Energy and the Built Environment
CRP 470.004 /570.004

Christian E. Casillas

Lecture 1

Intro, Energy and Power, Units

Class outline

1. Introductions
2. Class logistics
3. Course overview
4. Discussion of readings

Break 1:15 – 1:30

4. Energy and Power
5. Units and conversions

Student Introductions

- Personal background
- Area of study/major
- Career interests
- Why you are taking this class?
- What topics are of primary interest
- Relevant course background (physics, engineering, building efficiency, etc)

Logistics

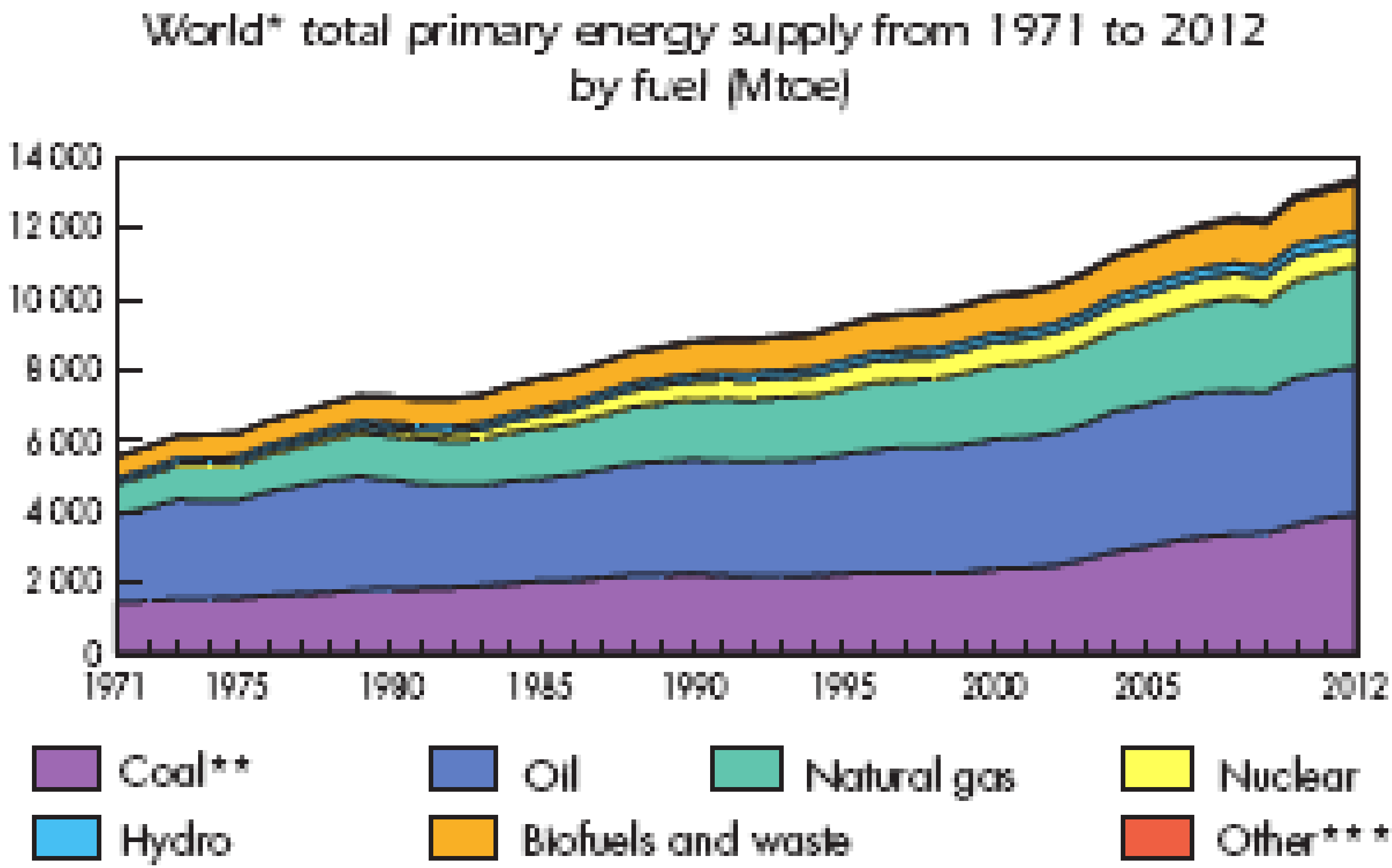
- **Meeting Time** Wednesdays, 12 – 2:30 pm, George Pearl Hall, room P130
- **Course format** The course will be composed of lectures and discussions, supplemented by weekly reading. There will be 4-5 homework sets that will be assigned during the first half of the course.
- **Grading** Problem sets – 20%, Midterm – 15%, Final – 20%, Project – 30%, Participation – 15%
- **Reading** The exact course content and readings will be posted at least 1 week in advance of class. All readings will be provided online, and should be completed before class. Student pairs will be responsible for leading discussion of reading each week. This will be a significant part of class participation.
- **Problem Sets** There will be 4-5 problem sets. The first one will be handed out on 1/21 and will be due 1/28.

