Russell Energy Corporation

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Energy Efficiency

- The government standard for measuring power generation efficiency.

  A. Heat rate defined by the United States Energy Information Administration is the amount of energy used by an electrical generator or power plant to generate one kilowatthour (kWh) of electricity.

  Source: http://www.eia.gov/tools/faqs/faq.cfm?id=107&t=3

  B. 3412 BTUs make one kWh of electricity

  C. BTU (British Thermal Unit) is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit at a specified temperature (39°F)

Energy Efficiency

Table 8.1. Average Operating Heat Rate for Selected Energy Sources,

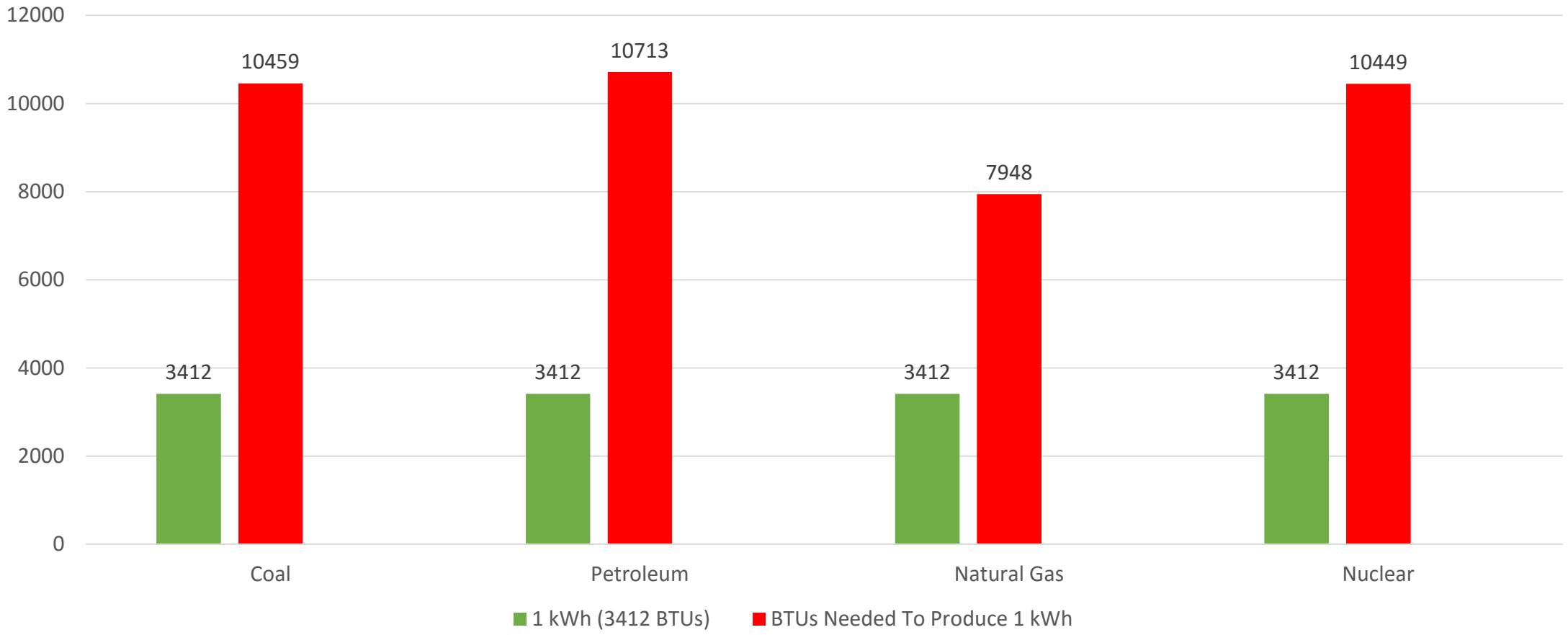
2003 through 2013 (Btu per Kilowatthour)

