

## Assignment #1: Due at end of class on Tuesday, 1/22/2019

### Assignments:

1. Download the first two "Energy Systems" slide decks from course website.
2. Attend lectures 1 and 2 and take very good notes.
3. Download and read Module B2 from course website.
4. Download book from library (see slide 1 of "Energy Systems" slide deck) and read chapter 1.

Answer the following questions.

### A. From Module B2:

1. What are the three main subsystems of the electric power system?  
→ Generation, transmission, distribution.

### B. From Kirtley:

2. Identify the most common forms of fossil fuels used to produce electricity.  
→ Coal, natural gas, petroleum.
3. Identify the most common renewable forms of energy used to produce electricity.  
→ Hydro, wind, solar, biomass, geothermal
4. Define "heat rate."  
→ The fuel energy input to a power plant to produce one kw-hr.
5. It is well-known that burning fossil fuels produce carbon dioxide. What other contaminants are produced by burning fossil fuels?  
→ Mercury, sulfur oxides, nitrogen oxides
6. In 2009, how many nuclear power plants were there in the US?  
→ 104
7. What is the "head" of a hydroelectric power plant?  
→ The height the water falls.
8. What are the two main operating modes of a pumped storage hydro plant?  
→ Generation and pumping
9. Wind turbines extract energy from the kinetic energy of the wind. The power production of a wind turbine is proportional to what power of wind speed velocity?  
→ 3
10. What are the two principal means of producing electricity from solar energy?  
→ Solar towers (also called concentrated solar thermal) and photovoltaic.
11. For a power plant, what is the difference between generating capacity and generated energy?  
→ Generating capacity is the maximum capability of the plant to produce power, measured in MWs (Mjoules/second). Generated energy is the amount of electric energy produced by the power plant over a time period, measured in MW-hrs (Mjoules\*hrs/sec).

B. From Slide deck #1 on “Energy Systems”:

12. What is “economies of scale”?

→ Infrastructure services become less expensive when they are made larger.

13. What is an important feature of a natural monopoly?

→ It is not socially efficient to have multiple competitors.

14. What motivated the 1935 Public Utility Holdings Company Act (PUCHA)?

→ The need to break up the economic/political power of the small number of holding dominant companies who owned 75% of the operating companies, without regulation.

15. What was the growth rate of electric energy from 1938-1964?

→ 8%/year

16. What is NERC and how did it get started?

→ The North American Electric Reliability Corporation; it was created following the 1965 Northeast Blackout, in order to monitor and enforce reliability requirements in the electric system.

17. How many interconnected asynchronous grids are in the continental US?

→ Three, the Eastern Interconnection, the Western Interconnection, and ERCOT (most of Texas).

18. What is FERC and what is its electricity-related responsibilities?

→ The Federal Energy Regulatory Commission. It regulates transmission and wholesale sale of electricity in interstate commerce.

19. What is DOE and what is its energy-related responsibilities?

→ The US Department of Energy is responsible to address US policies regarding energy and safety in handling nuclear material.

20. In 2017, in which states do the highest average electricity price per kwhr occur? What is the average electricity price in Iowa?

→ The highest average prices are in California, Rhode Island, Massachusetts, New Hampshire, Connecticut, and Alaska (greater than 15 cents/kwhr). The average price in Iowa is between 7 and 9 cents/kwhr.

21. The 1996 FERC Orders 888 and 889 initiated *unbundling*. What did this mean?

→ That generation and transmission could no longer be operated together by the same organization.

22. What is “ISO”? Identify seven of them in the US? What are their responsibilities?

→ “ISO” stands for “Independent system operator.” The seven in the US are PJM, ISONE, ERCOT, CALISO, NYISO, MISO, and SPP. They are responsible for operating the grid, planning the grid, and operating the markets.

23. What precipitated the 2000-2001 California Energy Crisis?

→ Drought, hot weather, outaged generation, natural gas shortage, transmission bottlenecks, flawed market design, and problematic political forces.

