Rough Values of Power of Various Processes (watts)

Solar power in all directions	10^{27}
Solar power incident on earth	10^{17}
Solar power avg. on U.S.	10^{15}
Solar power consumed in photosynthesis	10^{14}
U.S. power consumption rate	10^{13}
U.S. electrical power	10^{12}
Large electrical generating plant	10^{9}
Automobile at 40 mph	10^{5}
Solar power on roof of U.S. home	10^{4}
U.S. citizen consumption rate	10^{4}
Electric stove	10^{4}
Solar power per m^2 on U.S. surface	10^{2}
One light bulb	10^{2}
Food consumption rate per capita U.S.	10^{2}
Electric razor	10^{1}

Energy Content of Fuels (in Joules)

Energy Unit	Joules Equivalent (S.I.)
gallon of gasoline	$1.3x10^{8}$
AA battery	10^{3}
standard cubic foot of natural gas (SCF)	$1.1x10^{6}$
candy bar	10^{6}

barrel of crude oil (contains 42 gallons)	$6.1x10^9$
pound of coal	1.6×10^7
pound of gasoline	2.2×10^7
pound of oil	2.4×10^7
pound of Uranium-235	3.7×10^{13}
ton of coal	3.2×10^{10}
ton of Uranium-235	7.4×10^{16}

Energy Conversions

Energy Unit	Equivalent				
1 Btu	1055 joules	or	778 ftlb	or	252 cal
1 calorie	4.184 joules				
1 food Calorie	1000 calories	or	1 kilocalorie		
1 hphr	$2.68\ 10^6$ joules	or	0.746 kwh		
1 kwh	3.6110^6 joules	or	3413 Btu		
1 eV	1.610^{-19} joules				

Fuel Requirements for a 1000MWe Power Plant

($2.4\ 10^{11}$ Btu/day energy input)

Coal: 9000 tons/day of 1 "unit train load" (100 90 - ton cars/day)

Oil: 40,000 bbl/day or 1 tanker per week (note: "bbl" means barrels)

Natural Gas: $2.4\ l0^8$ SCF/day

Uranium (as ^{235}U): 3 kg/day

Note: 1000 MWe utility, at 60% load factor, generates 5.310^9 kwh/year, enough for a city of about 1 million people in the U.S.A.

(Note: MWE is an abbreviation for megawatts-electrical output)

Geographic Energy Needs

U.S. Total Energy Consumption (1990)

= $82.1 10^{15}$ Btu (82.1 Quads) = 38.8 MBPD oil equivalent = $86.6 10^{9}$ GJ

Everyday Usage and Energy Equivalencies

1 barrel of oil = driving 1400 km (840 miles) in average car

1 kwh electricity

= 1½ hours of operation of standard air conditioner

= 92 days for electric clock

= 24 hours for color TV

One million Btu equals approximately

90 pounds of coal

125 pounds of ovendried wood

8 gallons of motor gasoline

10 therms of natural gas

1.1 day energy consumption per capita in the U.S.

Power Tables

Power is the amount of energy used per unit time - or how fast energy is being used. If we multiply a unit of power by a unit of time, the result is a unit of energy. Example: kilowatt-hour.

Power Conversions

Power Unit	Equivalent				
1 watt	1 joule/s	or	3.41 Btu/hr		
1 hp		or	2545 Btu/hr	or	746 watts

Power Converted to Watts

Quantity	Equivalent
1 Btu per hour	0.293 W
1 joule per second	1 W
1 kilowatt-hour per day	41.7 W
1 food Calorie per minute	69.77 W
1 horsepower	745.7 W
1 kilowatt	1000 W
1 Btu per second	1054 W
1 gallon of gasoline per hour	39 kW
1 million barrels of oil per day	73 GW

Rough Values of the Energies of Various Occurrences

Occurrence	Energy (J)
Creation of the Universe	10^{68}
Emission from a radio galaxy	10^{55}

$E = mc^2$ of the Sun	10^{47}
Supernova explosion	10^{44}
Yearly solar emission	10^{34}
Earth moving in orbit	10^{33}
D-D fusion energy possible from worlds oceans	10^{31}
Earth spinning	10^{29}
Earth's annual sunshine	10^{25}
Cretaceous-Tertiary extinction theory meteorite	10^{23}
Energy available from earth's fossil fuels	10^{23}
Yearly U.S. sunshine	10^{23}
Annual tidal friction	10^{20}
U.S. energy consumption	10^{20}
Exploding volcano (Krakatoa)	10^{19}
Severe earthquake (Richter 8)	10^{18}
100-megaton H-bomb	10^{17}
Fission one ton of Uranium	10^{17}
$E = mc^2$ of 1 kilogram	10^{17}
Burning a million tons of coal	10^{16}
Energy to create Meteor Crater in Arizona	10^{16}
1000-MW power station (1 year)	10^{16}
Hurricane	10^{15}
Thunderstorm	10^{15}
Atomic Bomb (Hiroshima)	10^{14}
$E = mc^2$ of 1 gram	10^{14}
Energy to put the space shuttle in orbit	10^{13}
Energy used in one year per capita U.S.	10^{12}
Atlantic crossing (one way) of jet airliner	10^{12}
Saturn V rocket	10^{11}
Energy to heat a house for one year	10^{11}
D-D fusion energy possible from 1 gal. of water	10^{11}
One year of electricity for the average house	10^{10}
Lightening bolt	10^{10}
Burning a cord of wood	10^{10}
One gallon of gasoline	10^{8}

100-W light bulb left on for one day	10^7
Human daily diet	10^7
One day of heavy manual labor	10^7
Explosion of 1 kg of TNT	10^6
Woman running for 1 hr	10^6
Candy bar	10^6
Burning match	10^3
1AA battery (alkaline)	10^3
Hard-hit baseball	10^3
Lifting an apple 1 m	1
Human heartbeat	0.5
Depressing typewriter key	10^{-2}
Cricket chirrup	10^{-3}
Hopping flea	10^{-7}
Proton accelerated to high energy (one trillion eV)	10^{-7}
Fission of 1 uranium nucleus	10^{-11}
Energy released in D-D fusion	10^{-12}
Electron mass-energy	10^{-13}
Chemical reaction per atom	10^{-18}
Photon of light	10^{-19}
Energy of room-temperature air molecule	10^{-21}

Cost of Various Fuels

Type	Unit	Cost/Unit	Uses
Electricity	1 Kwh	$0.10	appliances, motors
Gasoline	1 gallon	1.20	transportation
Natural Gas	1 Therm	0.60	heating
AA battery	1 battery	0.80	portable electronics
Milky Way candy bar	1 bar	0.60	food

Worldwide Power Use-History

"Developed" countries average (1990):

- 1.2 billion people 7.5 kilowatts/per person = 9.0 terawatts

The rest of the world (1990):

- 4.1 billion people 1.1 kilowatts/person = 4.5 terawatts

World Population (est.) (billion persons)	Year	Average Power Use (terawatts)
5.5	1990	13.5
3.6	1970	8.4
2.5	1959	3.2
2.0	1930	2.3
1.7	1910	1.6
1.5	1890	1