Year	Coal	Petroleum	Natural Gas	Nuclear
2003	10297	10610	9207	10422
2004	10331	10571	8647	10428
2005	10373	10631	8551	10436
2006	10351	10809	8471	10435
2007	10375	10794	8403	10489
2008	10378	11015	8305	10452
2009	10414	10923	8160	10459
2010	10415	10984	8185	10452
2011	10444	10829	8152	10464
2012	10498	10991	8039	10479
2013	10459	10713	7948	10449

1. **Coal** **3412/10459=.3262 (32.62%)**
2. **Petroleum** **3412/10713=.3184 (31.84%)**
3. **Natural Gas** **3412/7948= .4292 (42.92%)**
4. **Nuclear** **3412/10449=.3265 (32.65%)**

Source: htttp://www.eia.gov/electricity/annual/html/epa_08_01.html

Heat Rate for Selected Energy Sources For 2013



Energy Efficiency

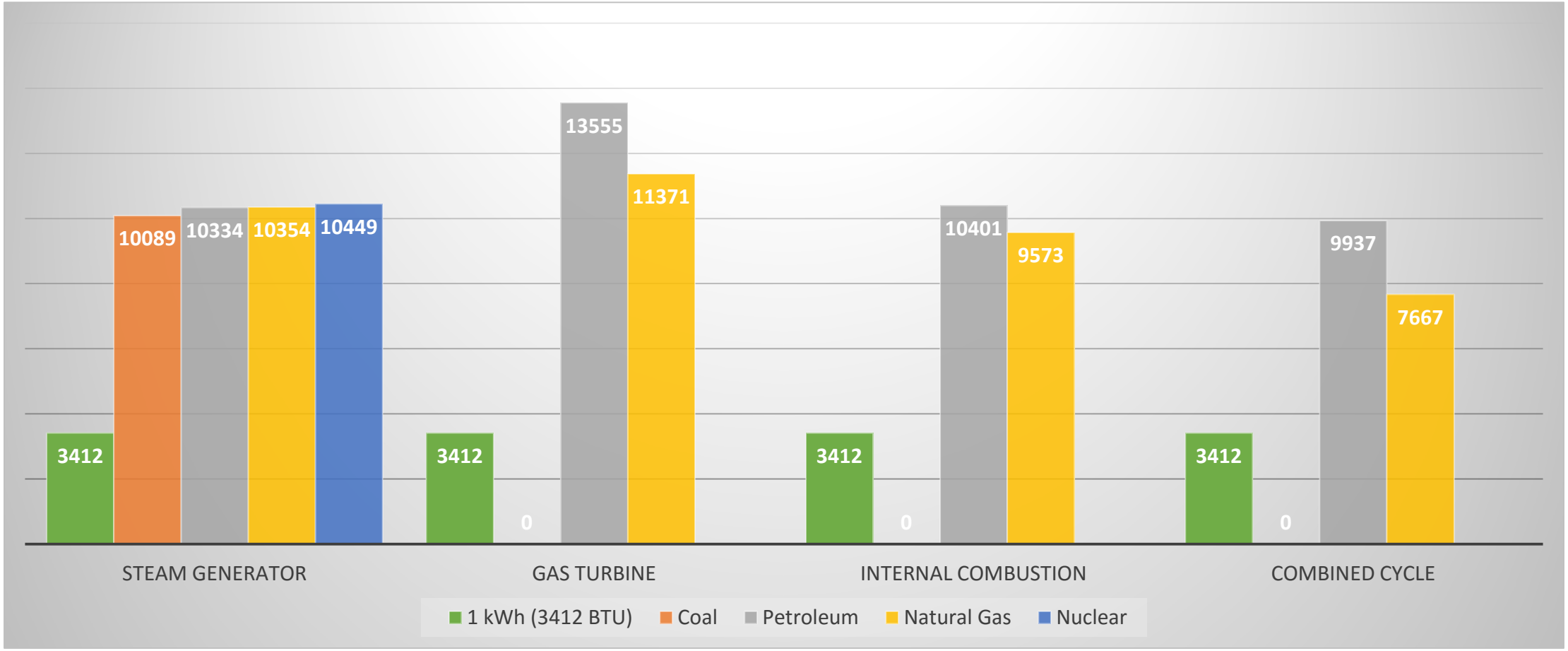
Table 8.2. Average Tested Heat Rates by Prime Mover and Energy Source, 2007 - 2013
(Btu per Kilowatthour)

