Energy Overview From NREL

This document has no connection to cold fusion, but it is valuable public domain information, it is no longer in print, and it does not appear to be available elsewhere on the Internet.


Page 17 shows a graph published by the Lawrence Livermore National Laboratory in 2001. The graph shows that most energy is lost as “rejected energy” (waste heat), especially in Electricity generation (70% waste) and Transportation (80% waste). Better technology would greatly reduce this waste. Most generators convert only 33% of the heat from burning coal or gas into electricity; advanced generators convert 40%. Most automobiles convert only 15% of the heat from gasoline into useful vehicle propulsion; hybrid and electric automobiles convert 30% or more. This graph is based on the DoE Energy Information Administration *Annual Energy Review*. This review is an excellent, comprehensive source of online information. See:

[http://www.eia.doe.gov/emeu/aer/contents.html](http://www.eia.doe.gov/emeu/aer/contents.html)
Exhibit A.2
Transportation Current Technologies

CRUDE OIL/GASOLINE

<table>
<thead>
<tr>
<th>Process</th>
<th>Cost ($/kW)</th>
<th>Total Cost ($/kW delivered)</th>
<th>Emissions (g/kWh delivered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refinery</td>
<td>9.5</td>
<td>1000</td>
<td>CO₂: 2.400, NOₓ: 4.2, SO₂: trace</td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 1000
Total Cost ($/kW delivered): 50
Total Emissions (g/kWh delivered): CO₂: 2.400, NOₓ: 4.2, SO₂: trace

AVERAGED FOSSIL FUELS/ELECTRICITY/HYDROGEN

<table>
<thead>
<tr>
<th>Process</th>
<th>Cost ($/kW)</th>
<th>Total Cost ($/kW delivered)</th>
<th>Emissions (g/kWh delivered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Process</td>
<td>25.9</td>
<td>1500*</td>
<td>CO₂: 22.637, NOₓ: 62.9, SO₂: 169.6</td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 1500* 1000* 100
Total Cost ($/kW delivered): 71420
Total Emissions (g/kWh delivered): CO₂: 22.637, NOₓ: 62.9, SO₂: 169.6

PHOTOVOLTAICS/HYDROGEN

<table>
<thead>
<tr>
<th>Process</th>
<th>Cost ($/kW)</th>
<th>Total Cost ($/kW delivered)</th>
<th>Emissions (g/kWh delivered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photovoltaics</td>
<td>51.8</td>
<td>5000*</td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 5000 300* 1000* 100
Total Cost ($/kW delivered): 323140
Total Emissions (g/kWh delivered): 0

* These devices are rated on input power; all others are sized on output power levels.
Exhibit A.2
Transportation Current Technologies (Continued)

AVERAGED FOSSIL FUELS/ELECTRICITY/BATTERY

(T-4)

Fossil Fuels
Averaged

5.1

Thermal Process

0.39

1.8

Transmission

0.92

1.7

EV Battery

0.70

1.2

Motor

Drive

0.85

1.0

Vehicle

Propulsion

Unit Cost ($/kW): 1500

Total Cost ($/kW delivered): 3,240

Total Emissions (g/kWh delivered): CO₂: 1,505, NOₓ: 4.2, SO₂: 11.3

NATURAL GAS/ICE

(T-5)

Natural Gas

11.2

Transmission

0.95

10.6

On-Board Storage

0.65

6.9

IC Engine

0.17

1.2

Motor

Drive

0.85

1.0

Vehicle

Propulsion

Unit Cost ($/kW): 50

Total Cost ($/kW delivered): 530

Total Emissions (g/kWh delivered): CO₂: 1300, NOₓ: 4.0

PHOTOVOLTAICS/BATTERY/ELECTRICITY

(T-6)

