EE80J: Introduction to Renewable Energy Sources

EE180J: Advanced Renewable Energy Sources

- Instructor:
- Mike Isaacson

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.

Instructor: Mike Isaacson

- **Office:** Baskin 237
- **E-mail:** msi@soe.ucsc.edu
- **Office Hours:** by appointment
- **Lecture:** MWF, 9:30-10:40am
- Thimann 1
- **Teaching Assistant**: Fa Chang, fachang@ucsc.edu
- **Course Administrator:** Rachel Cordero, rcordero@soe.ucsc.edu

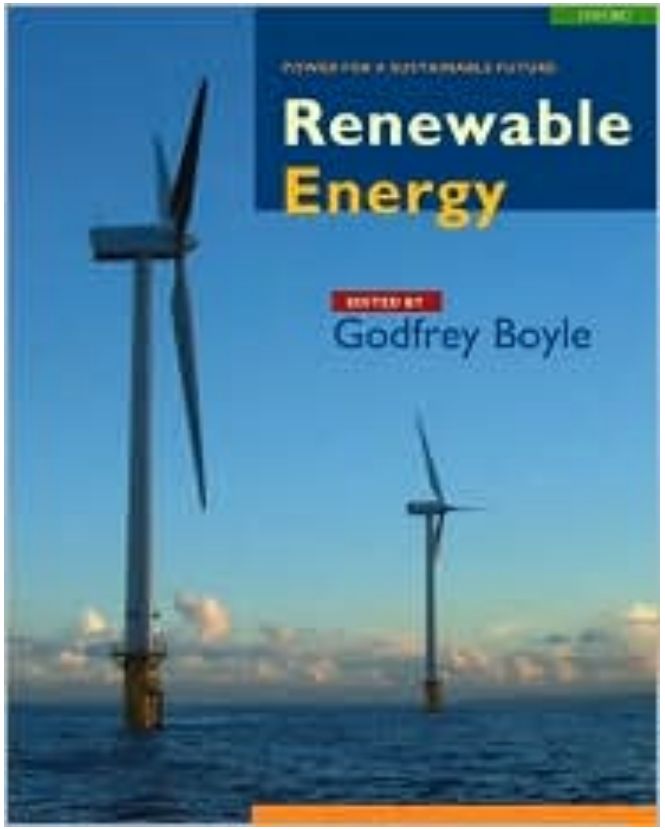
Prerequisites

- **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.
- Please let me know if you need a permission code.

Text

- Renewable Energy, Godfrey Boyle, 3rd Edition, 2012
- Out of Gas, David Goodstein, 2004 (optional)

Available at Amazon.com



Class Web-Site

https://courses.soe.ucsc.edu/courses/ee80j/Spring16/01

Lectures and Homework

3/28. Lecture 1: Introduction and Overview

3/30. Lecture 2: Scientific Notation, Energy Conversion and Efficiency, Energy Basics, Heat and Temperature.

https://courses.soe.ucsc.edu/courses/ee80j/Spring16/01

look at: http://www.youtube.com/watch?v=80hLpNpmCZ8

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 Friday, May 13th, 2016 at 4pm*
- *Proposal Rough Draft Due Friday, May 20th, 2012 at 4pm on eCommons*
- *Final Proposal Due Friday, June 3th, 2012 at 4pm*
- *Self/Peer Evaluation Form Due Friday, June 3rd, at 4pm on eCommons*
- *Final Presentations May 30th &, June 1st & 3rd.*

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):