Prime Mover	Coal		Petroluem		Natural Gas		Nuclear	
2013								
Steam Generator	**33.81%**	10,089	**33.01%**	10,334	**32.95%**	10,354	**32.65%**	10,449
Gas Turbine		--	**25,17%**	13,555	**30.00%**	11,371		--
Internal Combustion		--	**32.80%**	10,401	**35.64%**	9,573		--
Combined Cycle		W	**34.33%**	9,937	**44.50%**	7,667		--

Notes: W = Withheld to avoid disclosure of individual company data.

Heat rate is reported at full load conditions for electric utilities and independent power producers.
The average heat rates above are weighted by Net Summer Capacity.
Coal Combined Cycle represents integrated gasification units.
Source: http://www.eia.gov/electricity/annual/html/epa_08_02.html

Average Tested Heat Rates by Prime Mover and Energy Source for 2013



Energy Efficiency

Table F1. Conversion Efficiencies of Noncombustible Renewable Energy Sources (Percent)

Source: http://www.eia.gov/totalenergy/data/annual/pdf/sec17.pdf

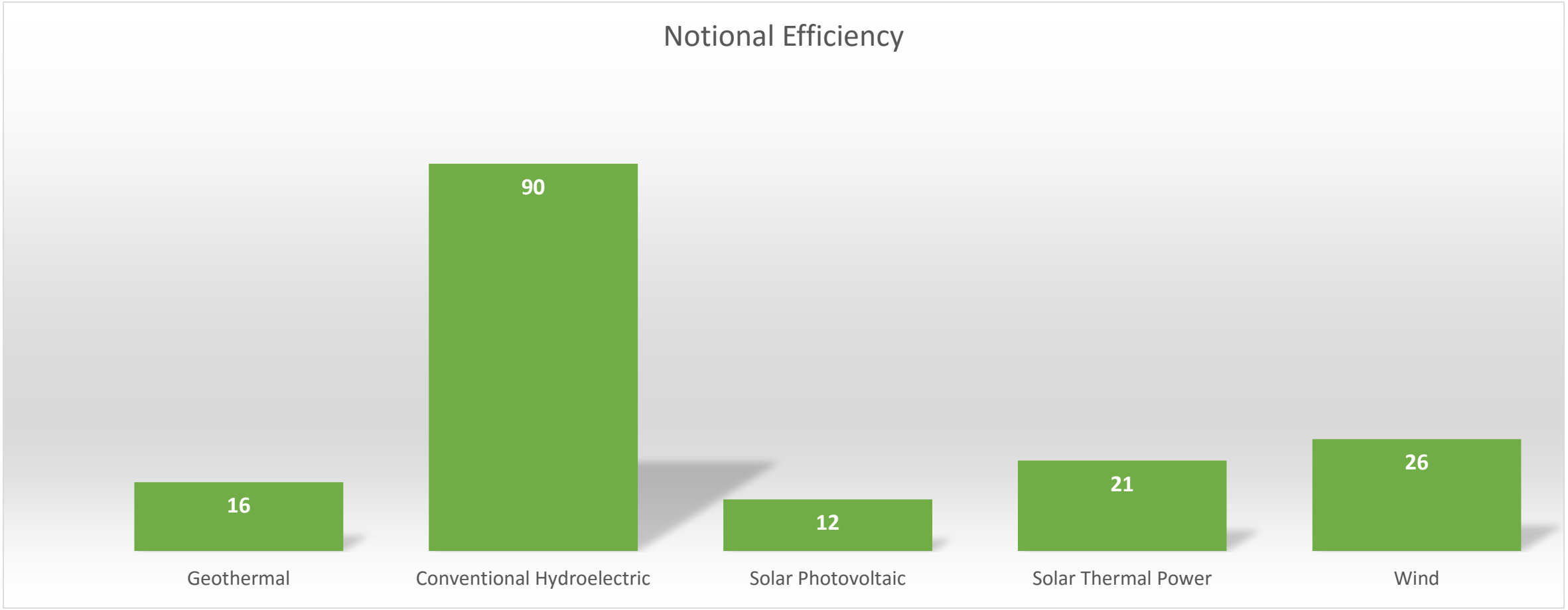
This appendix is reprinted from the Annual Energy Review 2010. EIA continues to review alternative options for accounting for energy consumption and related losses, such as those associated with the generation and distribution of electricity.

