Alternative Energy Science

Dr. Tali Zohar
3 weekly hours, 3 credits, undergraduate

Abstract
Modern society relies on stable, readily available energy supplies. Renewable energy is an increasingly important component of the new energy mix. The course covers history, utilization and storage for renewable technologies such as wind, solar, biomass, fuel cells and hybrid systems. The course also touches upon the environmental consequences of energy conversion and how renewable energy can reduce air pollution and global climate change.

Course Objectives and goals
I. Understand the utilization and storage for renewable technologies such as wind, solar, biomass, fuel cells and hybrid systems and for more conventional fossil fuel-based technologies.
II. Understand the environmental consequences of energy conversion and how renewable energy can reduce air pollution and global climate change.
III. Understand and evaluate the regional environmental problems and the role of the renewable energy in solving and minimizing these problems.

Course structure
This course will focus on new developments in renewable energy technologies. There will be 12 course sessions of 3 hours each. The program is based on lectures, site visits, homework, exams and discussion periods.

Grading
The final grade will be based on Attendance & Punctuality **(15%)** of the grade, quizzes (**15%**), midterm exam (**20%**) final exam (**30%**) and a term project (**20%**).

#	Lecture	Explanation	Readings
1	**World Energy and world related green gas emissions**	This lecture will cover the forms of pollution and the share of energy sources and uses on this pollution in the world and the region. Also the environmental impacts of the conventional and renewable sources will be discussed.	Readings International energy Agency, World Energy Outlook 2018 (To read the executive summary) https://webstore.iea.org/download/summary/190?fileName=English-WEO-2018-ES.pdf
2	**Solar Thermal Energy**	This lecture reviews the technologies and applications of solar thermal energy, power production and heating applications. Solar heating and cooling, both domestic and industrial.	Boyle, G., Renewable Energy: Power for Sustainable Future, Oxford University Press Inc. New York, 2004. Chapter 2. Shinnar, R., Francesco Citro f. 2007. Solar thermal energy: The forgotten energy source. Technology in Society, 29 (3). pp. 261-270.
3	**Solar energy and Photovoltaics**	This lecture will discuss the need of solar energy in the world and the region. Also will examines the basics of converting sunlight into electricity; the behavior of solar cells; cell properties; system components; applications; grid connection; and applications. Experimental work will be carried out at experimental park at the Arava Institute.	Infield D. 2008. Solar energy: Photovoltaics. Future Energy, pp 225-238 *Tester, J. W., E. M. Drake, M. W. Golay, M. J. Driscoll, and W. A. Peters.* Sustainable Energy: Choosing Among Options. Cambridge, MA: MIT Press, 2005. Chapter 13. Nadarajah Kannan, Divagar Vakeesan. Solar energy for future world: - A review. Renewable and Sustainable Energy Reviews, Volume 62, September 2016, Pages 1092-1105
4	**Agricultural Biomass and Bioenergy**	This lecture will review the use of agricultural crops, animal wastes and agricultural wastes in the production of alternative fuels. Energy plants: examples of uses: Sugar cane, Jatrofa, Sugar beet, sweet sorghum	Tester, J. W., E. M. Drake, M. W. Golay, M. J. Driscoll, and W. A. Peters. Sustainable Energy: Choosing Among Options. Cambridge, MA: MIT Press, 2005. Chapter 10. Paiano, A. and Giovanni Lagioia, G. 2016. Energy potential from residual biomass towards meeting the EU renewable energy and

		and various grasses, Alga: examples of uses: biodiesel from power plants and cement factories, biomass fermentation. Different bioreactors. Biodiesel: procession and final product. Advantages and weaknesses. Ethanol/methane: procession and final product. Advantages and weaknesses. Whole biomass: procession and final product. Economic considerations.	climate targets. The Italian case. Energy Policy, 91 pp.161-173.
5	**Field trip Southern Arava**	Solar energy installations and energy storage sites	
6	**Wind Energy**	This lecture will outline the principles of wind turbine and; will review the process of electricity generation and supply to the grid (wind farms).	Readings: Tester, J. W., E. M. Drake, M. W. Golay, M. J. Driscoll, and W. A. Peters. Sustainable Energy: Choosing Among Options. Cambridge, MA: MIT Press, 2005. Chapter 15. Philippe, S. and Moe, B.G. 2009. Status plans and technologies for offshore wind turbines in Europe and North America. Renewable Energy, 34(3) pp. 646-654
7	**Global Energy Transition** **Guest Lecture: Jozsef Kader**	Status of the energy transition, what does the energy transition mean in different continents/countries? Israeli energy transition will be discussed	

8	**Energy storage, Fuel cells, hydrogen and Geothermal**	This lecture will cover the energy storage technologies, the production and storage methods of hydrogen and the principles and applications of the fuel cells. Also this lecture will cover the uses of geothermal energy and the geothermal power plants.	Tester, J. W., E. M. Drake, M. W. Golay, M. J. Driscoll, and W. A. Peters. Sustainable Energy: Choosing Among Options. Cambridge, MA: MIT Press, 2005. Chapter 16. Paul Grad P., 2006. Storing solar energy: Solar technologies for a future Hydrogen economy. Refocus, 7(5). pp32-36 Tester, J. W., E. M. Drake, M. W. Golay, M. J. Driscoll, and W. A. Peters. Sustainable Energy: Choosing Among Options. Cambridge, MA: MIT Press, 2005. Chapter 11. Pruess, K. 2006. Enhanced geothermal systems (EGS) using CO2 as working fluid- A novel approach for generating renewable energy with simultaneous sequestration of carbon. Geothermics, 35(4). pp 351-367
9	**Renewable energy and off Grid Technologies**	Hands on session in the research park	
10	**The future of the electricity market**	How will future energy system will look like? What is a micro-grid? What kind of changes in consumption patterns we are expecting? This lecture will review the ways to integrate RE in the electricity grid, prosumerism, the integration of electric transportation and consider questions of energy justice	Mwasilu, Francis, et al. "Electric vehicles and smart grid interaction: A review on vehicle to grid and renewable energy sources integration." Renewable and sustainable energy reviews 34 (2014): 501-516. McCauley, D., Ramasar, V., Heffron, R. J., Sovacool, B. K., Mebratu, D., & Mundaca, L. (2019). Energy justice in the transition to low carbon energy systems: Exploring key themes in interdisciplinary research. Applied Energy, 233, 916-921. Parag, Y., & Sovacool, B. K. (2016). Electricity market design for the prosumer era. Nature energy, 1(4), 1-6.

			Mengelkamp, E., Gärttner, J., Rock, K., Kessler, S., Orsini, L., & Weinhardt, C. (2018). Designing microgrid energy markets: A case study: The Brooklyn Microgrid. Applied Energy, 210, 870-880.
11	**Review session & Students Project Presentation**	This lecture will review all topics learned in the class	
12	**Final exam**		

Recommended readings

1. International Energy Agency. Worldwide Trends in Energy Use and Efficiency- *Key Insights from IEA Indicator Analysis* 2008.
2. Twiddel J. and Weir, T., 2006, Renewable Energy Resources. Francis & Tylor, NY, USA, Chap. 1.
3. Campbell, K.M. and Price, J., 2008, The Global Politics of Energy. THE Aspen Institute, Washington DC, USA. Chap.1 and 6.

Other recommended readings will be provided during the course