Principles of Energy Conversion

Part 2. Energy Perspectives

January 15, 2018

3 Energy Information

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Article 3

Energy Information

3.1 “lies, damned lies, and statistics”

“There are three kinds of lies: lies, damned lies, and statistics.”¹ It is exceeding easy to obtain misleading or incorrect statistical information on energy from the popular press, which includes the internet. Aside from political and technical biases, there are conflicting data sets on existing resource availability. For projections of energy utilization, there are dozens of growth models available.

One criteria of discerning the accuracy of statistical data is to ask ‘is the primary purpose of this source to provide data or to provide analysis and commentary on data?’ If the purpose is the latter, then use caution. The data provided will nearly always be a subset of a larger data set and you will not know for certain what information has been excluded.

Below are a few, generally reliable sources of information² on energy, historical and projected energy utilization, energy resource availability, and efficiency:

- DOE Energy Information Agency (EIA)
  https://www.eia.gov/

- EIA Annual Energy Review (AER)
  https://www.eia.gov/totalenergy/data/annual/index.php

- EIA Forecasts & Analysis
  https://www.eia.gov/outlooks/aeo/

- EIA Levelized Cost of New Generation Resources
  https://www.eia.gov/outlooks/aeo/electricity_generation.php

- International Energy Agency
  http://www.iea.org

- BP Statistical Review of World Energy - 2016
  BP Statistical Review (url changes annually)

- Lawrence Livermore National Lab
  https://flowcharts.llnl.gov/

- US Geological Survey
  https://energy.usgs.gov/

¹Phrase popularized by Mark Twain in Chapters from My Autobiography (1906).
²weblinks accessed January 15, 2018
3.2 Historical U.S. Energy Consumption

Figure 3.1: Historical U.S. energy consumption by source, 1635-2008. [1]

Figure 3.2: Historical U.S. energy consumption by source, 1949-2016. [2]
3.2.1 Production and Consumption by Source

Production:
By Major Source, 1949-2010

Consumption:
By Major Source, 1949-2010

Energy Information Agency [3]
3.2.2 Energy Consumption and Expenditure

**Energy Consumption, 1949-2010**

**Energy Expenditures, 1970-2009**

**Energy Consumption per Person, 1949-2010**

**Energy Expenditures per Person, 1970-2009**

---

*Source: Table 1.5.*

*¹ See "Nominal Dollars" in Glossary

*² In chained (2005) dollars, calculated by using gross domestic product implicit price deflators, See Appendix D1.

Energy Information Agency [3]
### 3.2.3 Household Energy Consumption

#### Table 2.5 Household Energy Consumption and Expenditures by End Use and Energy Source, Selected Years, 1978-2005

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural Gas Consumption (quadrillion Btu)</th>
<th>Electricity Consumption (quadrillion Btu)</th>
<th>Fuel Oil Consumption (quadrillion Btu)</th>
<th>LPG Consumption (quadrillion Btu)</th>
<th>Total Consumption (quadrillion Btu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>4.26</td>
<td>0.40</td>
<td>2.05</td>
<td>0.23</td>
<td>5.98</td>
</tr>
<tr>
<td>1979</td>
<td>3.41</td>
<td>0.27</td>
<td>1.30</td>
<td>0.23</td>
<td>5.31</td>
</tr>
<tr>
<td>1980</td>
<td>3.69</td>
<td>0.26</td>
<td>1.06</td>
<td>0.23</td>
<td>5.58</td>
</tr>
<tr>
<td>1981</td>
<td>3.69</td>
<td>0.26</td>
<td>1.06</td>
<td>0.23</td>
<td>5.58</td>
</tr>
<tr>
<td>1982</td>
<td>3.14</td>
<td>0.25</td>
<td>0.86</td>
<td>0.21</td>
<td>4.74</td>
</tr>
<tr>
<td>1983</td>
<td>3.31</td>
<td>0.28</td>
<td>1.17</td>
<td>0.22</td>
<td>5.74</td>
</tr>
<tr>
<td>1984</td>
<td>3.38</td>
<td>0.28</td>
<td>1.05</td>
<td>0.22</td>
<td>5.48</td>
</tr>
<tr>
<td>1985</td>
<td>3.37</td>
<td>0.30</td>
<td>0.93</td>
<td>0.19</td>
<td>5.30</td>
</tr>
<tr>
<td>1986</td>
<td>3.67</td>
<td>0.41</td>
<td>0.95</td>
<td>0.30</td>
<td>5.48</td>
</tr>
<tr>
<td>1987</td>
<td>3.61</td>
<td>0.40</td>
<td>0.91</td>
<td>0.26</td>
<td>5.48</td>
</tr>
<tr>
<td>1988</td>
<td>3.32</td>
<td>0.39</td>
<td>0.62</td>
<td>0.28</td>
<td>4.86</td>
</tr>
<tr>
<td>1989</td>
<td>3.32</td>
<td>0.39</td>
<td>0.62</td>
<td>0.28</td>
<td>4.86</td>
</tr>
<tr>
<td>1990</td>
<td>2.95</td>
<td>0.28</td>
<td>0.75</td>
<td>0.32</td>
<td>4.28</td>
</tr>
</tbody>
</table>

