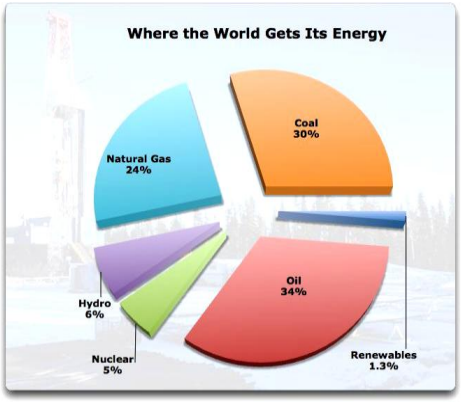
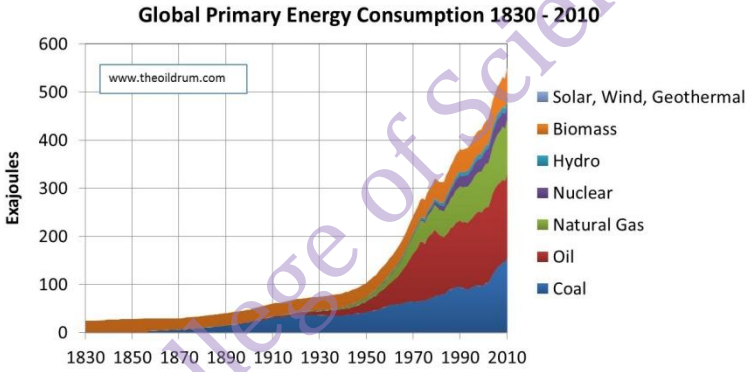
Energy Resources

Types of energy sources

Energy sources can be classified into two types: nonrenewable and renewable. Nonrenewable resources, such as fossil fuels and nuclear material, are removed from the earth and can be depleted. These resources have been the most used type of energy in the modern era. The US, has less than 6% of world population consumes almost 33% of the world energy (exajoules = 10^{-18} J).



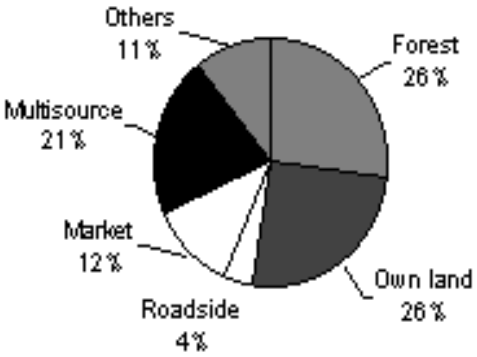


Renewable resources, such as firewood, wind, water, solar, and geothermal, come from sources that regenerate as fast as they are consumed and are continuously available. Some, such as biofuel produced from food crops and other plants, are replenished every growing season. In the early part of the twenty-first century, renewable sources have become more popular as nonrenewable sources have begun to be depleted.

A. Firewood

Firewood is any wooden material that is gathered and used for fuel. Generally, firewood is not highly processed and is in some sort of recognizable log or branch form. Firewood is a renewable resource. However, demand for this fuel can outpace its ability to regenerate on local and regional level. For example in some places in the world and through history, the demand has led to desertification. The new study confirms consumption levels from recent years. Total consumption in 2009 was 25.1 PJ (Petajoules= 10^{-15} J).

Fig. 2: Source of Firewood



By Prof. S D Rathod
Dept. of Zoology
B N Bandodkar College of Science, Thane, India

VPM's B N Bandodkar College of Science, Thane

The moisture content of firewood determines how it burns and how much heat is released. Unseasoned (green) wood moisture content varies by the species; green wood may weigh 70 to 100 percent more than seasoned wood due to water content. Fuelwood is mainly used for cooking and horticulture residues from the coconut trees are used for water heating purposes.

Figure 1: Break-down of firewood consumption in TJ (10^{-12}J).

Many households rely on more than one source and the belief that firewood is free resource is no more true for many in the area because about 12% of the households purchase firewood from market. Commercialization of firewood is an indicator of difficult access in the area, though there are some social reasons for this. Firewood is also used for converting it to charcoal for various purposes.

