NPRE 475
Wind Power Systems
Spring 2022

<u>Online Temporary Alternative Coverage and access during Covid-19 Pandemic and possible resurgence through mutations and variants</u>

1. Please read the assigned-reading lecture-notes chapters.
2. Then answer the corresponding written assignment,
3. For questions about the assignments, please access the teaching assistants by email:
https://www.mragheb.com/NPRE%20402%20ME%20405%20Nuclear%20Power%20Engineering/talist.htm
4. Submit the corresponding written assignment through email to https://canvas.illinois.edu
5. Please use either the Word or pdf formats
6. In case of internet "rationing" (e. g. to health and government authorities), instability, or collapse through overload, please read the lecture notes and submit the corresponding assignments. Already-taken tests and submitted assignments would be used in assessing the final grade.

Threat of Nuclear War:
https://www.youtube.com/watch?v=M7hOpT0lPGI

Regrettably, some 3,278 colleges and universities across the USA have been impacted by the Covid-19 pandemic, with many temporarily closing their campuses and switching to online classes, affecting more than 22 million students.
To all and everyone we wish good health and well-being.

Number	Date Assigned	Due Date	Description
1	1/19	1/26	**Reading Assignment** **Preface** **Written Assignment** One megawatt of electrical power (1 MWe) supplies the electrical use of 240-300 average American homes with a family of four. For the whole USA population, estimate the range of the hypothetical required wind installed capacity in GWe at an intermittence (capacity) factor of 40 percent for the following levels of wind electrical market penetration: 1. Seven percent (e. g. Ameren Illinois electrical utility in 2016), 2. Twenty percent (e. g. Iowa and South Dakota in 2011), 3. Thirty-three percent (Renewable Energy Standard, RES for California, 2020). Note: The USA is the third most populous country in the world, with an estimated population of 329,968,629 persons as of November 10, 2019.
2	1/21	1/28	**Reading Assignment** **1. Introduction** **Written Assignment** List the environmental concerns associated with the successful implementation of wind power generation as an industrial process. List the components of the envisioned Internet of Things (IoT) for a future energy system.

			Automobile engines are designed to operate for about 5,000 hours. Compare this to the required number of design operational hours for a wind turbine operating at an intermittency or capacity factor of 20-40 percent for a design lifetime of 20 years.
3	1/24	1/31	**Reading Assignment** NEW **1. Introduction** **Written Assignment** List the perceived advantages of wind power as an energy source. The Suzlon S.66/1250, 1.25 MW rated power at 12 m/s rated wind speed wind turbine design has a rotor diameter of 66 meters and a rotational speed of 13.9-20.8 rpm (revolutions per minute). Calculate the range of the tip of its rotor's linear speed v in m/s, km/hr and miles/hr. Discuss the safety implication regarding the possible inclement-weather ice formation on the blades. Hints: $v = \omega r,\ \omega = 2\pi f,\ f = \frac{rpm}{60}$ r is radius in meters, f is rotational frequency in rotations/sec (Hz), ω is angular speed in radians per second, v is linear speed in meters/sec.
4	1/26	2/2	**Reading Assignment** NEW **1. Introduction** NEW **2. Global Wind Power Status** **Written Assignment** What is the usually used unit in the measurement of the wind's power flux? List the components of a typical of a utility level Horizontal Axis Wind Turbine, HAWT. Access the Lawrence Livermore National Laboratory's (LLNL) Sankey Diagram and deduce from it: 1. The total USA primary energy resources in units of "quads." 2. The overall efficiency of energy use as energy services. 3. The percentage of energy used as electricity. 4. The percentage of primary energy in the form of carbon sources. 5. The percentage of primary energy in the form of non-carbon sources. 6. The percentage of primary energy in the form of wind resources. Note: The quad is a unit of energy equal to one quadrillion or 10^{15} BTUs (British Thermal Units) or 1.055 quintillion or exajoules or1.055 × 10^{18} Joules.
5	1/28	2/4	**Reading Assignment** NEW **3. USA Wind Energy Resources** **Written Assignment** Construct a table showing the relationship between the wind power categories, their power fluxes in Watts/m^2 versus the wind speed in meters/sec and in miles per hour. List the voltages of the High Voltage Alternating Current, HVAC transmission lines used in the North American power grid system,
6	1/31	2/7	**Reading Assignment** NEW **4. Properties and Statistical Analysis of the Wind** **Written Assignment**