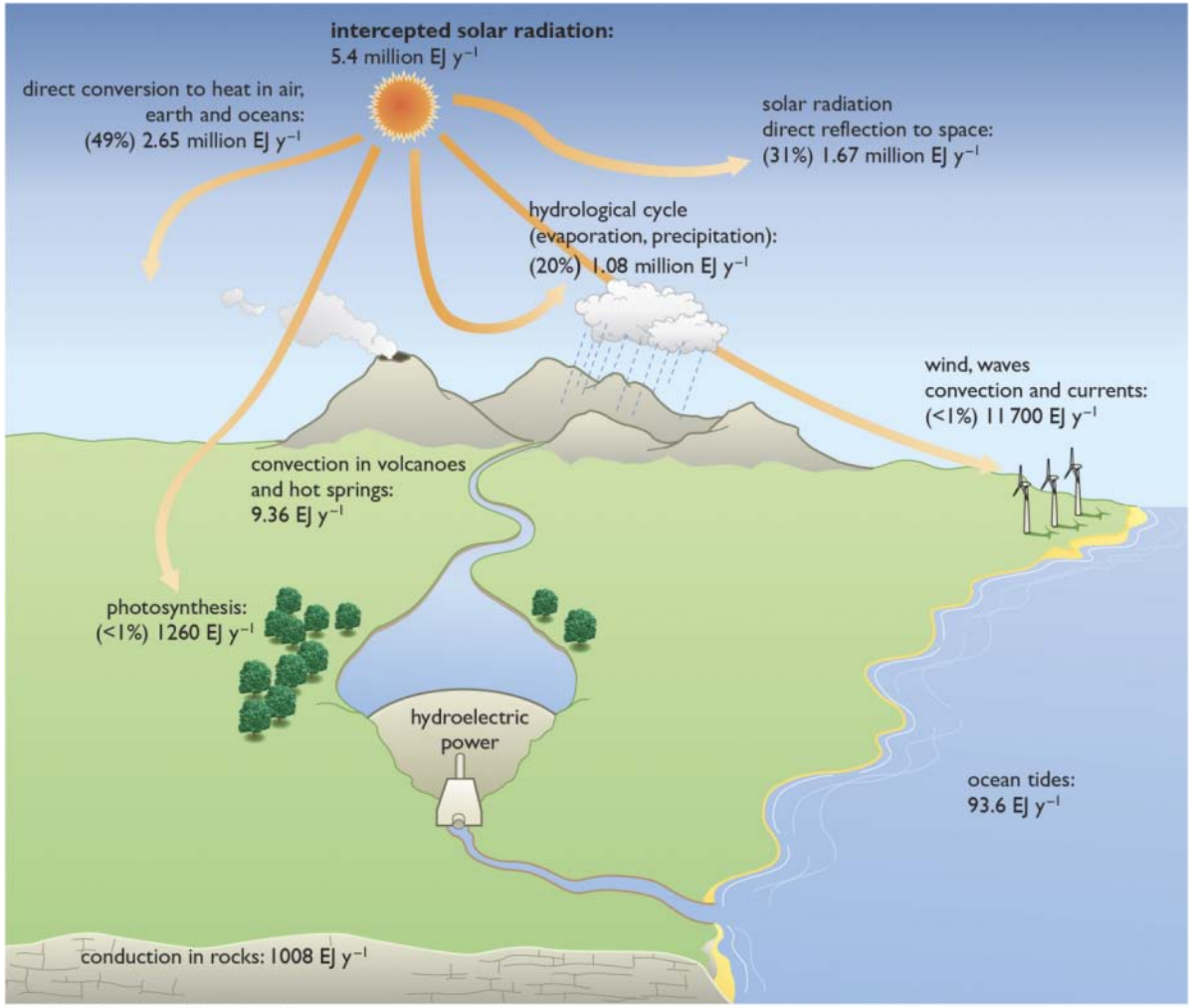
- Copying results or other information during in-class activities or final.
- Submitting a report that is not your own work.
- Using material from internet, books, journals, other people's reports without proper referencing

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.

