

**Energy in the 21<sup>st</sup> Century**  
**GEO 3150 or PHYS 3150**  
**3 credits 1:30-2:45 Tues, Thurs**  
**Room 215 Business**  
**FALL 2011 Depth AND QI**

**Rationale**

Energy is a fundamental subject in our society that crosses disciplines that include science, engineering, politics, economics, climate change, and international relations. Modern economies of the world currently rely on abundant and steady supplies of inexpensive energy sources. Developing countries are demanding larger shares of energy resources to achieve greater standards of living.

Our current energy resources are based primarily on fossil fuels (oil, natural gas, and coal), and nuclear energy, which have always been assumed to be plentiful. However, there is a growing realization of the limits of some of these resources, the negative consequences of reliance upon them, and their roles in emitting CO<sub>2</sub>, which is a leading cause of global climate change. At present, society is confronting choices of future energy resources. New technologies to harness the oldest of resources and those to harvest energy from a variety of exotic sources are being researched and developed. The companies and nations that can figure out the energy puzzle – how to provide more energy for more people on the planet, all of whom want a better life, while trying to limit CO<sub>2</sub> and other emission will have a significant advantage. The U.S. produces ~ 25 % of the global GDP, and consumes ~ 25% of the global energy demand; as other countries emerge as economic powers, where will our energy come from? How much will it cost? What are the environmental consequences?

Despite its critical role in the state of the world, most university students are rarely exposed to issues that surround energy resources in their typical curriculum. Few have much of any understanding of the basic chemistry, geology, and physics of energy; few students understand where energy comes from, the economic and environmental costs, and issues related to renewable energy. We also do not provide a strong basis for the personal budget implications of energy, and how efficient various energy systems are. We have an obligation to offer a means for future students to become literate about energy, and for some to add it to their professional training.

*Energy in the 21<sup>st</sup> Century* will provide students with a science-based overview of energy resources. While a complex topic, the class can be subdivided into several distinct areas. We will use a variety of instructors, and methods, to demonstrate key concepts. Our key learning outcomes are:

1. Understand what our current energy use patterns are, and what the primary energy sources are – in the US, and globally. We will examine energy consumption patterns as a function of national GDP, population, geography, and use sectors.
2. Evaluate where our current energy resources come from; this means examining the full-cycle resource cycle of our current energy resources – oil, natural gas, coal, and nuclear fuel.
3. Examine the fundamentals of the physics of energy, and the basic chemical and physical principles that limit any energy use. We will also acquire a working understanding of “energy efficiency”.
4. Discuss the positive economic services provided by energy consumption, and the environmental and climate implications of hydrocarbon use
5. Examine future energy resources – their basic physics, their potentials, their limitations, and their distribution.
6. Understand the fundamental terminology and concepts of energy, and to be able to make some basic calculations regarding the economics and science of energy.

**Instructors**

Dr. James Evans, Geology [james.evans@usu.edu](mailto:james.evans@usu.edu); 797-1267 Room 204 Geology  
Office Hours M, W, F 1130-1230; T – TH 200-315

Dr. Michael Taylor, Physics  
Guest lecturers in economics, biofuels, solar energy, and energy consumers such as USU, Logan City, USTAR, and EDL speakers

Undergraduate teaching fellows – Nathan Giles and Brennan Young. Office hrs TBA

### Nature of the class

Small lecture class with discussions, problem sets, quizzes, and papers

### Tentative grading scheme

8-10 problem sets 50 pts each	45 %
Calculations of energy resources, energy content, energy economics	
Short research essay – focus on the nature of an energy resource, its impacts [economic, social, environmental], and includes some basic analysis of energy potential and “efficiencies” of the resource 3-5 pgs	10%
2 quizzes	20%
2 mini-quizzes	10%
Final exam	15%

FINAL EXAM - Dec. 13, 130-320.

### text

Sustainable Energy – Without the Hot Air

By. David MacKay, <http://www.withouthotair.com/>

**NOTE:** This book is available for **FREE** online. It is written with a focus on the UK, but the fundamentals, and many examples are applicable globally. It also does not cover all aspects of what we want to cover, so you will be assigned other readings. Many of these readings will be the source of material that you need to understand to do the problem sets.

Other resources

Energy and the Environment (Paperback)

by Robert A. Ristinen (Author), Jack P. Kraushaar (Author)

Wiley; 2 edition

Language: English

ISBN-10: 0471739898

Supplemental materials and reading

The Economist – weekly news and business magazine which provides a better coverage of energy-related issues than most sources

The New York Times – they have been running a series of articles regarding energy resources in the past year. <http://www.nytimes.com/ref/science/earth/energy.html>.