			List the names of the local winds and their associated different global locations. One percent of the solar radiation power of 1.7×10^8 GW is converted into wind power. The floral or plant global Net Primary Production (NPP) in all the links of the food and energy chain is: $NPP = 4.95 \times 10^6$ [cal / (m^2.year)]. The Earth's surface area is: $A_{Earth} = 5.09 \times 10^{14}$ m^2. 1. Estimate the power stored as biomass in Watts. 2. What is the ratio of wind to biomass power generated from solar radiation? Discuss the implication regarding wind and biomass power generation.
7	2/4	2/11	**Reading Assignment** **4. [Properties and Statistical Analysis of the Wind]** **Written Assignment** The probability density function (pdf) of the two parameter Weibull distribution used in modelling wind duration curves is: $$W(v) = \frac{k}{C}\left(\frac{v}{C}\right)^{k-1} e^{-\left(\frac{v}{C}\right)^k}$$ $where: \ k = shape \ parameter \ or \ slope$ $C = scale \ parameter \ or \ charactreristic \ wind \ speed$ As special cases, deduce the forms of: 1. The Rayleigh distribution, 2. The Exponential distribution. Consider the exponential probability density function (pdf): $$p(v)dv = \frac{1}{C} e^{-\frac{v}{C}} dv$$ 1. Apply the normalization condition to prove that it is indeed a probability density function (pdf). 2. Derive the expression for its cumulative distribution function (cdf). 3. Derive the expression for its complementary cumulative distribution function (ccdf).
8	2/7	2/14	**Reading Assignment** **6. [Wind Shear, Roughness Classes and Turbine Energy Production]** **Written Assignment** a) Consider the average wind speed at the Champaign Willard airport location from the graph in the lecture notes as about 5 m/s. b) Determine its wind class classification. c) Plot the corresponding Rayleigh probability density function. d) Using the power curve for the Gamesa G52-850 kW wind turbine, generate the graph of the potential energy production as a function of wind speed. e) Estimate the yearly total energy production. f) Compare the total potential energy production for this wind class site to that obtainable from a wind class 7 location. Hint: You can use the data for the Rayleigh pdf from the table in the lecture notes. The wind speed at 20 meters height at the Eiffel Tower, Paris, France, is about 2 m/s, and it is about 7-8 m/s at 300 meters above ground. What range of values of the coefficient n best fits the Eiffel Tower situation? Hint: Solve for n by taking the natural logarithm of both sides of the power wind shear equation:

