Phys 310 Problem Set #1

① Graph is attached.

I found it interesting how much more European countries use wind power compared to the USA. Also, the states that produce the most wind energy are not all the states that have the largest share of their total electricity generation from wind!

② We have 110 ZJ of Oil & consume 5 TW = 5×10^{12} J/s

$$110 \times 10^{21}\,J \times \frac{1\,s}{5 \times 10^{12}\,J} \times \frac{1\,hr}{3600\,s} \times \frac{1\,day}{24\,hr} \times \frac{1\,year}{365\,day}$$

Did you estimate this without a calculator?

= 697.6 years

are your answers good to 4 significant figures?

③ www.eia.gov ⇒ $181.16 (10)^{15}$ BTU/year

$$\frac{181.16(10)^{15} BTU}{year} \times \frac{1\,yr}{365\,d} \times \frac{1\,day}{24\,hr} \times \frac{1\,hr}{3600\,s} \times \frac{1055\,J}{1\,BTU} = 6.06 \times 10^{12}\,J/s$$

~ 6 TW which is a little off from 5 TW but petroleum use has been going up!

4) radius of Earth = 6,371 km   7.125 billion people

SA of Earth $= 4\pi(6{,}371 \times 10^3)^2 = 510 \times 10^{12}\ m^2$

$\frac{\text{Area}}{\text{Person}} = \frac{510 \times 10^{12}\ m^2}{7.125 \times 10^9 \text{ people}} = \boxed{71.6 \times 10^3\ m^2/\text{person}}$

7 Hectares - lots of land (and water)

5) Solar energy $\sim 1000\ W/m^2$

a) $\frac{1000 W}{m^2} \times \frac{71.6 \times 10^3\ m^2}{\text{person}} = \boxed{71.6 \times 10^3\ kW/\text{person}}$

1 BTU = 1,055 J

$71.6 \times 10^6 \frac{J}{s} \times \frac{1 \text{ BTU}}{1055 J} \times \frac{\text{hr ton}}{12000 \text{ BTU}} \times \frac{3600 s}{1 \text{ hr}}$

$= \boxed{20.36 \times 10^3 \text{ tons (of ice per day)/person}}$

b) $71.6 \times 10^6 \frac{J}{s} \times \frac{3600 s}{hr} \times \frac{24 hr}{1 day} \times \frac{365 day}{year}$

$= \boxed{2.26 \times 10^{15}\ J/\text{year per person}}$

$\frac{2.26 \times 10^{15} J}{year} \times \frac{1 \text{ BOE}}{5861520000 J} = \boxed{3.856 \times 10^5 \text{ BOE/year}}$

Please use scientific notation

$\frac{3.856 \times 10^5 \text{ BOE}}{yr} \times \frac{\$86}{1 \text{ BOE}} = \boxed{3.316 \times 10^7\ \$/\text{year}}$

c) $71.6 \times 10^3\ m^2/\text{person} \times \frac{1000 W}{m^2} \times \frac{0.15 W}{W} \times \frac{365 d}{yr} \times \frac{24 hr}{1 d} \times \frac{1 kW}{1000 W} \times \frac{\$0.15}{kW\,hr}$

$= \boxed{1.41 \times 10^7\ \frac{\$/\text{person}}{\text{year}}}$

These are all too big by a factor of 4 or 5 or 6 ⇒ we don't get 1000 W/m² all day and night!

