Name:____

EE 552, Energy System Planning, Exam 1, Take-home, Open book, Open notes, Closed Neighbor (you must work alone). Spring 2024. Due 3/26.

1. (4 pts) Heat rate data is given for four plants below. One of the heat rates is incorrect. Identify which one and how you know it is incorrect.
   - Plant 1: Heat rate=10.0MBTU/MWh
   - Plant 2: Heat rate=6.0 MBTU/MWh
   - Plant 3: Heat rate=12.0MBTU/MWh
   - Plant 4: Heat rate=2.9 MBTU/MWh
2. (9 pts) We provided the below emissions coefficients in class.

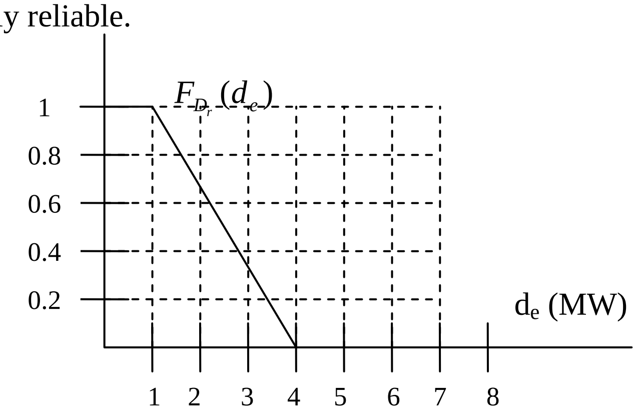
State	2002 MT/mwh
Vermont	0.013
Washington	0.111
California	0.275
New York	0.389
Penn	0.574
Georgia	0.619
Texas	0.664
Ohio	0.817
Iowa	0.854
Kentucky	0.911
N Dakota	1.017
US Avg	0.606

State	2015 MT/mwh
Vermont	0.028
Washington	0.085
California	0.205
New York	0.211
Penn	0.388
Iowa	0.453
Georgia	0.454
Texas	0.476
Ohio	0.665
N Dakota	0.755
Kentucky	0.887
US Avg	0.453

State	2022 MT/mw
Vermont	0.00045
Washington	0.08394
California	0.16878
New York	0.21597
Penn	0.30989
Iowa	0.28766
Georgia	0.31897
Texas	0.36298
Ohio	0.50998
N. Dakota	0.60708
Kentucky	0.7863
US Avg.	0.36479

   a. Why are N.Dakota & Kentucky so high in 2002?
   b. What happened in N. Dakota from 2002-2022?
   c. Use typical efficiencies and heat rates to support your answer to the following question: In 2022, does N. Dakota emissions look more like those of a wind plant, a gas-combined cycle plant, a gas turbine, or a coal-fired plant?
3. (4 pts) A generator is on-line (committed) and producing power in a network run via a real-time market using the security-constrained economic dispatch. There is no congestion in the network, and the marginal loss component of the LMP is negligible. The cost of energy from this generator is \$30/MWh, and that is what it offers into the market. Explain the conditions under which it might get paid at \$40/MWh; also, explain why the generator does not offer \$40/MWh?
4. (4 pts) In considering whether to build a nuclear plant or an onshore wind plant with storage, a planning engineer argues for nuclear on the basis that the Lazard 2023 LCOE data indicates that the LCOE for nuclear can cost as little as \$31/MWh whereas the cost of an onshore wind plant with storage ranges between \$42/MWh and \$114/MWh. Indicate whether you agree or disagree with the argument and why.
5. (6 pts) The NREL ATB data for wind can be found here: https://atb.nrel.gov/electricity/2023/land-based_wind.
   CAPEX and FOM data can be found for three "scenarios" (conservative, moderate, and advanced).
   a. Why do these three curves decrease with time?
   b. Assume these data are given in constant dollars. If you used these numbers in a GEP, should you use real or nominal discount rate?
6. (6 pts) If the least-cost low-carbon option to supply East Coast load is to build Midwestern wind together with transmission to move it, why is it that some East Coast states are so strongly supportive of building offshore wind?
7. (6 pts) The amount of US electrical energy production from natural gas combined cycle (NGCC) plants has increased from less than 10% in 2000 to over 32% in 2022.
   a. What have been the primary causes of this growth?
   b. Do you think this trend will continue beyond 2030? Why or why not?

