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- Major types of fossil fuels; their global distribution, and for how long the resources are expected to last.
- Major types of heat engines: piston steam, steam turbine, gas turbine, gasoline engine, Diesel engine; what is the thermal efficiency of each type (approximately).
- Laws of thermodynamics; entropy; reversible and irreversible processes. The effect of the irreversibility of a process on the entropy.
- What is the difference between "heat" and "internal energy"? Is it OK to say, e.g.: *the amount of heat contained by a heated body is 1000 J*?
- Be sure that you understand the meaning of the terms: "hot source", "heat sink"
- The famous Carnot Equation: $\varepsilon = 1- T_c/T_h$. What is the meaning of the symbols in this equation? What is the physical meaning of entire the equation? If Q is the amount of heat transferred from a hot source to an ideal thermal engine, how much of it is converted to mechanical work, and how much is "dumped" into the "heat sink"?
- Be sure that you understand the difference between the <u>absolute temperature</u> (measured in Kelvins) and the temperature expressed in the units of Celsius and Fahrenheit degrees, and that you know how to convert Celsius degrees to Kelvins, and Fahrenheit degrees to Celsius degrees.
- What is the thing that an ideal thermal engine, such as, e.g., the Carnot Engine, *does not* deliver? What is the meaning of the "modified" Carnot Equation $\varepsilon' = 1- (T_c/T_h)^{1/2}$?
- What is the "heat of combustion"? You don't need to remember its values for different fuels, but at least you should know which one hat the highest of all, which one goes next, and so on (there is a table in one of the Polwer Points).
- Be sure that you know how to calculate the amount of CO_2 created by burning 1 kg of a fuel, if its chemical formula and the chemical reaction occurring when it burns are known.
- The largest hydropower plant in the USA and in the world
- Pumped storage hydropower plants – why are they built?
- Why there are no such plants in Oregon? Where in the USA the existing conditions are more favorable for pumped storage hydropower plants? Where is the largest one of all American pumped storage hydropower plants located?
- The dependence of the power usage on the time of day; how is the operation of a pumped storage hydropower plant synchronized with that?
- Wind power: global resources.
- Wind power: what is the power carried by wind passing through a unit surface area perpendicular to the wind's velocity vector? How does it depend on the air density and the wind speed?
- What is the "Betz limit"?
- What are the best locations for building wind farms in the US?
- Types of wind turbines. What is the most often used turbine type in wind farms?
- What is the power output of typical turbines currently used in wind farms? What is the "world-record" power delivered by a single turbine?
- What is the advantage of the "multi-blade American wind turbine" compared with other turbine types?
- Disadvantages of the wind power. The "dance partner" problem. (not yet discussed in class, but will be before the test).
- Solar power. Its global "resources".

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- Insolation – its definition. How does it depend on the geographic latitude? What are the other factors that determine the insolation at a given location on the globe?
- Concentrating solar power plants. In what are they similar to conventional thermal power plants? (i.e., those using coal or natural gas as a fuel). Their advantages: good efficiency (how good it can be?), ability of storing energy and delivering power after the sunset.
- Techniques of energy-storage in concentrating solar power plants
- Types of concentrating solar power plants, and types of mirrors ("heliostats") used in them, depending on the power level delivered. What is the design of a system that can deliver "medium" power (tens of kilowatts, not megawatts). Why concentrating solar power electricity-generating devices are not good for a single household?
- Why building a concentrating solar power plant in Corvallis would not be a good idea? What are the "good" locations for such plants in the US and other geographic areas, and why building such plants in most European countries would be a waste of money?
- What is the typical efficiency of converting solar light into electric power in mass-produced photovoltaic panels?
- What is the approximate price per watt of electric output power for single-household solar power system? What is the reasonable estimate of the maximum power the system has to be able to deliver during the hours of maximum suns hine, the system is meant to make the household completely independent on the utility power?
- What components other than photovoltaic panels are needed in a single-household solar power system, if the system has to make the household completely independent ot the utility power? In particular, what is the role of a device commonly referred to as the "inverter"?
- Concentrating solar power plants deliver zero power if the weather is cloudy. What about solar panels? Atomic nucleus: what are the "building blocs" it is made of? What is the meaning of the Z and A numbers. Isotopes: if an element has two or more isotopes, which of these two numbers is the same for all of them, and which one is different for each isotope?
- Some Concentrated Power Plants can deliver power long after the sunset, taking advantage of the so-called "molten salt technology". Be sure that you can explain the basic principles of this technology. Why are molten salts used, and no, for instance, molten metals?

