جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Energy and the Environment - ERPE 200

Division	Physical Science and Engineering Division
Course Number	ERPE 200
Course Title	Energy and the Environment
Academic Semester	Fall
Academic Year	2019/2020
Semester Start Date	08/25/2019
Semester End Date	12/10/2019
Class Schedule (Days & Time)	10:30 AM - 12:00 PM | Wed , 02:30 PM - 04:00 PM | Sun Thu

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Tadeusz Wiktor Patzek	tadeusz.patzek@kaust.edu.sa	+966128087242	3220, 5, Al-Kindi (bldg. 5)	10:30 AM - 12 PM Wednesdays, we will have recitation sessions/overflow lectures as needed

Teaching Assistant(s)

Name	Email
Natalia Odnoletkova	natalia.odnoletkova@kaust.edu.sa

Course Information

Comprehensive Course Description	Some of the subjects, not necessarily lecture topics, covered will be: 1. What the earth can and cannot do for us (Lovelock, 1988; Odum, 1998) (a) Accumulations (coal, petroleum, old growth forest) and fluxes (solar irradiation) (b) Differences between old and new solar energy (Odum, 1998) (rate of use, rate of sequestration) (c) Ecosystems, their dynamics and equilibria (Odum, 1998) (d) The earth as a system closed to mass flow and open to heat flow (Ulanowicz and Hannon, 1987; Patzek, 2004) (e) Accumulation of wastes on the earth (Georgescu-Roegen, 1971) 2. Introduction to thermodynamics: Review briefly classical thermodynamics as in (Planck, 1926; Stodola, 1927; Abbott and Van Ness, 1972). Introduce the extended laws of thermodynamics in terms of gradients (Carath´eodory, 1976; Hatsopoulos and Keenan, 1965; Kestin, 1966; Schnei-der and Kay, 1994), but not in terms of classical entropy and free energy. (a) Law of mass conservation for an old accumulation and an ecosystem (b) First and Second Laws of Thermodynamics for an old accumulation and an ecosystem (Slesser, 1974; Slesser, 1975). Thermodynamic functions in ecosystems (Ulanowicz and Hannon, 1987; Schneider and Kay, 1994; Ho and Ulanowicz, 2005). The Second Law as a manifestation of the arrow of time (Georgescu-Roegen, 1971; Kondepudi and Prigogine, 1998) (c) Entropy, free energy, availability (exergy), dissipation of imposed gradients 3. Solar spectrum, reflection, transmission and adsorption of solar energy 4. Earth as a thermodynamic machine and a system open to heat flow, but closed to mass flow (Stodola, 1927; Keenan, 1951) 5. Photosynthesis and its energy efficiency (Good and Bell, 1980; Taiz and Zeiger, 1998; Odum, 1998) (the Hill reaction, theoretical photosynthetic efficiency, practical efficiency as deduced from the CO2 fluxes with eddy- covariance method) 6. Energy efficiencies of major crop systems (Patzek, 2004; Patzek and Pimentel, 2005) 7. Solar cells and their overall energy efficiency 8. Wind turbines and their overall energy efficiency 9. Carbon, nitrogen and sulfur cycles (Smil, 1985) 10. Mineral and micro-element cycles as in (Patzek, 2004; Patzek and Pimentel, 2005; Reich et al., 2006)

11. Thermodynamic requirements for ecosystem survival and stability (sustainability) as in (Ulanowicz and Hannon, 1987; Schneider and Kay, 1994; Ho and Ulanowicz, 2005; Patzek, 2004; Patzek and Pimentel, 2005)

12. Multiscale storage of energy in natural ecosystems vs. simplified, man- made ecosystems (Schneider and Kay, 1994; Ulanowicz and Hannon, 1987; Ho and Ulanowicz, 2005)

13. Net biomass productivity (Patzek, 2004; Patzek and Pimentel, 2005; Kimbrell, 2002; Cavalli-Sforza and Cavalli-Sforza, 1995)

14. Biofuel production schemes: fermentation, pelleting, and gasification (Patzek, 2004; Patzek and Pimentel, 2005)

15. Old plant energy: coal

16. Old plant energy oil and natural gas

17 Thermodynamics of petroleum recovery

References

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Press, Cambridge, Massachusetts.

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Taiz, L. and Zeiger, E. 1998, *Plant Physiology*, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, 2 edition.

Ulanowicz, R. E. and Hannon, B. M. 1987, Life and the production of entropy, *Proc. Royal Soc.*

London. Series B, Biological Sci. **232(1267)**: 181–192.

Wildererc, P. A. and Grambow, M. (eds.) 2016, *Global Stability through Decentralization?: In Search for the Right Balance between Central and Decentral Solutions*, Science, Springer Verlag, New York.