8. (6 pts) Nuclear power generation using Gen II technology represents a zero-carbon electricity provider and so might be a considered a possible growth technology for the future. However, the number of nuclear power plants has been declining over the past 20 years.
    a. Describe what you think are the major drawbacks of Gen II nuclear power plant technology.
    b. Small modular reactors (SMRs) have been considered a technology that might overcome the drawbacks of Gen II nuclear power plants. Why is this?
9. (6 pts) Hydropower is attractive not only because it is zero-carbon, but it also is effective in providing ancillary services.
    a. Identify seven types of ancillary services hydro provides.
    b. Why can the US not satisfy its low-carbon electric energy needs by building a great deal more hydro?
10. (8 pts) Utility-scale wind farms hold a lot of promise in providing zero-carbon energy for the US. Describe four challenges common to this technology that must be addressed in order to grow them significantly for providing our nation's energy.
11. (4 pts) What are the four US areas of interest for developing offshore wind; identify which of these will most likely see offshore wind buildout the soonest, and identify the reasons for this.
12. (4 pts) There is potential for 100 GW of enhanced geothermal capacity in the US. It is attractive as it is considered a zero-carbon resource. Describe its positives and negatives.
13. (4 pts) A capacity auction ensures that there is sufficient capacity in the system to cover the annual peak demand. In a capacity auction, once the market clearing price (MCP, $/MW-day) is determined, how are the capacity auction revenues obtained, and how are those revenues then distributed to the capacity providers?
14. (11 pts) A load duration curve expected to characterize the next year for a power system on a small Greek island is given below. The power system has recently experienced a problem such that the system generation capacity for the next year will be only 3 MW.
    a. (3 pts) Identify the minimum load, the loss of load probability, the loss of load expectation, and the expected unserved energy, assuming the 3 MW of capacity is perfectly reliable.



    b. (3 pts) The Greeks have a relatively old generation fleet, and it is estimated that the average time required for any of the units in the Greek island's power system to fail is 900 hours and that the average time it takes for any of these units to be repaired is about 100 hours. All units have 1 MW capacity. Compute the availability and unavailability for one of these units. Ignore maintenance.

c. (3 pts) The Greeks decide to retire all of their old units and purchase one new 4 MW unit with forced outage rate of 0.01. If this unit supplies all of the island's electric energy, compute loss of load probability and expected unserved energy.

d. (2 pts) Compute the energy expected to be produced by the 4 MW unit over the year.

15. (4 pts) In the equivalent assisting unit (EAU) approach to two-area resource adequacy evaluation, where two areas are connected by a perfectly reliable capacitated transmission line, it was suggested that the LOLP can be obtained from a composite capacity outage table obtained as a convolution of the capacity outage tables of the two respective areas. Will this work? Explain why or why not.
16. (4 pts) An RTO with an annual peak of early evening in the summer, is discussing with its stakeholders whether an "average" ELCC should be applied for all solar resources (both new and existing), or an "average" ELCC should be applied for all existing solar and a "marginal" ELCC should be applied for all new solar. There is already significant solar connected to the system. Assume that you are developing a new solar plant for which you will be the owner. What is your preference, and why?
17. (6 pts) In the GEP notes, we formulated a problem called GEP-5 using a generalized form of "capacity credit".
    a. Explain, in what sense was this used of "capacity credit" generalized?
    b. Briefly describe a method by which you would determine these various "capacity credits" terms used in GEP-5.
18. (4 pts) In GEP-6, three different formulations were given to account for annual energy production. Which one would you choose, and why?