Source	Notional Efficiency1
Geothermal	**16**
Conventional Hydroelectric	**90**
Solar Photovoltaic	**12**
Solar Thermal Power	**21**
Wind	**26**

1 Efficiencies may vary significantly for each technology based on site-specific technology and environmental factors. Factors shown represent engineering estimates for typical equipment under specific operational conditions.

Sources: **Geothermal:** Estimated by EIA on the basis of an informal survey of relevant plants. **Conventional Hydroelectric:** Based on published estimates for the efficiency of large-scale hydroelectric plants. See http://www.usbr.gov/power/edu/pamphlet.pdf. **Solar Photovoltaic:** Based on the average rated efficiency for a sample of commercially available modules. Rated efficiency is the conversion efficiency under standard test conditions, which represents a fixed, controlled operating point for the equipment; efficiency can vary with temperature and the strength of incident sunlight. Rated efficiencies are based on the direct current (DC) output of the module; since grid-tied applications require alternating current (AC) output, efficiencies are adjusted to account for a 20 percent reduction in output when converting from DC to AC. **Solar Thermal Power:** Estimated by dividing the rated maximum power available from the generator by the power available under standard solar conditions (1,000 W/m2) from the aperture area of solar collectors. **Wind:** Based on the average efficiency at rated wind speed for a sample of commercially available wind turbines. The rated wind speed is the minimum wind speed at which a turbine achieves its nameplate rated output under standard atmospheric conditions. Efficiency is calculated by dividing the nameplate rated power by the power available from the wind stream intercepted by the rotor disc at the rated wind speed.

Conversion Efficiencies of Noncombustible Renewable Energy Sources (Percent)



Energy Efficiency US Transportation

- What about transportation?
  - **Vehicle efficiency 21% Sources:**

http://courses.washington.edu/me341/oct22v2.htm

http://www.consumerenergycenter.org/transportation/consumer_tips/vehicle_energy_losses.html

1. **4,362 TWh Gasoline Consumed 2011**
2. **3,446 TWh Gasoline Wasted 2011**

a. Formula (130,597 million gallons annual X 114,000 (btu per gallon)= 14,888,058,000,000,000 btu X .000293 (convert btu to kwh)= 4,362,200,994,000 kwh (4,362 TWh) x .79 (loss due to inefficiency)= 3,446,138,785,260 kwh (3,446 TWh wasted))

3. **1,515 TWh Diesel Consumed 2011**
4. **1,196.8 TWh Diesel Wasted 2011**

a. Formula (39,929 million gallons annual x 129,500 (btu per gallon)= 5,170,805,500,000,000 btu x .00293 (convert btu to kwh)= 1,515,046,011,500 kwh (1,515TWh) X .79 (loss due to inefficiency) = 1,196,886,349,085 kwh (1196.8 TWh diesel wasted))

Source: http://www.statista.com/statistics/189410/us-gasoline-and-diesel-consumption-for-highway-vehicles-since-1992

