Understanding Energy

I'm not used to girls being that quiet unless they're medicated. Normally I go out with girls who talk so much you could hook them up to a wind turbine and they could power a small New Hampshire town. — Adrian.

Ivo Welch

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More Energy

Magnitudes

- What magnitudes are we talking about?
- Without magnitudes, you have only platitudes.
- Everything in this course is **huge**.

Power

- Power: Lifting weight at specific rate.
- Boffins measure power in **Watts**.
  - 1 Joule per second = 1 Watt
  - 1 horsepower is 0.75 Kilo-Watts.
- We have to operate in huge numbers:
  - Metric system: K, M, G, T, P.
  - P = 1,000 trillion = 1 million million.

Power Estimates

Activity	Watts
Lifting 1 kg at rate of 1m/10secs	1W
Light bulb, 800 lmn, LED	10W
Incandescent 800 lmn	60W

Power Estimates

Activity	Watts
Human	
at rest (metabolism)	100W
cycling (metabolism)	600W
output at pedals	150W
Car engine, 100hp, max power output	75,000W
65mph, typical power	15,000W

Power Estimates (Peak)

Activity	Watts
Solar Power, **per sqm**	1,360W
Ground, per sqm	1,000W
Solar Cell, per sqm	150W
Typ Roof Solar	6,000W
Typ 50m Wind Turbine	2,500,000W
Typ Coal Plant	600,000,000W
Typ Nuclear Plant	1,500,000,000W

Power Estimates (Activity)

Activity	Watts
Bitcoin Mining, 2020	7,000,000,000W

Power Estimates

Activity	Watts
USA	
Avg US Electric Only	450,000,000,000W
Peak US Electric	789,480,000,000W
Instlld US Electric Power	1,200,000,000,000W
Avg Total Primary	3,000,000,000,000W
World	
Avg Global Electricity	2,600,000,000,000W
Avg Global Total Primary	18,000,000,000,000W
All Life (living things)	130,000,000,000,000W

Energy

- Power applied for time.
- Power is rate is per time. Energy is rate per time multiplied by time.

We will use (Kilo)**Watt-hours** for energy.

- There are *many* other energy measures
  - BTU, tonne of oil, barrel of oil, therm, cuft natgas, calories, joule, quad...
- We have to operate in huge numbers:
  - Metric system: K, M, G, T, P.

One-Time Use

Activity	Watt-Hours
Lift/drop 60 kg meters	1 Wh
LED bulb, 800 lumen, 1h	10 Wh
incandescent, 1h	60 Wh
Cyclist Pedal Output, 1h	150 Wh
Food Diet, 2000 (k)cal, 1day	2,300 Wh
Automobile, 100hp/2, One Commute, 1h	35,000 Wh
Tesla Battery Model 3	75,000 Wh

One-Day Use (Pppd= Per-Person-Per-Day)

Activity	Watt-Hours
pPpD, Africa	10,000 Wh
pPpD, EU	100,000 Wh
pPpD, USA	200,000 Wh
pPpD, Electr USA	30,000 Wh
Roundtrip Flight, LA-FRA, 11h*2	10,000,000 Wh

Typical Yearly Use

Activity	Watt-Hours
LED, 800lum, 2h/d	7,500 Wh
60 “Wall-Warts”	189,000 Wh
Air Conditioning	3,500,000 Wh
All Household Elec (US)	10,600,000 Wh
Car Commute, 1h/day	13,000,000 Wh

Yearly (8,766 Hours) Generation

Activity	Watt-Hours
Roof Solar, 20 panels	13,000,000
Typ Wind Turbine	3,285,000,000
Typ Coal Plant, if 24/7	4,380,000,000,000
... typ utilized rate	2,628,000,000,000
Average US Nuclear Plant	10,000,000,000,000

Yearly (8,766 Hours) Consumption

Activity	Watt-Hours
Global Bitcoin Mining, 2020	67,000,000,000,000

Yearly (8,766 Hours) Generation

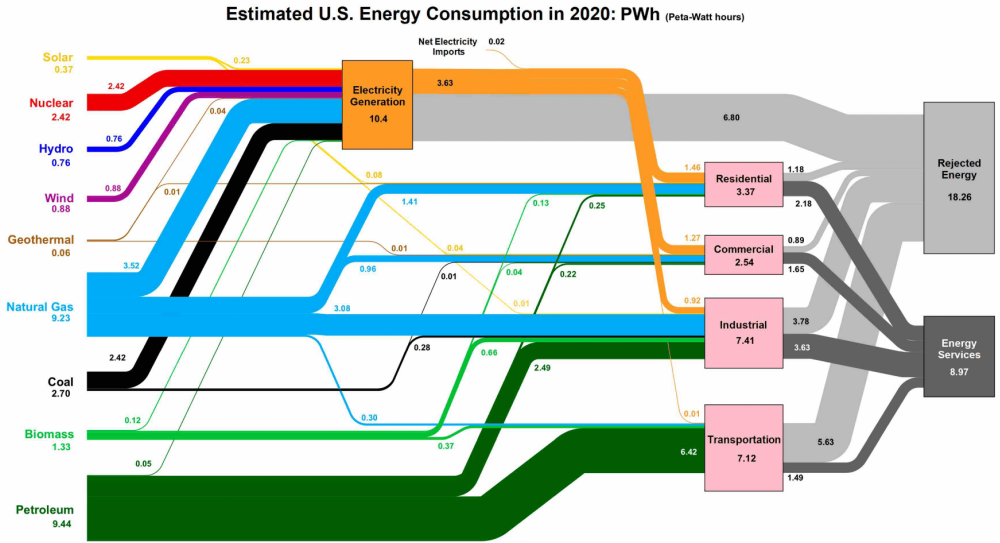
Activity	Watt-Hours
U.S. Electricity	4,000,000,000,000,000
World Electricity	23,000,000,000,000,000
U.S. Primary Energy	26,000,000,000,000,000
World Primary Energy	165,000,000,000,000,00

Skip

165 "Peta-Wh" = 165 million gigawatt-hours.

Careful: read about nominal and nameplate power, as well as primary energy.

Us Energy Flows, LLNL



Warning

- Understand differences in how power and energy are quoted
- Nameplate, primary, secondary.
- See book.