ENERGY:
Part I: Definition of the Problem...

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Sci-102 Lecture
What is energy?

- Defined as the ability to do work.

- If an object or organism does work (exerts a force over a distance to move an object) the object or organism uses energy.
Nature of Energy

• Energy is all around you!
  – You can hear energy as sound.
  – You can see energy as light.
  – And you can feel it as wind.
Living organisms need energy for growth and movement.
Nature of Energy

• Energy is involved when:
  – a bird flies.
  – a bomb explodes.
  – rain falls from the sky.
  – electricity flows in a wire.
What are the different Forms of Energy?

- The five main forms of energy are:
  - Heat
  - Chemical
  - Electromagnetic
  - Nuclear
  - Mechanical

ULTIMATE ENERGY SOURCE IS SUN...
Heat Energy

• The internal motion of the atoms is called heat energy, because moving particles produce heat.
• Heat energy can be produced by friction.
• Heat energy causes changes in temperature and phase of any form of matter.
Chemical Energy

- Chemical Energy is required to bond atoms together.
- And when bonds are broken, energy is released.

ATP is the chemical human use for energy

ULTIMATE ENERGY SOURCE IS SUN...
Chemical Energy

- Fuel and food are forms of stored chemical energy.
Electromagnetic Energy

- Power lines carry electromagnetic energy into your home in the form of electricity.
Electromagnetic Energy

• Light is a form of electromagnetic energy.

• Each color of light (ROYGBIV) represents a different amount of electromagnetic energy.

• Electromagnetic Energy is also carried by X-rays, radio waves, and laser light.
Nuclear Energy

- The nucleus of an atom is the source of nuclear energy.
Nuclear Energy

- Nuclear energy is the most concentrated form of energy.

- The sun’s energy is produced from a nuclear fusion reaction in which hydrogen nuclei fuse to form helium nuclei.

- When the nucleus splits (fission), nuclear energy is released in the form of heat energy and light energy.
Mechanical Energy

• When work is done to an object, it acquires energy. The energy it acquires is known as mechanical energy.

• When you kick a football, you give mechanical energy to the football to make it move.
The Problem: Energy Conversion and by-products

• All forms of energy can be converted into usable forms.
  – The sun’s energy through solar cells can be converted directly into electricity.
  – Green plants convert the sun’s energy (electromagnetic) into starches and sugars (chemical energy).
  – In a battery, chemical energy is converted into electromagnetic energy.
The Problem: Energy Conversion and by-products

Chemical $\rightarrow$ Heat $\rightarrow$ Mechanical

- In an automobile engine, fuel is burned to convert chemical energy into heat energy. The heat energy is then changed into mechanical energy.
Where do we get that ENERGY?

The Role of Renewable Energy in the Nation’s Energy Supply, 2009

- Total = 94.578 Quadrillion Btu
- Total = 7.744 Quadrillion Btu

- Petroleum 37%
- Natural Gas 25%
- Coal 21%
- Nuclear Electric Power 9%
- Renewable Energy 8%
- Biofuels 20%
- Wind 9%
- Wood 24%
- Hydropower 35%
- Solar 1%
- Geothermal 5%
- Biomass waste 6%

Note: Sum of components may not equal 100% due to independent rounding.
Fossil Fuels: Petroleum, Natural Gas, Coal, etc.

We call them fossil fuels because they are buried dead organisms...
BY-PRODUCTS of Burning Fossil Fuels

The WORST player is $\text{CO}_2$ and the others such as $\text{SO}_2$, and $\text{NO}_x$.

$\text{CO}_2$ is accepted as the reason of GLOBAL WARMING.
Global Warming
Due to fossil fuel burning for energy...

Hence, we need to find better alternative and sustainable energy sources for high and increasing energy demand...
Alternative sustainable energy sources:

Nuclear Energy
Hydroelectric Energy
Solar (Sun) Energy
Wind Energy
Biofuels
ENERGY:
Part II: Solutions...
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First and The Best Solution?

Consume less...
Think twice...
Use more efficient devices...
Recycle no matter what...
Recycle everything you can...
Examples for personal saving energy...

- Binlarınızı yalıtın
- Tasarruflu ampül kullanın
- Gereksizse sönürün
- Enerji verimli cihazları kullanın
- Elektronik cihazlarınızı stand-by da bırakmayın düğmesinden kapatın
- Toplu taşıma araçlarını kullanın
- Kısa mesafeleri yürüyün
Examples...

Energy needed for a person travelling from *Istanbul* to *Ankara* (~600 km)

by car: ~60 liters of gasoline for a person
by bus: ~10 liters of gasoline for a person
by plane: ~20 liters of gasoline for a person
Examples for better energy conversion: Fuel cells (using hydrogen to waste as fuel)

✓ It is the conversion device which converts *electromagnetic energy* of fuel into *electricity*. 
Alternative sustainable energy sources:

Nuclear Energy
Hydroelectric Energy
Solar (Sun) Energy
Wind Energy
Biofuels
Nuclear Energy

• Nuclear energy is the most concentrated form of energy.

• When the nucleus splits (fission), nuclear energy is released in the form of heat energy and light energy.
It is the conversion of heat energy of fuel (Uranium) into mechanical then electricity.
Nuclear Energy: Dangerous!!!