= 5800000 BTU
= 5861520000 J

(6) 1 BOE = 42 US gal

1 gal of gas ≅ 6 lbs

Ave. Weight = 160 lbs

North American Population = 528.7×10^6 people

1/4 Ave. Weight = 40 lbs

North America energy Consumption = 116.191×10^{15} BTU

$$\frac{116.191 \times 10^{15} \text{ BTU/year}}{528.7 \times 10^6 \text{ people}} \times \frac{1 \text{ BOE}}{5800000 \text{ BTU}} \times \frac{42 \text{ gal}}{1 \text{ BOE}} \times \frac{6 \text{ lbs}}{1 \text{ gal}} \times \frac{1 \text{ yr}}{365 \text{ day}}$$

$= \frac{26.16 \text{ lb}}{160 \text{ lb}} = .1635 \approx 16\%$ body weight which is much less than a fourth!

you're right! I should have said "U.S. American"

How about if we look at only the United States?

$$\frac{98.324 \times 10^{15} \text{ BTU/year}}{318.9 \text{ people}} \times \frac{1 \text{ BOE}}{5800000 \text{ BTU}} \times \frac{42 \text{ gal}}{1 \text{ BOE}} \times \frac{6 \text{ lbs}}{1 \text{ gal}} \times \frac{1 \text{ yr}}{365 \text{ days}}$$

$= \frac{36.7 \text{ lbs}}{161.5 \text{ lbs}} \approx 22.7\%$ which is much closer to a quarter of avg. body weight!

yes! Mexico uses much energy per capita than ~~Ed~~ us!

This means Americans are using more energy than other North Americans on average!

(7) During a workout, I burn on average, 130 Watts ~~in~~ *for* 30 min.

$$\frac{130 \text{ W}}{\cancel{30 \text{ min}}} \times \frac{1 \text{ hp}}{746 \text{ W}} \times \cancel{\frac{60 \text{ min}}{\text{hr}}} = \boxed{.3485 \text{ hp/hr}}$$ *≈ 0.17 hp*

(8) e^{it} is a solution to $dQ/dt = iQ$

if $Q = e^{it}$

$$\frac{dQ}{dt} = i\underbrace{e^{it}}_{Q}$$

so $\frac{dQ}{dt} = iQ$ ✓

⑨ $P_1 = e^{\lambda t_1}$ $P_2 = e^{\lambda t_2}$

$$\frac{P_2}{P_1} = \frac{e^{\lambda t_2}}{e^{\lambda t_1}} = e^{\lambda(t_2 - t_1)} = 3$$

$$t_2 - t_1 = t_{triple} = \frac{\ln(3)}{\lambda} \approx \boxed{\frac{1.1}{\lambda}}$$

b)

$(2.25E15 \ J/yr)\left(\frac{\quad}{5.862E9 \ J}\right)$

Current barrel price: \$50

$(383828 \text{ barrels})(\$50/\text{barrel}) = \boxed{\$19.2E6}$

c) $\$19.2E6(0.15) = \boxed{\$2.88E6}$

6. From EIA: North America used 116.191 quads in 2012.

$$116.191 \frac{\text{quads}}{\text{yr}}\left(\frac{25.2E6 \ TOE}{1 \text{ quad}}\right)\left(\frac{1000 \text{ kg}}{1 \text{ tonne}}\right)\left(\frac{1 \text{ yr}}{365.25 \text{ day}}\right)$$

$= 8.0165E9$ kg/day

2012 North American population $\approx 529E6$

$$\frac{8.0165E9 \ \frac{kg}{day}}{529E6 \text{ people}} = 15 \frac{kg}{\text{day person}} \longrightarrow$$ DH was correct.

