Table A Capacity of Calvert Cliffs Nuclear power plant

Unit 1: General Electric	Capacity Unit 1: 873 MW	Unit 1: 8,104 GWh	Unit 1: 1975 startup
Unit 2: Westinghouse	Capacity Unit 2: 863 MW	Unit 2: 6,807 GWh	Unit 2: 1977 startup

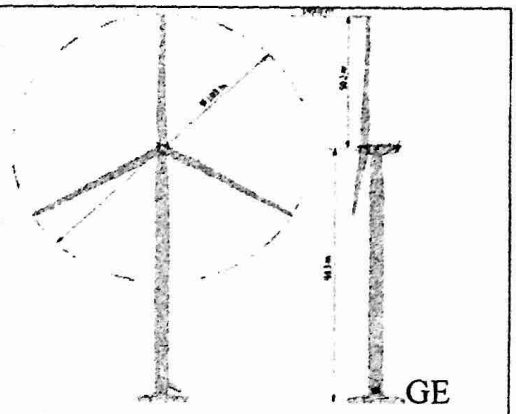
Group 1 Problems- Scientific Research and Development 40 pts

A 300 MW wind farm is being planned. Site study indicates that each GE 3.2 MW turbine with a 103m diameter, Est costs $ 5.2 million and will operate at a local wind capacity of 0.24.

1./6 pts ME students estimated the required number of wind turbines for 300 MW capacity. One estimated 94 turbines The other estimated 391 turbines. Which is correct? _____Why?

2. /7 pts Using 400 turbines, estimate the total cost of the wind turbines $_____

3. /7 pts The 400 turbines will be staggered 80 across and 5 rows. Estimate the site requirements assume the hub to hub separation (X direction) is 3 x diameter and the row separation Y direction is 3 x diameter. Include a 10 m border Answer _____m^2



3.2 MW wind turbine

Pumped Energy storage Analysis -National Renewable Energy Laboratory (NREL) recommends the pumped energy has an elevation 100< z < 500 m. The pipes will have a diameter of 2m < D< 4 m.

4. /15 pts The Potential energy estimate for pumped water is $P = \rho Q g Z \eta$ eq 1 here $\rho = 1000$ kg/m^3, $g = 9.81$ m/s^2 Typical system efficiency is $\eta = 0.85$

Required: Estimate the available power for Case A, B and C Note 1 x 10^6 kg-m/s^3=1 MJ/s =1 MW

A: Q= 75m^3/s, Z = 100m	B: Q= 100m^3/s, Z =100m	C: Q= 100m^3/s Z = 125m
P = 83.385 MW	P = MW	P = MW
Homes= 166 080	Homes =	Homes =

5. /5 pts How many Homes with 0.5kW (i.e. 12kWh/day) average electricity use would this power?

Group 2 Problems- Renewable Energy Process (45pts)

Improve the grid-use energy storage during low load periods and retire a 100MW coal fired power plant

6. /10 pts Estimate CO_2 reduction /year from removing the 100 MW plant from the electric grid(Assume 0.93 Kg CO_2 per Kw-hr). What is the total carbon credit for $10/metric ton CO_2?

7. 15 pts Compare 3 plans A and B - pumped energy storage, and C-battery storage.

Plan A involves using the Chesapeake Bay and building a lake. Cost estimated at a $500 Kw/hr

Plan B involves using an underground cavern and building a lake. Cost estimated at $625 kw/hr.

Plan C involves using batteries. Cost estimated at $500 kw/hr

For the 150MW energy storage system estimate the cost and list environmental impact (EI) concerns.

Plan A	Cost	EI Concerns are:
Plan B	Cost	Concerns are:
Plan C	Cost	EI Concerns are:

Plans are to replace Unit 1 with an alternate plant in 2030: a wind farm, diesel generators and a natural gas turbine. (ENGR 535 is evaluating a solar panel power plant alternative.)

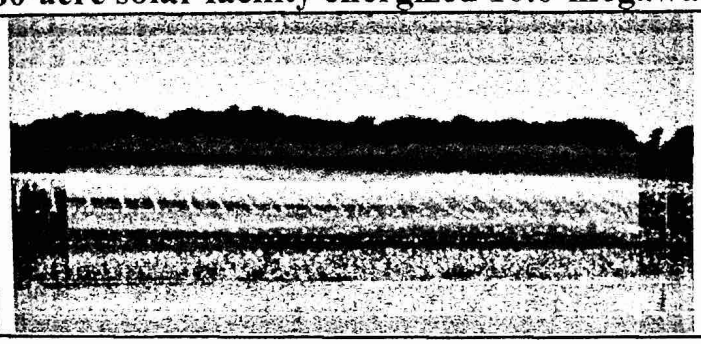
8. /5 pts Diesel generators have a capital cost ranging from $300-900/kW, Estimate the Capitol cost For replacing Unit 1 with diesel generators - Low_____High _____.