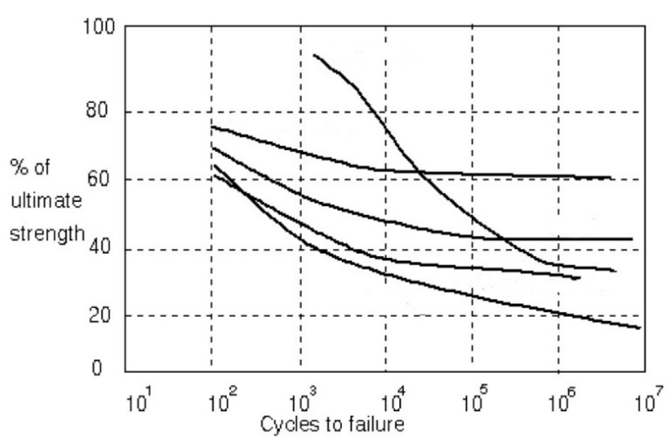
			$\frac{V}{V_0} = \left(\frac{H}{H_0}\right)^n$
9	2/9	2/16	**Reading Assignment** NEW **5. Wind Generators History** NEW **6. Wind Shear, Roughness Classes and Turbine Energy Production** **Written Assignment** A Japan Steel Works (JSW) J82-2.0 / III wind turbine has a rotor blade length of 40 m. Estimate the wind speed at the tips of its blades at the maximum and minimum heights they attain, if the hub height is: a. 65 meters. b. 80 meters. Assume the turbine is built within an area with a roughness class of 2.5, for a wind blowing at V_{ref} = 8 m/sec at a height of z_{ref} = 20 m. Hint: Use the logarithmic wind shear formula: $V(z) = V_{ref} \frac{\ln \frac{z}{Z_0}}{\ln \frac{z_{ref}}{Z_0}}$
10	2/11	2/18	**Reading Assignment** NEW **9. Energy and Power Content of the Wind** **Written Assignment** The Suzlon S.66/1250, 1.25 MW rated power at 12 m/s rated wind speed wind turbine design has a rotor diameter of 66 meters. For the same rated wind speed, what would the rated power be, if: 1. The rotor diameter is halved to 33 meters. 2. The rotor diameter is doubled to 132 meters. A wind turbine has a rated power of 3 MW at a site with an average wind speed of 5 m/s and an intermittence factor of 0.4. Estimate: 1. Its maximum possible power output in MW, 2. Its maximum possible yearly energy production in MW.hrs, at sites with the following average wind speeds: a) 8 m/s, b) 10 m/s, c) 15 m/s. Hint: Use the equation $P = \frac{1}{2}\rho \pi R^2 V^3$
11	2/14	2/21	**Reading Assignment** NEW **10. Wind Energy Conversion Theory, Betz Equation** **Written Assignment** Write the Betz's Equation and identify the Betz Limit in it. By differentiation of the expression of the power coefficient or efficiency of a wind turbine: $C_p = \frac{P}{W} = \frac{1}{2}\left(1-b^2\right)\left(1+b\right)$

			with respect to the interference factor b, determine analytically the value of the Betz' limit for wind machines. Explain its physical meaning.
Reading Assignment12	2/16	2/23	**Reading Assignment** **10. Wind Energy Conversion Theory, Betz Equation** **13. Components of Wind Machines** **Written Assignment** A wind turbine that operates in an area with a wind power flux resource of 200 Watt/m^2 (measured at 50 m height) has the following operational parameters: 1. Rotor blade radius R = 30 m. 2. Coefficient of performance C_p = 40 percent. 3. Transmission (gearbox) efficiency: 97 percent. 4. Electrical generator efficiency: 98 percent. 5. Intermittency factor (capacity factor): 30 percent. Calculate: 1. The rotor swept area. 2. The rated power of the turbine. 3. The transmission power. 4. The electrical generator power. 5. The overall electrical power production in MWe. Compare the values of the calculated parameters to those in an area with a wind power flux resource of 600 Watts/m^2. List the materials used in the rotor blades construction.
13	2/18	2/25	**Reading Assignment** **30. Historical Wind Generators Machines** **Written Assignment** Construct two tables comparing the technical specifications of: 1. The Charles Brush and the Smith Putman turbines, 2. The MOD-1 and the MOD-2 turbines.
14	2/21	2/28	**Reading Assignment** **13. Components of Wind Machines** **14. Orography and Wind Turbine Siting** **Written Assignment** Construct a table comparing the characteristics, advantages and disadvantages of: 1. Horizontal Axis Wind Turbines, HAWTs, 2. Vertical Axis Wind Turbines, VAWTs. Assuming the same pressure drop and density, compare the resulting ratio of wind speeds: $\frac{V_2(\beta = 0.9)}{V_2(\beta = 0.1)}$ due to the tunnel speedup effect for a decrease of the constriction ratio from β = 0.9 to β = 0.5.
15	2/23	3/2	**Reading Assignment** **15. Offshore Wind Farms Siting** **16. Airborne Wind Turbine Concepts** **Written Assignment** Construct a table comparing the characteristics of: 1. Offshore wind projects, 2. Onshore wind projects.

