San José State University
Mechanical Engineering
ME 172 Alternative Energy Sources
Fall 2016

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Office Hours:	Friday 8:30-9:00 AM
Class Days/Time:	Friday 9:00 to 11:45 AM – Engineering Building Room ENG 401
Prerequisites:	ME 114 or CHE/ME 109 or CHE 190 with a C- or better

Faculty Web Page and MYSJSU Messaging

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on Canvas Leaning Management System course login website at http://sjsu.instructure.com. You are responsible for regularly checking with the messaging system through MySJSU at http://my.sjsu.edu to learn of any updates.

Course Description

Essentials of Alternative Energy. Theory and Applications of Solar thermal, Photovoltaics, Biomass biogas and biofuels, Fuel cells, Wind, Geothermal Energy, Marine Energy and Electric Vehicles.

Course Goals

This course is focused on sustainable energy conversion and storage to prepare young engineers to the opportunities of the up-coming Energy Transition. The prospect of producing clean, sustainable power from renewable energy sources is fast raising interest worldwide. Driven by increasing concerns over the environmental impact and sustainability of traditional fossil fuels, and stimulated by recent technological developments alternative energy sources have grown from marginal 10 years ago to commonly used today and most surely dominant in only few decades. The course aims to describe the different technological options and to apply engineering tools to compare their performance and identify possible improvements. The integration into the complex energy mix of developed and emerging countries is also presented. The course covers a

broad range of technologies to offer a comprehensive assessment: photovoltaics, electric vehicles, biomass, biogas, biofuels, fuel cells, thermal solar, wind, tidal, wave, and geothermal energy.

Course Learning Outcomes (CLO)

Students who complete all of the course assignments, including attending lectures, preparing homework problems, reading assignments, and completing student projects, should be able to…

Introduction to renewable energy

1. Compare the energy consumption across different sectors in the US and internationally.
2. Compare the energy sources internationally.
3. Distinguish between force, energy, heat, and power.
4. Discuss factors causing global warming.
5. Understand global warming forecast and the challenge to control it.
6. Describe the evolution of regulations to address global warming
7. Analyze different renewable energy technologies based on simple economic models.

Solar Resource

8. Calculate declination, hour angle, and days of sunlight based on location.
9. Distinguish between different vectors of irradiance.
10. Know irradiance standards used in solar cell testing.
11. Calculate the irradiance on a surface based on location, geometry of surface, time of day and season.
12. Distinguish between irradiance and insolation.
13. Understand the concept of Capacity Factor
14. List ways to measure solar irradiance.
15. List factors that influence actual solar radiance that are not accounted for in simple calculations.
16. Understand differences between trackers, concentrators and fix panels.
17. Simulate solar irradiance.

Solar Thermal

18. Compare different solar water heater designs including thoughts on cost, maintenance, and effectiveness.
19. Apply thermodynamic concepts to solar collectors
20. Identify the influence of location effect (solar irradiance, outside temperature, wind speed) on effectiveness of water heater.
21. Distinguish between radiation, convection, and conduction and give examples in solar water heaters.
22. Calculate the convective heat transfer coefficient based on location and design.
23. Define absorbance, transmission, and emittance.
24. Calculate the time to heat a system or the maximum temperature based on design parameters and location.
25. Know the concept of Trombe wall

26. Calculate the temperature change in a forced circulation system.
27. Discuss the advantages and disadvantages of using a concentrator.
28. Calculate the influence of a concentrator on the effectiveness of a water heater.
29. Know the different types of concentrated Solar Power plants

Photovoltaics

30. Understand the physics of photovoltaic effect
31. Utilize physics of a PN junction to explain the IV plot for a PV device.
32. Label open circuit voltage, short circuit current, maximum power, and fill factor.
33. Describe how the properties of the cell change in series and parallel.
34. Define n-type and p-type semiconductor.
35. Describe the drift and diffusion of carriers across a junction.
36. Explain built in voltage and analyze what happens to it under different biases.
37. Calculate minority carrier lifetime and diffusion length of carriers and relate their significance to PV performance.
38. Analyze fabrication steps in a basic single crystalline Si PV device based on their importance for device performance.
39. Explain limitations on conversion rate in PV devices including the Schokley-Queisser principle.
40. Describe how a PV cell is designed to minimize loss.
41. Distinguish between first, second, and third generation PV technologies.
42. Design a PV array for a specific application and evaluate the limitations based on cost, location, etc.
43. Design a solar panel system and calculate its annual electricity generation
44. Understand the concept of Balance of System
45. Analyze costs of the installation of a photovoltaic system
46. Discuss different incentive programs and the integration of distributed solar system in the electricity grid

Windpower

47. Describe the advantages and disadvantages of wind power from engineering, economical, environmental, and societal perspectives.
48. Describe the physical sources of wind on earth, explain effect of terrain.
49. Calculate the energy contained in the wind.
50. Draw the components of a wind turbine including specific dimensions and angles of the blade.
51. Compare and contrast different turbine designs.
52. Calculate the optimum speed and pitch of a blade.
53. Calculate the force (thrust), torque, and power.
54. Calculate wind speed as a function of height.
55. Calculate the capacity factor.
56. Discuss wind power markets for on-shore and off-shore locations
57. Design a wind power system to maximize power for a given scenario.

Geothermal

58. Describe the advantages and disadvantages of geothermal power from engineering, economical, environmental, and societal perspectives.