Solar

34.8

17.4

Photovoltaics

0.15

5.2

Battery

0.70

2.6

DC ELEC

3.6

Transmission

0.92

1.6

Stored ELEC

1.7

1.2

Motor

Drive

0.85

1.0

Vehicle

Propulsion

Unit Cost ($/kW): 5000

Total Cost ($/kW delivered): 120

Total Emissions (g/kWh delivered): 300

Total Emissions (g/kWh delivered): 27,512

0

* These devices are rated on input power; all others are sized on output power levels.
Exhibit A.3
Transportation Advanced Technologies

CRUDE OIL/GASOLINE

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cost ($/kW)</th>
<th>Emissions (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery</td>
<td>0.90</td>
<td>6.7</td>
</tr>
<tr>
<td>Distribution</td>
<td>0.97</td>
<td>6.0</td>
</tr>
<tr>
<td>Delivered</td>
<td>0.19</td>
<td>5.8</td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 1000
Total Cost ($/kW delivered): 50*
Total Emissions (g/kWh delivered): CO₂: 1.384, NOₓ: 3.1, SO₂: (trace)

AVERAGED FOSSIL FUELS/ELECTRICITY/HYDROGEN

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cost ($/kW)</th>
<th>Emissions (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal</td>
<td>0.42</td>
<td>12.9</td>
</tr>
<tr>
<td>Electrolysis</td>
<td>0.75</td>
<td>5.4</td>
</tr>
<tr>
<td>Storage</td>
<td>0.75</td>
<td>4.1</td>
</tr>
<tr>
<td>Pipeline</td>
<td>0.97</td>
<td>3.1</td>
</tr>
<tr>
<td>Storage</td>
<td>0.75</td>
<td>2.9</td>
</tr>
<tr>
<td>Delivered</td>
<td>0.50</td>
<td>2.2</td>
</tr>
<tr>
<td>Delivered</td>
<td>0.90</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 1200
Total Cost ($/kW delivered): 8,140
Total Emissions (g/kWh delivered): CO₂: 3.445, NOₓ: 2.8, SO₂: 1.2

COAL GASIFICATION/HYDROGEN

<table>
<thead>
<tr>
<th>Stage</th>
<th>Cost ($/kW)</th>
<th>Emissions (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>0.65</td>
<td>6.3</td>
</tr>
<tr>
<td>Bulk Storage</td>
<td>0.75</td>
<td>4.1</td>
</tr>
<tr>
<td>Pipeline</td>
<td>0.97</td>
<td>3.1</td>
</tr>
<tr>
<td>On-board Storage</td>
<td>0.75</td>
<td>2.9</td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>0.50</td>
<td>2.2</td>
</tr>
<tr>
<td>Delivered</td>
<td>0.90</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 900
Total Cost ($/kW delivered): 4,000
Total Emissions (g/kWh delivered): CO₂: 1.845, NOₓ: 1.4, SO₂: 1.0

* These devices are rated on input power; all others are sized on output power levels.
Exhibit A.3
Transportation Advanced Technologies (Continued)

NATURAL GAS/HYDROGEN

Unit Cost ($/kW):
50*
Total Cost ($/kW delivered): 175
Total Emissions (g/kWh delivered): CO₂: 358

PHOTOVOLTAICS/HYDROGEN

Unit Cost ($/kW):
2500 250* 50 50*
Total Cost ($/kW delivered): 30,870
Total Emissions (g/kWh delivered): 0

DIRECT SOLAR/HYDROGEN

Unit Cost ($/kW):
2500 50 50*
Total Cost ($/kW delivered): 21,120
Total Emissions (g/kWh delivered): 0

* These devices are rated on input power; all others are sized on output power levels.
Exhibit A.3
Transportation Advanced Technologies (Continued)

PHOTOVOLTAICS/BATTERY

(T-13)

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost ($/kW)</th>
<th>Emissions (g/kWh delivered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>2500</td>
<td>0</td>
</tr>
<tr>
<td>DC Elec</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Battery</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Inverter</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Transmission</td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>EV Battery</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>Power Train</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>VEHICLE PROPULSION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 2500
Total Cost ($/kW delivered): 10,706
Total Emissions (g/kWh delivered): 0