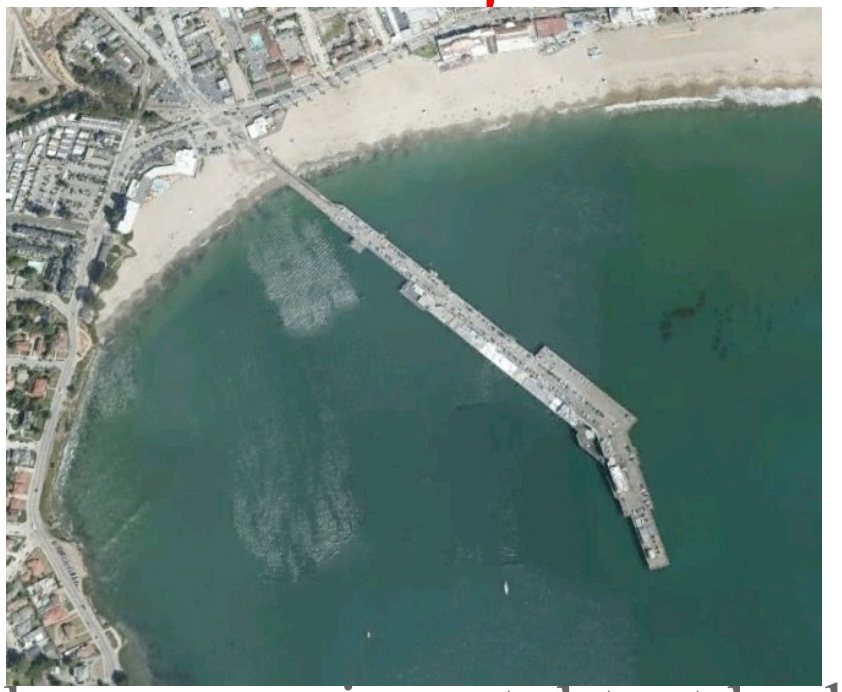
Renewable Energy Sources

Overview

Some renewable energy sources



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

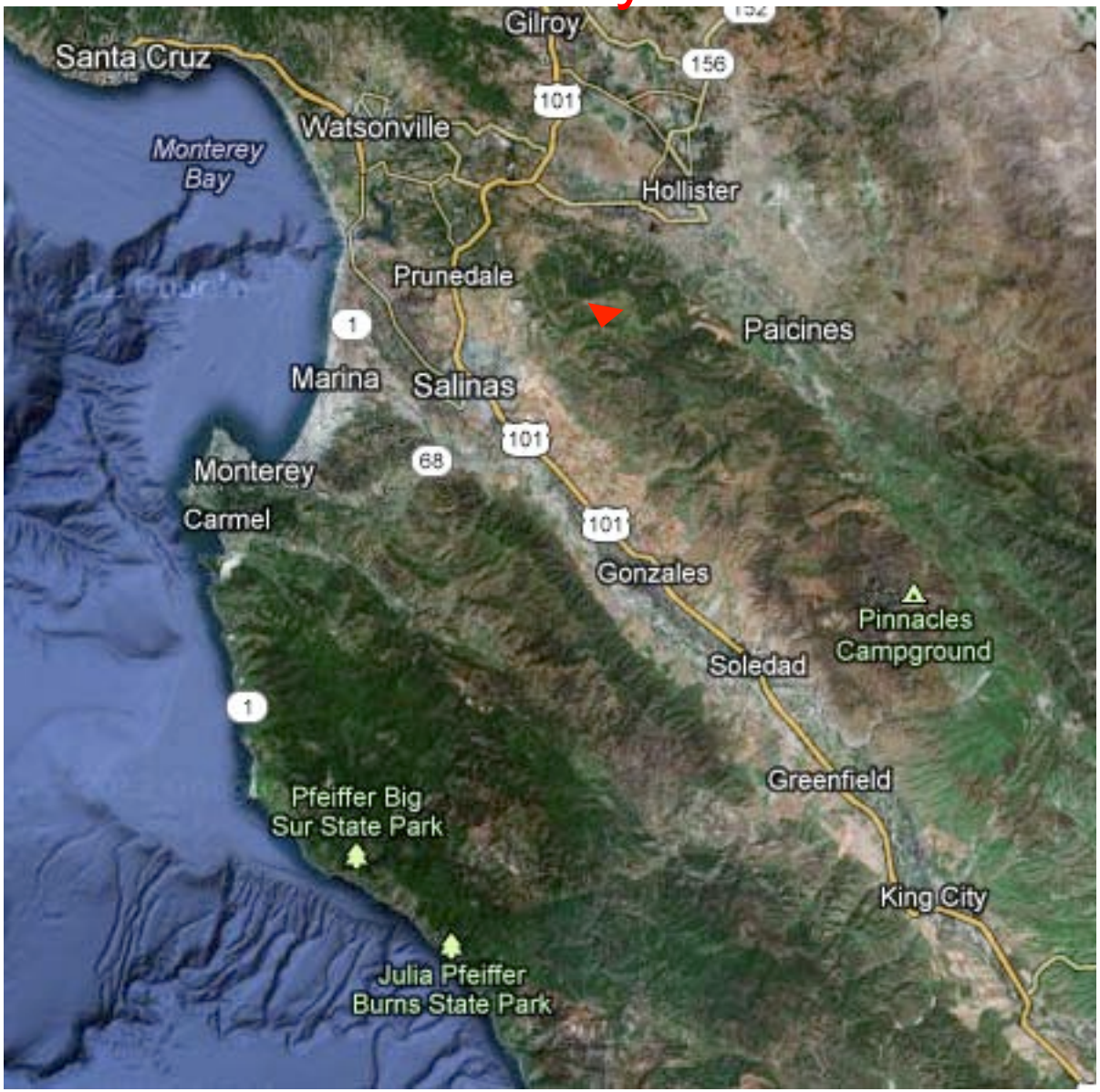
The Center for Sustainable Energy and Power Systems