			Calculate the obtainable peak electrical power for a cruising kite situation with: The ground wind speed = 9 m/s The altitude wind speed V_w = 15 m/s The kite speed V_k = 80 m/s The mean air density ρ = 1 kg/m^3 The kite area A= 40 m^2 Product of generator efficiency and gearbox efficiency $\eta_{gear\ box}\eta_{generator}$ = 0.70 The mean cos α = 0.45 Lift to drag ratio C_L /C_D = 18 Drag coefficient C_D = 0.06 Thrust to axial speed coefficient $C_{thrust\ to\ axial\ speed} = 2$
16	2/25	3/2	**Reading Assignment** **17. [Vertical Axis Wind Turbines]** **18. [Small Wind Generators]** **Written Assignment** List the advantages of Vertical Axis Wind Turbines. Show a diagram of a wind turbine: 1. Darrius design 2. Savonius design List the technical specifications of the Air-X 24 small wind turbine.
17	2/28	3/2	**Reading Assignment** **31. [Environmental Considerations]** **Written Assignment** Calculate the collision probability between a flying object and the rotating blades tips of a wind turbine for the number of rotor blades: 1. n=1, 2. n=2, 3. n=3. for a rotational frequency f=20 rpm, a thickness of the blades of 0.3 m, and the perpendicular speed of a flying bird of 10 m/sec. Briefly describe the two forms of flicker resulting from rotor blades rotation. List the environmental concerns associated with the successful implementation of wind power generation as an industrial process. Compare the avian mortality from different causes. Compare the noise level in db for wind turbines to the noise level of other sources.
Wed	3/2	During class period	First midterm exam
18	3/4	3/11	**Reading Assignment** **19. [Modern Wind Generators]** **Written Assignment** List Seven major developments that characterize modern wind machines designs. Briefly describe the characteristics and the justification regarding the capacity factor of the Haliade-X, 10-12 MW of rated power GE turbine for offshore applications.

19	3/7	3/21	**Reading Assignment** **19. [Modern Wind Generators]** **Written Assignment** Identify the engineering innovation features in wind turbine designs introduced by the following manufacturers 1. Siemens, 2. GE, 3. Enercon, 4. Japan Steel Works, JSW, 5. Envision.
20	3/9	3/21	**Reading Assignment** **23. [Wind Energy Converters Concepts]** **Written Assignment** Use a diagram to explain the occurrence of the Magnus Effect. Briefly describe: 1. Flettner turbine, 2. Thom rotor, 3. Lesh rotor.
21	3/11	3/21	**Reading Assignment** **23. [Wind Energy Converters Concepts]** **Written Assignment** Construct a table comparing the technical characteristics, advantages, and disadvantages of: 1. HAWTs, 2. VAWTs.
22	3/21	3/28	**Reading Assignment** **7. [Fluid Mechanics, Euler and Bernoulli Equations]** **Written Assignment** Euler's equation applies to an incompressible inviscid fluid flow with no body forces. It relates the change in velocity along a streamline dV to the change in pressure dp along the same streamline: $dp = -\rho V dV$ From Euler's equation, derive Bernoulli's equation. Explain its physical meaning in terms of the static and kinetic (dynamic) pressures. A wind rotor airfoil is placed in the air flow at sea level conditions with a free stream speed of 10 m/s. The density at standard sea level conditions is 1.23 kg/m^3 and the pressure is 1.01×10^5 Newtons / m^2. At a point along the rotor airfoil the pressure is 0.90×10^5 Newtons / m^2. By applying Bernoulli's equation estimate the speed at this point.
23	3/23	3/30	**Reading Assignment** **8. [Aerodynamics of Rotor Blades]** **25. [Computational Fluid Dynamics]** **Written Assignment** List the names of the four basic equations governing the field of Computational Fluid Dynamics (CFD). List the variables usually used in one phase flow CFD.

