FFR170 Sustainable Energy Futures 2019
Course schedule and reading assignments

1 Course schedule

Date	Lecture	Content	Instructor
Week 36			
Tue 03-Sep	1. Global energy perspectives	Course introduction, challenges for the global energy system	Sonia Yeh
Thu 05-Sep	2. Climate crash course with the CCC model	Climate sensitivity, implications for future emission reductions	Niclas Mattson
Fri 06-Sep	3. Energy efficiency	End-use efficiency, price elasticity of demand, the energy efficiency gap, rebound effects	Jonas Nässén
Week 37			
Tue 10-Sep	4. Fossil fuels I	Fossil fuel resources and markets	Sonia Yeh, David Daniels
Thu 12-Sep	5. Methods and tools I: Energy systems analysis	Systems thinking, allocating emissions, marginal vs average electricity and net energy analysis	Niclas Mattson
Thu 12-Sep	*Calculations 1*	*Global CO2 emission budget, marginal electricity and emission allocation*	*TAs*
Fri 13-Sep	6. Methods and tools II: Energy economics	Investment analysis, costs and prices, external costs, marginal cost, discounting	Fredrik Hedenus
Week 38			
Tue 17-Sep	7. Fossil fuels II	Carbon capture and storage: CO2 capture technologies	Magnus Rydén
Thu 19-Sep	8. Nuclear power I	Nuclear physics, neutron economy, moderators, light water reactor design and safety	Anders Nordlund
Thu 19-Sep	*Calculations 2*	*Energy efficiency*	*TAs*
Fri 20-Sep	9. Nuclear power II	Nuclear fuel cycles, waste management, fast breeders, link to nuclear weapons, nuclear power in the global energy system	Mariliis Lehtveer
Week 39			
Tue 24-Sep	10. Renewables I	Solar energy and intermittency	Niclas Mattson
Tue 24-Sep	*Debate 1.*	*Can we achieve the "below 2-degree target" without negative emissions?*	*TAs*

Date	Lecture	Content	Instructor
Thu 26-Sep	11. Renewables II	Wind power, hydro power and grid integration of intermittent renewables	Lisa Göransson
Thu 26-Sep	*Calculations 3*	*Nuclear power*	*TAs*
Fri 27-Sep	12. Renewables III	Biomass & bioenergy	Sonia Yeh
Week 40			
Tue 01-Oct	13. Grid integration	Energy storage, demand side management, and grid management	Mikael Odenberger
Tue 01-Oct	*Debate 2.*	*Can the world rely upon 100% renewable electricity without nuclear?*	*TAs*
Thu 03-Oct	14. Transportation I	Transport energy use in a global perspective	Sonia Yeh, David Blekhman
Thu 03-Oct	*Calculations 4*	*Renewable energy*	*TAs*
Fri 04-Oct	15. Transportation II	Three revolutions in the transport space	Sonia Yeh
Week 41			
Tue 08-Oct	16. Energy storage	Batteries, fuel cells & hydrogen	Bengt-Erik Mellander
Tue 08-Oct	*Debate 3.*	*The future of rail is hydrogen*	*TAs*
Thu 10-Oct	17. Climate policy	Carbon taxes, direct support vs technology neutral policies, other instruments	Sonia Yeh
Thu 10-Oct	*Calculations 5*	*Bioenergy*	*TAs*
Week 42			
Tue 15-Oct	18. Energy access I	Electric power grids and renewable electricity production: limitations and opportunities	Elas Hartvigsson
Tue 15-Oct	*Debate 4.*	*Should Preem be allowed to expand their refinery plant?*	*TAs*
Thu 17-Oct	19. Energy access II	Rural electrification in developing countries: are we on the right track?	Elas Hartvigsson
Thu 17-Oct	*Calculations 6*	*Energy system scenarios and economics*	*TAs*
Fri 18-Oct	20. International outlook	Energy in China and Japan	Tomas Kåberger
Week 43			
Tue 22-Oct	21. (optional)	Concluding perspectives, evaluation & preparation for the exam	

Lecturers

David Blekhman, California State University Los Angeles
David Daniels, U.S. Energy Information Administration
Lisa Göransson, Energy technology, Chalmers
Elias Hartvigsson, Energy Technology, Chalmers
Fredrik Hedenus, Physical Resource Theory, Chalmers
Tomas Kåberger, Physical Resource Theory, Chalmers
Niclas Mattsson, Physical Resource Theory, Chalmers
Bengt-Erik Mellander, Solid state physics, Chalmers
Anders Nordlund, Nuclear Engineering, Chalmers
Jonas Nässén, Physical Resource Theory, Chalmers
Mariliis Lehtveer, Energy Technology, Chalmers
Mikael Odenberger, Energy technology, Chalmers
Magnus Rydén, Energy technology, Chalmers
Sonia Yeh, Physical Resource Theory, Chalmers

Time and Place

Lectures: 13:15 – 15:00 HC4
Calculations: 15:15 – 17:00 FL 62, 63, 72, 73
Debates: 15:15 – 17:00 FL 62, 63, 72, 73
Exam: Time and location TBD

2 Reading assignments

1. Global energy perspectives — Course introduction, challenges for the global energy system (03/09)

   Grubler, et al. (2012) Chapter 1 - Energy Primer. In Global Energy Assessment - Toward a Sustainable Future.

