Sustainable energy for the 21st century: challenges and opportunities

Instructor: Dr. Yael Parag

Academic year: 2019/20
Semester: Summer.
Course No: 0920.6465.01
Credit hours: 2
Course will take place: Tuesdays 9:15-12:30, Wednesdays 9:15-12:30 and Thursdays 12:15-15:30. Porter, Room 105
Email: yael.parag@gmail.com
Course website: Moodle (all required readings will be available on Moodle)

General course objectives:
Humans' ability to generate energy on a large-scale from fossil fuels enabled the industrial revolution, and therefore marks the beginning of the Modern era. Today, in the developed world (and increasingly in emerging economies) energy in its different forms is used for nearly everything: from heating and cooling to manufacturing, trading, cooking, commuting, communicating and more. In other words – we have become an energy dependent society.
At the same time, about 70% of the anthropogenic greenhouse gases (GHG) are emitted by our energy system, making it the greatest man-made contributor to climate change. Hence, mitigating climate change and becoming a sustainable low carbon society imply some socio-techno-economic fundamental changes to our energy systems. These changes include a sharp increase in the deployment and use of low carbon and renewable energy sources; a much greater efficiency of energy production and consumption; the development of new energy storage technologies; as well as the development of innovative demand side management programs.
The course will introduce the students to the fundamentals of the 21st century energy world and the challenges it faces.
The following topics will be covered: technologies of energy production and consumption; conventional and non-conventional fossil fuels (oil, coal, gas, gas shales, oil shales and tar sands); nuclear energy (fission and fusion); renewable sources (biomass, geothermal, hydro, ocean, solar and wind); energy storage technologies (heat, batteries, fuels cells, flywheels and pumped storage); the electricity grid (smart grid and microgrids); energy efficiency; demand side management.
The course will provide matrixes for evaluating the sustainability as well as the feasibility of each fuel, energy source and technology.
Total of 26 academic hours.

The Department of Environmental Studies
Porter School of the Environment and Earth Sciences

The Raymond and Beverly Sackler Faculty of Exact Sciences
Tel Aviv University

הפקולטה למדעים מדויקים
ע״ש ריימונד ובברלי סאקלר
אוניברסיטת תל אביב

החוג ללימודי הסביבה
בית הספר לסביבה ולמדעי כדור הארץ על שם פורטר

Course outline*

Class	Main topics	Lesson covers	Terminology
21/7 9:15- 12:30	What is energy? What is sustainable energy?	Matrixes for evaluation the sustainability of fuels and energy sources: GHG emission and climate change; Kaya identity; energy-water-food nexus; Health, growth and jobs	Energy units; Units of power and work; Primary energy; Forms of energy; Laws of thermodynamics Reading: Heinberg, R., & Fridley, D. (2016) Mackay (2009) Boyle et al (2012) UNEP (2016)
22/7 9:15- 12:30	Fossil fuels Unconventional fossil fuels Carbon capture and storage	Coal, gas and oil Gas shale, oil shale, tar sands Fracking	Energy carriers; Energy density; Electricity generation in thermal power plants (single and combined cycle). Reading: Boyle et al (2012) IEA report EIA report
23/7 12:15- 15:30	Nuclear energy Geothermal energy Hydropower	Nuclear Fission and fusion; Geothermal sources Hydroelectric dams; Flow of the river; Pumps storage.	Radiation; Nuclear waste. Reading: Johansson et al (2012) IRENA – renewable status report 2016
28/7 9:15- 12:30	Biomass Ocean energy	Traditional and modern biomass; Biofuels and energy crops; 1st and 2nd generation of energy crops. Tide, waves, OTEC, Salinity.	Direct and indirect land-use change; Intermittent energy sources. Reading: Elliott (2013) IRENA reports

29/7 9:15- 12:30	Wind Solar Energy storage	Wind turbine Solar thermal, Solar PV Pump storage (air and water), heat, batteries, fuel cells, flywheels. Electric vehicle	The electricity grid; Capacity factor. Reading: Elliott (2013) Mackay (2009) IRENA reports
30/7	**No class- Tisha B'Av**		
4/8 9:15- 12:30	Energy efficiency Demand side management Macrogrid vs. Microgrid	Negawatts Demand side management	Distributed Energy Resources (DER) Smart grid Energy markets Reading: Narayan, Ko and Underdahl (2016) Fereidoon P. and Sioshansi (eds) (2017)
5/8 11:15- 12:45	The future of the energy markets: Prosumers Virtual power plants (VPP)	Virtual power plant Alternative models for electricity markets	Prosumers; peer-to-peer; VPP Reading: Fereidoon P. and Sioshansi (eds) (2017) Parag and Sovacool (2016) Rocky Mountain Institute report

*Lectures listed by date are subject to change throughout the semester

Final exam: August 9, 2020, between 9:00-11:00

Reading:

Elliott, David (2013) Renewables: A review of sustainable energy supply options. IOP Publishing, Bristol, UK.

Everett et al. (eds)(2012) Energy systems and sustainability : power for a sustainable future. 2nd edition. Open University.

Fereidoon P. and Sioshansi (eds) (2017) Innovation and Disruption at the Grid's Edge, Academic Press.

Heinberg, R., & Fridley, D. (2016). Our Renewable Future: Laying the Path for One Hundred Percent Clean Energy. Washington, DC: Island Press

Johansson et al. (eds.) (2012) Global Energy Assessment (GEA). International Institute for Applied Systems Analysis.

MacKay, David JC (2009) Sustainable Energy – Without the Hot Air. Can be downloaded for free from http://www.withouthotair.com/

Narayan, Ko and Underdahl (2016) Flexibility at the Grid Edge (for dummies). AutoGrid Special Edition. John Wiley & Sons, Inc.

Parag, Yael, and Benjamin K. Sovacool (2016) "Electricity market design for the prosumer era." *Nature Energy* 1: 16032.

UNEP (2016) Green Energy Choices: The benefits, risks, and trade-offs of low-carbon technologies for electricity production. Report of the International Resource Panel. E.G.Hertwich, J. Aloisi de Larderel, A. Arvesen, P. Bayer, J. Bergesen, E. Bouman, T. Gibon, G. Heath, C. Peña, P. Purohit, A. Ramirez, S. Suh.

Additional reports and data sources:

- The International Renewable Energy Agency (IRENA) (http://www.irena.org/)
- International Energy Agency (IEA) (http://www.iea.org/)
- US Energy Information Administration (EIA) (https://www.eia.gov/)
- Rocky Mountain Institute (http://www.rmi.org/)
- Switch energy project (http://www.switchenergyproject.com/)
- Energy 101 (https://energy.gov/eere/education/energy-101)

Course policies

Attendance: All lectures
Grading: 10% for active participation in class
Final exam: 90%

Plagiarism Policy

The strength of the university depends on academic and personal integrity. In this course, you must be honest and truthful. Plagiarism is the use of someone else's work, words, or ideas as if they were your own. Here are three reasons not to do it:

1. By far the deepest consequence to plagiarizing is the detriment to your intellectual and moral development: you won't learn anything, and your ethics will be corrupted.
2. Giving credit where it's due but adding your own reflection will get you higher grades than putting your name on someone else's work. In an academic context, it counts more to show your ideas in conversation than to try to present them as sui generis.
3. Finally, Tel Aviv University punishes academic dishonesty severely. The most common penalty is suspension from the university, but students caught plagiarizing are also subject to lowered or failing grades as well as the possibility of expulsion.