Logistics

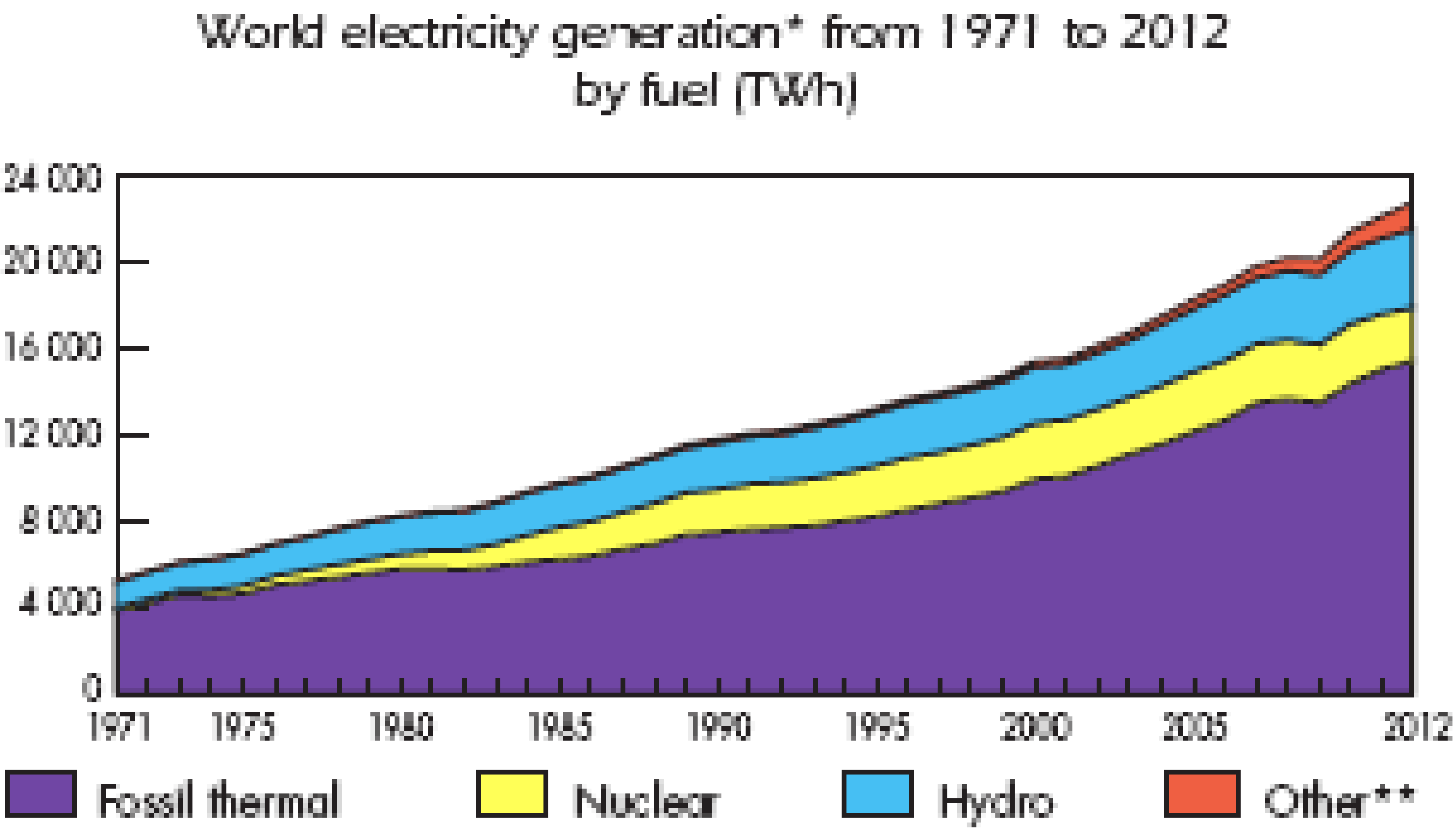
- **Attendance Policy** Regular and punctual attendance is required. UNM Pathfinder policies apply, which in part means instructor drops based on non-attendance are possible. This policy applies regardless of the grading option you have chosen.
- **Cell Phones and Technology** As a matter of courtesy, please turn off cell phones and other communication and entertainment devices prior to the beginning of class
- **Office Hours** Wednesdays, before or after class. By appointment.
- **Contact** cecasillas@gmail.com
- **NOTE:** Class on Wed 1/28 will end at 1:30. Are students available to come before 12 ?