B. Fossil fuel

Fuel	Proven energy reserves in ZJ (end of 2009)
Coal	19.8
Oil	8.1
Gas	8.1

ZJ = zettajoule (10^{-21} J)

The proven fossil fuel numbers are not full proof because of the scanty knowledge about the earths crust and about 1/3rd available sources are unapproachable in the sea-bed since they are deeper than 3 km.

1. **Coal:** Coal is the most abundant and burned fossil fuel and is available in lignite, bituminous and anthracite form. This was the fuel that launched the industrial revolution and has continued to grow in use; China, which already has many of the world's most polluted cities. Use of coal is a sort of global warming concerns and other pollutants. According to the International Energy Agency the proven reserves of coal are around 909 billion tonnes, which could sustain the current production rate for 155 years, although at a 5% growth per annum this would be reduced to 45 years, or until 2051. In the United States, 49% of electricity generation comes from burning coal. India

Country	Reserve	Country	Reserve
USSR	5.7 TT (trillion ton)	W Germany	287 BT
USA	1.5 TT	UK & Poland	165 BT
China	1.0 TT	Australia	108 BT

VPM's B N Bandodkar College of Science, Thane

2. **Oil and gas:** It is estimated that there may be 57 ZJ of oil reserves on Earth (although estimates

Changes to proved reserves, 2010		
World Reserves	Crude oil billion barrels	Natural gas trillion cubic feet
Reserves at December 31, 2009	22.3	283.9
Total discoveries	2.1	48.9

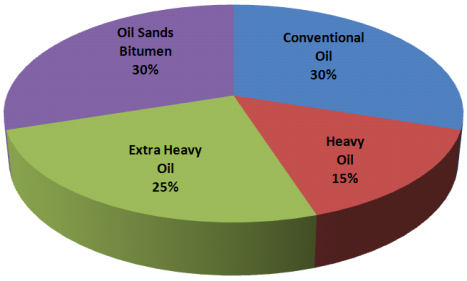
Major Refineries in India

Plant	Location/Production (Barrels/Day)		
Reliance Petroleum	Jamnagar (660,000)		
IOC	Koyali (185,100)	Mathura (156,000)	Panipat (120,000)
Mangalore Refinery and Petrochemicals Ltd	Mangalore (180,000)		
Hindustan Petroleum Corporation	Vishakapatnam (164,250)	Mahul (132,000).	
Kochi Refineries Ltd	Ambalamugal (152,000)		
Chennai Petroleum Corporation	Madras (130,660)		
Bharat Petroleum Company Ltd	Mahul (120,000)		

vary from a low of 8 ZJ. The estimate may be stretched to 110 ZJ including estimates for unconventional sources such as tar sands and oil shale which is not readily usable. Natural gas is another energy source USa is largest producer and consumer of NG. NG is available in mixture of propane, ethane, **methane** and butane.

The International Energy Agency (IEA) believes that oil will peak between "2013 and 2037" and Saudi Arabia, Kuwait, Iraq and Iran, four countries with much of the world are known reserves. The world holds enough proved reserves for 40 years of supply and at least 60 years of gas supply at current consumption rates. Top 7 oil reserves owner countries according to OPEC (*Organization of the Petroleum Exporting Countries*) with

Total World Oil Reserves



VPM's B N Bandodkar College of Science, Thane

descending order are Venezuela, Saudi Arabia, Canada, Iran, Iraq, Kuwait and United Arab Emirates.

