Energy Systems – I

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Course Website: https://piazza.com/iitk.ac.in/firstsemester2017/me301a

Course Overview

Class Schedule

Day	Monday	Friday
Time	11:00AM to 11:50 AM	11:00AM to 11:50 AM
Venue	L-3	L-3

Marks Distribution

Total Marks	Distribution
Attendance	5%
4 HWs	10%
4 Announced Quizzes	15%
Mid Semester Exam	25%
End Semester Exam	45%

Course Content

- Fuels and combustion: stoichiometry, enthalpy of formation, enthalpy of reaction, adiabatic flame temperature, chemical equilibrium, chemical kinetics, quasi steady state assumption, partial equilibrium
- Internal Combustion Engine: Classifications, Real Cycles, Combustion, Emissions, Performance and Testing.
- Power Plant Technology: Rankine cycle, reheat, regeneration, supercritical cycle, binary and combined cycles, equipment in a power plant, non-conventional/renewable power plants, energy storage.
- Refrigeration and Air-conditioning Systems: reverse Carnot cycle, vapor compression refrigeration cycle, cascading, multi-staging, absorption refrigeration cycle, air conditioning, dew point, WBT, psychometric processes, winter and summer air conditioning, applications

Recommended Books

- SR Turns – Introduction to Combustion
- Heywood – Internal Combustion Engines
- P K Nag – Power Plant Engineering
- CP Arora – Refrigeration and air- conditioning

Additional resource materials: Will be supplied from time to time in the class/ course website. Questions may be asked from these materials.

Introduction of Energy

- Energy creates the power to drive tools and machines, to process materials into manufactured products and to create structures.
- Power is generated from nonrenewable energy sources such as coal, oil, and gas, or can be generated from natural resources such as geothermal, solar, and gravitational energies.
- Energy can be defined as the capacity or ability to do the work. Any physical activity in this world is caused due to the flow of energy in one form to another form.
- The combination of energy and matter make up the universe. Matter is substance, and energy is the mover of substance.

Historical Overview of Energy

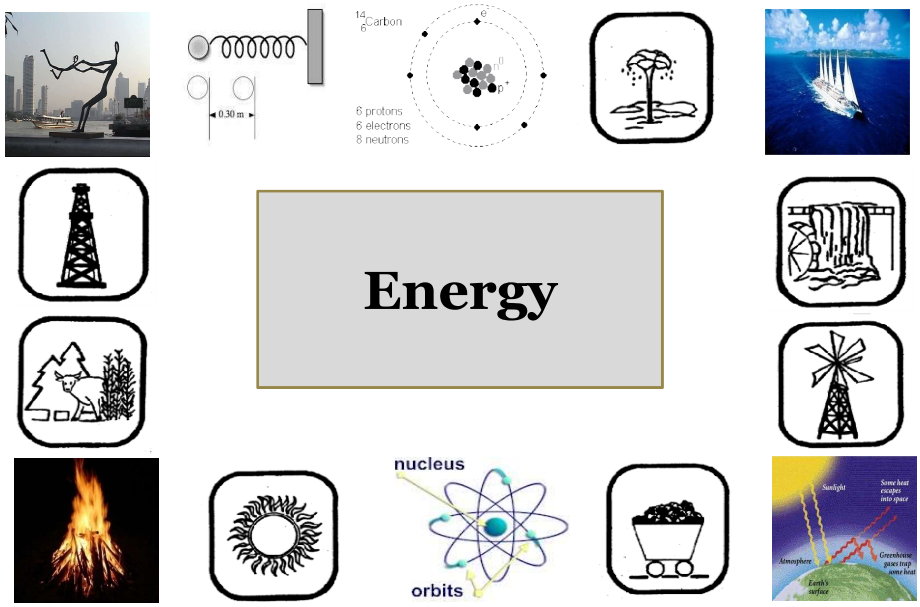
- The word energy derives from the Greek word en-ergon, which means “activity”. It is also defined as the ‘in-work’ or ‘work content’.
- Energy is subject to the law of conservation. According to this law, energy can neither be created (produced) nor destroyed by itself. It can only be transformed.
- The concept of energy emerged out of the idea of vis viva (living force), which Gottfried Leibniz defined as the product of the mass of an object and its velocity squared; he believed that total vis viva was conserved.