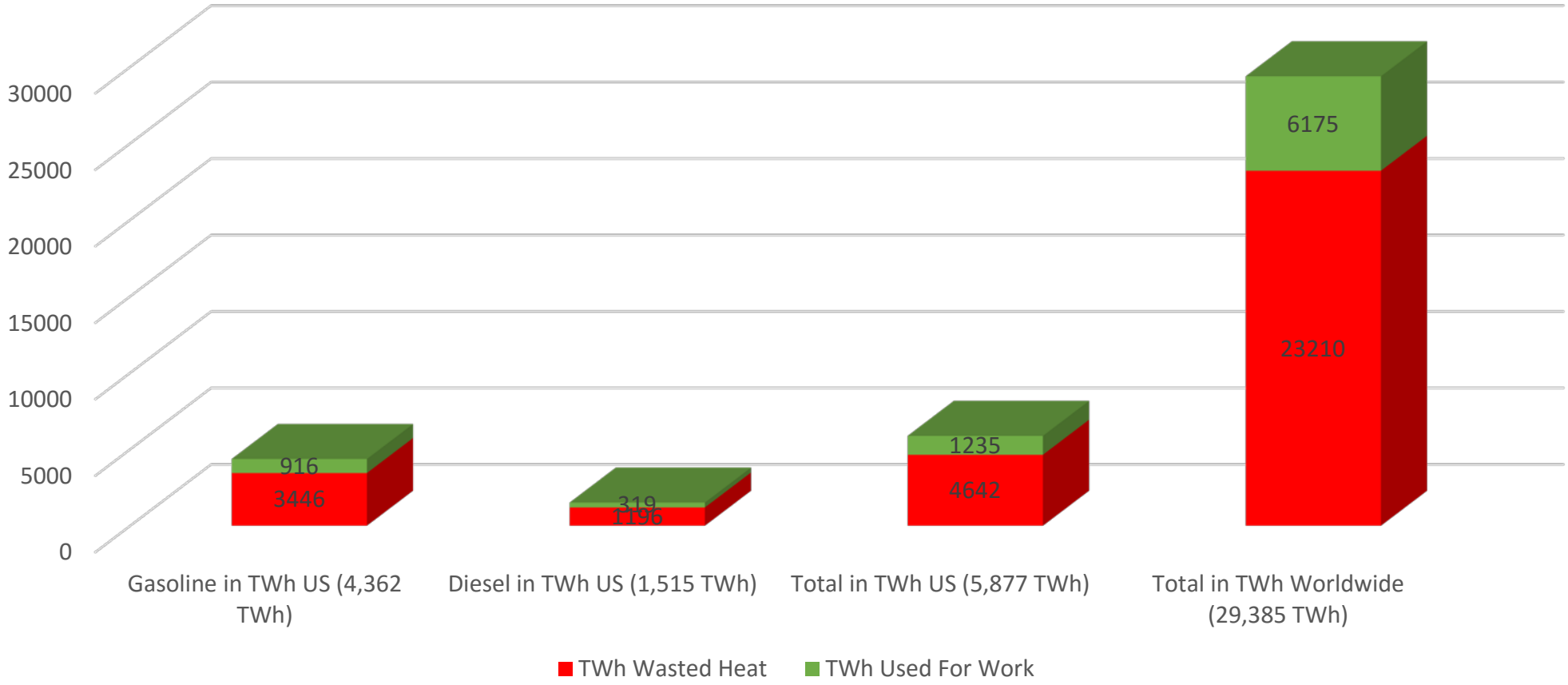
5. **5,877 TWh Total Consumed 2011**
6. **4642.8 TWh Total Loss for gasoline and diesel 2011 (3446.1 TWh + 1196.7 TWh)**

Energy Efficiency Global Transportation

1. **1.2 billion cars and trucks in the world today**
   Source: http://www.greencarreports.com/news/1093560_1-2-billion-vehicles-on-worlds-roads-now-2-billion-by-2035-report
2. **253 Million in the US representing approximately 1/5th of the worlds vehicles**
3. **4,642 TWh of wasted heat energy in transportation for the US**
4. **23,210 TWh of wasted heat energy (5 X 4,642)**

Gasoline and Diesel Consumption for 2011 in the US

Gasoline: 130,597 Million Gallons= 4,362 tWh
Diesel: 39,929 Million Gallons= 1,515 tWh



Energy Efficiency Global Summary 2014

1. **22,352 TWh** 2014 world electric power generation
    1. Source: http://www.tsp-data-portal.org/Breakdown-of-Electricity-Generation-by-Energy-Source#tspQvChart US EIA datasourceAn
    2. US 4,255 TWh or 19% of global generation

2. **17,435 TWh** or 78% or is derived from heat producing power generation plants

