ESM 288: Energy, Technology, and the Environment

Syllabus, Fall 2021

Logistics:

Time & Location:	Tuesdays & Thursdays, 3:30-4:45pm, BH 1424
	No class on 11/11 (Veterans Day) and 11/25 (Thanksgiving)
Assignments:	There are 4 assignments
Exams:	There are 2 exams:
	Midterm: Monday, 11/1 (remote access via GauchoSpace)
	Final: Monday, 12/6 (remote access via GauchoSpace)
Instructor:	Roland Geyer, BH3426, extension 7234, rgeyer@ucsb.edu
Office hours:	By appointment

Book suggestions:

- Energy: Its Use and the Environment, R. A. Hinrichs & M. Kleinbach, Fifth Edition, Brooks/Cole, Boston, MA,2013.
- Technical: Energy Science – Principles, Technologies, and Impacts, J. Andrews & N. Jelley, Third Edition, Oxford University Press, 2017.
- Energy and Fuels in Society, L. R. Radovic (available at http://www.ems.psu.edu/~radovic/matsc101.html).
- Sustainable Energy – Without the Hot Air, David J. C. MacKay, UIT Cambridge, 2008 (available at http://www.withouthotair.com/).

Each of these books has its strengths and weaknesses. Hinrichs & Kleinbach comes closest to my ideal textbook. Andrews & Jelley contains more energy physics than all the other books, some of which is too advanced for most MESM students. Radovic is free and has several nice introduction chapters. It's pretty old, though, so some material is dated by now. MacKay is also free, but a bit too opinionated and idiosyncratic, IMHO. Since there is no perfect energy book out there, I mix and match the course reading and post it as pdfs on GauchoSpace. **This means that there is no need for you to have of any of the books above to take this course.**

Grading:

- Participation, online or offline, includes mini-assignments (10%)
- Assignments (4 x 15%)
- Midterm exam (15%)
- Final exam (15%)

How to get the most out of this course:

Before the lecture:	Read the assigned reading material.
During the lecture:	Never hesitate to ask question if something is unclear.
After the lecture:	Review the slides. Ask if something is unclear.
Assignments:	Start them as soon as they are posted.
	Reach out to me immediately when you get stuck.
Exams:	Review the slides. Ask if something is unclear.

Date	Topics & Readings
Session 1: Introduction to Energy	
9/23	Topics: • Definitions of energy, work, and power • Units and unit conversions • Energy forms, sources & uses • 1st and 2nd law of thermodynamics No reading for Session 1
Session 2: Energy Forms I	
9/28	Topics: • Mechanical energy • Chemical energy Reading: • Chapter 2 (Energy Mechanics) from "Energy: Its Use and the Environment", Hinrichs & Kleinbach, 2013, Fifth Edition, Brooks/Cole, Boston
Session 3: Energy Forms II	
9/30	Topics: • Electromagnetic energy • Nuclear energy ***Hand out 1st assignment*** Reading: • Chapter 2: Concept of Energy pp.7-25 in L R Radovic, Energy and Fuels in Society
Session 4:	
10/5	Topics: • Temperature and heat, • Heat transfer • Ideal gas equation • Thermodynamic processes Reading: • Review slides from Session 1, 2, and 3
Session 5: Conversion Technologies & Their Efficiencies	
10/7	Topics: • Thermodynamic cycles • Heat engines, heat movers • Overview of conversion technologies ***Hand in 1st assignment*** Reading: • Chapter 4: Efficiency of Energy Conversion pp.53-76 in L R Radovic, Energy and Fuels in Society