**For fundamental data on US and worldwide reserves, production, etc.**

**Energy Information Administration – [www.eia.doe.gov](http://www.eia.doe.gov)**

**British Petroleum**, Statistical Review of World Energy 2011,

<http://www.bp.com/sectionbodycopy.do?categoryId=7500&contentId=7068481>

### Class schedule

Date	Topic	Reading	Professor, problem set
August 30	Introduction to the class: Intro to Energy Some Basics – Why care? What is energy?	I-1 MacKay	Evans
Sept 1	Units and Basic terms. The lay of the land nationally and globally; Who has the energy; In what form is it? How we use it; How it gets from source to consumers	I-2, handouts	Evans
Sept 6	Hydrocarbon men and women: The good, the bad, the ugly - Our Hydrocarbon World; Oil and Gas basics	Chap 2, R&K; handouts	Evans
Sept 8	Hydrocarbons, cont'd Oil, Gas, Coal basics	Chap 2, R&K; handouts	Evans
Sept 13	Fundamentals of Energy; units, heat, temperature	Chap II-23	Taylor
Sept 15	2 <sup>nd</sup> law of thermo - efficiencies, loss; power from heat; Miniquiz 1 online	Chap. I-2, MacKay	Taylor
Sept 20	Efficiency, loss; power from heat; coal; consequences of burning hydrocarbons		Evans
Sept 22	Electricity generation Nuclear Energy fission	II-24, chap. 6 R&K: handouts	Tripplett
Sept 27	Nuclear Energy		Tripplett
Sept 29	Review; In class exercise; Quiz 1 posted		
Oct 4	The small players: geothermal, hydroelectricity	I-8, I-16 MacKay	Evans
Oct 6	Implications of current energy use; Climate, atmosphere, water	handouts	Hipps
Oct 11	Climate issues, Cont.		Hipps
Oct 13	Distribution of winds and solar potential in the U. S.		Hipps
Oct 18	Solar Power - the physics	Chap I-6 & III-D	
Oct 20	No Class – Friday Schedule; Miniquiz 2 online		
Oct 25	Solar Power – the distribution problem	handouts	Evans
Oct 27	Wind Power - the physics	I-4, III-B,	
Nov 1	Review, open		
Nov 3	Quiz 2	I-4	
Nov 8	Wind Power - the methods	I-13, I15; III- E, III-F, G	Evans
Nov 10	Other alternatives: Tides, storage, geothermal, biomass	II-19, II-21	
Nov 15	Reducing the consumption: conservation and increasing efficiencies		Mike Taylor [sun]
Nov 17	Creating policies and Incentives	II-20; III-A	Evans, Mike Taylor s
Nov 22	Transport	II-22, 26	
Nov 29	Electrical systems; miniquiz 3	II-29; III-E	
Dec 1	Heating		
Dec 6	Geopolitics – Energy producers, energy consumers, and the implications for social and foreign policies		
Dec 8	Summary of the class		
Dec. 13, 1:30-3:20	Final Exam		

## Utah State University Selected Policies and Procedures

**Students with Disabilities:** The *Americans with Disabilities Act* mandates that reasonable accommodation will be made for students with disabilities in order to assure equal participation in this class. Students requesting such accommodation should meet with me during the first week of classes and must coordinate such accommodations with the Disabilities Resource Center (DRC) in Room 101 of the University Inn, 797-2444 voice, 797-0740 TTY, or toll free at 1-800-259-2966. Please contact the DRC as early in the semester as possible. Alternate format materials of course materials (Braille, large print or digital) are available with advance notice.

**Classroom etiquette.** While you are no doubt enmeshed in the wide range of communication devices, it is to your benefit, and the benefit of faculty and classmates, to eliminate or reduce the use of electronic communication devices during class. PLEASE NO TEXTING during class; no email, skype, blogging, videorecording, cellphone photography, im'ing, etc. as well. And remember that university computer policy prohibits the display of materials that others might find offensive on computers that can be publically viewed. Please do not use your laptop for general surfing on the web, facebook, or whatever new technology that develops in the next 4 months.

### Withdrawal Policy and "I" Grade Policy

Students are required to complete all courses for which they are registered by the end of the semester. In some cases, a student may be unable to complete all of the coursework because of extenuating circumstances, but not due to poor performance or to retain financial aid. The term 'extenuating' circumstances includes: (1) incapacitating illness which prevents a student from attending classes for a minimum period of two weeks, (2) a death in the immediate family, (3) financial responsibilities requiring a student to alter a work schedule to secure employment, (4) change in work schedule as required by an employer, or (5) other emergencies deemed appropriate by the instructor.