59. Describe the physical forces needed to create useable geothermal resources on earth.
60. List types of geothermal plants and their uses.
61. Calculate the performance of different geothermal power plant cycles
62. Describe geothermal heat pumps for buildings and calculate performance compared to traditional heating and cooling systems.

Biomass, Biogas and Biofuels

63. Describe the advantages and disadvantages of biomass and biofuels from engineering, economical, environmental, and societal perspectives.
64. List examples of biomass, biogas and biofuel processes.
65. Classify biomass processes into categories: thermochemical, biochemical, and agrochemical (extraction). Compare the different processes in each category.
66. Understand the physical, bio-chemical and chemical phenomena involved in the production of bio-fuels.
67. Assess the potential of biofuel production from different sources
68. Calculate the heat of reaction, fuel consumed, and CO_2 produced for different combustion reactions.

Fuel Cells

69. Describe the advantages and disadvantages of fuel cells from engineering, economical, environmental, and societal perspectives.
70. Define anode, cathode, and half cell reaction.
71. Describe different examples of fuel cells including the materials used to make them, the half cell reactions, fuel used, and by products created, and advantages and disadvantages of the system.

Electric Vehicles

72. Describe the advantages and disadvantages of electric vehicles from engineering, economical, environmental, and societal perspectives.
73. Understand losses in a gasoline and in an electric vehicle
74. Characterize battery operation
75. Understand impact of electric vehicle charging on utility systems
76. Discuss challenges and opportunities of deployment of electric vehicle

Tidal Energy

77. Describe the advantages and disadvantages of tidal power from engineering, economical, environmental, and societal perspectives.
78. Describe the physical processes that cause tides on earth.
79. Label the components of a tidal power facility.
80. Describe factors to measure and average the height of a tide.
81. Calculate the power generated from a tidal site.
82. Describe resonance and calculate the size on an estuary needed for resonance.
83. Design a tidal current system.
84. Design a tidal power system to maximize power for a given scenario.

Wave Power

85. Describe the advantages and disadvantages of wave power from engineering, economical, environmental, and societal perspectives.
86. Describe the physical forces that cause waves on earth.
87. Compare and contrast different wave energy conversion technologies.
88. Calculate the amplitude, height, period, frequency, velocity, and power of a wave.
89. Describe methods of measuring and averaging the wave height and power.
90. Calculate the energy and power of a wave front and group of waves.
91. Design a wave power system to maximize power for a given scenario.

Required Texts/Readings

The field of alternative energy is permanently changing; therefore the class does not follow a specific text book and is up-dated every year in function of new technologies, regulations and market conditions.

There is No required text book.

Here is a list of books that may be used by students to review or learn more about some concepts presented during the class:

Alternative Energy Sources by Efstathios E. Stathis Michaelides at Springer-Verlag Berlin Heidelberg in 2012, ISBN 978-3-642-20950-5

Photovoltaic Systems Engineering, Third Edition by Roger Messenger and Jerry Ventre at CRC Press in 2010, ISBN 1439802920

Wind Power Plants Fundamentals, Design, Construction and Operation by Robert Gasch and Jochen Twele at Springer-Verlag Berlin Heidelberg in 2012, ISBN 978-3-642-22937-4

Bioenergy Biomass to Biofuels by A Dahiya at Academic Press in 2014, ISBN 9780124079090

Fuel Cells From Fundamentals to Applications by S Srinivasan at Springer US in 2006, ISBN 978-0-387-25116-5

Electrochemical Power Sources: Batteries, Fuel Cells, and Supercapacitors by Vladimir S. Bagotsky, Alexander M. Skundin, Yurij M. Volfkovich at Wiley in 2015, ISBN: 978-1-118-46023-8

Electricity from Wave and Tide: An Introduction to Marine Energy by Paul A. Lynn, at Wiley in 2014, ISBN 978-1118340912

Course Requirements and Assignments (Required)

Students are required to complete:

- One homework for each class session: homework must be submitted by the start of class period.
- One Mid-term exam in class
- Two mini-projects (3-4 people groups)
- One Final Exam

You are invited to actively participate in class to discuss the concepts and the elements presented during the lecture. Homework is reviewed and discuss during the class. The best benefit is captured by students who come well prepared.

Grading Information

Course Element:	%
Homework	20%
Projects	20%
Midterm	30%
Final Exam	30%
Total	100%

Total Course Score	Letter Grade
>= 100	A+
90-99	A
85-89	A-
80-84	B+
70-79	B
65-69	B-
60-64	C+
50-59	C
45-49	C-
20-44	D
< 20	F

University Policies

Per University Policy S16-9, university-wide policy information relevant to all courses, such as academic integrity, accommodations, etc. will be available on Office of Graduate and Undergraduate Programs' Syllabus Information web page at http://www.sjsu.edu/gup/syllabusinfo/"

Course Schedule

Date	**Lecture**
1: 8/26	Introduction
2: 9/2	Introduction (2)
3: 9/9	Solar Resource, Solar Thermal
4: 9/16	Photovoltaics
5: 9/23	Photovoltaics
6: 9/30	Wind Power
7: 10/7	Wind Power
8: 10/14	Guest Speaker, Electric Vehicle
9: 10/21	Mid term review and preparation
10. 10/28	**Tu: Midterm** Biomass
11: 11/4	Biogas, Biofuel, Fuel Cells
12: 11/6	Geothermal Energy
13: 11/11	Holiday
14: 11/18	Tide Energy
15: 11/25	Holiday
16: 12/2	Wave Energy
17: 12/9	Review
18: 12/15	**Final Exam 7:15 – 9:30 AM**