CENSEPS

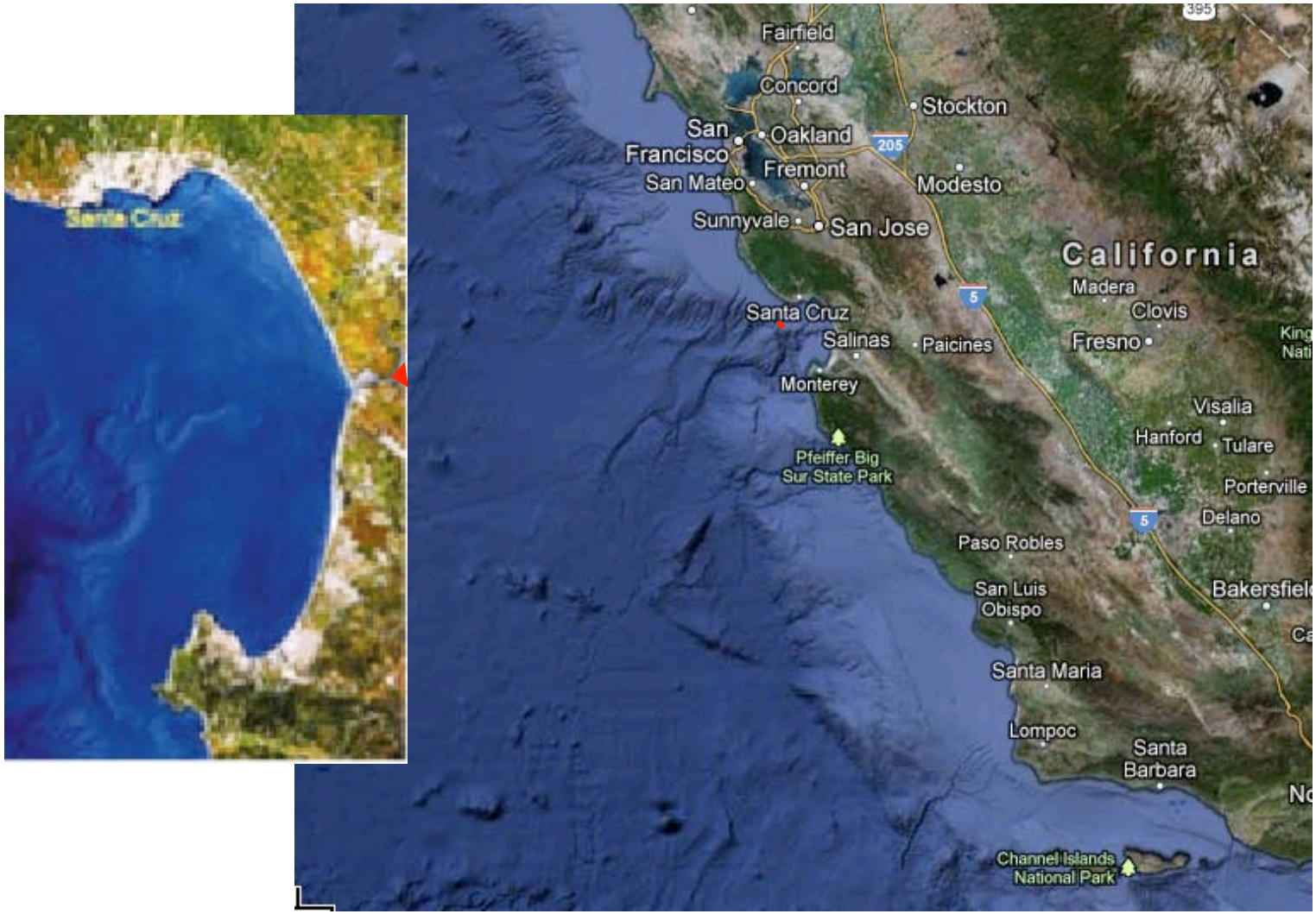
The Center for Sustainable Energy and Power Systems