Outline of topics (subject to slight modification)

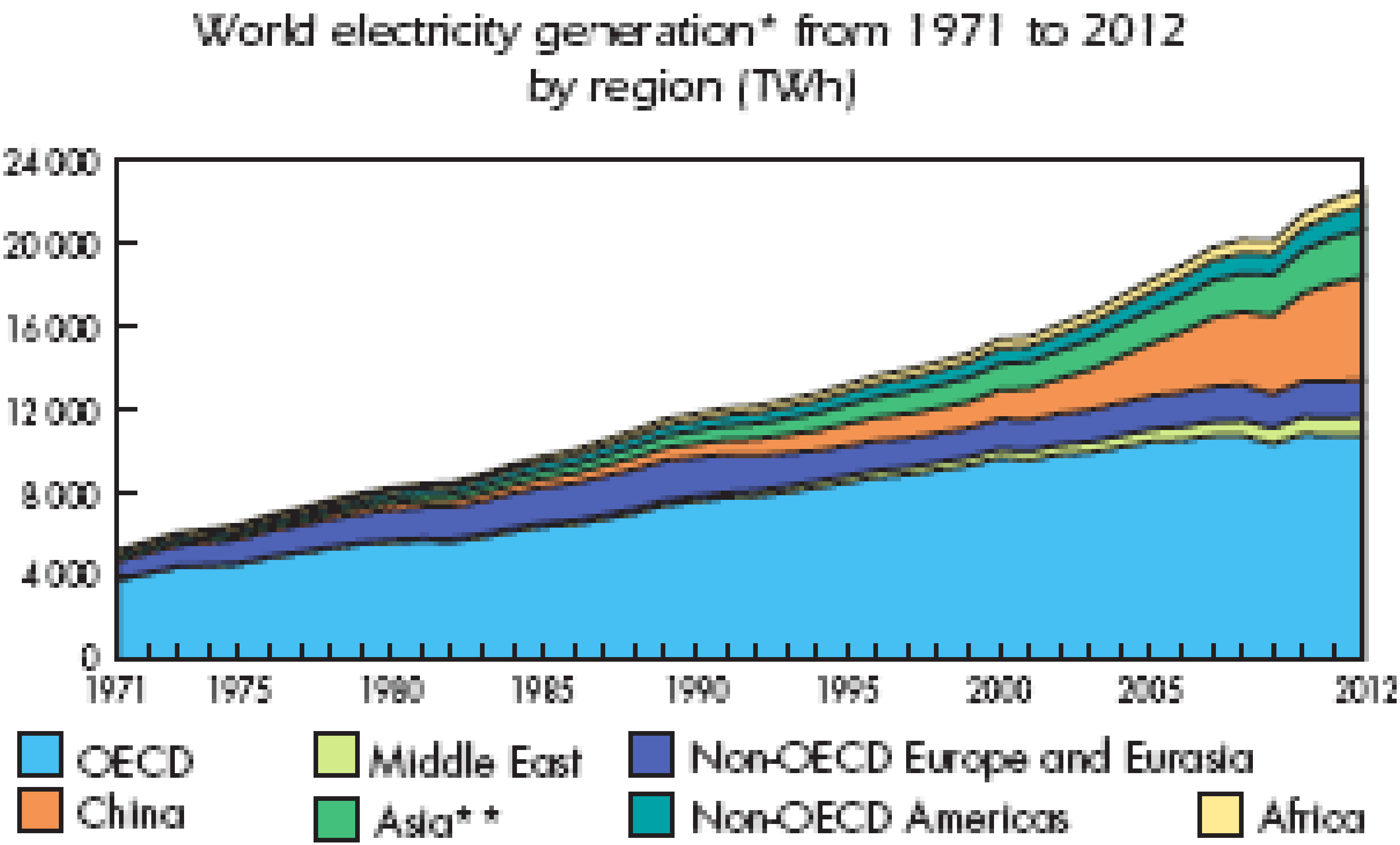
Week	Topics	Key Concepts
1	Energy and Power	Units, conversions, and analysis Back of the envelope calculations
2	Energy Industry	Energy Economics, Energy Efficiency, Life-cycle Assessment
3	Energy Use	Breakdown of energy use by country Generation and transportation use in the US
4	Science of heat and power	Combustion and emissions Thermodynamics basics
5	Electricity	Types of electricity generation Coal, oil, and natural gas Solar, wind, hydro, and biomass
6	Energy use in urban environments	Emissions Transportation, industry, residences Food production and waste treatment
7-8	Energy use in buildings	Heating, cooling, and lighting in buildings Fundamentals of heat transfer Energy efficiency: lighting and motors/pumps Examples of low energy use buildings
9	Energy and the environment	Metrics of sustainability Emissions and climate change
10-11	Energy policies and the built environment	Regulatory approaches vs Market mechanisms LEED, housing density, energy efficiency, water use, household solar.
12-14	Impacting energy use in the built environment – group projects	Class will choose several contemporary energy issues in their communities, and work together in small groups (2-3) to 1) develop a quantitative analysis of the issue, which will include data collection and 2) propose a solution, which might include public awareness campaign, or proposed policy change.