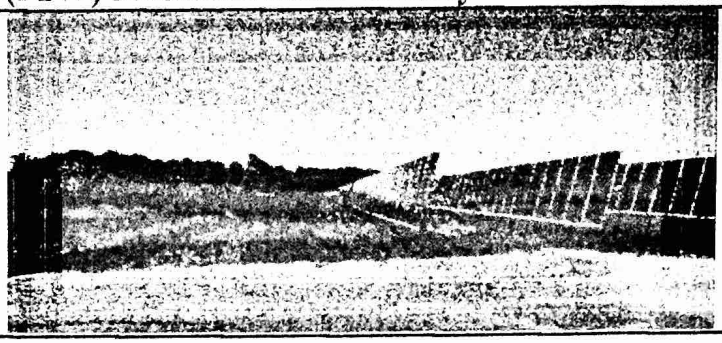
15/pts A natural gas turbine - capital cost (initial cost of the equipment)of $500/kW, fixed O&M of $15/kW-yr, and variable O&M of 0.0055 $/kWh" with an additional $100/kW estimated for transmission and delivery to the urban center. Complete the natural gas turbine project cost Table

NG Turbine	Fixed O&M	Variable O&M	Transmission	Project Total

Rockfish Solar farm Worksheet 14 November Visit Background Design and Questions /15

80-acre solar facility energized 10.0-megawatt (MW) Rockfish Solar facility





1. Background The state of Maryland requires all electric utilities to acquire renewable energy to fulfill their renewable portfolio obligation. In 2015 Utilities are obligated to purchase 0.5 percent of their load from solar energy resources. The percentage increases each year until reaching two percent in 2020. Utilities that don't purchase the required amount of solar energy must pay a penalty.

Southern Maryland Energy Cooperative (SMECO)

In December 2012, SMECO completed construction of a 5.5-MW solar array on 33 acres adjacent to its engineering and operations center in Hughesville, Maryland. The array capacity factor is 18.5 percent. The project was completed in just under two years. The construction and commissioning period took approximately five months. The 23,716 MEMC 280-W DC module solar arrays are connected to the local electric distribution system using 11 Advanced Energy 500-kW inverters. Total output of the array is 5.5-MW AC. The 5.5 MW solar array meets the SEMCO overall power portfolio needs both for energy and meeting Maryland state mandate for renewable energy.

In April, 2014 SMECO signed a second power purchase agreement with Juwi solar, Inc. (JSI) to develop, design, and construct the 10.0-megawatt (MW) Rockfish Solar facility. SMECO will purchase generated energy, capacity, and solar renewable energy credits from the Rockfish plant for the next 20 years.

2. Design The Rockfish solar farm is a 10 MW (approximately 12.63 MW DC) using single axis tracking technology with 42,240, 310-watt Hanwah solar panels(1972 mm x 992 mm x 40 mm). Solar panels run north south and are mounted on a single-axis tracking array system that rotates them to follow the path of the sun east to west for optimal panel power production. The facility generates roughly 21,000 megawatt-hours per year of operation. An average SMECO household uses 1,300 kilowatt-hours per month. So the Redfish solar would power about 1,300 homes annually. Strings of panels are aggregated in DC combiner boxes (DCBs). These DCBs would feed inverters that convert the DC generated electricity from the panels to AC power for the SMECO distribution system. The inverters send power to MVTs designed to step up the inverter output voltage to the 12.47 kV SMECO interconnection voltage.

3. Project Cost Estimate (2014) Its cost estimated between $17 and $23 million to construct with approximately 80 to 110 construction jobs. Note: Nov 2016 gives **Hanwha Solar** 310W **Solar** Panel, Q.PRO L-G2 310 Poly Silver Frame price = **$167.40**

4. Site Selection The Solar Power Prospector TGY data indicates that the site has an average daily global horizontal solar irradiance of 4.23 kilowatt hour per meter squared per day (kWh/m2/day) and a typical total annual global horizontal irradiance of 1,544 kWh/m2/yr.

"This project will provide renewable energy right here in our service area, helping us to meet our regulatory requirements and to avoid costly transmission fees," according to Austin J. Slater, Jr., SMECO president and CEO. "Our customer-members will be glad to know that the cost of the energy provided by this solar project is very reasonable and will have a positive effect on customer rates."

Question No 9 5pts Using $210/panel what percent of the $20 million cost is the solar panels? ____ %

No10 5pts Total 42,240 solar panel serves 1,300 home or 32.5 panels per home. Why?

No 11 5 pts Assuming the SMECO also supplies solar panel to its customers, could they be counted in meeting the Maryland renewable energy percentage? How could it work? Hint selling excess to the grid.