CENSEPS

Salinas Valley `



OVERVIEW OF RENEWABLE ENERGY SOURCES



History

Early Human Societies

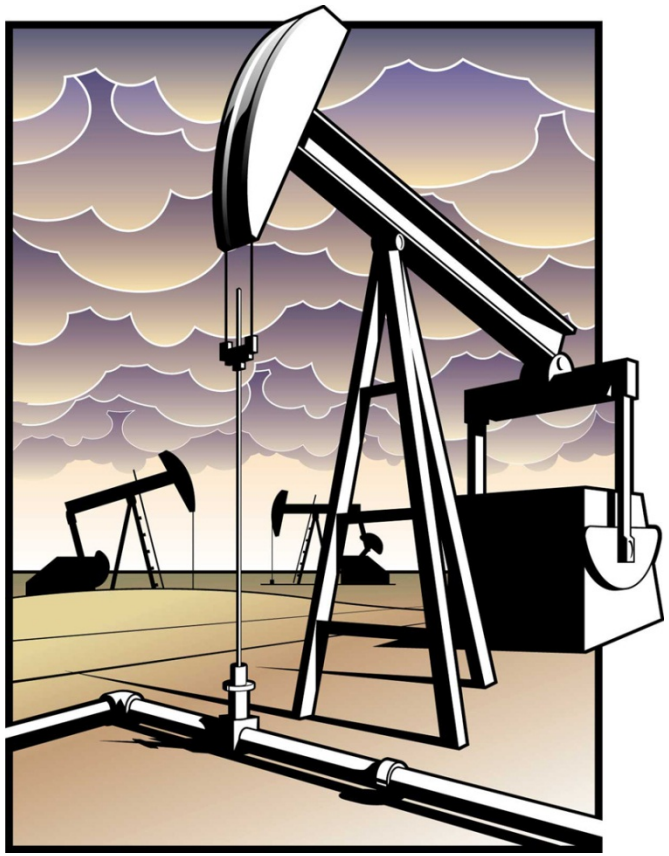
- Harvested movements of water and wind to grind corn, irrigate crops and propel ships.

Industrial Revolution

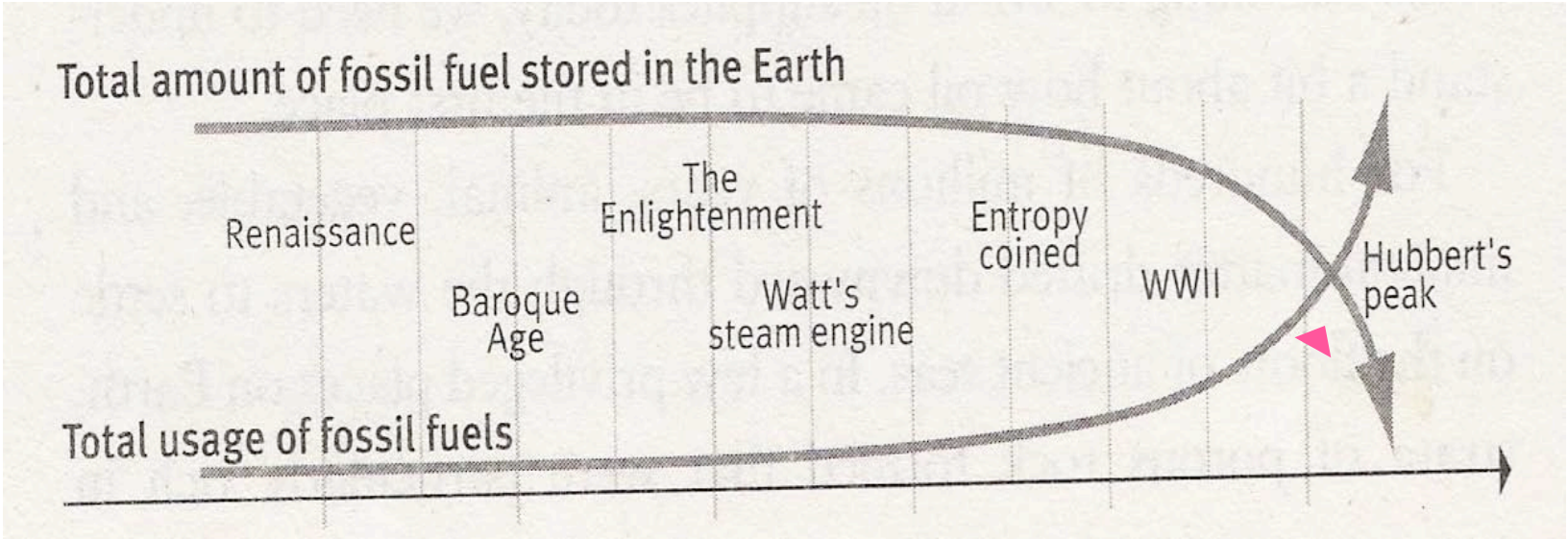
- Coal & Oil & Natural Gas
- ¾ of world's energy
  - Oil crisis

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?
  - 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?