   - Ch 1.1 – 1.3,
   - Appendix B Conversion Tables

   Azar Ch 1 – 5

2. Climate crash course with the CCC model — Climate sensitivity, implications for future emission reductions (05/09)

Q. Schiermeier et al. (2008) Electricity without carbon.
Azar Ch 1 – 5

3. Energy efficiency — End-use efficiency, price elasticity of demand, the energy efficiency gap, rebound effects (06/09)

Grubler, et al. (2012) Ch 1.4 – Energy efficiency and intensity. In Global Energy Assessment - Toward a Sustainable Future.
Jaffe and Stavins (1994) The energy-efficiency gap. What does it mean?

4. Fossil fuels I — Fossil fuel resources and markets (10/09)
These references give you the flavor of the key controversies surrounding fossil fuels. Pick any of the two references that you'd like to read further.

Farrell and Brandt (2006) Risks of the oil transition.

Masnadi, M. S., et al. (2018). "Global carbon intensity of crude oil production." Science 361(6405): 851-853.

5. Methods and tools I: Energy systems analysis — Systems thinking, allocating emissions, marginal vs average electricity and net energy analysis (12/09)

C. Azar (modified in 2017). Thinking about energy systems.
C. Azar (2015) System consequences of variable renewable electricity sources.
"How solar growth will wreck the economics of existing power markets"

6. Methods and tools II: Energy economics — Investment analysis, costs and prices, external costs, marginal cost, discounting (13/09)

McAfee – Introduction to Economic Analysis.

7. Fossil fuels II — Carbon capture and storage: CO2 capture technologies (17/09)

Benson, S. M., K. Bennaceur, P. Cook, J. Davison, H. de Coninck, K. Farhat, A. Ramirez, D. Simbeck, T. Surles, P. Verma and I. Wright, 2012: Chapter 13 - Carbon Capture and Storage. In Global Energy Assessment - Toward a Sustainable Future, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria, pp. 993-1068.

8. Nuclear power I — Nuclear physics, neutron economy, moderators, light water reactor design and safety (19/09)

9. Nuclear power II — Nuclear fuel cycles, waste management, fast breeders, link to nuclear weapons, nuclear power in the global energy system (20/09)

E.L. McFarland et al. (1994) Energy from the nucleus – fission. W.C. Sailor et al. (2000) A nuclear solution to climate change. Azar Ch. 10

10. Renewables I —Solar energy and intermittency (24/09)

11. Renewables II — Wind power, hydro power and grid integration of intermittent renewables (26/09)

Rogner et al (2012) Energy Resources and Potentials Ch 7.8-7.11. In Global Energy Assessment - Toward a Sustainable Future. Götz et al. (2014) Negative Electricity Prices: : Causes and Effects. An analysis of recent developments and a suggestion for a flexibility law. Joskow, P.L. (2011), "Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies," American Economic Review: Papers and Proceedings 2011, 100:3 (2011), 238-241. Azar Ch. 10

12. Renewables III — Biomass & bioenergy (27/09)

Azar (2011) Biomass for energy: a dream come true. . . or a nightmare? Azar Ch. 9

13. Grid integration — Energy storage, demand side management, and grid management (01/10)

Azar Ch. 8, 11-13 Ueckerdt, F., et al. (2013). "System LCOE: What are the costs of variable renewables?" Energy 63: 61-75.

14. Energy for transportation I — Transport energy use in a global perspective (03/10)

Schäfer, A. W. (2015) "Long-term trends in domestic US passenger travel: the past 110 years and the next 90." Transportation, 1-18, doi:10.1007/s11116-015-9638-6.

15. Energy for transportation II — Three revolutions in the transport space (04/10)

Creutzig, F. et al. Transport: A roadblock to climate change mitigation? Science 350, 911-912, doi:10.1126/science.aac8033 (2015).

Chum, H.et al., 2011: Bioenergy. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Azar Ch. 7

16. Energy storage — batteries, fuel cells and hydrogen (08/10)

Pellow, M. A., et al. (2015). "Hydrogen or batteries for grid storage? A net energy analysis." Energy & Environmental Science 8(7): 1938-1952.
Azar Ch. 8, 11-13.

17. Policies for climate & technological change — Carbon taxes vs cap & trade schemes, direct support vs technology neutral policies, other instruments (10/10)

Barrett, Scott, P Bohm, B Fisher, M Kuroda, J Mubazi, A Shah, and Robert N Stavins. "Policy Instruments to Combat Climate Change." In Climate Change 1995: Economic and Social Dimensions of Climate Change, Intergovernmental Panel on Climate Change, Second Assessment Report, Working Group III, Chapter 11. Cambridge, England: Cambridge University Press, 1996.

Azar Ch. 8, 11-13.

18. Energy access I — Electric power grids and renewable electricity production: limitations and opportunities (15/10)

Renewable Energy Boom Is Pushing The Grid To Its Limits, Prompting Operators To Reinvent Themselves (weblink) by Jean-Marc Ollagnier, Forbes, Jan 14, 2019

19. Energy access II — Rural electrification in developing countries: are we on the right track? (17/10)

Detchon and Leeuwen (2014) "Policy: Bring sustainable energy to the developing world." Nature 508(7496):309-11.
Aklin, M., C.-y. Cheng, J. Urpelainen, K. Ganesan and A. Jain (2016). "Factors affecting household satisfaction with electricity supply in rural India." Nature Energy 1: 16170.

20. International outlook — Energy in China and Japan (18/10)

Victor et al. (2017) Prove Paris was more than paper promises.