24. What are the three primary ways of moving large amounts of energy that is or can become electricity throughout the nation?

→ Electric transmission, gas transmission, and rail (for coal).

25. In terms of electric energy production, the sum of what three sources of electrical energy has been almost constant since 2000? How have each individually changed?

→ The sum of coal, gas, and wind has remained between 67-71% since 2000. During this time, coal has reduced from 57% to 27%, gas has increased from 10% to 34%, and wind has increased from 0% to 8.3%.

26. What is typical voltage ranges for generation, transmission, and distribution in the US?

→ Generation is below 30kV, transmission is between 69kV-765kV, and distribution is below 34.5kV.

27. What does an energy control center do?

→ Monitors and controls the bulk electric power system (generation and transmission).

28. What are the three main mechanism of an ISO's balancing system?

→ Automatic generation control, real-time market, and day-ahead market.

29. What causes faults in power systems?

→ Lightning, Natural events (wind and snow, earthquakes, wildfires...), Deterioration (insulation failure), Animals, vehicles and construction (accidents), mistakes during maintenance

30. Identify three main causes of the 2003 Northeast Blackout.

→ Tree contact (lack of tree trimming maintenance), insufficient reactive power, backup protection

B. From Slide deck #2 on "Energy Systems":

31. Before 2005, the US gas supply was mainly from the Gulf of Mexico and Canada. Although these still remain natural gas suppliers, most US gas come from onshore facilities in several states – what states are these? And what technology has enabled this change?

→ Texas, Pennsylvania, West Virginia, Ohio, Oklahoma, Montana, North Dakota

→ Hydraulic fracturing has enabled access to shale and tight gas.

32. What is a quad?

→ A unit of energy equal to  $10^{15}$  BTUs.

33. Approximately what percent of the US total energy supplied for any use is supplied for electricity production? Approximately what percent of the US total energy supplied for any use is supplied for transportation needs?

→ 37% for electricity production and 28% for transportation needs.

34. Approximately what percent of the US total energy supplied is ultimately "rejected" (lost)? What is the major cause of rejected energy?

→ 67%

→ Heat loss from thermal power plants and from combustion processes used in transportation.

35. Rank the following ways to supply electric energy from lowest LCOE to highest LCOE: Coal, Gas Peaking, Gas Combined Cycle, Solar PV Thin Film Utility Scale, Solar PV Rooftop C&I, Solar PV-Community, Solar PV – Rooftop residential, Onshore wind, offshore wind, nuclear. Use the minimum of the range for each technology.

→ Onshore wind, Solar PV Thin Film Utility Scale, Gas Combined Cycle, Coal, Solar PV–Community, Solar PV-Rooftop C&I, Offshore wind, Nuclear, Gas peaking, Solar PV-Rooftop residential.

36. What are the top 5 states for wind capacity added in 2017? What are the top 5 states for cumulative wind capacity at the end of 2017? What are the top 5 states for wind generation as a percentage of in-state generation? What are the top 5 states for R-factor (wind potential/annual retail sales)?

→ Added in 2017: Texas, Oklahoma, Kansas, New Mexico, Iowa

→ Cumulate at end of 2017: Texas, Oklahoma, Iowa, California, Kansas

→ % of in-state-generation: Iowa, Kansas, Oklahoma, South Dakota, North Dakota

→ R-factor: Montana, South Dakota, North Dakota, Wyoming, Nebraska, New Mexico

37. Answer the following questions:

- Is all PV also DG? → NO
- Is most rooftop PV also DG? → YES
- Does all PV have the same LCOE? → NO
- Does all rooftop PV have same LCOE? → NO
- Are all dist systems having DG also microgrids? → NO
- Is all utility-scale PV owned by utilities? → NO
- Is all DG renewable? → NO
- Is most wind also DG? → NO