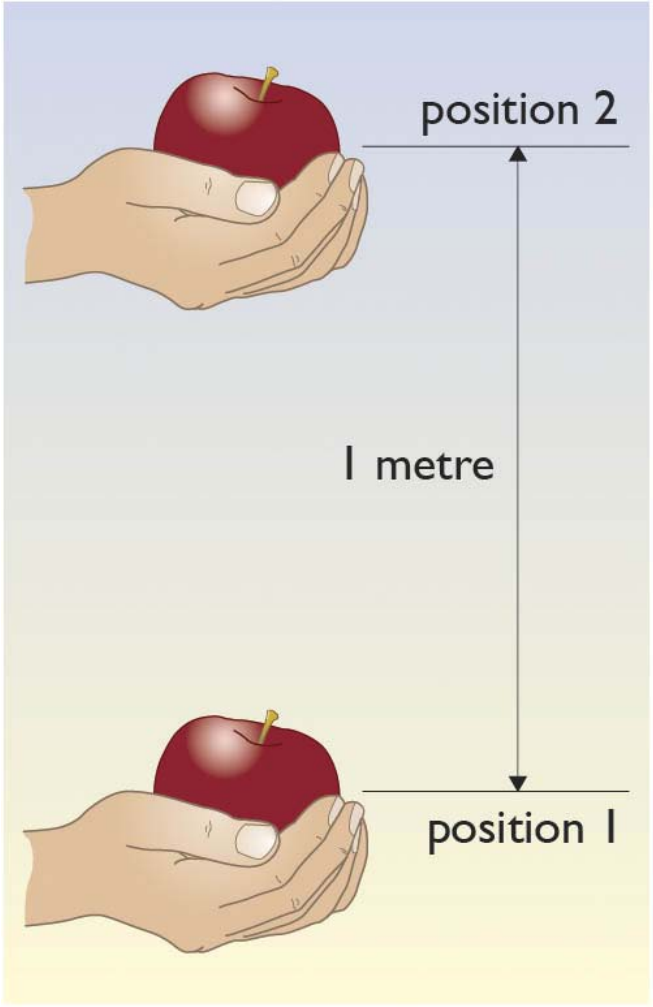
Energy

- 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

Kinetic (thermal)

Gravitational

Electrical (chemical)

Carnot, Sadi (1824). *Réflexions sur la puissance motrice du feu et sur les machines propres à développer cette puissance*. Paris: Bachelier.

Nicolas Léonard Sadi Carnot in 1813 at age of 17 in the traditional uniform of a student of the École Polytechnique

Born	1 June 1796 Palais du Petit-Luxembourg, Paris, France
Died	24 August, 1832 (age 36) Paris, France
Nationality	French
Fields	Physicist and engineer
Institutions	French army
Alma mater	École Polytechnique École Royale du Génie Sorbonne Collège de France
Academic advisors	Siméon Denis Poisson André-Marie Ampère François Arago
Known for	Carnot cycle Carnot efficiency Carnot theorem Carnot heat engine

Forms of Energy

Kinetic (thermal)

Gravitational

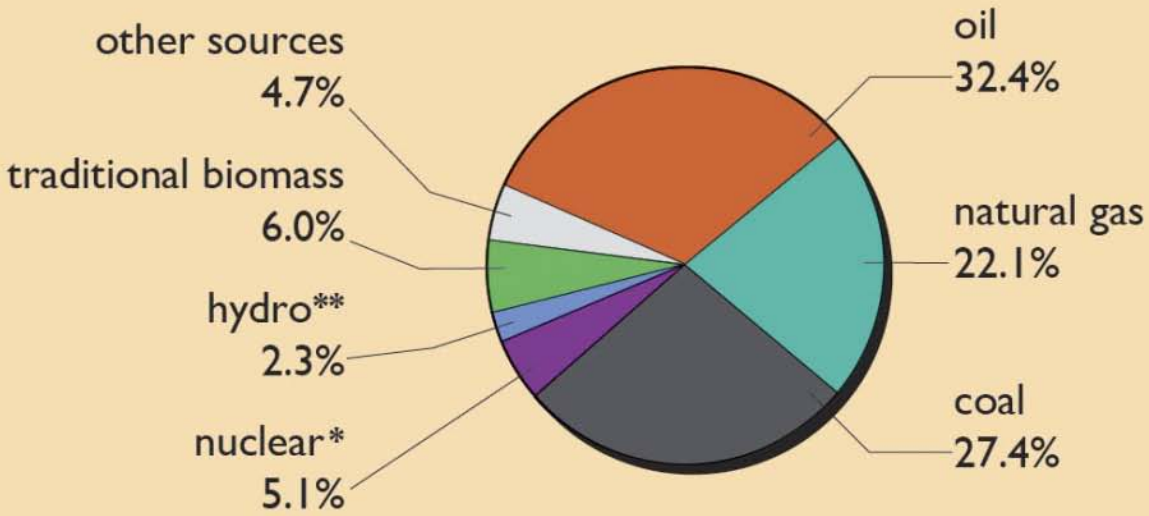
Electrical (chemical)

