

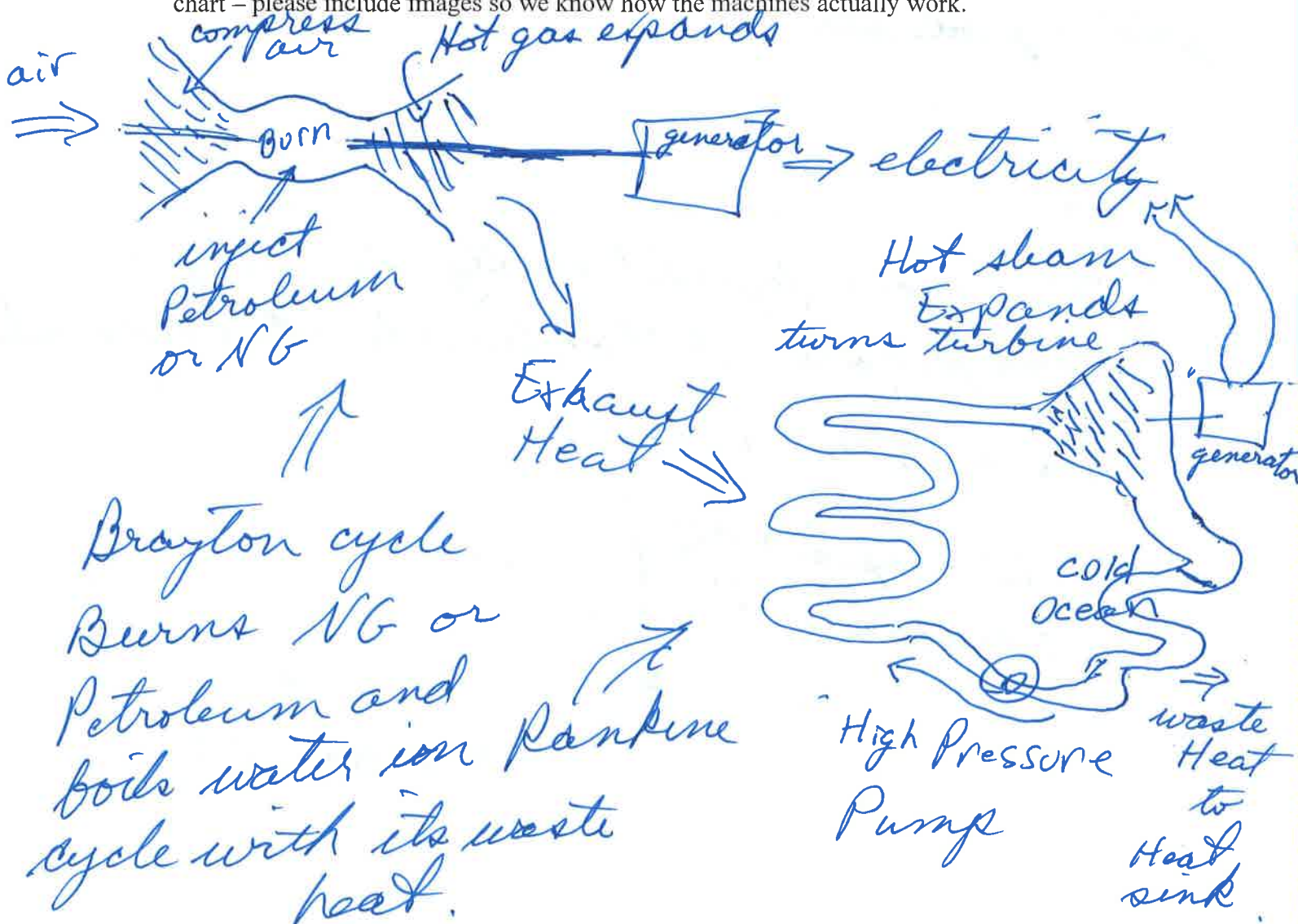
- 1) What portion of the world's people live in US?  $\sim 5\%$
- 2) What portion of the world's people live in California?  $\sim 0.5\%$
- 3) The United States consumes about what portion of the world's energy?  $\sim 20\%$   $\frac{\sim 100 \text{ Quad}}{\sim 500 \text{ Quad}}$
- 4) What is the maximum power output of an average car?  $\sim 100 \text{ kW}$
- 5) What is the power output of your body working hard for 5 minutes?  $\sim 50 \text{ W}$
- 6) What is the average total electrical power consumption of the USA?  $\sim 400 \text{ GW}$   
 Please put any relevant calculations for this on last sheet.  $17 \text{ TW}$  ← world rate

Some Longer Endeavors

- 1) Combined Cycle Electrical Generation:
  - a) What is the main benefit of combined cycle facilities?

*high efficiency.*

- b) Please explain how a combined cycle electrical facility works with a drawing – not just a flow chart – please include images so we know how the machines actually work.



$\frac{400 \text{ GW}}{17 \text{ TW}} = 2.35\%$   
 $\frac{400 \text{ GW}}{17 \text{ TW}} = 2.35\%$  ← efficiency  
 % to USA Electricity

Brayton cycle  
 Burns NG or Petroleum and  
 boils water in Rankine  
 cycle with its waste heat.