### Academic Freedom and Professional Responsibilities

Academic freedom is the right to teach, study, discuss, investigate, discover, create, and publish freely. Academic freedom protects the rights of faculty members in teaching and of students in learning. Freedom in research is fundamental to the advancement of truth. Faculty members are entitled to full freedom in teaching, research, and creative activities, subject to the limitations imposed by professional responsibility. Faculty Code Policy #403 further defines academic freedom and professional responsibilities: <http://personnel.usu.edu/policies/403.htm>.

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### Academic Integrity – "The Honor System"

Each student has the right and duty to pursue his or her academic experience free of dishonesty. The Honor System is designed to establish the higher level of conduct expected and required of all Utah State University students.

The Honor Pledge: To enhance the learning environment at Utah State University and to develop student academic integrity, each student agrees to the following Honor Pledge: "I pledge, on my honor, to conduct myself with the foremost level of academic integrity." A student who lives by the Honor Pledge is a student who does more than not cheat, falsify, or plagiarize. A student who lives by the Honor Pledge:

- Espouses academic integrity as an underlying and essential principle of the Utah State University community;
- Understands that each act of academic dishonesty devalues every degree that is awarded by this institution;
- and
- Is a welcomed and valued member of Utah State University.

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### Plagiarism

Plagiarism includes knowingly "representing, by paraphrase or direct quotation, the published or unpublished work of another person as one's own in any academic exercise or activity without full and clear acknowledgment. It also includes the unacknowledged used of materials prepared by another person or agency engaged in the selling of term papers or other academic materials." The penalties for plagiarism are severe.

They include warning or reprimand, grade adjustment, probation, suspension, expulsion, withholding of transcripts, denial or revocation of degrees, and referral to psychological counseling.

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### **Grievance Process (Student Code)**

Students who feel they have been unfairly treated [in matters other than (i) discipline or (ii) admission, residency, employment, traffic, and parking - which are addressed by procedures separate and independent from the Student Code] may file a grievance through the channels and procedures described in the Student Code: [http://studentlife.tsc.usu.edu/stuserv/pdf/student\\_code.pdf](http://studentlife.tsc.usu.edu/stuserv/pdf/student_code.pdf) (Article VII. Grievances, pages 25-30).

### **Sexual Harassment**

Sexual harassment is defined by the Affirmative Action/Equal Employment Opportunity Commission as any "unwelcome sexual advances, requests for sexual favors, and other verbal or physical conduct of a sexual nature." If you feel you are a victim of sexual harassment, you may talk to or file a complaint with the Affirmative Action/Equal Employment Opportunity Office located in Old Main, Room 161, or call the AA/EEO Office at 797-1266.

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## **Topics**

### **The Budgets of Energy**

Energy - What is it? Where does it come from? How much is there? Who has it? How much energy does the world use? How do we use it? How much do we waste?

- units – basics of numbers
- How do we measure it
- Measures of efficiency
- The 2<sup>nd</sup> law of thermodynamics – the great limitation

### **Energy from the Sun**

- Basics of the Sun. How much energy is received from the sun?
- What happens to the sun's energy on the planet? Evaporation, heating etc.
- Measuring solar energy variations on the planet
  
- A. Sun's fossil energy – fossil fuels
  - Big Three oil, gas, coal
  - How are these formed? Environments of oil, gas, and coal creation and preservation
  - Who has the goods? Where on the planet are the reserves?
  - How do we explore, produce, and exploit these resources? What are the impacts of these activities?
  - Carbon budgets
  
- B. Direct resources "solar power"
  - How do we generate power from the sun?
  - How much is there?
  - Emerging technologies for solar power
  - Relations to atmospheric greenhouse gases
  
- C. The sun's indirect sources
  - Wind
    - o Why do we have winds?
    - o Where are the winds the best for power?
    - o What is a wind mill? How do the modern versions work?
    - o Where do we want to locate our windmills? What are the problems?

- D. Biofuels sources - Physics and Chemistry; efficiencies; impacts

**D. Nuclear Power** – the good, the bad, the ugly

Basic physics – where the energy comes from  
Containment of the reactions  
Fuel sources  
Energy outputs  
Waste products

**E. Hydropower**

Basic physics  
Where the resources are  
Economics  
Environmental issues

**F. Geothermal Energy**

Basics  
Resource base – geography  
“active” vs “passive” geothermal systems  
limitations

**G. Other sources – Tidal, compressed gas storage, fusion**

**H. Conservation and resource management**

**Climate Change and Carbon Emissions**

The climate puzzle  
Connections to energy use

**Economics of energy**

Who pays? Who wins? Who loses?  
Some basic concepts of Energy economics

**Energy “efficiencies” – the battle for the optima**

Physical and Chemical efficiency  
Economic efficiency  
Carbon-based efficiency

**Geopolitics of Energy**

How does who has what affect how they act? How do producer nations and consumer nations depend and relate to each other?