles and aviation had been included in the panel’s analysis.

The basis for comparison for the buildings and industry sectors is the reference scenario of the U.S. Department of Energy’s Annual Energy Outlook 2008 (EIA, 2008a) and the panel’s similar but slightly modified baseline for the transportation sector.

The AEF Committee’s report (NAS-NAE-NRC, 2009) estimated the amount of possible savings as 15–17 quads (about 15 percent) by 2020 and 32–35 quads (about 30 percent) by 2030. Since the release of that report, further analysis by the panel refined the amount of possible savings in 2020 to 17–20 percent.
**Overarching Finding 2**

The full deployment of cost-effective, energy-efficient technologies in buildings alone could eliminate the need to add to U.S. electricity generation capacity. Since the estimated electricity savings in buildings exceeds the EIA forecast for new net electricity generation in 2030, implementing these efficiency measures would mean that no new generation would be required except to address regional supply imbalances, replace obsolete generation assets, or substitute more environmentally benign generation sources.

Barriers to implementing the energy efficient technologies....???
The barriers to improving energy efficiency are formidable. Overcoming these barriers will require significant public and private support, as well as sustained initiative. The experience of leading states provides valuable lessons for national, state, and local policy makers in the leadership skills required and the policies that are most effective.

Buildings can last decades...capital investment and equipment when a building is built are barriers to implementing energy efficient technologies.
Overarching Finding 4

Long-lived capital stock and infrastructure can lock in patterns of energy use for decades. Thus, it is important to take advantage of opportunities (during the design and construction of new buildings or major subsystems, for example) to insert energy-efficient technologies into these long-lived capital goods.
Total energy consumption in the United States in 2008, by sector and fuel. Shown are electricity consumption—with the losses in generation, transmission and distribution allocated to the end-use sectors—and the fuels used on-site in each sector. Electricity is generated off-site using fossil, renewable, and nuclear energy sources.

Source: EIA 2009a, as updated by EIA, 2009c.
Household Use........

Space Heating/Cooling

Water Heating

Lighting

Appliances

Sustainability?
For humans to live sustainably, the Earth's resources must be used at a rate at which they can be replenished. However, there is now clear scientific evidence that humanity is living unsustainably, and that an unprecedented collective effort is needed to return human use of natural resources to within sustainable limits.

Since the 1980s, the idea of human sustainability has become increasingly associated with the integration of economic, social and environmental spheres. In 1989, the World Commission on Environment and Development articulated what has now become a widely accepted definition of sustainability: "[to meet] the needs of the present without compromising the ability of future generations to meet their own needs."
Significant amounts of energy are flushed out of buildings in the water, air and compost streams. **Off the shelf**, on-site energy recycling technologies can effectively recapture **energy from waste** hot water and stale air and transfer that energy into incoming fresh cold water or fresh air. Recapture of energy for uses other than gardening from compost leaving buildings requires centralized **anaerobic digesters**.
Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of creating energy in the form of electricity or heat from the incineration of waste source. WtE is a form of energy recovery. Most WtE processes produce electricity directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels.
What is the role of the government in Energy Conservation?

set mandatory standards...

Never passed

2005...Energy Policy Act
Reduce Natural energy consumption
Tax credits for hybrids/diesel cars

2011...everything derailed
<table>
<thead>
<tr>
<th>Policy or Program</th>
<th>Electricity Savings (TWh/yr)</th>
<th>Primary Energy Savings (Quads/yr)</th>
<th>Year</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAFE vehicle efficiency standards</td>
<td>—</td>
<td>4.80</td>
<td>2006</td>
<td>NRC, 2002&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Appliance efficiency standards</td>
<td>196</td>
<td>2.58</td>
<td>2006</td>
<td>Nadel et al., 2006&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>PURPA and other CHP initiatives</td>
<td>—</td>
<td>1.62</td>
<td>2006</td>
<td>Shipley et al., 2008&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>ENERGY STAR&lt;sup&gt;®&lt;/sup&gt; labeling and promotion</td>
<td>132</td>
<td>1.52</td>
<td>2006</td>
<td>EPA, 2007&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Building energy codes</td>
<td>—</td>
<td>1.08</td>
<td>2006</td>
<td>Nadel, 2004&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>Utility and state end-use efficiency programs</td>
<td>90</td>
<td>1.06</td>
<td>2006</td>
<td>York and Kushler, 2006&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
<tr>
<td>DOE industrial efficiency programs</td>
<td>—</td>
<td>0.40</td>
<td>2005</td>
<td>DOE, 2007&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weatherization assistance program</td>
<td>—</td>
<td>0.14</td>
<td>2006</td>
<td>DOE, 2006&lt;sup&gt;g&lt;/sup&gt;</td>
</tr>
<tr>
<td>Federal energy management program</td>
<td>—</td>
<td>0.11</td>
<td>2005</td>
<td>FEMP, 2006&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>—</td>
<td>13.32</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