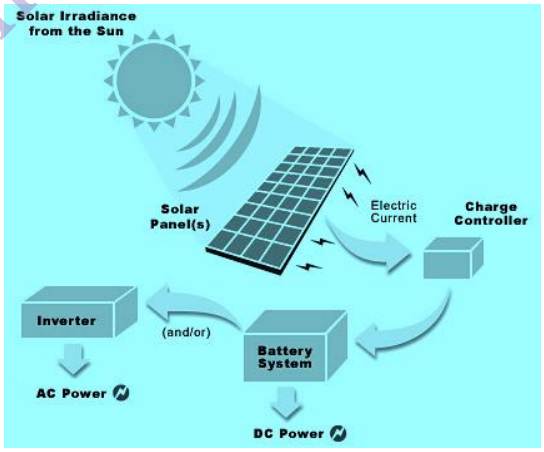
Oil shale, also known as **kerogen shale**, is an organic-rich fine-grained sedimentary rock containing **kerogen** from which liquid hydrocarbons called shale oil can be produced. Deposits of oil shale occur around the world, including major deposits in the United States. Estimates of global deposits range from 2.8 to 3.3 trillion barrels (450×10^9 to 520×10^9 m^3) of recoverable oil. **Tar sands** are a combination of clay, sand, water, and bitumen, which is a heavy hydrocarbon. Like the kerogen in oil shale, tar sands' bitumen can be upgraded to synthetic crude oil. The largest known deposits of tar sands occur in the Athabasca River valley of western Canada.

Major Refineries in India

Oil Production as of 2007 was 880,000 barrels per day, of which 79% was crude oil. Currently India is the fourth largest consumer of petroleum products. The estimated refining capacity and crude requirement by the year 2025 will be in the range of 355-360 MMT. Many companies in India involve in fuel production such as ONGC, Oil India, Indan Oil, HPCL, BPCL, GAIL etc.

C. Solar energy

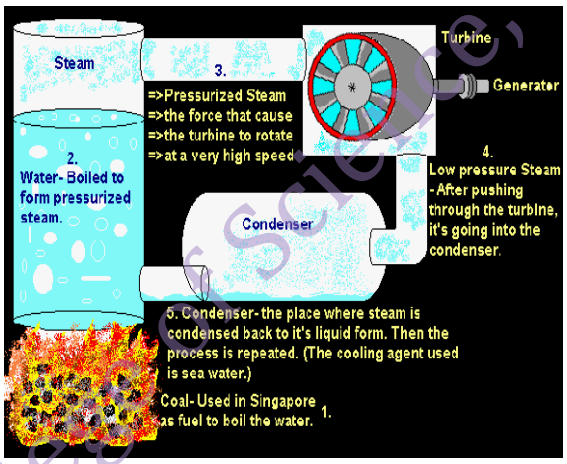
Solar energy one of the renewable energy sources are even larger than the traditional fossil fuels and in theory can easily supply the world's energy needs. While it is not possible to capture all solar energy, capturing less than 0.02% would be enough to meet the current energy needs. But the availability of solar radiation is limited due to weather, season and the cost of solar cells (PV cells). Current solar generation does not produce electricity at night, which is a particular problem in high northern and southern latitude countries; energy demand is highest in winter while availability of solar energy is lowest. Globally, solar generation is the fastest growing source of energy, seeing an annual average growth of 35% over the past few years. Japan, Europe, China, U.S. and India are the major growing investors in solar energy. India receives abundant sunshine about 1648 – 2108 KW/m^2/yr with nearly 250-300 days of useful sunshine. In the solar energy sector, some large projects have been proposed, and a 35,000 km^2 area of the Thar Desert has been set aside for solar power projects, sufficient to generate 700 GW to 2,100 GW. Also India's Ministry of New and Renewable Energy has released the JNNSM.