#### Expenditures (billion dollars 9)

<table>
<thead>
<tr>
<th>Year</th>
<th>Natural Gas Expenditures</th>
<th>Electricity Expenditures</th>
<th>Fuel Oil Expenditures</th>
<th>LPG Expenditures</th>
<th>Total Expenditures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>11.49</td>
<td>3.53</td>
<td>8.06</td>
<td>1.05</td>
<td>15.30</td>
</tr>
<tr>
<td>1979</td>
<td>9.09</td>
<td>3.05</td>
<td>7.51</td>
<td>0.94</td>
<td>14.58</td>
</tr>
<tr>
<td>1980</td>
<td>13.22</td>
<td>3.78</td>
<td>10.48</td>
<td>1.78</td>
<td>17.44</td>
</tr>
<tr>
<td>1981</td>
<td>16.59</td>
<td>3.97</td>
<td>12.62</td>
<td>2.00</td>
<td>21.18</td>
</tr>
<tr>
<td>1982</td>
<td>17.74</td>
<td>3.21</td>
<td>11.50</td>
<td>1.69</td>
<td>21.40</td>
</tr>
<tr>
<td>1983</td>
<td>20.66</td>
<td>4.22</td>
<td>14.48</td>
<td>2.00</td>
<td>26.36</td>
</tr>
<tr>
<td>1984</td>
<td>18.05</td>
<td>5.53</td>
<td>13.25</td>
<td>1.85</td>
<td>26.36</td>
</tr>
<tr>
<td>1985</td>
<td>18.59</td>
<td>6.16</td>
<td>17.42</td>
<td>2.01</td>
<td>27.26</td>
</tr>
<tr>
<td>1986</td>
<td>21.95</td>
<td>8.66</td>
<td>19.24</td>
<td>2.31</td>
<td>33.26</td>
</tr>
<tr>
<td>1987</td>
<td>24.11</td>
<td>8.56</td>
<td>19.57</td>
<td>2.79</td>
<td>36.68</td>
</tr>
<tr>
<td>1988</td>
<td>31.84</td>
<td>8.98</td>
<td>20.66</td>
<td>4.04</td>
<td>46.98</td>
</tr>
<tr>
<td>1989</td>
<td>31.97</td>
<td>7.42</td>
<td>19.99</td>
<td>6.35</td>
<td>55.74</td>
</tr>
</tbody>
</table>

**Notes:**
- 1 Wood used for space heating is included in “Total Wood.”
- 2 A small amount of natural gas used for air conditioning is included in “Total Natural Gas.”
- 3 Includes refrigerators.
- 4 A small amount of distillate fuel oil and kerosene used for appliances is included in “Fuel Oil” under “Total.”
- 5 Retail electricity.  One kilowatthour=3,412 Btu.
- 6 Distillate fuel oil and kerosene.
- 7 Liquefied petroleum gases.
- 8 Wood used for both space heating and ambiance.
- 9 Prices are not adjusted for inflation.  See “Nominal Dollars” in Glossary.
- NA=Not available.
- Data are estimates.
- For years not shown, there are no data available.
- Totals may not equal sum of components due to independent rounding.

