EE80J: Introduction to Renewable Energy Sources

EE180J: Advanced Renewable Energy Sources

- Instructors:
  - Mike Isaacson
  - Oxana Pantchenko
Welcome

This is an introduction to energy conversion and storage with special emphasis on renewable sources. Fundamental energy conversion limits based on physics and existing material properties will be discussed. Various sources such as solar, wind, hydropower, geothermal and fuel cells will be described. An analysis of different alternative sources will be performed and key scientific, economical and social roadblocks for large scale implementation will be examined. Finally, the latest research on new renewable energy sources and storage systems will be discussed.
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Lecture: Tuesday & Thursday, 10:00 -11:45am
        Merrill 102
Teaching Assistant: Dan O’Leary, dan@soe.ucsc.edu
Course Administrator: Sheryl Robertson, sherylr@soe.ucsc.edu
Prerequisites

- **EE80J Pre-requisites**: This class does not have any math, physics or engineering prerequisites. All the necessary concepts will be introduced during the course.

- **EE180J Pre-requisites**: calculus, differential equations. Enrollment is limited to 50. Please let me know if you need a permission code.
Text

- Out of Gas, David Goodstein, 2004
Class Web-Site

https://courses.soe.ucsc.edu/courses/ee80j/Spring13/01
Hands-on Laboratories (Jack Baskin Engineering 302)

This provides an opportunity for students to see how various energy conversion devices work and understand better the advantages and difficulties of harnessing energy from renewable sources. Most of the experiments are done in groups of two.

- Lab 1: Greenhouse effect
- Lab 2: Solar Pathfinder
- Lab 3: Flywheel
- Lab 4: Wind turbine
- Lab 5: Hydroelectricity
- Lab 6: Concentrating Solar Power
- Lab 7: Thermoelectricity
- Lab 8: Hydrogen fuel cell car

Note: Labs order may be changed depending upon the weather.
8 hands-on laboratory experiments (6 are required)
Solar Concentrators

EE80J/180J lab

Pantchenko, et.al. (2013)

Barstow, Ca. Mojave desert (1980’s), 10 MWatts
Labs start next week at JBE 302

- Wednesday 2:00 – 3:10
- Wednesday 3:30 - 4:40
- Friday 12:30-1:40
- Friday 2:00 – 3:10
- Friday 3:30 – 4:40

Anyone who can’t make it to one of these sections, please write down your available times and pass this information to me or your TA.
LECTURE AND HW SCHEDULE (tentative)

4/2/2013 Introduction
4/4/2013 Energy Overview
4/9/2013 Energy Basics, Temperature & Heat
4/11/2013 Personal Energy Audit (by Oxana Pantchenko)
4/16/2013 Photovoltaics
4/18/2013 Local efforts on renewable energies, project formation
4/23/2013 Local efforts of renewable energies
4/25/2013 Bioenergy
4/30/2013 Social aspects of renewable energy
5/2/2013 Hydrogen Economy, Fuel Cells, Storage
5/7/2013 Midterm
5/9/2013 Nuclear Energy
5/14/2013 Wind Power
5/16/2013 Wind Power (by Oxana Pantchenko)
5/21/2013 Wind Power (by Oxana Pantchenko)
5/23/2013 Hydroelectricity, Ocean Power, Geothermal (by Oxana Pantchenko)
5/28/2013 Hydroelectricity, Ocean Power, Geothermal (by Oxana Pantchenko)
5/30/2013 Class Overview (by Oxana Pantchenko)
6/4/2013 Proposal Presentations
6/6/2013 Proposal Presentations
6/11/2013 12:00-3:00PM Final
Lectures and Homework

4/2/2013 Lecture 1: Introduction and Overview
HW: Read Boyle, Renewable Energy, Chapter 1, Appendix A & Out of Gas Book pages 1-40.

HW: Read Boyle, Chapter 1
EE180J HW Only: [HW1](#) Due 4/11/2013

https://courses.soe.ucsc.edu/courses/ee80j/Spring13/01

look at: http://www.youtube.com/watch?v=80hLPnpmCZ8
Personal Energy Audit (individual work)

Due 4/23/2013 at 4PM on eCommons in pdf format

Part I: Report
Report format:
- Abstract (5pts)
- Introduction (should include information about student) (5pts)
- Calculations and Analysis
  - List of energy services and sources (5 pts)
  - Hot water consumption (15 pts)
  - Transportation (15 pts)
  - Electricity usage (kWh/day) & (J / week)
    - Calculated from labels (15 pts)
    - Measured with “Kill a Watt” meter (15 pts)
      - When appliances are on
      - When appliances are off
  - Conclusion (should include qualitative and quantitative analysis summary from previous section). Should answer following questions (15 pts).
    - See class web-site for more information.
Personal Home Energy Audit (individual work)

Due 4/23/2013 at 4PM.