VPM's B N Bandodkar College of Science, Thane

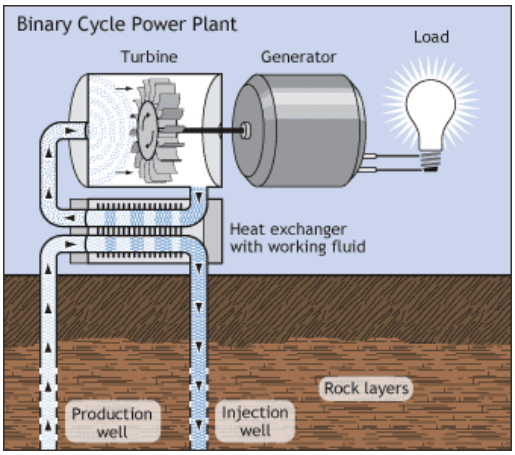
D. Thermal

A **thermal power station** is a power plant in which the prime mover is steam driven. Water is heated, turns into steam and spins a steam turbine which drives an electrical generator. After it passes through the turbine, the steam is condensed in a condenser and recycled to where it was heated; this is known as a Rankine cycle. The greatest variation in the design of thermal power stations is due to the different fuel sources. The most frequently used fuel for thermal power plants in India is coal. About 70% of the electricity consumed in India is generated through thermal power plants. India is home to numerous thermal power plants which are renowned all over the world. Bakreswar Thermal Power Project - West Bengal**,** It is situated at a distance of just 260 Km away from Kolkata. The Bakreswar Thermal Power Project is running with five operational units having total installed capacity of 1050 MW. A coal based Thermal Power Plants in India the Panipat Thermal Power Station II is located in Panipat in Haryana. Developed under four stages this thermal power plant has 8 units in total with an installed capacity of 250 MW. Chandrapur super thermal power station (CSTPS) is the biggest pit head Thermal Power Station of the Maharashtra State Electricity Board and the Giants in India among all state Electricity Board. This giant project having ultimate capacity of 2340 MW.



E. Geothermal energy

Estimates of exploitable worldwide geothermal energy resources vary considerably, depending on assumed investments in technology and exploration and guesses about geological formations. It is considered to be cheapest of available energy sources. Geothermal energy is harnessed by pumping water or gas like propane in the hot earth crust to produce steam which ultimately drives the turbine. According to a 1999 study, it was thought that this might amount to between 65 and 138 GW of electrical generation capacity 'using enhanced technology'. Other estimates range from 35 to 2000 GW of electrical generation capacity, with a further potential for 140 x 10^{18}J/year of direct use [10^{18}J = EJ, Exajoule]. The United States has invested maximum of 1 billion US dollars in research and development over 15 years. the potential to increase this to over 2 YJ with technology improvements - sufficient to provide all the world's energy needs for several millennia. The



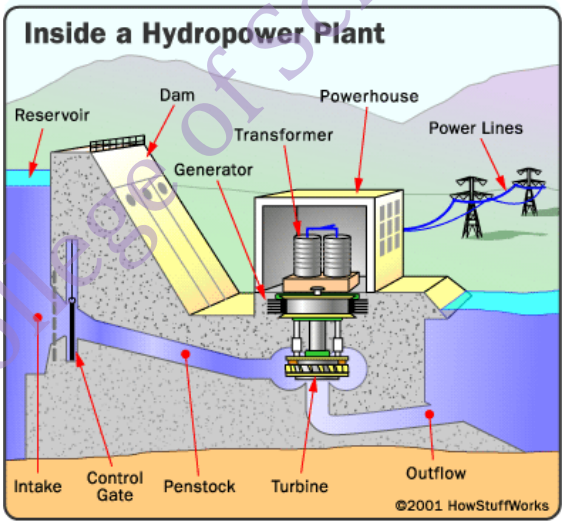
VPM's B N Bandodkar College of Science, Thane

total heat content of the Earth is 13,000,000 10^{24} Joules [10^{24} J=YJ, Yettajoule]. The first geothermal power station was built at Landrello, Italy. Other countries that have geothermal power stations are Japan, Iceland, the Philippines and the United States. In Iceland, geothermal energy is used for electricity and heat.

F. Hydel (hydro-electric) energy

In 2005, hydroelectric power supplied 16.4% of world electricity, down from 21.0% in 1973, but only 2.2% of the world's energy. **Hydropower** or **water power** is power derived from the energy of falling water, which may be harnessed for useful purposes. Since ancient times, hydropower has been used for irrigation and the operation of various mechanical devices, such as watermills, sawmills, textile mills, dock cranes, domestic lifts and paint making.

Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water.



It is the most widely used form of renewable energy, accounting for 16 percent of global electricity generation – 3,427 terawatt-hours of electricity production in 2010. Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32 percent of global hydropower in 2010. China is the largest hydroelectricity producer, with 721 terawatt-hours of production in 2010, representing around 17 percent of domestic electricity use. There are now three hydroelectricity plants larger than 10 GW: the Three Gorges Dam in China, Itaipu Dam across the Brazil/Paraguay border, and Guri Dam in Venezuela.