**Sources:**

**Web Page:** For related information, see [http://www.eia.gov/consumption/residential/].

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3.2 Historical U.S. Energy Consumption
### Table 2.6  Household End Uses: Fuel Types, Appliances, and Electronics, Selected Years, 1978-2009

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Space Heating - Main Fuel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Electricity</td>
<td>16</td>
<td>17</td>
</tr>
<tr>
<td>Liquefied Petroleum Gases</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Distilled Fuel Oil</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>Wood</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Other or No Equipment</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td><strong>Air Conditioning - Equipment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central System</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td>Window/Wall Unit</td>
<td>33</td>
<td>31</td>
</tr>
<tr>
<td>None</td>
<td>44</td>
<td>43</td>
</tr>
<tr>
<td><strong>Water Heating - Main Fuel</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Gas</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Electricity</td>
<td>33</td>
<td>32</td>
</tr>
<tr>
<td>Liquefied Petroleum Gases</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Distilled Fuel Oil</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td><strong>Appliances</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td>100</td>
<td>NA</td>
</tr>
<tr>
<td>Separate Freezer</td>
<td>35</td>
<td>NA</td>
</tr>
<tr>
<td>Clothes Dryer</td>
<td>59</td>
<td>NA</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>35</td>
<td>NA</td>
</tr>
<tr>
<td>Range/Stove/Oven</td>
<td>99</td>
<td>NA</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>14</td>
<td>NA</td>
</tr>
<tr>
<td>Electric</td>
<td>45</td>
<td>NA</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>35</td>
<td>NA</td>
</tr>
<tr>
<td>Range/Stove/Oven</td>
<td>99</td>
<td>NA</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>14</td>
<td>NA</td>
</tr>
<tr>
<td>Electric</td>
<td>45</td>
<td>NA</td>
</tr>
<tr>
<td>Microwave Oven</td>
<td>8</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Electronics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Television</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Digital Video Recorder (DVR)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Computer</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Printer</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Appliance</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Percent of Households</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Includes households that have but do not use space heating equipment.
2 Retail (delivered) electricity.
3 Includes kerosene.
4 Coal, solar, or other fuels.
5 Households with both a central system and a window or wall unit are counted only under “Central System.” Includes households that have but do not use air conditioning equipment.
6 Fewer than 0.5 percent of the households do not have a refrigerator.
7 The 2001 “Residential Energy Consumption Survey (RECS)” only had one question for VCRs and DVD players.
8 NA=Not available.

Data are estimates. • For years not shown, there are no data available. Totals may not equal sum of components due to independent rounding.
3.2 Historical U.S. Energy Consumption

Share of Households With Selected Appliances, 1980 and 2009

- **Refrigerators**
  - One: 86% (1980), 77% (2009)
  - Two or More: 14% (1980), 23% (2009)
- **Separate Freezer**
  - One: 38% (1980), 30% (2009)
  - Two or More: 1% (1980), 7% (2009)
- **Clothes Washer**
  - One: 74% (1980), 82% (2009)
  - Two or More: 6% (1980), 8% (2009)
- **Clothes Dryer**
  - One: 5% (1980), 14% (2009)
  - Two or More: 2% (1980), 1% (2009)
- **Dishwasher**
  - One: 37% (1980), 37% (2009)
  - Two or More: 14% (1980), 14% (2009)
- **Microwave Oven**
  - One: 96% (1980), 96% (2009)
  - Two or More: 4% (1980), 4% (2009)

Share of Households With Selected Electronics, 1997 and 2009

- **Television**
  - One: 61% (1997), 59% (2009)
  - Two: 77% (1997), 79% (2009)
  - Three or More: 35% (1997), 37% (2009)
- **VCR**
  - One: 88% (1997), 96% (2009)
  - Two or More: 27% (1997), 24% (2009)
- **DVR**
  - One: 29% (1997), 44% (2009)
  - Two: 19% (1997), 30% (2009)
- **Central System**
  - One: 63% (1997), 60% (2009)
  - Two or More: 37% (1997), 40% (2009)

Air-Conditioning Equipment, 1980 and 2009

- **Window/Wall Unit**
  - One: 43% (1980), 24% (2009)
  - Two: 30% (1980), 30% (2009)
  - Three or More: 0% (1980), 3% (2009)
- **Central System**
  - One: 21% (1980), 13% (2009)
  - Two or More: 27% (1980), 30% (2009)

Energy Information Agency [3]
3.3 Historical U.S. Proved Energy Reserves & Resources

The definition of an energy resource, such as coal, shale oil, or petroleum, is based on that portion which can be economically extracted. The portion of resource ready for extraction is referred to as reserves. There are a number of subdivisions of energy resources. [4]

Illustration from Probstein and Hicks [4]

**Total Resources:** comprised of identified and undiscovered resources.
**Identified Resources:** demonstrated and inferred resources.
**Demonstrated Resources:** proved plus indicated resources.
**Proved Resources:** resources that have been measured by detailed geological surveys.
**Indicated Resources:** resources based on some measurements and on estimates of geological projection.
**Demonstrated Reserve Base:** proved and indicated reserves.
**Hypothetical Resources:** inferred by extrapolation of geological data into unexplored regions known to contain some amount of the resource.
**Speculative Resources:** geological extrapolation into undiscovered areas.