Grades of Energy

- This energy efficiency rating is based on nature, availability and total base cost involved in its exploration.
- **A-C** grade energy comes under high grade energy due to its lower running cost and higher efficiency.
- **D-E** grade energy comes under medium grade energy due to either high running cost or lower efficiency .
- **F-G** grade energy comes under low grade energy due to its higher running cost and lower efficiency.

Reference: US conference report, EU Directive 2002/91/EC

Energy Chart



Classification of Energy

Energy sources are broadly classified into three types:

(1) On the basis of usability of energy

(a) Primary Resources: Available resources in raw form as petroleum, uranium etc.

(b) Intermediate Resources: Modified form of primary resources that can not be directly used

(c) Secondary Resources: End user form of energy that can be directly utilized as electrical energy, thermal energy etc.

(2) On the basis of traditional Use

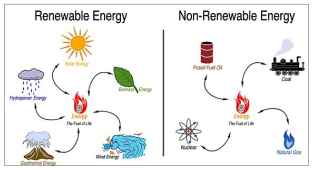
(a) Conventional Energy: Traditionally used energy resources as fossil fuels, nuclear.

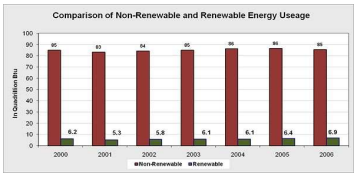
(b) Non Conventional Energy: Other than conventional resources as solar, wind , hydro, etc.

(3) Based on availability

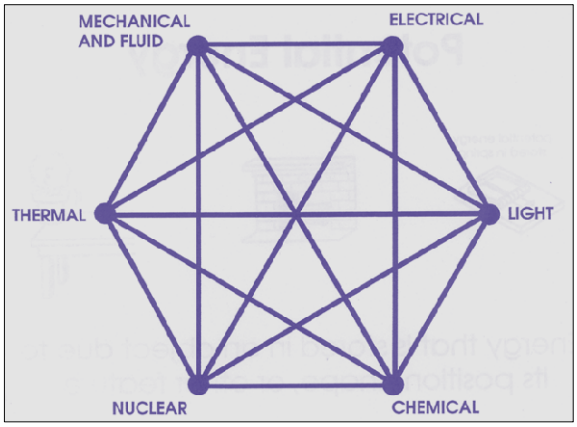
(a) Renewable Energy: It is the energy obtained from the repetitive currents of energy occurring in the natural environment.

(b) Non-renewable Energy: It is energy obtained from static deposit s of any sources that remains bound unless exploited by human interaction. (These are available as reserves or deposits)





Forms of Energy



- All forms of energy are related.
- Each form can be converted into any other form.
- Most important is that one can not create or destroy energy, one can only change its form.
- The ability of energy to do useful functions is realized, when energy is converted from one form to another via an energy conversion device.

Energy Conversion Matrix

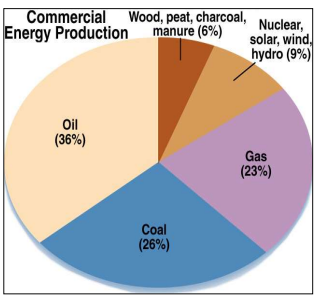
Energy Conversion Matrix

FROM ⇓ TO ⇒	Thermal	Mechanical	Acoustical	Chemical	Electrical & Magnetic	Electromagnetic Radiation	Nuclear	Elastic	Gravitational
Thermal	• Heat exchangers • Thermal conduction	• Steam turbine • Heat engines • Wind • Radiometer		• Endothermic reaction • "Cold packs"	• Thermo-electric effect • Thermionic emission	• Thermocouple • Incandescence	•Thermionic emission		• Convection • Hot air balloon • Popcorn
Mechanical	• Refrigerator • Heat pump • Brakes	• Gear box			• Wind turbine • Generator • Microphone	• X-ray tube		• Wishbone • Inflating a balloon	• Pendelum • B-ball pop fly
Chemical	• Furnace • Combustion • Exothermic reaction • "Hot packs"	• Combustion engines • Muscle action • Dynamite	• Chemical explosion	• Glycolysis • ADP to ATP • AMP to ADP	• Fuel cell • Chemical battery	• Bio - luminescence • Chemical lasers • Fireflies • Glowsticks		• Combustion expanding gas	• Rocket
Electrical & Magnetic	• Electric heater • Toaster	• Motor • Thunder		• Electrolysis • Electro-plating • Rechargeable batteries	• Transformer	• Lamp • LED • Radio broadcast		• Electrostriction • Magneto-striction	• Elevator
Electromagnetic Radiation	• Solar collector • Microwave oven	• Photoelectric effect		• Plants • Photography • Sunburn	• Solar cell	• Photo-luminescence			• Microwave popcorn
Nuclear	• Nuclear bomb • Fission reactor	• Nuclear bomb	• Nuclear bomb	• Nuclear bomb	• Nuclear bomb • Nuclear generator	• Nuclear bomb • Stars	• Nuclear bomb • Breeder reactor		• Nuclear propulsion
Elastic	• Compression of gas refrigerator	• Spring driven wristwatch • Bow & arrow			• Peizo-electric effect	• Peizo-luminescence		• Newton's cradle	• Trampoline • Toaster
Gravitational	• Contraction of a protostar	• Flowing water • Pendelum			• Hydropower		• Formation of a neutron star	• diving board	• One period of satellite orbit