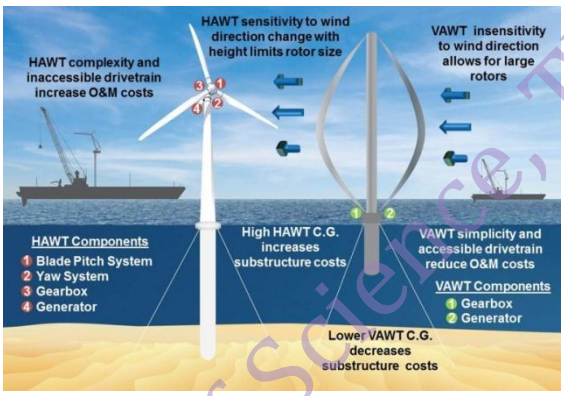
The cost of hydroelectricity is relatively low, making it a competitive source of renewable electricity. The average cost of electricity from a hydro plant larger than 10 megawatts is 3 to 5 U.S. cents per kilowatt-hour. Hydel is also a flexible source of electricity since plants can be controlled according to changing energy demands. However, damming interrupts the flow of rivers and can harm local ecosystems, and building large dams and reservoirs often involves displacing people and wildlife.

India is blessed with immense amount of hydro-electric potential and ranks 5th in terms of exploitable hydro-potential on global scenario. The present installed capacity as on 30-06-2011 is approximately **37,367.4 MW** which is 21.53% of total Electricity Generation in India. About 56 sites for pumped storage schemes with an aggregate installed capacity of 94,000 MW have been identified in India, namely Tehari

VPM's B N Bandodkar College of Science, Thane

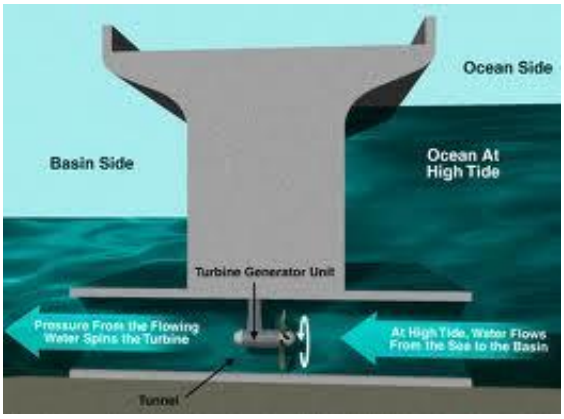
Dam, Uttarakhand; Srisailam Dam, AP; Sardar Sarowar, Gujarat; Kayana, Maharashtra; Bhakra-Nangal, Punjab; Naptha_jhakari, HP; Sharavathi and Kalinadi at Karnataka as big projects.

G. Wind energy



The available wind energy estimates range from 300 TW to 870 TW (Trillion Watts or terawatts). Using the lower estimate, just 5% of the available wind energy would supply the current worldwide energy needs. Most of this wind energy is available over the open ocean. Wind energy is harnessed by using HAWT (horizontal axis wind turbine) or VAWT (vertical axis wind turbine). The oceans cover 71% of the planet and wind tends to blow more strongly over open water because there are fewer obstructions. India is already a leader in wind power generation. Phase 2 Draft Policy, Wind energy sector in India is all set to add over 5,000 MW generation capacity per annum by 2015, a top official of the Indian Wind Turbine Manufacturers Association has said. According to the data supplied by the association, the country today has about 11,000 MW of installed wind energy capacity and the utilisation (plant load factor) is between 15 to 20 per cent. The states like Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Madhya Pradesh, Karnataka and Tamil Nadu has great potential for wind energy generation. India generates about 150MW from wind energy.

