ESM 288: Energy, Technology, and the Environment

Syllabus, Fall 2024

Logistics:

Time & Location:	Mondays & Wednesdays, 3:30-4:45pm, BH 1424
In-Person Classes:	There are 19 lectures.
Attendance Policy:	Up to two allowable absences for medical or professional reasons. Additional absences will lead to a reduced grade.
Assignments:	There are 4 assignments.
Exams:	Midterm: TBD (open book) Final: TBD (open book)
Instructor:	Roland Geyer, BH 3426, rgeyer@ucsb.edu
TA:	Wen-Tien Wang, BH 3001, wentien@bren.ucsb.edu

Books on Energy:

- 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, much 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 (10%)
- Assignments (4 x 15%)
- Midterm exam (15%)
- Final exam (15%)

How to get the most out of this course and get a good grade:

Before the lecture:	Read the assigned reading material.
During the lecture:	Never hesitate to ask questions 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 us immediately when you get stuck.
Exams:	Review the slides. Ask if something is unclear.

Date	Topics & Readings
Session 1: Introduction to Energy	
Mon, 9/30	Topics: • Physical quantities • Units, unit conversions, rounding • Definitions of energy, work, and power No reading for Session 1
Session 2: Energy Forms I	
Wed, 10/2	Topics: • Sources, end uses, and forms of energy • Relevant physical laws • Mechanical energy Start 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	
Mon, 10/7	Topics: • Using formulas • Chemical energy • Nuclear energy Finish reading: • Chapter 2 (Energy Mechanics) from "Energy: Its Use and the Environment", Hinrichs & Kleinbach, 2013, Fifth Edition, Brooks/Cole, Boston
Session 4: Energy Forms III	
Wed, 10/9	Topics: • Nuclear energy, continued • Electricity • Electromagnetic radiation ***Hand out 1st assignment*** Reading: • Chapter 2: Concept of Energy pp.7-25 in L R Radovic, Energy and Fuels in Society
Session 5: Energy Forms IV	
Mon, 10/14	Topics: • Temperature and heat • Specific heat capacity • Heat transfer Reading: • Review slides from Session 1, 2, 3, and 4

Date	Topics & Readings
Session 6: Heat engines, heat movers, other conversion technologies	
Wed, 10/16	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 7: Energy conversion efficiencies	
Mon, 10/21	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 8: Transportation Energy Use	
Wed, 10/23	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 9: Renewable Energy - Solar	
Mon, 10/28	Topics: • Solar radiation • Concentrating solar power • Photovoltaics Reading: • Chapter 17: Solar Energy pp.313-333 in L R Radovic, Energy and Fuels in Society

Date	Topics & Readings
Session 10: Biomass & Sun-to-Wheels	
Wed, 10/30	Topics: • Photosynthesis • Bioenergy, biofuels ***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 11: Renewable Energy - Wind	
Mon, 11/4	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 12: Renewable Energy – Water, Nuclear Energy	
Wed, 11/6	Topics: • Hydropower • Wave power • Tidal energy • Nuclear 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 • Chapter 14 (Nuclear Power: Fission) from "Energy: Its Use and the Environment", Hinrichs & Kleinbach, 2013, Fifth Edition, Brooks/Cole, Boston

Date	Topics & Readings
Session 13: Intermittency, Storage, Hydrogen	
Wed, 11/13	Topics: • Intermittency of renewable electricity and the smart grid • Batteries and other energy storage technologies • Hydrogen and fuel cells 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	
Mon, 11/18	Topics: • Coal, crude oil & natural gas ***Hand in 3rd assignment*** Reading: • 2024 Statistical Review of World Energy, https://www.energyinst.org/statistical-review
Session 15: Environmental Impacts I	
Wed, 11/20	Topics: • Climate change • Criteria air pollutants ***Hand out 4th assignment*** Reading: • Chapter 11: Fossil Fuels: Environmental Effects pp.191-218 in L R Radovic, Energy and Fuels in Society
Session 16: Environmental Impacts II	
Mon, 11/25	Topics: • Land use • Electricity production 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	
Wed, 11/27	Topics: • Energy use per country, per capita and per GDP • Energy use per source, per end use • I=PAT • The rebound effect ***Hand in 4th assignment*** Reading: • 2024 Statistical Review of World Energy, https://www.energyinst.org/statistical-review • Sorrell, Dimitropoulos & Sommerville, Empirical estimates of the direct rebound effect: A review, Energy Policy 37(2009) 1356-1371
Session 18: Energy economics	
Mon, 12/2	Topics: • Cost of energy • Levelized cost of electricity Reading: • Lazard's Levelized Cost of Energy Analysis, Version 17.0 Lazard's Levelized Cost of Storage Analysis, Version 9.0 Lazard's Levelized Cost of Hyrdogen Analysis, Version 4.0 https://www.lazard.com/research-insights/levelized-cost-of-energyplus/
Session 19: Renewable Energy Pathways	
Wed, 12/4	Topics: • Renewable energy scenarios • Pathways to phasing out fossil fuels • Course review Reading: • Jacobson & Delucchi, A Path to Sustainable Energy by 2030, Scientific American, pp. 58-65, November 2009