Nuclear (fission, fusion)

Scientific Notation

- Femto (f) 10^{-15}= 1/1000,000,000,000,000
- Pico (p) 10^{-12}= 1/1000,000,000,000
- 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}= 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
- Exa (E) 10^{18}=1,000,000,000,000,000,000

World energy consumption

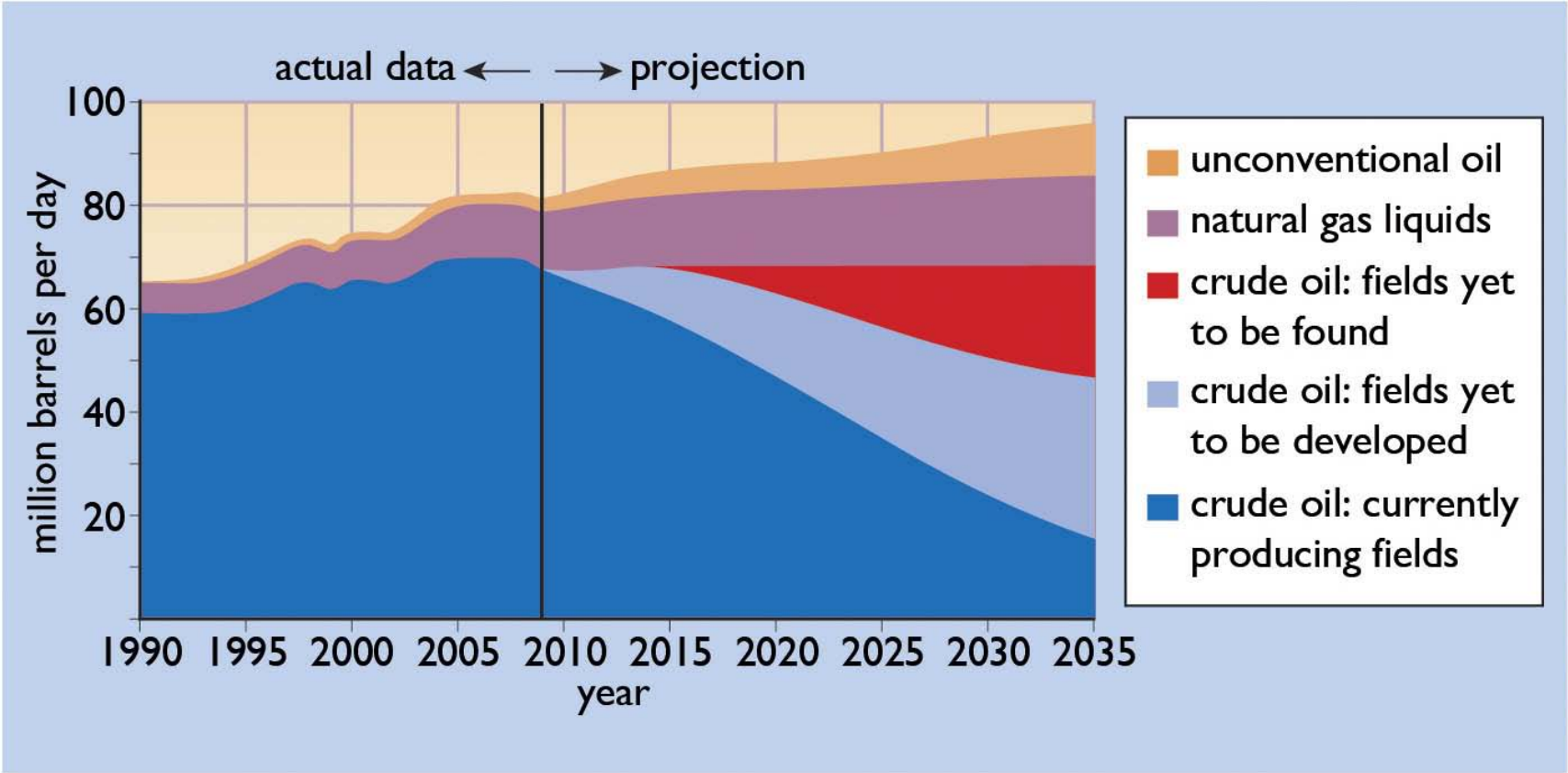


* The nuclear contribution is the notional primary energy that would be needed to produce the actual output at an efficiency of 38%.