BIOMASS/HYDROGEN

(T-14)

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost ($/kW)</th>
<th>Emissions (g/kWh delivered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>Biomass</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Produced Hydrogen</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Stored Hydrogen</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Delivered Hydrogen</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>On-board Hydrogen</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>Fuel Cell</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Power Train</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>VEHICLE PROPULSION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 1000
Total Cost ($/kW delivered): 4,410
Total Emissions (g/kWh delivered): CO₂: 0

BIOMASS/ETHANOL

(T-15)

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost ($/kW)</th>
<th>Emissions (g/kWh delivered)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>1000</td>
<td>0</td>
</tr>
<tr>
<td>Biomass</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Produced Ethanol</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>Distributed Ethanol</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Delivered Ethanol</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>I.C. Engine</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Rotary Power</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>VEHICLE PROPULSION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 1000
Total Cost ($/kW delivered): 5,460
Total Emissions (g/kWh delivered): CO₂: 639, NOₓ: 1.8

* These devices are rated on input power; all others are sized on output power levels.

** CO₂ produced during H₂ and ethanol production is reabsorbed by subsequent biomass crops.
Exhibit A.3
Transportation Advanced Technologies (Continued)

AVERAGED FOSSIL FUELS/ELECTRICITY/BATTERY

(T-16) 3.5 Thermal Process 0.42 1.5 Transmission 0.95 1.4 EV Battery 0.80 1.1 Motor Drive 0.90 1.0 VEHICLE PROPULSION

FOSSIL FUELS AVERAGED
AC ELEC DELIVERED ELEC ROTARY POWER

Unit Cost ($/kW):
1200
300*

Total Cost ($/kW delivered):
2,250

Total Emissions (g/kWh delivered):
CO₂: 957  NO₂: 0.77  SO₂: 0.33

* These devices are rated on input power; all others are sized on output power levels.
Exhibit A.4
Utility Current Technologies

**AVERAGED FOSSIL FUELS/ELECTRICITY**

3.4
(U-1) Thermal Process 0.36 1.2 Transmission 0.92 1.1 Motor Drive 0.50 1.0
Fossil Fuels Averaged AC Elec Grid AC Elec Delivered Factory Power

Unit Cost ($/kW): 1500 300*

Total Cost ($/kW delivered): 2,160

Total Emissions (g/kWh delivered): CO₂: 1,003, NOₓ: 2.8, SO₂: 7.5

**AVERAGED FOSSIL FUELS/BATTERY/ELECTRICITY**

5.0
(U-2) Thermal Process 0.36 1.8 Battery** 1.3 Inverter 1.2 Transmission 0.92 1.1 Motor Drive 0.90 1.0
Fossil Fuels Averaged AC Elec Grid DC Elec Stored AC Elec Grid AC Elec Delivered Factory Power

Unit Cost ($/kW): 1500 120 (included) 300*

Total Cost ($/kW delivered): 3,216

Total Emissions (g/kWh delivered): CO₂: 1,505, NOₓ: 4.2, SO₂: 11.3

* These devices are rated on input power; all others are sized on output power levels.
** Other forms of electric storage (i.e., pumped storage) operate at similar efficiencies.
Exhibit A.4
Utility Current Technologies (Continued)

AVERAGED FOSSIL FUELS/ELECTRICITY/HYDROGEN

Unit Cost ($/kW):
- 1500
- 300* 1000*

Total Cost ($/kWh delivered): 7,930
Total Emissions (g/kWh delivered): CO₂: 2,424, NO₂: 6.7, SO₂: 18.2

AVERAGED FOSSIL FUELS/HYDROGEN/ELECTRICITY

Unit Cost ($/kW):
- 1500
- 300* 1000*

Total Cost ($/kWh delivered): 19,380
Total Emissions (g/kWh delivered): CO₂: 5,936, NO₂: 16.5, SO₂: 44.4