- **Nuclear energy:**
- Radioactive decay: what are the three basic types, and what particles are emitted in each of them?
- What is the "half-life" of a radioactive isotope? If a sample contains N nuclei of a radioactive isotope, how many nuclei of this isotope will be still in it after two "half-life" periods? After three?
- Nuclear fission: what particles can trigger a fission, or a "splitting" of a nucleus of the Uranium isotope with Z=92 and A=235? What are the "products" of such a nuclear reaction? What energy is released in the fission of a single ^{235}U nucleus? What is the meaning of the term "chain reaction"?
- Why neutrons created in the process of ^{235}U fission need to be "moderated", i.e., slowed down, in a nuclear reactor? What substance is most often used in reactors as the "moderator"? Should it consist of heavy nuclei, or of light nuclei?

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- **Energy from oceans and seas:**
- Methods of "extracting energy": waves, tides, and ocean thermal energy conversion.
- Tidal forces: their origin (free fall of a sizable body in the gravitational field of another body). Their dependence on the body-body distance (R^{-3}). The "Roche Limit".
- Briefly explain how one can utilize the tide for generating electric power.
- Ocean thermal energy conversion: where was the first US facility installed? How much power did it generate?
- Wave energy: how much power is carried by waves at the Oregon Coast? (in kilowatts per meter, in summertime and in wintertime?). The total length of Oregon Coast is about 300 miles, or about 500 kilometers. If we could harness 10% of the total wave energy at the Oregon Coast in wintertime, how much it would be in MegaWatts?
- Devices for converting wave energy into electricity ("attenuators", orf , "actuators": how do they work? In particular, explain how the device developed at OSU works, and how the devices described in Ch. 7, pp.

- **Electric power transmission:**
- basic relations between the voltage (V), current (I), and resistance (R), and power (P): $I=V/R$ (Ohm's Law), $P = I \times V = I^2 \times R$.
- The primary winding of a step-up transformer has 100 turns, and the secondary winding has 1000 turns. The primary (input) voltage is 110 V, and the primary current is 50 A. What is the secondary (output) voltage? The secondary (output) current? Hint: assume that the transformer is ideal, there is no power loss in it, so that the output power is the same as the input power.
- Explain why we use a step-up transformer at the "in-take end" of a transmission line, and a step-down transformer at the "output end".
- Thomas Edison was a strong proponent of developing a utility system based exclusively on direct current – and Nikola Tesla advocated the use an alternating current. Tesla's idea won! Can you explain why? Important: there two types of current, AC (alternating) and DC (direct). Only one of them can be transformed by common conventional electromagnetic transformers – which one?

- **Biofuels:**
- Explain how bioethanol can be obtained from sugar cane, and from corn starch. Which process is easier, and which is more elaborate, and why?
- What are the microorganism capable of converting sugar to ethanol in a process known as "fermentation"?
- Why those microorganism can not do the same with starch? What has to be done with starch to convert it into fermentable sugar?
- Be able to calculate, based on the chemical reaction formula, how much ethanol can be obtained from a kilogram of sugar.
- Explain what the "cellulosic bioethanol" is. What are the benefits of such biofuel, and what are the major challenges in producing it? Be able to list the several phases of the technological process used for making cellulosic ethanol.
- Biodiesel: why vegetable oil (e.g., canola oil) is not an ideal fuel for a diesel

engine? How can it be changed into a biofuel that is as good as the petroleum-based diesel fuel?

- Is the production of bioethanol the best way of utilizing biomass? Is there another possible way of more energy-efficient usage of biomass? Hint: read the article posted at the course Web page in wbyhich this problem is discussed.

- **Geothermal energy (GTE):**
- What is its origin? It may be "primordial" heat (Earth still cooling down, even though it was formed 4.5 billion years ago), or the decay of radioactive elements in the planet's body. Which one is believed to be the dominant source?
- The "easy way" of harnessing the GTE: where it can be done and how? The more difficult way: "GTE mining". What is the "geothermal gradient", and what is its typical value in most locations over the globe?
- More things related to the "easy way": what are the "tectonic plates"? What happens at their boundaries, where two tectonic plates meet? Explain the meaning of the terms "convergent plate boundary", "divergent plate boundary", "hot spot", "subduction zone". Oregon is located near a tectonic plate boundary: is it a "convergent", or "divergent" boundary? What "bad effects" occur near the tectonic plate boundaries?
- In locations where the GTE has to be "mined": how deep a well should be drilled in order to pump water hot enough to generate electric power?
- What is a "flash steam power plant"?
- What country has the highest installed geothermal power? How many MegaWatts?
- What country relies almost exclusively on geothermal power?
- Explain what a "heat pump" is. How can a heat pump be used for harnessing the so-called "shallow geothermal power"?

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