- Once upon a time – nuclear power was seen as the answer. Huge amounts of power could be produced from a small amount of uranium.
- However, it was not well known that it produced radioactive waste, and there is no secure place to store.
- Public confidence has also been shattered by the explosions at Chernobyl, Russia in 1986 and at Fukushima, Japan resulting from tsunami after earthquake.
Advantages of using natural energy sources

- They are inexhaustible – they will always be available – they are renewable
- They are clean and will not damage the Earth
- There are several types – so one or more of them is present in each country
- Most natural sources can be used on a small scale and serve local needs therefore cutting costs of transmitting the energy
Alternative: HES (HydroElectric System)

It is the conversion of mechanical energy of water into electricity.
**HES:**

**Benefits...**

Environmental Benefits of Hydro

- No operational greenhouse gas emissions
- Savings (kg of CO$_2$ per MWh of electricity):
  - Coal 1000 kg
  - Oil 800 kg
  - Gas 400 kg
- No SO$_2$ or NO$_X$

**Disadvantages**

The loss of land under the reservoir.

- Interference with the transport of sediment by the dam.
- Problems associated with the reservoir.
  - Climatic and seismic effects.
  - Impact on aquatic ecosystems, flora and fauna.
Alternative: Tidal wave energy

- It is the conversion of mechanical energy of waves into electricity.
Alternative: Water flow energy

- It is the conversion of *mechanical energy* of flow into *electricity*.
Alternative: Harvesting Solar Energy

• Two types of harvesting:
  – Solar Thermal Systems
  – Solar Photovoltaic (PV)
Solar (Sun) Energy: Photovoltaic Electricity Generation

It is the conversion of electromagnetic energy of sunlight into directly electricity.
PV Solar Energy System

Typical output of a module (~30 cells) is ≈ 15 V, with 1.5 A current
PHOTOVOLTAIC MATERIALS: SILICON

SOLAR CELLS

Silicon nanocrystals are efficient for solar cells because they can produce two or three electrons per photon of high energy sunlight and they can wring two electrons from each photon of incoming light.

Silicon nanocrystals could lead to a new type of solar cell that is both cheap and more than twice efficient.
Silicon Crystalline Technology

- Currently makes up 86% of PV market
- Very stable with module efficiencies 10-16%

Mono crystalline PV Cells
- Made using saw-cut from single cylindrical crystal of Si
- Operating efficiency up to 15%

Multi Crystalline PV Cells
- Cast from ingot of melted and re-crystallized silicon
- Cell efficiency ~12%
- Accounts for 90% of crystalline Si market
Applications of PVs: Building Integrated systems

- **Water Pumping**: PV powered pumping systems are excellent, simple, reliable – life 20 yrs
- **Commercial Lighting**: PV powered lighting systems are reliable and low cost alternative. Security, billboard sign, area, and outdoor lighting are all viable applications for PV
- **Consumer electronics**: Solar powered watches, calculators, and cameras are all everyday applications for PV technologies.
- **Telecommunications**
- **Residential Power**: A residence located more than a mile from the electric grid can install a PV system more inexpensively than extending the electric grid
  (Over 500,000 homes worldwide use PV power as their only source of electricity)
However ....

- If a location is not currently connected to the “grid”, it is less expensive to install PV panels than to either extend the grid or set up small-scale electricity production.

- PV: Best suited for remote site applications having moderate/small power requirements consuming applications even when the grid is in existence.

- Isolated mountaintops and other rural areas are ideal for stand-alone PV systems where maintenance and power accessibility makes PV the ideal technology.
Alternative: Wind Energy

✓ It is the harvesting of mechanical energy of wind into electricity.
Wind: Uneven heating of earth’s surface and rotation

- Huge potential exists
  - Available potential can contribute five times the world energy demand
- 0.4% contribution to total energy
Wind Turbine Evolution

Used for

- Pumping water
- Grinding grain

Mainly used for

- Generating Electricity
Problems of Wind Energy

3 main problems: Noise, Bird killing, effects on living organisms.

Solution approaches:
• Noisy: build turbines far from residential areas
• Bird warnings: noise, visuals.
• Decrease activities on mating season of mammals
**Alternative: Biomass Energy**

- Biomass technology today serves many markets that were developed with fossil fuels and modestly reduces their use.

- Uses - Industrial process heat and steam, Electrical power generation, Transportation fuels (ethanol and biodiesel) and other products.

- Primary focus of the Biomass Program – development of advanced technologies.
Bio-refinery

- A facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass.

- Analogous to today's petroleum refineries

- It is based on the “Sugar Platform” and the “Thermochemical Platform”
Liquid Fuel Technology: Biodiesel

- Made by transforming animal fat or vegetable oil with alcohol.
- Fuel is made from rapeseed (canola) oil or soybean oil or recycled restaurant grease.
- Directly substituted for diesel either as neat fuel or as an oxygenate additive.
Solar electricity prices are today, around 30 cents/kWh, but still 2-5 times average Residential electricity use.
Conclusion: The Best Solution?

Consume less...
Think twice...
Use more efficient devices...
Recycle no matter what...