PHOTOVOLTAICS/HYDROGEN/ELECTRICITY

Unit Cost ($/kW):
- 5000
- 1000* 100 2500

Total Cost ($/kWh delivered): 92,200
Total Emissions (g/kWh delivered): CO₂: 0, NO₂: 0, SO₂: 0

* These devices are rated on input power; all others are sized on output power levels.
Exhibit A.4
Utility Current Technologies (Continued)

PHOTOVOLTAICS/BATTERY/ELECTRICITY

<table>
<thead>
<tr>
<th>Solar</th>
<th>DC Elec</th>
<th>Stored Elec</th>
<th>Delivered Elec</th>
<th>Factory Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.0</td>
<td>3.4</td>
<td>2.4</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>11.5</td>
<td>1.7</td>
<td>1.2</td>
<td>0.92</td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW):
- 2500
- 120
- 300

Total Cost ($/kW delivered): 9,508
Total Emissions (g/kWh delivered): 0

WIND/DC ELECTRICITY

<table>
<thead>
<tr>
<th>Wind Turbine</th>
<th>DC Elec</th>
<th>Stored Elec</th>
<th>Delivered Elec</th>
<th>Factory Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6</td>
<td>3.6</td>
<td>2.6</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>0.40</td>
<td>0.70</td>
<td>0.92</td>
<td>0.85</td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW):
- 1100
- 120
- 300

Total Cost ($/kW delivered): 5,052
Total Emissions (g/kWh delivered): 0

* These devices are rated on input power; all others are sized on output power levels.

** Other forms of electric storage (i.e. pumped storage) operate at similar efficiencies.
Exhibit A.5
Utility Advanced Technologies

AVERAGED FOSSIL FUELS/ELECTRICITY

Unit Cost ($/kW):
1200
300*

Total Cost ($/kW delivered):
1,850

Total Emissions (g/kWh delivered):
\( \text{CO}_2: 702, \text{NO}_x: 0.56, \text{SO}_2: 0.24 \)

AVERAGED FOSSIL FUELS/BATTERY/DC ELECTRICITY

Unit Cost ($/kW):
1200
300*
80

Total Cost ($/kW delivered):
2,184

Total Emissions (g/kWh delivered):
\( \text{CO}_2: 893, \text{NO}_x: 0.71, \text{SO}_2: 0.31 \)

AVERAGED FOSSIL FUELS/ELECTRICITY/HYDROGEN

Unit Cost ($/kW):
1200
300*
250*
50

Total Cost ($/kW delivered):
3,530

Total Emissions (g/kWh delivered):
\( \text{CO}_2: 1.276, \text{NO}_x: 1.02, \text{SO}_2: 0.44 \)
Exhibit A.5
Utility Advanced Technologies (Continued)

**AVERAGED FOSSIL FUELS/HYDROGEN/DC ELECTRICITY**

*Using Utility Waste Heat*

<table>
<thead>
<tr>
<th>Process</th>
<th>AC Output</th>
<th>Produced Hydrogen</th>
<th>Stored H₂</th>
<th>Delivered Hydrogen</th>
<th>DC Elec</th>
<th>Factory Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fossil Fuels Averaged</td>
<td>3.0</td>
<td>3.0</td>
<td>2.2</td>
<td>2.1</td>
<td>1.05</td>
<td>1.0</td>
</tr>
<tr>
<td>Thermal Process</td>
<td>0.42</td>
<td>0.75</td>
<td>0.95</td>
<td>0.97</td>
<td>0.50</td>
<td>0.95</td>
</tr>
<tr>
<td>NO₂, SO₂</td>
<td>HEAT</td>
<td>7.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 1200 250* 50 50*
Total Cost ($/kW delivered): 4,642
Total Emissions (g/kWh delivered): CO₂: 1,914, NO₂: 1.53, SO₂: 0.66