Course Description from Program Guide	Possible futures of humanity based on current trends. Analyses based on laws of mass and energy conservation and thermodynamics to evaluate overall efficiencies of major human energy supply schemes: fossil, solar, wind, and biomass. Irreversible linear processes, and sustainable/unsustainable cycles. Relationship between ecosystems (ancient and new), their energy storage and throughput, and energy production and its side effects. Analysis of inadequate economic theories that hamper understanding of the relationship between human economy and the Earth's economy (ecology). Most course assignments will be done in MATLAB
Goals and Objectives	My goal in this course is to assemble a large, intricate puzzle from simple but numerous pieces. The puzzle will show a clear, I hope, picture of the possible and impossible paths of supplying humanity with energy and the environmental costs of following some of these paths. Individual pieces of the puzzle will be contributed by science. Economics, which usually is more of a philosophical belief than science will play a supporting role. Finance and credit allow the interlocking economic wheels to turn with less friction, but they will not be a part of this course. You are expected to gain a working knowledge and good understanding of how the earth functions as a global system, what constraints she imposes on human economy that is based on natural resources, not just fossil fuels and "reconstructables," wind, solar PV, solar thermal and dams, but also air, water, soil, forests, oceans, and so on. You will be required to understand the scales of different power supply schemes, and be fluent in the relevant calculations. I hope that you will develop an imagination that will help to guide you through the years to come.
Required Knowledge	There are no prerequisites, but you are expected to know basic math (usually algebra), physics, chemistry and biology. You need to be able to program in MATLAB.
Reference Texts	Course reader by T. W. Patzek, papers on a list distributed in class, etc.
Method of evaluation	**40.00**% - Final exam **20.00**% - Midterm exam **40.00**% - Homework /Assignments
Nature of the assignments	Comprehensive homework assigments due every two weeks sharp Assigned reading to be checked in pop-up quizzes The final exam may be replaced with class papers/presentations
Course Policies	Assignments are to be turned in on time. Late assignments will not be generally accepted. Classes start sharp at the appointed time. Absences will be quickly noticed and need to be excused.
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Sun 08/25/2019	Semester starts, introductions, discuss course content, start introductory lecture
1	Wed 08/28/2019	Recitation as needed
1	Thu 08/29/2019	Introductory lecture: Our life styles, mass and energy (power) consumption, and the environment.
2	Sun 09/01/2019	Introductory lecture: The Green New Deal, what and how?
2	Wed 09/04/2019	Recitation as needed
2	Thu 09/05/2019	First lecture: Primary energy that powers the world, its major uses, greenhouse gas emissions, and possible transitions
3	Sun 09/08/2019	Second lecture: Possible electrical futures, solar PV and wind turbines. What else? How?
3	Wed 09/11/2019	Recitation as needed
3	Thu 09/12/2019	Third lecture: Energy primer, units, energy use in the world
4	Sun 09/15/2019	What the earth can and cannot do for us: Accumulations (coal, petroleum, old growth forest) and fluxes (solar irradiation).
4	Wed 09/18/2019	Recitation as needed
4	Thu 09/19/2019	Gross primary productivty and net primary productivty of ecosystems and the planet
5	Sun 09/22/2019	University holiday
5	Wed 09/25/2019	Recitation as needed
5	Thu 09/26/2019	Climate change as the wild card in all of our environmental and economic predictions
6	Sun 09/29/2019	The earth as a system closed to mass flow and open to heat flow. Accumulation of wastes on the earth.
6	Wed 10/02/2019	Recitation as needed
6	Thu 10/03/2019	Economics: Fallacies of moder economic theories. Biophysical economics
7	Sun 10/06/2019	Chapter 5. Exponential growth
7	Wed 10/09/2019	Recitation as needed
7	Thu 10/10/2019	Chapter 6 Geologic times scales on the Earth
8	Sun 10/13/2019	Chapter 7: Basic thermodynamics
8	Wed 10/16/2019	Recitation as needed
8	Thu 10/17/2019	Mass conservation, First and Second Law of Thermodynamics
9	Sun 10/20/2019	The solar power that drives the Earth
9	Wed 10/23/2019	Midterm
9	Thu 10/24/2019	Physcial chemisstry of life-giving water
10	Sun 10/27/2019	Mid-semester break
10	Wed 10/30/2019	Mid-semester break
10	Thu 10/31/2019	Mid-semester break
11	Sun 11/03/2019	Mid-semester break
11	Wed 11/06/2019	Mid-semester break
11	Thu 11/07/2019	Mid-semester break
12	Sun 11/10/2019	Mid-semester break
12	Wed 11/13/2019	Mid-semester break
12	Thu 11/14/2019	Mid-semester break
13	Sun 11/17/2019	Mid-semester break

13	Wed 11/20/2019	Mid-semester break
13	Thu 11/21/2019	Mid-semester break
14	Sun 11/24/2019	Mid-semester break
14	Wed 11/27/2019	Mid-semester break
14	Thu 11/28/2019	Mid-semester break
15	Sun 12/01/2019	Mid-semester break
15	Wed 12/04/2019	Mid-semester break
15	Thu 12/05/2019	Mid-semester break
16	Sun 12/08/2019	Exams

Note

The instructor reserves the right to make changes to this syllabus as necessary.