good! you ran up some stairs! ↘

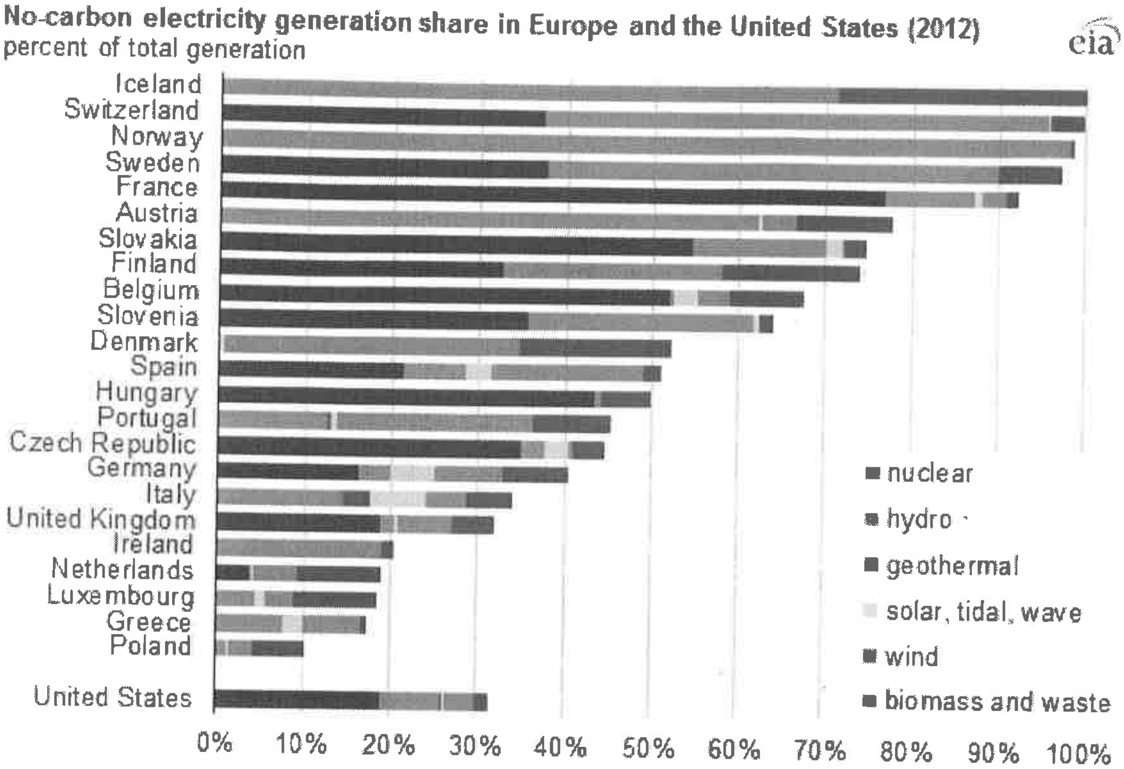
7. $$W = \frac{F \cdot d}{t} = \frac{mgh}{t} = \frac{\left(\frac{1}{2.2}\frac{kg}{lb}\right)(200 \ lbs)(9.81 \ m/s^2)(15 \ ft)\left(\frac{0.3048 \ m}{1 \ ft}\right)}{4 \ s}$$

$$= 1.0E3 \ \frac{kg \ m^2}{s^2}\left(\frac{1}{s}\right) = 1.0E3 \ W \longrightarrow hp = \frac{W}{746} = \frac{1.0E3W}{746} = \boxed{1.3 \ hp}$$

($\frac{kg \ m^2}{s^2}$ = J, J/s)

Graph:

No-carbon electricity generation share in Europe and the United States (2012)
percent of total generation



Statistics:

U.S. states leading in electricity generated from wind

In 2013, EIA data shows that 39 states had some electricity generation from wind facilities with a generation capacity of at least 1 megawatt. Among those, 23 states increased their electricity generation from wind by more than 10% above their 2012 production levels.

In 2013, the five states that generated the most electricity from wind were:

- **Texas** (35.9 million megawatthours)
- **Iowa** (15.6 million megawatthours)
- **California** (13.2 million megawatthours)
- **Oklahoma** (10.9 million megawatthours)
- **Illinois** (9.6 million megawatthours)

However, the five states that had the largest share of their total electricity generation from wind in 2013 were:

- **Iowa** (27.4%)
- **South Dakota** (26%)
- **Kansas** (19.4%)
- **Idaho** (16.2%)
- **Minnesota** (15.7%)

Did you know?
Steam coming out of nuclear cooling towers is just hot water. ← Fun Fact.