*(1) Storage efficiency increased from 0.75 to 0.95 due to utilization of power plant waste heat for hydride discharge.*

**COAL GASIFICATION/HYDROGEN/DC ELECTRICITY**

<table>
<thead>
<tr>
<th>Process</th>
<th>Produced Hydrogen</th>
<th>Stored Hydrogen</th>
<th>Delivered Hydrogen</th>
<th>DC Elec</th>
<th>Factory Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Gasification</td>
<td>4.5</td>
<td>2.9</td>
<td>2.2</td>
<td>2.1</td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>Gasification</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 900 50 50*
Total Cost ($/kW delivered): 2,830
Total Emissions (g/kWh delivered): CO₂: 1,305, NO₂: 0.96, SO₂: 0.73

**NATURAL GAS/HYDROGEN/DC ELECTRICITY**

<table>
<thead>
<tr>
<th>Process</th>
<th>Natural Gas</th>
<th>Delivered Natural Gas</th>
<th>DC Elec</th>
<th>Factory Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>3.4</td>
<td>2.4</td>
<td>1.1</td>
<td>1.0</td>
</tr>
<tr>
<td>Storage</td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission</td>
<td>0.97</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refiner &amp; Fuel Cell</td>
<td></td>
<td></td>
<td>0.43</td>
<td></td>
</tr>
</tbody>
</table>

Unit Cost ($/kW): 50 50*
Total Cost ($/kW delivered): 250
Total Emissions (g/kWh delivered): CO₂: 358, NO₂: 0.13
Exhibit A.5
Utility Advanced Technologies (Continued)

PHOTOVOLTAICS/HYDROGEN/DC ELECTRICITY

Unit Cost ($/kW):
2500 250* 50 50*
Total Cost ($/kW delivered): 21,605
Total Emissions (g/kWh delivered): 0

DIRECT SOLAR/HYDROGEN/DC ELECTRICITY

Unit Cost ($/kW):
2500 50 50*
Total Cost ($/kW delivered): 14,680
Total Emissions (g/kWh delivered): 0

PHOTOVOLTAICS/BATTERY/DC ELECTRICITY

Unit Cost ($/kW):
2500 80* 300*
Total Cost ($/kW delivered): 7,336
Total Emissions (g/kWh delivered): 0
Exhibit A.5
Utility Advanced Technologies (Continued)

BIOMASS/HYDROGEN/DC ELECTRICITY

Unit Cost ($/kW): 1000
Total Cost ($/kW delivered): 2,310
Total Emissions (g/kWh delivered): 0

BIOMASS/ELECTRICITY

Unit Cost ($/kW): 900
Total Cost ($/kW delivered): 1,320
Total Emissions (g/kWh delivered): CO$_2$: 0** NO$_x$: 0.73

WIND/DC ELECTRICITY

Unit Cost ($/kW): 850
Total Cost ($/kW delivered): 3,292
Total Emissions (g/kWh delivered): 0

** CO$_2$ produced during H$_2$ and ethanol production is reabsorbed by subsequent biomass crops.
## APPENDIX C: TECHNOLOGY ASSUMPTIONS