			Discretize the equation of motion or conservation of momentum for a fluid into its finite difference form and derive the corresponding updated speeds: $\frac{du}{dt} = -V\nabla p = -V\frac{\partial p}{\partial x} = -V\frac{\Delta p}{\Delta x}$ Discretize the conservation of energy equation for a fluid into its finite difference form and derive the corresponding updated specific energies using the thermodynamic relation: $dE = -pdV$ $\Delta E \simeq -p\Delta V$
24	3/25	4/1	**Reading Assignment** **12. Optimal Rotor Tip Speed Ratio** **Written Assignment** For a wind speed of 15 m/s and a 3 bladed rotor radius of 10 meters rotating at 1 rotation / sec, calculate: 1. The angular rotational frequency, 2. The rotor tip speed, 3. The tip speed ratio. Compare this value to the optimal tip speed ratio. Repeat the comparison for a 2 and 4 bladed turbines.
25	3/28	4/4	**Reading Assignment** **11. Torque Generation in Wind Turbines** **Written Assignment** Complete the design steps for the high speed and low speed shaft *radii* for a wind turbine transmission or gearbox. Consider the design of a wind generator with an electrical output of: $P_e = 0.75 MWe$ Accounting for the generator efficiency, the power at the transmission output would be: $P_t = \frac{P_e}{\eta_g}$ For a generator efficiency of 90 percent, this would be: $P_t =$ ________________ $Watts$ And the power at the transmission input would be: $P_m = \frac{P_t}{\eta_t} = \frac{P_e}{\eta_g \eta_t}$ For a transmission efficiency of 90 percent, this would be: $P_m =$ _____________ $Watts$ Taking the rotational speed of the generator at 1,200 rpm, yields: $\omega_t = 2\pi\frac{1,200}{60} = 40\pi[\frac{\text{radians}}{\text{sec}}]$ Taking the rotational speed of the rotor shaft as 24 rpm, corresponding to a gearing ratio of: $Gearing\ ratio : GR =$ _____________ yields: $\omega_m = 2\pi\frac{24}{60} = \frac{4}{5}\pi[\frac{\text{radians}}{\text{sec}}]$ The torques at the high speed and low speed shafts torques become:

			$T_t = \frac{P_t}{\omega_t} =$ ________________ $[\frac{\text{N.m}}{\text{rad}}]$ $T_m = \frac{P_m}{\omega_m} =$ ________________ $[\frac{\text{N.m}}{\text{rad}}]$ A maximum stress for steel shafts is recommended as 55 Mpa. Accounting for a factor of safety FS of 3 and an ignorance factor IF of 2 yields for the design maximum stress: $\sigma_{s,\max}(r_0) = \frac{\sigma_s(r_0)}{FS.IF} = \frac{\sigma_s(r_0)}{3x2} = \frac{\sigma_s(r_0)}{6}$ $\sigma_{s,\max}(r_0) = \frac{55}{6} = 9.2MPa$ The high speed and low speed shaft radii are respectively: $r_{0,t} = \sqrt[3]{\frac{2T_t}{\pi\sigma_{s,\max}(r_0)}} =$ ________________________________ cı $r_{0,m} = \sqrt[3]{\frac{2T_m}{\pi\sigma_{s,\max}(r_0)}} =$ ________________________________ cr What is the design implication regarding the low speed shaft design? ____________________
26	3/30	4/4	**Reading Assignment** **20. [Wind Turbines in the Urban Environment]** **21. [Dynamic and Structural Loading in Wind Turbines]** **22. [Fatigue Loading in Wind Turbines]** **Written Assignment** On the percent of ultimate strength versus the number of cycles to fatigue failure, identify the curves for the following materials: Aluminum, carbon composites, steel, wood laminates and fiber glass composites.  Which material is expected to be associated with: 1. The longest rotor blade operational lifetime, 2. The shortest rotor blade operational lifetime.
27	4/1	4/4	**Reading Assignment** **24. [Control of Wind Turbines]** **29. [Structural Towers]** **53. [Decommissioning Wind Turbines]**