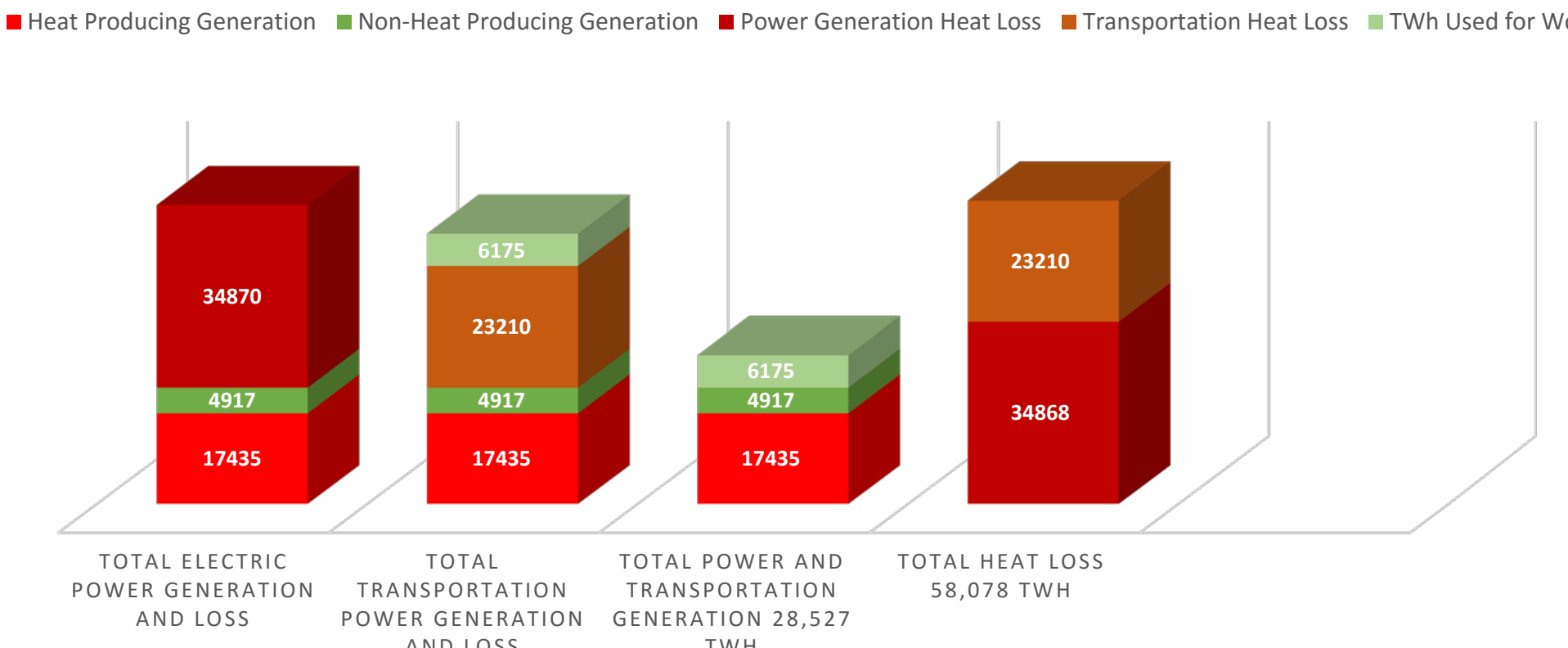
3. **4,917 TWh** or 22% derived from non-heat producing power generation

3. **34,870 TWh** (2 X 17,435 TWh) An approximation of wasted heat from electric power generation

4. **28,527 TWh** (6,175 TWh transportation + 17,435 TWh heat power generation + 4,917 TWh non-heat generation) used for work

5. **58,078 TWh** (23,210 TWh transportation + 34,870 TWh power generation) wasted heat

Energy Efficiency Global Summary 2014



Energy Efficiency Considerations

1. Efficiency
2. Heat loss
3. Type of fuel used for power generation
4. How the fuel is used for power generation
5. Distributed power generation
6. Portable power generation
7. Use renewable fuel in a local, efficient device that uses the heat from combustion to increase power