### TABLE C-1

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Efficiency (%)</td>
<td>Cap. Cost ($)</td>
</tr>
<tr>
<td>1</td>
<td>Central Baseload Fossil Plant</td>
<td>36</td>
<td>1,500</td>
</tr>
<tr>
<td>2</td>
<td>Electricity Transmission (500 miles)</td>
<td>92</td>
<td>300</td>
</tr>
<tr>
<td>3</td>
<td>Electric Motor Drive</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td>4</td>
<td>Electrolysis</td>
<td>65</td>
<td>1,000</td>
</tr>
<tr>
<td>5</td>
<td>Hydrogen Storage (5 hours)</td>
<td>65</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>Natural Gas Pipeline (500 miles)</td>
<td>95</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>Hydrogen Pipeline (500 miles)</td>
<td>95</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>Fuel Cell</td>
<td>40</td>
<td>2,500</td>
</tr>
<tr>
<td>9</td>
<td>Battery Storage (5 hours)</td>
<td>70</td>
<td>120</td>
</tr>
<tr>
<td>10</td>
<td>Photovoltaics</td>
<td>15</td>
<td>5,000</td>
</tr>
<tr>
<td>11</td>
<td>Photoconversion</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>12</td>
<td>I.C. Engine (Fed. Urban Dr. Cycle)</td>
<td>15</td>
<td>50</td>
</tr>
<tr>
<td>13</td>
<td>Vehicle Power Train</td>
<td>85</td>
<td>10</td>
</tr>
<tr>
<td>14</td>
<td>Refinery</td>
<td>85</td>
<td>1000</td>
</tr>
<tr>
<td>15</td>
<td>Gas Furnace</td>
<td>90</td>
<td>—</td>
</tr>
<tr>
<td>16</td>
<td>Industrial Boiler</td>
<td>70</td>
<td>—</td>
</tr>
<tr>
<td>17</td>
<td>Combined Cycle- Baseload Coal Plant</td>
<td>39</td>
<td>—</td>
</tr>
<tr>
<td>18</td>
<td>Combustion Turbine</td>
<td>25</td>
<td>—</td>
</tr>
<tr>
<td>19</td>
<td>Steam Reforming (natural gas)</td>
<td>68</td>
<td>—</td>
</tr>
<tr>
<td>20</td>
<td>Biomass Conversion (ethanol)</td>
<td>—</td>
<td>—</td>
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<tr>
<td>21</td>
<td>Biomass Conversion (hydrogen)</td>
<td>—</td>
<td>—</td>
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<tr>
<td>22</td>
<td>Coal Gasification</td>
<td>55</td>
<td>1,200</td>
</tr>
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1. **Central Baseload Fossil Plant**  

2. **Transmission**  

3. **Motor Drive**  
   Lawrence Berkeley Laboratory, "Technology Assessment: Adjustable-Speed Motors and Motor Drives," U.S. DOE, 1988  
   EPRI, Technical Brief, "Efficient Electric Motors and Drives," 1987
4. Electrolysis
PG&E, 1990 (Ibid.)
"The Hydrogen Technology Assessment, Opportunities for Industry and Research, Phase I," National Hydrogen Association

5. Hydrogen Storage
National Hydrogen Association, 1991 (Ibid.)
PG&E, 1990 (Ibid.)
(See references in Appendix B)

6. & 7. Hydrogen Pipeline
PG&E, 1990 (Ibid.)
(The long distance hydrogen pipeline data in this reference is based on calculations and projections, not actual transmission data)

8. Fuel Cell

9. Battery Storage

10. Photovoltaics

11. Photoconversion
U.S. DOE, 1990 (Ibid.)
Personal communication to W. Hoagland, NREL, June 1991

12. I.C. Engine
Jet Propulsion Laboratory (JPL), "Advanced Vehicle Systems Assessment," Vol 1: Executive Summary, K. Hardy, 1985

13. Vehicle Power Train
JPL, 1985 (Ibid.)

14. Refinery
DOE Staff Communication, 1991

15. Gas Furnace
EPRI TAG, End-Use, 1987

16. Industrial Boiler
EPRI TAG, End-Use, 1987

17. Combined Cycle Baseload Coal Plant
Electricity Supply, WES, DOE/EIA, 1991 (Ibid)

18. Combustion Turbine
EPRI TAG, 1986 (Ibid)

19. Steam Reforming


22. Coal Gasification
Net Primary Resource Consumption 98.5 Quads

Source: Production and end-use data from Energy Information Administration, Annual Energy Review 2000
*Net fossil-fuel electrical imports
**Biomass/other includes wood and waste, geothermal, solar, and wind.