			Written Assignment List the types pf control strategies adopted in wind power generation. List the types of structural towers used in wind power generation**.**
	4/4		Second Midterm Exam, during class period
28	4/6	4/13	**Reading Assignment** **34. Economics of Wind Energy** **Written Assignment** 1. Calculate the "present value" of a yearly income stream of $68,250 that is expected 10 and 20 years into the future, considering: 1. A discount rate of i=4 percent. 2. The "real interest rate" r with a discount rate of i=3 percent in addition to an inflation rate of s=7 percent. Hint: The Present Value Factor (PVF) is: $PVF = \frac{1}{(1+r)^t}, r = i + s$
29	4/11	4/18	**Reading Assignment** **34. Economics of Wind Energy** **Written Assignment** Historically, the installation of wind turbines in the USA has fluctuated with the Production Tax Credit (PTC). This government incentive or subsidy provides wind farm owners with a 2.3 cent credit per kilowatt.hour (kWhr) of electric energy generated on their facility for the first 10 years of operation. Gear boxes or transmissions are the weakest link in existing wind turbine installations worldwide and need replacement after about five years of operation. Using present value cost analysis, complete the following work sheet for the economic assessment of a single wind turbine project, neglecting the depreciation, interest payments and taxes, but taking into account: 1. The subsidies and tax incentives provisions, 2. The replacement cost of the gear box if it amounts to 10 percent of the turbine cost. **Investment** Expected lifetime = 20 years Turbine rated power: 600 kW Turbine price: $450,000 Installation costs: 30 percent of turbine price = $____________________ Total turbine cost = Turbine cost + Installation cost = $_____________________ **Payments** The payments, including the initial payment, are used to calculate the net present value and the real rate of return over a 20 years project lifetime since this is the main economic aspect of the analysis. (Consider that the capital is in the form of available invested funds: if the capital cost is all borrowed funds, then the interest payment on the loan or the bonds must be accounted for.) Operation and Maintenance: 1.5 percent of turbine price =________________ $/year. Total expenditure = Total turbine cost + Operation and maintenance cost (over expected lifetime) = $_______________________________________ **Current income and expenditures per year** Capacity factor: 28.54 percent = 0.2854.

Energy produced in a year: ______________________________________ kWhr / year.
Price of electricity: $0.05 / kWhr
Yearly income from electricity sale = __________________________$ / yr.
Yearly income from Production Tax Credit (PTC) = __________________________$ / yr (Over first ten years of project).
Cost of gearbox replacement: ___________________________________$.
(Please fill up ***all*** the table entries)

	Expenditures $	Gross Income Stream $	Gearbox, Transmission replacement	Production Tax Credit (PTC) $	Net Income Stream $	Present value factor $1/(1+r)^n$ r = 0.05	Net present value of inc $
0	-585,000	-	-	-	-	-	-
1						0.9524	
2						0.9070	
3						0.8638	
4						0.8227	
5						0.7835	
6						0.7462	
7						0.7107	
8						0.6768	
9						0.6446	
10						0.6139	
11						0.5847	
12						0.5568	
13						0.5303	
14						0.5051	
15						0.4810	
16						0.4581	
17						0.4363	
18						0.4155	
19						0.3957	
20						0.3769	
Total						12.462	

Economic assessment

Net present value of future income stream at r = 5 percent/year real rate of interest: $______________________

$$\text{Yearly net real rate of return} = \frac{\text{Net present value of income stream}}{\text{Total turbine cost}} \cdot \frac{1}{\text{Project lifetime}}$$

= _____________________________ percent/year.

			$$\text{Present value of electricity per kWhr} = \frac{\text{Net present value of income stream}}{\text{Yearly energy production . Project lifetime}}$$ = ______________________ cents / kWhr. The Production Tax Credit pays the following percentage of the cost of the turbine: ____ In comparison to a bank Certificate of Deposit (CD) providing a yearly rate of return of 3 percent/year, would you recommend this wind turbine project? ____
30	4/13	4/20	**Reading Assignment** **52.[Wind Turbines Gearbox Technologies]** **Written Assignment** In order to produce AC power at the required 50 Hz for Europe or 60 Hz for the USA, as the number of poles of a generator increases, the rpm required to operate the generator decreases linearly: $\omega_{generator} = 120\frac{f}{N} rpm$ i) Calculate the rotational speed of an USA 8-pole generator. ii) Calculate the rotational speed of an USA 200 pole generator. iii) Calculate the rotational speed of an EU 8-pole generator. iv) Calculate the rotational speed of an EU 200 pole generator. For a 4-poles generator operating at 1,500 rpm and rotor blades rotating at 20 rpm, calculate the gearing ratio of a wind turbine transmission. On the other hand, for a 200-poles wind turbine generator operating at 30 rpm and rotor blades also rotating at 30 rpm, calculate the gearing ratio. Discuss the implication of these results.
31	4/15	4/22	**Reading Assignment** **37. Safety of Wind Systems** **Written Assignment** Identify the sources of risk associated with wind turbines operation. Rank them according to what you perceive as their level of risk.
32	4/18	4/25	**Reading Assignment** **37. Safety of Wind Systems** **35. Wind Project Development and Financing** **Written Assignment** Briefly describe the two forms of flicker resulting from rotor blades rotation. Compare the noise level in db for wind turbines to the noise level of other sources. Define: Debt Service Coverage ratio Gearing, Leverage List the different forms of equity financing for a wind project.
33	4/20	4/27	**Reading Assignment** **40. Energy Storage with Wind Power**