Reference: http://www.eoearth.org/files/186001_186100/186073/energyconversionmatrix.png

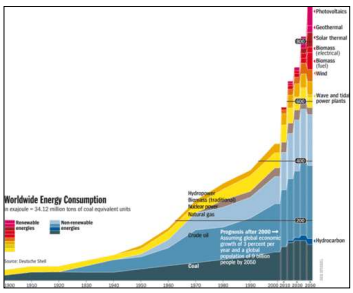
Fossil Fuels: Introduction

- Fossil fuels are formed by natural processes such as anaerobic decomposition of buried dead organisms. The age of the organisms and their resulting fossil fuels is typically millions of years, and sometimes exceeds 650 million years.
- Crude Oil contains many hydrocarbons which are fraction recrystalized at different temperatures.
- In oil refineries, diesel, kerosene and gasoline is distilled from the crude oil which are the basic fossil fuels used in industries and vehicles.
- Fossil fuels contain high percentages of carbon. General formula of fossil fuel can be given as $C_xH_yO_z$.
- Most of the world's energy is derived from Fossil Fuels. Fossil fuels are the 85% of the world commercial energy.
- The Major usage of Fossil fuels are:
  - ✓ Transportation (26.5%)
  - ✓ Industrial (32.5%)
  - ✓ Residential/Commercial (41.0%)
  - ✓ Electrical Power (40.7%)
- Top three sources of Fossil fuels are:
  - (a) Oil: Liquid form of non renewable fuel (Crude oil)
  - (b) Coal: Solid form of non renewable fuel
  - (c) Natural Gas: Gaseous form of non renewable fuel

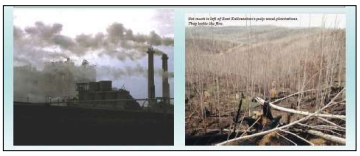


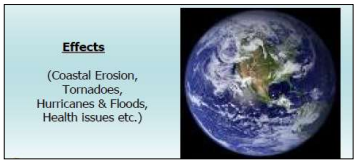
Why is this such a big deal environmentally?

- Fossil fuels have to be extracted from the Earth or the Ocean; often there are environmental consequences from extracting fossil fuels (e.g. strip mining, oil spills, etc.)
- Fossil fuels are pollutants, especially crude oil. Major oil leaks create an environmental/economic/political nightmare.
- Burning fossil fuels releases greenhouse gases (CO_2, Methane, etc.), which have been associated with global climate change.
- Burning fossil fuels releases several pollutants:
  - ✓Coal burning releases sulfates in the air that produce acid rain
  - ✓Burning of gasoline releases CO_2, volatile organic compounds, nitric oxides, and ozone.



Increased demand of renewable fuels and its consumption





Reference: http://www.cpe.mrt

Renewable Energy Resources: Solution of energy crisis

- Renewable energy uses energy sources that are continually replenished by nature—the sun, the wind, water, the Earth's heat, and plants.
- The renewable energy is ready to harnessed, inexhaustible and more importantly it is clean alternative to fossil fuel .
- Today we primarily use fossil fuels but we have a limited supply of these fuels on the Earth. We are using them much more rapidly than they are being created. Eventually, they will run out.
- Burning of fossil fuel, such as coal, oil and natural gas will cause green house effect, rise in sea effect, impact on our ecosystem and agriculture production, and most commonly pollutants into atmosphere.

Advantages

- Available in unlimited extent.
- Very low operational cost.
- Very low maintenance cost.
- They cause no or very little pollution

Disadvantages

- High capital cost.
- Low output in terms of power and efficiency.
- Conveyance from one place to other is difficult.
- Storage is difficult.