Session 6: Energy System Efficiencies	
10/12	Topics: • Electricity production • Heating • Transportation Reading: • Chapter 21: Smarter Heating pp. 140-154 in Sustainable Energy - without the hot air, David JC MacKay, UIT, Cambridge, UK, 2009
Session 7: Transportation Energy Use	
10/14	Topics: • Transportation energy demand by mode • Automotive energy demand by force • Power train efficiency • Modeling vehicle energy demand ***Hand out 2nd assignment*** Reading: • Chapter 20: Better Transport pp. 118-139 in Sustainable Energy - without the hot air, David JC MacKay, UIT, Cambridge, UK, 2009
Session 8: Renewable Energy - Solar	
10/19	Topics: • Solar radiation • Concentrating solar power • Photovoltaics Reading: • Chapter 17: Solar Energy pp.313-333 in L R Radovic, Energy and Fuels in Society
Session 9: Biomass I & Sun-to-Wheels	
10/21	Topics: • Photosynthesis • Bioethanol, biodiesel, bioelectricity ***Hand in 2nd assignment*** Reading: • Chapter 6: Solar pp.38-49, Chapter D: Solar II pp.283-288 in Sustainable Energy - without the hot air, David JC MacKay, 2009 • Geyer, Stoms, Kallaos (2013), Spatially-Explicit LCA of Sun-to-Wheels Transportation Pathways in the U.S., EST, 47(2), 1170-1176
Session 10: Renewable Energy - Wind	
10/26	Topics: • Wind profiles • Wind turbines Reading: • Chapter 4: Wind pp.32-34, Chapter 10: Offshore wind pp.60-67, Chapter B: Wind II pp.263-268 in Sustainable Energy - without the hot air, David JC MacKay, UIT, Cambridge, UK, 2009

Session 11: Renewable Energy - Water	
10/28	Topics: • Hydropower • Wave power • Tidal energy ***Hand out 3rd assignment*** Reading: • Chapter 12: Wave pp.73-75, Chapter 14: Tide pp.81-87 in Sustainable Energy - without the hot air, David JC MacKay, 2009
Session 12: Nuclear Energy and Biomass II	
11/2	Topics: • Nuclear energy • Bioenergy, biomass Reading: • Chapter 2 (Nuclear Power: Fission) from "Energy: Its Use and the Environment", Hinrichs & Kleinbach, 2013, Fifth Edition, Brooks/Cole, Boston
Session 13: Intermittency, Storage, Hydrogen	
11/4	Topics: • Intermittency of renewable electricity and the smart grid • Batteries and other energy storage technologies • Hydrogen and fuel cells ***Hand in 3rd assignment*** Reading: • Chapter 10 (Electricity and Energy Storage) from "Energy Science – Principles, Technologies, and Impacts", Andrews & Jelley, 2017, Third Edition, Oxford University Press
Session 14: Fossil Energy	
11/9	Topics: • Coal, crude oil & natural gas Reading: • BP Statistical Review of World Energy, 2021, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html
Session 15: Environmental Impacts I	
11/16	Topics: • Climate change • Criteria air pollutants Reading: • Chapter 11: Fossil Fuels: Environmental Effects pp.191-218 in L R Radovic, Energy and Fuels in Society

Session 16: Environmental Impacts II	
11/18	Topics: • Land use • Electricity production ***Hand out 4th assignment*** Reading: • Fthenakis & Kim, Land use and electricity generation: A life-cycle analysis, Renewable & Sustainable Energy Rev. 13 (2009) 1465–1474
Session 17: Global and U.S. Energy Consumption	
11/23	Topics: • Energy use per country, per capita and per GDP • Energy use per source, per end use • I=PAT • The rebound effect Reading: • BP Statistical Review of World Energy, 2021, https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html • Sorrell, Dimitropoulos & Sommerville, Empirical estimates of the direct rebound effect: A review, Energy Policy 37(2009) 1356-1371
Session 18: The Cost of Energy	
11/30	Topics: • Cost of energy • Levelized cost of electricity ***Hand in 4th assignment*** Reading: • Lazard's Levelized Cost of Energy Analysis, Version 14.0 https://www.lazard.com/media/451419/lazards-levelized-cost-of-energy-version-140.pdf
Session 19: Renewable Energy Pathways	
12/2	Topics: • Renewable energy pathways • Renewable energy scenarios • Course review Reading: • Jacobson & Delucchi, A Path to Sustainable Energy by 2030, Scientific American, pp. 58-65, November 2009