Source: IEA, Key Statistics, 2014



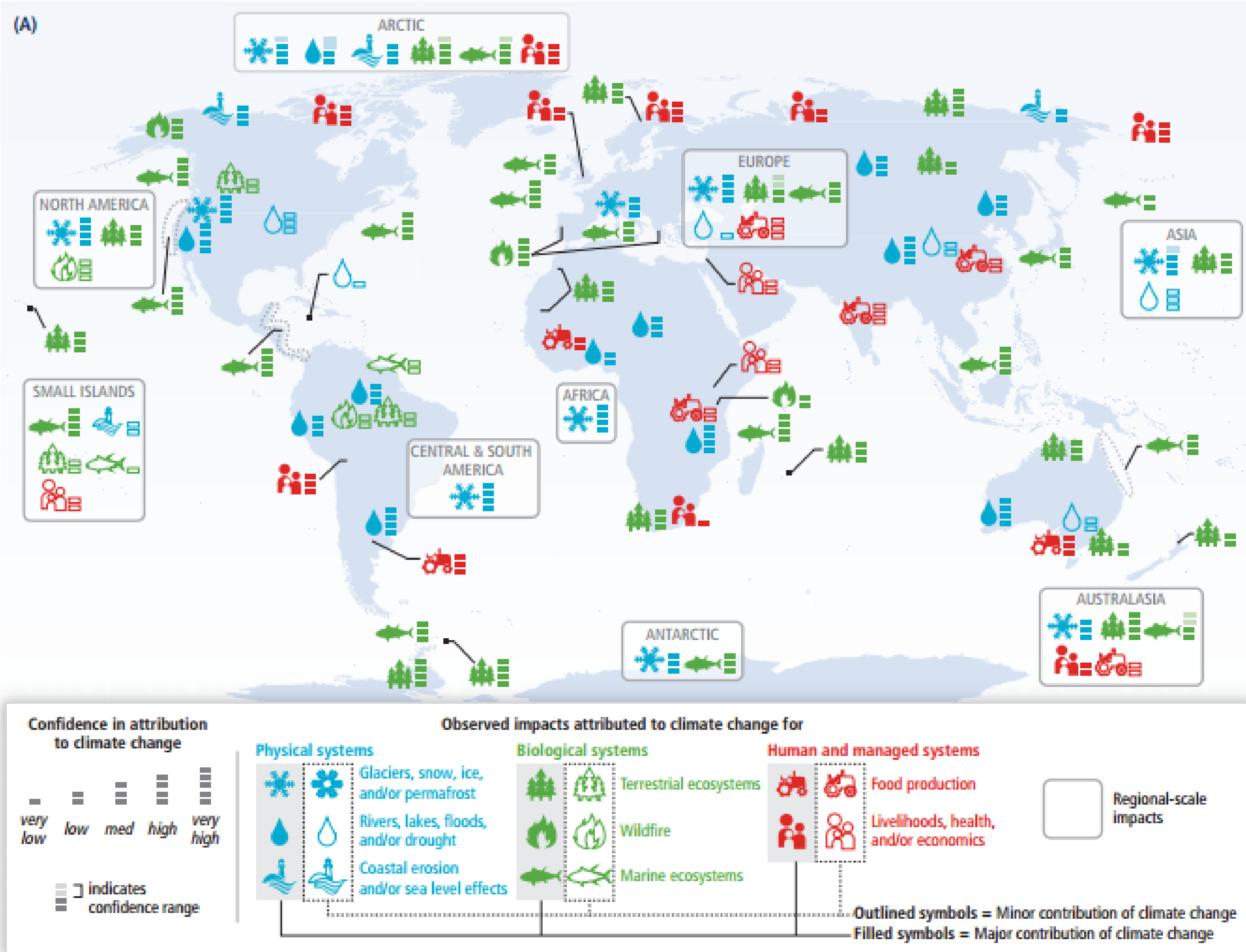
Source: IEA, Key Statistics, 2014



Source: IEA, Key Statistics, 2014

Climate change

- Human influence has been detected in warming of the atmosphere and the ocean, in changes in the global water cycle, in reductions in snow and ice, in global mean sea level rise, and in changes in some climate extremes...It is extremely likely that human influence has been the dominant cause of the observed warming since the mid-20th century. {10.3–10.6, 10.9}
- Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions. {6, 11–14}
- Changes in the global water cycle in response to the warming over the 21st century will not be uniform. The contrast in precipitation between wet and dry regions and between wet and dry seasons will increase, although there may be regional exceptions
- The global ocean will continue to warm during the 21st century. Heat will penetrate from the surface to the deep ocean and affect ocean circulation. {11.3, 12.4}
- It is very likely that the Arctic sea ice cover will continue to shrink and thin and that Northern Hemisphere spring snow cover will decrease during the 21st century as global mean surface temperature rises. Global glacier volume will further decrease. {12.4, 13.4}
- Global mean sea level will continue to rise during the 21st century
- Most aspects of climate change will persist for many centuries even if emissions of CO2 are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO2. {12.5}
- Source: IPCC Summary for Policy Makers, 2013



Source: IPCC AR5, 2013

Energy and Power

Energy

Energy can be defined as the capacity to do work or to transfer heat.
Energy is usually classified into one of two general categories:

Kinetic Energy
(Energy of Motion)




Potential Energy
(Stored Energy)



Which of the above examples possess both kinetic and potential energy?

Units: Joule (J), kilowatt-hour (kWh), watt-hour (Wh), calorie,

Example of stored energy content

	kWh/kg	MJ/kg
dung	4.2	15
wood	4.4	16
charcoal	8.1	29
kerosene	12	43.2
petrol	13.3	48

1st Law of Thermodynamics

Energy cannot be created or destroyed, but only changed from one form to another.

*(**Thermodynamics** is the study of energy and its transformations)*

- In what form does earth receive most of its energy?
- Can you trace most of the energy 'sources' that we utilize back to one or two initial sources?
- In what form does earth lose most of its energy?