- Part II: Questionnaire
- To complete the Questionnaire (10pts) please click here.
Group Project (in groups of 5 or 6)

EE80J: Write a 10 page proposal related to renewable energy. More details on this later.

EE180J: Write a 20 page proposal on making Santa Cruz Wharf green. Two group meetings on Skype. Ask questions in class forum. More details on this later.

- **Proposal Outline** Due Thursday, May 16th, 2012 at 4pm on eCommons

- **Proposal Rough Draft** Due Thursday, May 23rd, 2012 at 4pm on eCommons

- **Final Proposal** Due Thursday, June 6th, 2012 at 4pm on eCommons.

- **Self/Peer Evaluation Form** Due Thursday, June 6th, 2012 at 4pm on eCommons

- **Final Presentations** May 28th & 30th, June 4th & 6th.
Grading

EE80J Grading:
- Midterm (10%)
- Personal energy audit (20%)
- Quizzes (10%) (6 top scores) or Final (10%)
- Labs (30%) (6/8 top scores)
- Group project (30%) (outline, rough draft, proposal and final presentation)

EE180J Grading:
- Midterm (10%)
- Personal energy audit (20%)
- Quizzes (10%) (6 top scores)
- Homework (10%) (4 assignments total)
- Labs (20%) (6/8 top scores)
- Group project (20%) (includes outline, rough draft, proposal and final presentation)
- Final (10%)
Classroom accommodations information

If you qualify for classroom accommodations because of a disability, please get an Accommodation Authorization from the Disability Resource Center (DRC) and submit it to me in person outside of class (e.g., office hours) within the first two weeks of the quarter. Contact DRC at 459-2089 (voice), 459-4806 (TTY), or http://drc.ucsc.edu for more information on the requirements and/or process.
Academic Dishonesty and Cheating

Any confirmed academic dishonesty including but not limited to copying reports or cheating on exams, will result in a no-pass or failing grade. You are encouraged to read the campus policies regarding academic integrity. Examples of cheating include (but are not limited to):

- Copying results or other information during in-class activities or final.
- Submitting a report that is not your own work.
- Using material from internet, books, journals, other people’s reports without proper referencing

If there is any question as to whether a given action might be construed as cheating, see me before you engage in any such action.
Renewable Energy Sources

Overview
Some renewable energy sources

intercepted solar radiation: 5.4 million EJ y⁻¹

direct conversion to heat in air, earth and oceans: (49%) 2.65 million EJ y⁻¹

solar radiation direct reflection to space: (31%) 1.67 million EJ y⁻¹

hydrological cycle (evaporation, precipitation): (20%) 1.08 million EJ y⁻¹

wind, waves convection and currents: (<1%) 11 700 EJ y⁻¹

conduction in rocks: 1008 EJ y⁻¹
Santa Cruz Green Wharf Project

**Mission:** Provide an experimental test bed facility for sustainable energy education, research and outreach to the public

**Initial objective:** Establish an experimental test bed facility on the Santa Cruz Municipal Wharf, teaming with the City and other institutions

**First Project:** Pilot test bed on rooftop for solar and wind energy research, evaluation and test
1 KW Vertical Axis Wind Turbine, Santa Cruz Municipal Wharf
Salinas Valley
OVERVIEW OF RENEWABLE ENERGY SOURCES
History

Early Human Societies
- Harvested movements of water and wind to grind corn, irrigate crops and propel ships.

Industrial Revolution
- Coal & Oil & Natural Gas
- \(\frac{3}{4}\) of world’s energy
  - Oil crisis

WWII
- Nuclear power
  - Cost, safety and waste disposal
Fossil Fuel

From Goodstein, “out of gas”
Sustainable Energy Source

- What is your definition of a sustainable energy source?
Sustainable Energy Source

- What is your definition of a sustainable energy source?
- Not substantially depleted by continued use
Sustainable Energy Source

- What is your definition of a sustainable energy source?
  - Not substantially depleted by continued use
  - Does not entail significant pollutant emissions or other environmental problems
Sustainable Energy Source

- What is your definition of a sustainable energy source?
  - Not substantially depleted by continued use
  - Does not entail significant pollutant emissions or other environmental problems
  - Does not involve the perpetuation of substantial health hazards or social injustices
Basic Energy Concepts

- International System of Units
  - Meter
  - Kilogram
  - Second

- What is the unit of energy?
Energy
- The energy supplied by force of one newton in causing movement through a distance of 1 meter.
- Joule (J) - the unit of energy
- Energy (J) = Force (N) x Distance (m)

Power
- The rate at which energy is converted from one form to another or transferred from one place to another.
- Watt (W)
- Power (W) = Energy (J) / Time (sec)
1 joule
Forms of Energy
Forms of Energy

Kinetic (thermal)
Forms of Energy

Kinetic (thermal)

Gravitational
Forms of Energy

Kinetic (thermal)

Gravitational

Electrical (chemical)
Forms of Energy

Kinetic (thermal)

