

PHYS-320 Efficiency and Electricity
Schwartz Problem Set #3

- 1) Society, and Environment... What's going to happen?
 - a) Identify something you like about the projected federal policies and/or cabinet nominees
 - b) Identify something you are concerned about the projected federal policies and/or cabinet nominees.

Check the validity of your references and the bias that they may have. Did you reference a news agency? What is their priority?
- 2) Cogeneration <-> Combined Cycle
 - a) What is the difference between Cogeneration and Combined Cycle?
 - b) Please state how each process increases efficiency.
- 3) Coal Power Production

Coal and natural gas are the two predominant forms of fossil fuels used for generating electricity in the world. Compared to the NGCC, coal is a worse polluter on two levels – criteria pollutants (like toxins), and in terms of greenhouse gas (CO₂) production.

 - a) Name a few criteria pollutants that you are most concerned about
 - b) What does NGCC stand for?
 - c) Why does burning coal emit more toxins into the atmosphere and what are some of these toxins?
 - d) For the same amount of electricity, coal emits more CO₂ than the most efficient Natural Gas electricity generation – about how much more?
 - e) Why is it that Coal Electricity emits more CO₂ than natural gas electricity generation? Please give two reasons.
 - f) What portion of the world's coal does the US consume? China? What portion of the world's NG does the US consume? China? You could start with the US EIA (Energy Information Administration): <https://www.eia.gov/outlooks/ieo/coal.cfm>
- 4) You meet three people, and each tries to convince you to invest in their technologies. Please indicate how you would respond.
 - a) This person wants you to invest in a new invention that will power a car. It has many spinning magnets in it that generate electricity, which drives an electric motor. The beauty of this is that the device requires no fuels or external power supply.
 - b) This person says that you can turn the thermal energy in your house directly into electricity. The result is that your house gets cooler as you generate electricity from the lost heat in your room. This will be particularly desirable in super-hot places such as Phoenix, Texas and LA in the summer.
 - c) This person has designed a near frictionless motor that can turn fuel into electricity with almost 100% efficiency because there is no friction.
- 5) Remember your friend who left his 100 W incandescent light on for a weekend? This choice resulted in the emission of how much mass of CO₂ into the atmosphere...:
 - a) if the electricity was generated with a new NGCC power plant.
 - b) the electricity was generated with an old coal-fired Rankin Cycle facility.

6) Running a Natural Gas Combined Cycle

Let's say you're in charge of a NGCC for Southern LA. You control the flow of NG to the Brayton Cycle turbine and you can monitor the (a) electrical current, (b) the torque (how hard the turbine has to push the generator to keep it going), (c) the spinning frequency of the turbine, and the (d) output voltage. At 5:30 PM, everyone gets home and turns on their electrical appliances – especially air conditioners.

- a) When this happens, what do you notice about measurements in (a) – (d) above?
- b) How do you respond with the flow of NG to the Brayton Cycle Turbine?
- c) After your action, how do measurements (a) – (d) change?

7) Transmission

Why do we need Transformers?

- a) Why do we transport electricity via super high voltage?
- b) What role do transformers play in the transmission process?
- c) Do we still need AC today? If not, why do we still have it?

8) You take a weekend round trip to San Francisco.

- a) Estimate the amount of gas the trip it requires.
- b) Estimate the *mass* of gasoline the trip requires
- c) The mass of CO₂ emitted into the atmosphere is about three times the mass of the gasoline consumed. How much is that?
- d) Why is the mass of CO₂ about three times the mass of the gasoline consumed? Where does the rest of the mass come from?

9) I read that Diablo Nuclear Power Plant* produces about 2 GW of electricity using a Rankine cycle that boils water at about 285 °C (under pressure)**. The Pacific Ocean is about 15 °C.

- a) What is the maximum possible efficiency for this heat source?
- b) Diablo's actual efficiency is only about 33%. Estimate the rate at which Diablo dumps heat into the Pacific.
- c) The Pacific Coast is a lovely place to live. Consequently, we enjoy outrageous land prices! Why ever would someone put a *nuclear power facility* on this beautiful land? Why not in the desert somewhere, where no one wants to live***?
- d) Did you remember to use absolute temperature?

(*) https://en.wikipedia.org/wiki/Diablo_Canyon_Power_Plant

(**) https://en.wikibooks.org/wiki/Diablo_Canyon_Nuclear_Power_Plant:_The_WikiBook/Boiling_water_reactor

(***) https://en.wikipedia.org/wiki/Palo_Verde_Nuclear_Generating_Station

10) Engines:

- a) How does a gasoline engine work that is in your car? Please include a drawing.
- b) How is this different from a chain saw engine?
- c) How is this different from a diesel engine?