Example: conversion of energy

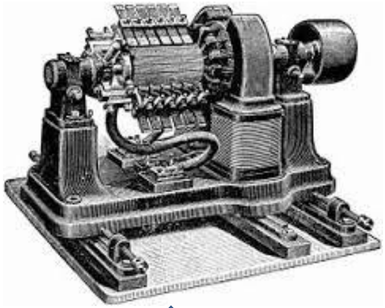
Fan

Kinetic energy

Electricity

Kinetic energy

Electricity Generator At Power House



Kinetic energy

Coal

Potential energy

Units

ENERGY

1 joule (J) = 1 kg m^2/sec^2 = 10^7 ergs = 0.2390 calories (cal)
1 joule (J) = 9.484 x 10^{-4} British thermal units (Btu)
1 joule (J) = 1 watt-second (Ws)
1 joule (J) = 6.242 x 10^{18} electron volts (eV)
1 joule (J) = 1 newton-meter (Nm)

1 kilowatt-hour (kWh) = 3.6 x 10^6 J = 3414 Btu

1 quad = 10^{15} Btu = 1.05 x 10^{18} J
1 Calorie = 1 kilocalorie (Kcal) = 10^3 cal
1 therm = 10^5 Btu
1 foot pound = 1.356 J
1 kiloton of TNT (KT) = 4.2 x 10^{12} J

POWER

1 watt (W) = 1 joule/second = 3.6 kJ/hour = 31.5 MJ/year
1 horsepower (hp) = 0.764 kilowatts (kW)

- IEA energy conversion calculator: http://www.iea.org/Textbase/stats/unit.asp

Units

- Nearly every country in the world (other than the U.S.) uses the international system of units (Système International d'Unités) , SI or metric system, for engineering and commerce.
- Almost all scientific research is carried out using the SI system. The SI system is based on the kilogram, meter, and second.
- The units of measure used in commerce in the USA is the British Imperial System (hardly even used in Great Britain anymore!) based on the foot, pound, and second.
- Although resolutions for conversion to SI units were passed by Congress more than 20 years ago, we are still a long way away from adopting SI units as the sole standard of measure in the U.S.

UNIT	Metric System	British Imperial System
FORCE	Newton (N)	Pound (lb)
ENERGY	Joule (J) watt-hour (Wh) kilowatt-hour (kWh)	British Thermal Unit (BTU)
POWER	watt (W) kilowatt (kW)	BTU/hr BTU/sec

Power

- Power is the **rate** at which energy is converted from one form to another
- It is used to tell us how quickly a device can *generate* power, and how quickly it can *consume* power
- Power is measured in SI units called watts (W) or kilowatts (1000 Watts). A watt is defined as 1 J/s.

Examples of generation capacity

1 horsepower (hp) = 746 W

130 hp = 97 kW

25 W

5 kW

2 GW

Examples of consumption (loads)

15 W

60 W

30 W

1 kW

2 kW

3.5 kW

Relationship between Energy and Power

Power = Energy / Time

1 watt = 1 joule / second

1 W = 1 Wh / hr

1 kW = 1 kWh / hr

Energy = Power x Time

1 joule = 1 watt x second

1 Wh = 1 W x hr

1 kWh = 1 kW x hr

Examples

1. A light bulb has a rating of 50 W. If the light is turned on for 3 hours, how much energy was changed from electricity into____and ____?
2. How many hours will it take for a 100 W light bulb to consume 1 kWh of electricity?
3. A solar panel has a rating of 50W under direct sunlight. If it receives direct sunlight for 3 hours, how much electricity will it generate? How many hours would this be able to power 4 LED light bulbs, of 3W each?

Example

- How many Joules are in a kWh of energy?
  - Hint: 1 kWh = 1000 Wh, and 1 W = 1 J/s

Example

- How many Joules are in a kWh of energy?
  - Hint: 1 kWh = 1000 Wh, and 1 W = 1 J/s
  - 1 kWh = 1000 Wh = 1000 J/s x h
  - 1000 J/s x 1 h x 60 min/ 1 h x 60 sec / 1 min
  - 3600000 J = 3.6 x 10^6 J