** The hydro contribution is the actual electrical output.

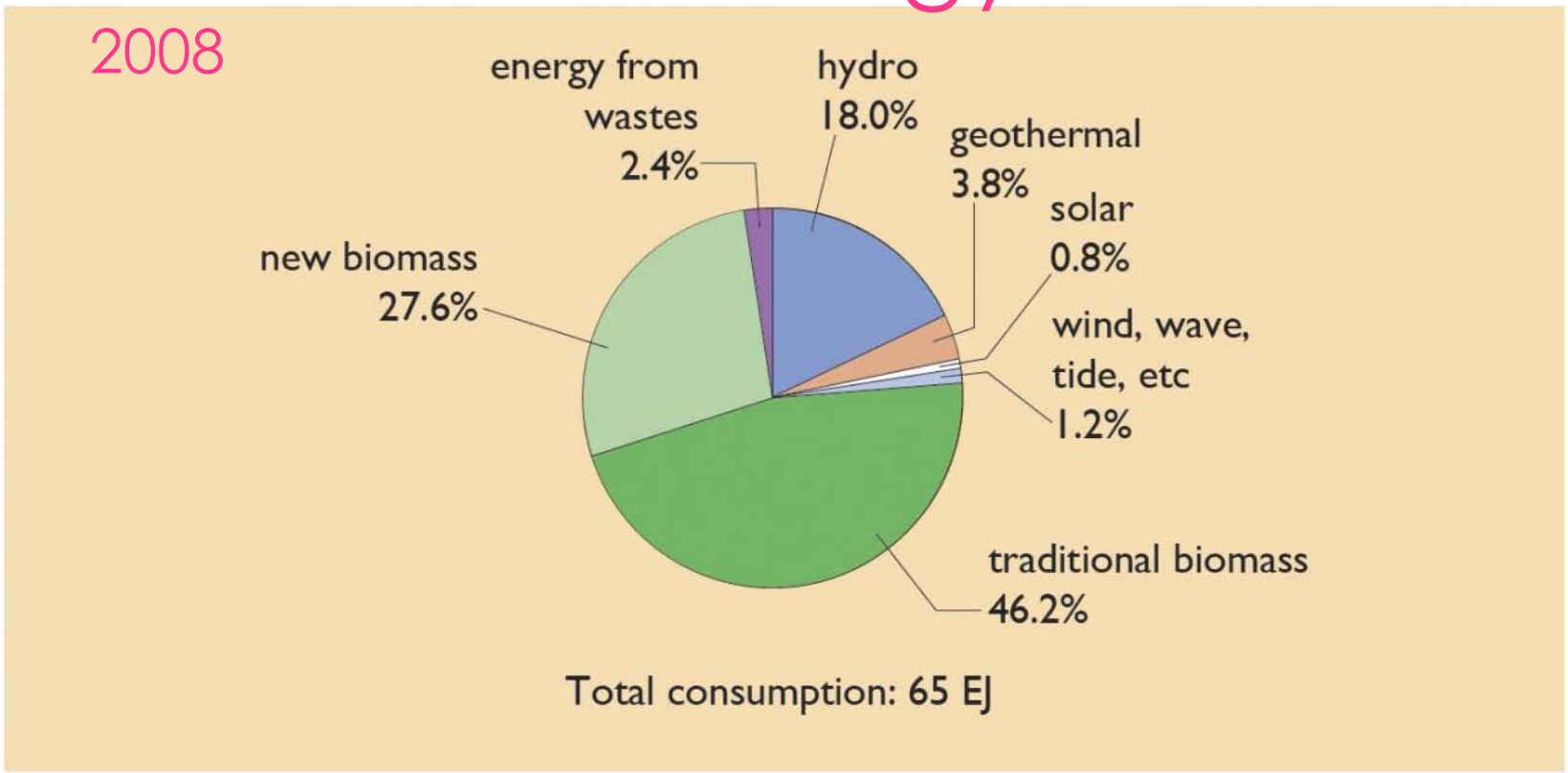
Total: about 502 EJ, equivalent to 12 billion tonnes of oil, or an average continuous rate of energy consumption of 15.9 TW.

Fossil Fuel (oil)



IEA World Energy Outlook Report (2010), International Energy Agency

Renewable Energy sources, 2008



EFFICIENCY AND CAPACITY

Efficiency = useful output/input x 100 (in %)

Capacity = actual energy output over a fixed period or time/ 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

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- Deca (dm) 10^{1} = 10
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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

1080 x 1920 pixels /image (frame) = 2.1million pixels/frame
= 0.021joules/frame
30 frames / second for video = 0.62 joules/sec = 0.62 watts

Or 37.2 joules/ 1 minute of video.