<sup>a</sup>Extrapolation of fuel savings estimated by the NRC to 2006, and assuming 75 percent of the energy savings from vehicle efficiency improvements are due to the CAFE standards.

<sup>b</sup>Interpolates between savings estimates by ACEEE for 2000 and 2010.

<sup>c</sup>Assumes that 85 percent of the energy savings from all CHP systems installed in 2006 was due to PURPA and other policy initiatives.

<sup>d</sup>Assumes only 75 percent of the energy savings estimated by U.S. EPA in order to avoid double counting savings with utility and state programs.

<sup>e</sup>Increases the energy savings estimate for new buildings constructed during 1990–1999 from Nadel (2004) by 100 percent to account for the impact of codes prior to 1990 and post-1999.

<sup>f</sup>Extrapolates the 2004 national electricity savings estimate to 2006 based on national DSM budget estimates for 2005 and 2006.

<sup>g</sup>Assumes 5.6 million weatherized households and average energy savings of 25 million Btu/yr per household, from Berry and Schweitzer (2003).

<sup>b</sup>Based on the reported reduction in energy use per square foot of floor area during 1985–2005 and actual primary energy use in federal buildings as of 2005 (i.e., excluding energy use by transport vehicles and equipment).
FIGURE 5.2 ENERGY STAR® appliance market shares (percent of new sales), 1997–2006.
Note: AC = air conditioner.
FIGURE 5.3 Per capita electricity consumption (not including on-site generation) in California, New York, and the United States, 1960–2006.
FIGURE 5.7 Annual electricity savings from key energy efficiency policies and programs implemented in California, 1975–2003.
<table>
<thead>
<tr>
<th></th>
<th>United States (kWh/person)</th>
<th>New York (kWh/person)</th>
<th>Difference (kWh/person)</th>
<th>Difference (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>4,514</td>
<td>2,508</td>
<td>2,006</td>
<td>41</td>
</tr>
<tr>
<td>Commercial</td>
<td>4,341</td>
<td>3,938</td>
<td>403</td>
<td>8</td>
</tr>
<tr>
<td>Industrial</td>
<td>3,378</td>
<td>776</td>
<td>2,602</td>
<td>53</td>
</tr>
<tr>
<td>Transportation</td>
<td>25</td>
<td>145</td>
<td>-121</td>
<td>-2</td>
</tr>
<tr>
<td>Total</td>
<td>12,258</td>
<td>7,367</td>
<td>4,890</td>
<td>100</td>
</tr>
</tbody>
</table>
FIGURE 5.8 New York State’s annual energy efficiency expenditures (in constant 2007 dollars) and achievements, 1990–2007.

Note: EE = energy efficiency; GWh = gigawatt-hours; LIPA = Long Island Power Authority; NYPAM = New York Power Authority; NYSERDA = New York State Energy Research and Development Authority.
Source: Courtesy of NYSERDA.
FIGURE 5.9 New York State’s energy efficiency achievements, 1990 through 2007: annual electricity use.

Note: EE = energy efficiency; LIPA = Long Island Power Authority; NYPA = New York Power Authority; NYSERDA = New York State Energy Research and Development Authority.

Source: Courtesy of NYSERDA.
2005...Energy Policy Act

changed **US energy policy** by providing tax incentives and loan guarantees for energy production of various types.

In Congressional bills an "authorization" of a discretionary program is a permission to spend money, while an "appropriation" is the actual decision to spend it; none of the authorizations will mean anything if the money is never appropriated.