Gravitational

Electrical (chemical)

Nuclear (fission, fusion)
Scientific Notation

- Femto (f) $10^{-15} = 1/1000,000,000,000,000,000$
- Pico (p) $10^{-12} = 1/1000,000,000,000,000$
- Nano (n) $10^{-9} = 1/1000,000,000$
- Micro (µ) $10^{-6} = 1/1000,000$
- Milli (m) $10^{-3} = 1/1000$
- Centi (cm) $10^{-2} = 1/100$
- Deca (dm) $10^1 = 10$
- Kilo (k) $10^3 = 1000$
- Mega (M) $10^6 = 1,000,000$
- Giga (G) $10^9 = 1,000,000,000$
- Tera (T) $10^{12} = 1,000,000,000,000$
- Peta (P) $10^{15} = 1,000,000,000,000,000,000$
- Exa (E) $10^{18} = 1,000,000,000,000,000,000,000$
World energy consumption

- Oil: 32.4%
- Natural gas: 22.1%
- Coal: 27.4%
- Hydro: 2.3%
- Nuclear: 5.1%
- Traditional biomass: 6.0%
- Other sources: 4.7%

* The nuclear contribution is the notional primary energy that would be needed to produce the actual output at an efficiency of 38%.
** The hydro contribution is the actual electrical output.

Total: about 502 EJ, equivalent to 12 billion tonnes of oil, or an average continuous rate of energy consumption of 15.9 TW.

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Renewable Energy sources, 2008

- total consumption: 65 EJ

- traditional biomass: 46.2%
- new biomass: 27.6%
- energy from wastes: 2.4%
- hydro: 18.0%
- geothermal: 3.8%
- solar: 0.8%
- wind, wave, tide, etc: 1.2%

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EFFICIENCY AND CAPACITY

Efficiency = \frac{\text{useful output}}{\text{input}} \times 100 \text{ (in \%)}

Capacity = \frac{\text{actual energy output over a fixed period or time}}{\text{maximum possible output}}

Examples: a 1MW power plant operating at full capacity for 1 year would generate 8760 MWh of output if operating at 100% capacity (capacity factor of 1)

A 1 MW wind turbine might only produce 3000 MWh of output in 1 year since wind doesn’t always blow, so its capacity would only be 34.2% (3000/8760)
## Scientific Notation

- **Femto** (f) \(10^{-15} = 1/1000,000,000,000,000,000\)
- **Pico** (p) \(10^{-12} = 1/1000,000,000,000,000\)
- **Nano** (n) \(10^{-9} = 1/1000,000,000\)
- **Micro** (\(\mu\)) \(10^{-6} = 1/1000,000\)
- **Milli** (m) \(10^{-3} = 1/1000\)
- **Centi** (cm) \(10^{-2} = 1/100\)
- **Deca** (dm) \(10^{1} = 10\)
- **Kilo** (k) \(10^{3} = 1,000\)
- **Mega** (M) \(10^{6} = 1,000,000\)
- **Giga** (G) \(10^{9} = 1,000,000,000\)
- **Tera** (T) \(10^{12} = 1,000,000,000,000\)
- **Peta** (P) \(10^{15} = 1,000,000,000,000,000,000\)
- **Exa** (E) \(10^{18} = 1,000,000,000,000,000,000,000\)
Scientific Notation

- Write 0.000000107 in scientific notation.

- How many kJ are there in GJ?
Energy Consumption

example

*Video camera in your cell phone*
Energy Consumption
example

Video camera in your cell phone

$10^{-8}$ Joules/ A-D conversion
Energy Consumption
example

Video camera in your cell phone

$10^{-8}$ Joules/ A-D conversion

$1080 \times 1920$ pixels/image (frame) = 2.1million pixels/frame
  = $0.021$ joules/frame
30 frames / second for video = 0.62 joules/sec = 0.62 watts
Energy Consumption
example

Video camera in your cell phone

$10^{-8}$ Joules/ A-D conversion

$1080 \times 1920$ pixels/image (frame) = 2.1million pixels/frame

= 0.021 joules/frame

30 frames / second for video = 0.62 joules/sec = 0.62 watts

Or 37.2 joules/ 1 minute of video.
HW for this week

Read:
Renewable Energy,
chapter 1, Appendix A
And “Out of Gas” Book pages 1-40.
Starting next week
meet your TA at JBE 302

- Wednesday 2:00 – 3:10,
- 3:30 -4:40
- Friday 12:30 -1:40,
- 2:00 -3:10, 3:30 -4:40
Lecture and HW schedule

4/2/2013  Lecture 1: Introduction and Overview
HW: Energy and the Environment
Introduction to Renewable Technologies, pg. 1-18
Scientific Notation
Out of Gas Book pages 1-40

HW: Read
Energy Conversion and Efficiency
EE180J HW Only: HW1 Due 4/11/2012 in class