The figure cited for the total resource can vary depending upon the amount of exploration in an area and the economic viability of resource extraction. For example, as the price of a barrel of crude oil rises, the amount of shale oil that can be recovered (demonstrated reserve base) will increase.
3.3.1 Crude Oil & Natural Gas

Crude Oil & Natural Gas Proved Reserves:

Total, 1949-2009

Energy Information Agency [3]
3.3.2 Coal Reserves
3.3.3 Demonstrated Coal Reserves - 2009

By Key State

By Region

West and East of the Mississippi
By Mining Method

By Rank

Energy Information Agency [3]
3.4 U.S. Renewable Energy Resources

3.4.1 Photovoltaic Flat Plate

3.4.1.1 Concentrated Solar Power
3.4.2 Hydro-Power

United States
Legend
- Small Hydro
- Low Power, Conventional
- Low Power, Unconventional
- Microhydro
- Existing Hydroelectric Plants
- Excluded Area
- Valid & Scenic River

Department of Energy [7]
Figure 16. Total gross power potential of water energy resources in the 50 states of the United States divided into feasible, other available, excluded, and developed power categories.
3.5 Energy Flow Diagrams

3.5.1 U.S. Energy Flow - 1970

Figure 1.6 The sources and utilization of fuel energy in the United States, 1970. (From charts presented to the Congressional Joint Committee on Atomic Energy at the May 3, 1973 meeting.)

Culp [8]
3.5.2 U.S. Energy Flow - 1980

Kraushaar and Ristinen [9]

* Excluding coal exports and increases in stocks
* Includes 1.8 QBU of biomass use not currently accounted for in DOE statistics
** Includes 0.2 QBU of imported hydroelectric power
*** Based on end-use efficiencies from 1979 Brookhaven data

Transportation Ratio ~ 0.13
End-use losses 28.5 QBU total (net of electricity efficiency gains)
3.5.3 U.S. Energy Flow - 2002

*Net fossil-fuel electrical imports.
**Biomass/other includes wood, waste, alcohol, geothermal, solar, and wind.

Ristinen and Kraushaar [10]
3.5.4 U.S. Energy Flow - 2008 (LLNL)

Estimated U.S. Energy Use in 2008: ~99.2 Quads

Source: LLNL, 2009. Data is based on DOE/EIA-0384(2008), June 2009. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EA reports flows for non-thermal resources (i.e., hydro, wind and solar) in BTU-equivalent values by assuming a typical thermal plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MA-410527
3.5.5 U.S. Energy Flow - 2010 (LLNL)

Estimated U.S. Energy Use in 2010: ~98.0 Quads

Source: LLNL 2011. Data is based on DOE/EIA-0384/2010, October 2011. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. QA reports flows for hydro, wind, solar and geothermal in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." (see EIA report for explanation of change to geothermal in 2010). The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 80% for the residential, commercial and industrial sectors, and as 25% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-NM-410527

Lawrence Livermore National Lab [11]
3.5.6 U.S. Energy Flow - 2012 (LLNL)

Estimated U.S. Energy Use in 2012: ~95.1 Quads

Source: LLNL. 2013. Data is based on DOE/EIA-0025/2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity value and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electric production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End-use efficiency is estimated as 45% for the residential and commercial sectors, 80% for the industrial sector, and 22% for the transportation sector. Totals may not equal sum of components due to independent rounding. LNL-MI-41027
3.5.7 U.S. Energy Flow - 2016 (LLNL)

Estimated U.S. Energy Consumption in 2016: 97.3 Quads

Source: LLNL Report, 2017. Data is based on DOE/EIA-0641 (2014). If this information is a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy. Data includes all energy sources and all sectors. The efficiency of electricity production is estimated as the total fossil electricity delivered divided by the primary energy input into electricity generation. The efficiency of transportation is estimated as the total fossil energy delivered divided by the primary energy input into transportation.
Bibliography