**Tax reductions by subject area**

- $4.3 billion for **nuclear power**[^9]
- $2.8 billion for fossil fuel production
- $2.7 billion to extend the **renewable electricity production** credit
- $1.6 billion in tax incentives for investments in **clean coal** facilities
- $1.3 billion for conservation and energy efficiency
- $1.3 billion for **alternative motor vehicles** and **fuels** (bioethanol, biomethane, liquified natural gas, propane)
- $500 million Clean Renewable Energy Bonds (CREBS) for **government agencies** for renewable energy projects.
General provisions

Authorizes loan guarantees for "innovative technologies" that avoid greenhouse gases, which might include advanced nuclear reactor designs (such as PBMR) as well as clean coal and renewable energy;

Increases the amount of biofuel (usually ethanol) that must be mixed with gasoline sold in the United States to 4 billion gallons by 2006, 6.1 billion gallons by 2009 and 7.5 billion gallons by 2012;

Seeks to increase coal as an energy source while also reducing air pollution, through authorizing $200 million annually for clean coal initiatives, repealing the current 160-acre cap on coal leases, allowing the advanced payment of royalties from coal mines and requiring an assessment of coal resources on federal lands that are not national parks;

Authorizes subsidies for wind and other alternative energy producers;

Adds ocean energy sources including wave and tidal power for the first time as separately identified, renewable technologies;
Authorizes $50 million annually over the life of the law for biomass grants;

Contains provisions aimed at making geothermal energy more competitive with fossil fuels in generating electricity;

Requires the United States Department of Energy to study and report on existing natural energy resources including wind, solar, waves and tides;

Authorizes the Department of the Interior to grant leases for activity that involves the production, transportation or transmission of energy on Outer Continental Shelf lands from sources other than gas and oil (Section 388);

Requires the U.S. Department of Energy to study and report on national benefits of demand response and make a recommendation on achieving specific levels of benefits and encourages time-based pricing and other forms of demand response as a policy decision;

Requires all public electric utilities to offer net metering on request to their customers;
Outer continental Shelf
Requires the DOE to designate National Interest Electric Transmission Corridors where there are significant transmission limitations adversely affecting the public. The Federal Energy Regulatory Commission may authorize federal permits for transmission projects in these regions.

Provides tax breaks for those making energy conservation improvements to their homes;

Provides incentives to companies drilling for oil in the Gulf of Mexico;

Exempts oil and gas producers from certain requirements of the Safe Drinking Water Act;

Extends daylight saving time by four to five weeks, depending upon the year (see below);

Requires that no drilling for gas or oil may be done in or underneath the Great Lakes;

Requires that Federal Fleet vehicles capable of operating on alternative fuels be operated on these fuels exclusively (Section 701.)

Sets federal reliability standards regulating the electrical grid (done in response to the Blackout of 2003):[1]
• Nuclear-specific provisions:[6]

  • Extends the Price-Anderson Nuclear Industries Indemnity Act through 2025;

  • Authorizes cost-overrun support of up to $2 billion total for up to six new nuclear power plants;

  • Authorizes a production tax credit of up to $125 million total per year, estimated at 1.8 US¢/kWh during the first eight years of operation for the first 6,000 MW of capacity[7]; consistent with renewables;

  • Authorizes $1.25 billion for the Department of Energy to build a nuclear reactor to generate both electricity and hydrogen;

  • Allows nuclear plant employees and certain contractors to carry firearms;

  • Prohibits the sale, export or transfer of nuclear materials and "sensitive nuclear technology" to any state sponsor of terrorist activities;

  • Updates tax treatment of decommissioning funds;

  • A provision for the U.S. Department of Energy to report in one year on how to dispose of high-level nuclear waste;
Directs the Secretary of the Interior to complete a programmatic environmental impact statement for a commercial leasing program for oil shale and tar sands resources on public lands with an emphasis on the most geologically prospective lands within each of the states of Colorado, Utah, and Wyoming.
Commercial building deduction

The Act contains provisions for commercial buildings that make improvements to their energy systems. Energy improvements completed in 2006 and 2007 are eligible for tax deductions of as much as $1.80 per square foot. The incentives focus on improvements to lighting, HVAC and building envelope. Improvements are compared to a baseline of ASHRAE 2001 standards.