			Written Assignment To address the intermittence problem, list the methods by which wind energy can be stored. Write a one-page summary about the use of batteries for the storage of wind energy.
34	4/22	4/29	**Reading Assignment** **51. Powerwall and Powerpack Tesla Batteries** **Written Assignment** Briefly describe the envisioned role of battery storage in the following energy fields: 1, Individual consumers, 2. Small businesses, 3. Electrical utilities
35	4/25	5/2	**Reading Assignment** **39. Wind Power for a Mars Mission** **48. Political Aspects of Wind Power** **Written Assignment** Describe the unique features of the atmosphere of Mars. What makes wind power a suitable alternative for a Mars mission? What are the provisions in a carefully written land lease agreement in view of avoiding societal and political conflicts?
36	4/27	5/4	**Reading Assignment** **42. High Voltage Direct Current for Wind Power** **Written Assignment** Give a simple explanation for why high voltage is favored for the long-range transmission of electrical power. Hint: Power = P = IV, Ohmic heating losses = $P_{ohmic} = I^2R$. Use two diagrams to discuss the desirability of HVDC over HVAC for the long-range transmission of wind-produced electrical power from the perspectives of: 1. Initial capital cost of the needed installations, 2. The operational costs in terms of transmission energy losses. List the advantages of HVDC in the transmission of wind-generated electricity**.**
37	4/29	5/4	**Reading Assignment** **36. Electrical Generation and Grid System Integration** **43. Sustainable Global Energy Desertec Concept** **Written Assignment** What does the acronym: EUMENA stand for? Write a short description of the Desertec project worldwide and the role of wind power in it. Draw a schematic of a Compressed Air Energy Storage (CAES) system associated with wind power generation.
38	5/2	5/6	**Reading Assignment** **47. Global Climatic Variation and Energy Use** **Written Assignment** Complete the table showing the effect of carbon dioxide concentration on temperature gradients and atmospheric heat fluxes. For a doubling of the atmospheric CO_2 concentration, the intensity of weather phenomena would be expected to increase by: ______________________ percent. For a quadrupling of the atmospheric CO_2 concentration, the intensity of weather phenomena would be expected to increase by: ______________________ percent.

Carbon dioxide concentration (ppmv)	Surface temperature (t_s)	Upper level temperature (t_u)	Temperature gradient, lower atmosphere (K/km)	Temperature gradient, upper atmosphere (K/km)	Net heat flux (x kA)	Relative increase (percent)
150	282	269	5.54	2.19		-
300	284	253	5.69	1.59		
600	286	242	5.85	1.19		

39	5/4 Last day of classes	5/6	**Reading Assignment** **47. Global Climatic Variation and Energy Use** **Written Assignment** Describe the proposed use of Flettner Wind Turbines in mitigating the effect of a possible runaway global warming situation. Write a one-page summary of the paper: Magdi Ragheb, "Restoring The Global Equatorial Ocean Current Using Nuclear Excavation," i-manager's Journal on Future Engineering & Technology, Vol. 5, No. 1, pp. 74-82, August-October, 2009.

Assignments Policy

Assignments will be turned in at the beginning of the class period, one week from the day they are assigned.
The first five minutes of the class period will be devoted for turning in, and returning graded assignments.
Late assignments will be assigned only a partial grade. Please try to submit them on time since once the assignments are graded and returned to the class, late assignments cannot be accepted any more.
If you are having difficulties with an assignment, you are encouraged to seek help from the teaching assistants (TAs) during their office hours. Questions may be emailed to TA's, but face-to-face interaction is more beneficial.
Although you are encouraged to consult with each other if you are having difficulties, you are kindly expected to submit work that shows your individual effort. Please do not submit a copy of another person's work as your own. Copies of other people's assignments are not conducive to learning, and are unacceptable.
For further information, please read the detailed assignments guidelines.