2) Edison and Tesla had a celebrated conflict over whether to make the US grid AC or DC (Edison wanted DC, remember?).

a) Explain why AC was necessary to reduce the costs and losses of transporting electricity be complete, a full paragraph may be required.

$$P_{\text{loss}} = I^2 R, \text{ but } P_{\text{delivered}} = I V, \text{ so we must boost } V$$

to lower  $I$ , we can only change  $V$  w/ AC Transformers because only rate of change of magnetic field induces voltage.

...If we can triple the transmission voltage, by what factor would the transmission losses change?

$$\underline{P = I V} \quad V = 3V_0 \quad I \Rightarrow \frac{1}{3} I_0$$

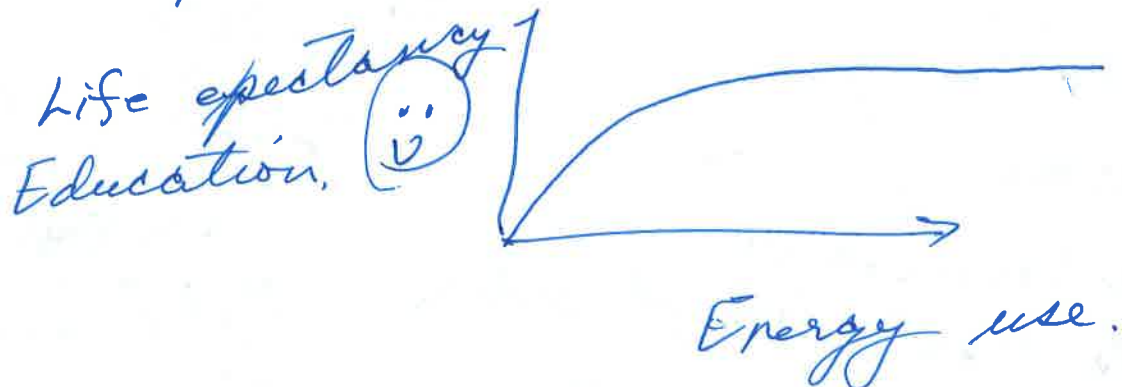
$$P_{\text{loss}} = I^2 R \quad P_{\text{loss}} \Rightarrow \frac{1}{9} P_0$$

b) Is AC still necessary? Explain why it is or isn't.

AC is still used because of present existing grid + products.

3) How do "quality of life" indicators (like health and wellbeing and education) correlate with energy use?

They grow proportionally for very poor people, but saturate at moderate levels of wealth.



4) One of my students was surprised to come back from a 3-day weekend to find he'd left his 1.5 kW electric space heater on the whole time. His room was toasty warm, ... BUT: (Presume the electricity was produced by single cycle coal. State other assumptions)

a) About how much money did this oversight cost him?

$$\text{Power} * \text{time} = \text{Energy} \approx 108 \text{ kWh}$$

$$\text{\$} = \text{Energy} * \text{pay rate} \approx \underline{\underline{\text{\$16}}}$$

~ \\$0.15 / kWh

b) How much CO<sub>2</sub> is this student's mistake responsible for emitting into the atmosphere?

$$E_{\text{coal}} \approx E_{\text{electricity}} \left( \frac{1}{\text{efficiency}} \right)$$

( "h" )

$$\text{CO}_2 = E_{\text{coal}} \left( \frac{25 \text{ g C}}{\text{MJ}} \right) \cdot \frac{44 \text{ g CO}_2}{12 \text{ g C}} \approx 100 \text{ kg}$$

$$\frac{108 \text{ kWh}}{30\%} \left( \frac{3.6 \text{ MJ}}{\text{kWh}} \right)$$

c) What else was emitted into the atmosphere that we should be concerned about?

Soot mercury NO<sub>x</sub> SO<sub>x</sub>

d) We assumed above that his use of electricity resulted in electricity being generated with coal. If he lives in SLO and took this trip in February, how was the extra electricity for his heater generated? Please support your answer.

~~30%~~ Solar, wind, are always used when available (they're free). Nuclear + Coal are always on (base load) ~~because~~, so we have NG single cycle + NGCC. Load is low because it's weekend in winter, so most likely marginal electricity is NGCC



5) Nuclear Power: Pros and Cons.

a) Provide two arguments promoting nuclear power.

- it's not coal  $\Rightarrow$  no soot,  $\text{CO}_2$ , heavy metals, etc.  
There's lots of fuel for it.

b) Common arguments against nuclear power are "long lived nuclear waste", and nuclear accidents such as Chernobyl. Please provide information that supports this as a legitimate concern, puts it in perspective, and/or dismisses it.

- if we keep the nuclear waste from people, there's no problem.  
- Nuclear catastrophes have cost far fewer lives than everyday use of coal (mostly due to soot causing respiratory problems).

c) Proliferation concerns: What is the role of Plutonium and the reprocessing of spent nuclear fuel in proliferation concerns?

Pu is chemically distinct from  $\text{U}^{238}$  and so can be easily purified to weapons grade by chemical means.

d) Costs. Please put the costs of nuclear in perspective and in particular describe the difference between the costs of keeping an old plant up and running versus building a new plant.

Construction costs dominate the cost of nuclear, so the life cycle costs  $\gg$  cost after mortgage is paid  
 $\sim 10\text{¢/kWh}$        $\leftarrow 2\text{¢/kWh}$

Hence once a nuclear facility is built, the utilities do NOT want to close them!