ASHRAE: American Society of Heating, Refrigeration, and Air-Conditioning Engineers

Many buildings are eligible for tax deductions for improvements completed or planned within the normal course of business, and can thus "free ride" for the new incentives. Achievement of these benefits requires cooperation between the facilities/energy division of a business and its tax department. A tax advisor with engineers on staff may serve as a bridge between these two historically separate business divisions. For municipal buildings, benefits are passed through to the primary designers/architects in an attempt to encourage innovative municipal design.
Energy management

The commercial building tax deductions can be used to improve the payback period of a prospective energy improvement investment.

Often the deductions are combined with participation in demand response programs where buildings agree to curtail usage at peak times for a premium.

The most common qualifying projects are in the lighting area. Industrial spaces such as Manufacturing, Warehouse and Distribution Centers are typically lit with 400W Metal Halide fixtures. These fixtures are commonly being upgraded with Hi-Bay Fluorescent fixtures that can cut energy use in half as well as qualify the building for tax deductions. In the Northeast paybacks for this project can get below one year.
Congressional Budget Office (CBO) cost estimate

The Congressional Budget Office review of the conference version of the bill estimated the Act will increase direct spending by $1.6 billion, and reduce revenue by $12.3 billion between 2006 and 2015. The CBO noted that the bill could have additional effects on discretionary spending, but did not attempt to estimate those effects.
Criticisms

The *Washington Post* contended that the spending bill is a broad collection of subsidies for United States energy companies; in particular, the nuclear and oil industries.

Texas companies in particular benefit from the bill. This criticism is heightened by the fact that President George W. Bush, the House Majority Leader (Tom DeLay), and the Chairman of the House Energy & Commerce Committee (Joe Barton) were all from Texas. The fact that the bill passed 66-29 with wide support from Democrats for the bill has not calmed this criticism (a *Philadelphia Inquirer* editorial on *July 28, 2005*, suggested Congress had a "let's pass it and claim we did something" attitude).

Speaking for the National Republicans for Environmental Protection Association, President Martha Marks said that the organization was disappointed in the bill: it did not give enough support to conservation, and continued to subsidize the well-established oil and gas industries that don't require subsidizing.

The bill did not include provisions for drilling in the Arctic National Wildlife Refuge (ANWR) even though some Republicans claim "access to the abundant oil reserves in ANWR would strengthen America's energy independence without harming the environment."

**HOME ENERGY EFFICIENCY IMPROVEMENT TAX CREDITS**
Consumers who purchase and install specific products, such as energy-efficient windows, insulation, doors, roofs, and heating and cooling equipment in existing homes can receive a tax credit for 30% of the cost, up to $1,500, for improvements "placed in service" starting January 1, 2009, through December 31, 2010.

See EnergyStar.gov's [Federal Tax Credits for Energy Efficiency](http://www.energystar.gov) for a complete summary of energy efficiency tax credits available to consumers.

**RESIDENTIAL RENEWABLE ENERGY TAX CREDITS**
Consumers who install solar energy systems (including solar water heating and solar electric systems), small wind systems, geothermal heat pumps, and residential fuel cell and microturbine systems can receive a 30% tax credit for systems placed in service before December 31, 2016; the previous tax credit cap no longer applies.

[http://www.energy.gov/media/HR_1424.pdf](http://www.energy.gov/media/HR_1424.pdf) [Energy Tax Incentives](http://www.energy.gov)
Rate of Heat transfer: $= \frac{\text{Area} \times (\Delta T)}{\text{R}}$

Example: A 1500 ft$^2$ wall has an R-value of 11 hr.F.ft$^2$/Btu, including the effects of inside and outside air layers. How many Btu are lost through this wall in a 5600 degree day heating season?

$$R \text{ value} = \text{thickness/thermal conductivity}$$

Degree days accumulated in one day = 5600 degrees = # days $(T_{\text{inside}} - T_{\text{outside}})$

$$Q = \left(\frac{\text{Area}}{\text{Total R value}}\right)(\Delta T)(\text{time})$$

$$Q = \left[\frac{1500 \text{ ft}^2}{(11 \text{ hr.F.ft}^2/\text{Btu})}\right] (5600 \text{ degree day})(24 \text{ hrs/day})$$

$$Q = 183272272 \text{ Btu}$$

$Q = 1.83 \times 10^8 \text{ Btu}$

- R value of plywood (3/4 inch) 0.94
- Urea foam per inch 5.25
- Poured concrete 0.08
- Fiberglass per inch 3.70