H. Tidal and wave energy



Due to the tidal forces created by the Moon (68%) and the Sun (32%), and the Earth's relative rotation with respect to Moon and Sun, there are fluctuating tides. These tidal fluctuations result in energy production in an average rate of about 3.7 TW. Tidal energy is trapped using turbine on the dykes constructed on the tidal passage on bay, creeks or estuaries. Waves are derived from wind, which is in turn derived from solar energy, and at each conversion there is a drop of about two orders of magnitude in available energy. Several models exist to harness the wave energy of which ANACONDA and DUCKS are popular. The total power of waves that wash against our shores add up to 3 TW. France already has the world's biggest power station located at La Rance Brittany which has a capacity of 240MW to supply 90 percent of Brittany's electricity demands. France already has the world's biggest power station located at La Rance Brittany which has a capacity of 240MW to supply 90 percent of Brittany's electricity demands. Asia's first commercial scale tidal power

VPM's B N Bandodkar College of Science, Thane

plant will be developed in India, at Gulf of Kutch which is identified as a site for installing the turbines from Atlantis Resource Corporation.

I. Bio-fuels

A **biofuel** is a type of fuel whose energy is derived from biological carbon fixation. Biofuels include fuels derived from biomass conversion, as well as solid biomass, liquid fuels and various biogases. Biofuels are gaining increased public and scientific attention, driven by factors such as oil price hikes and the need for increased energy security. Production of biomass and biofuels are growing industries as interest in sustainable fuel sources is growing. Utilizing waste products avoids a food vs fuel trade-off, and burning methane gas reduces greenhouse gas emissions, because even though it releases carbon dioxide, carbon dioxide is 23 times less of a greenhouse gas than is methane. Biofuels represent a sustainable partial replacement for fossil fuels, but their net impact on greenhouse gas emissions depends on the agricultural practices used to grow the plants used as feedstock to create the fuels. While it is widely believed that biofuels can be carbon-neutral, there is evidence that biofuels produced by current farming methods are substantial net carbon emitters.

Bioethanol is an alcohol made by fermentation, mostly from carbohydrates produced in sugar or starch crops such as corn or sugarcane. Cellulosic biomass, derived from non-food sources, such as trees and grasses, is also being developed as a feedstock for ethanol production. Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Bioethanol is widely used in the USA and in Brazil.

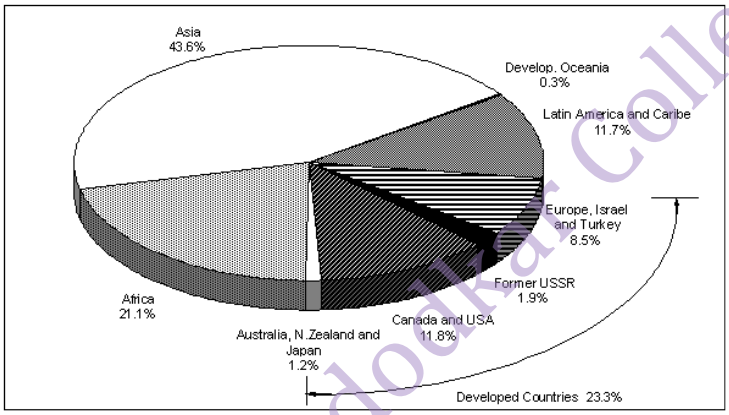


Figure: Utilisation of biomass as the energy source in the world

Biodiesel is made from vegetable oils and animal fats. Biodiesel is produced from oils or fats using **transesterification.** It involves methanol (CH3OH) is used to replace glycerol (C3H5(OH)3). Glycerol has three sites upon which fatty acids can be attached, while methanol has only one. Therefore, three moles of methanol are needed for every mole of vegetable oil. This being technically important reaction that has been used extensively in the soap and detergent manufacturing industry worldwide for many years. The chemical formula for biodiesel transesterification is:

$$C_3H_5(RCOOH)_3 + 3CH3OH <-> 3RCOCH_3O + C_3H_5(OH)_3$$

Almost all biodiesel is produced in a similar chemical process using base catalyzed transesterification as it is the most economical process, requiring only low temperatures and pressures while producing a 98%

VPM's B N Bandodkar College of Science, Thane

conversion yield. It is the most common biofuels in Europe. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles.

In 2010, worldwide biofuel production reached 105 billion liters (28 billion gallons US) and biofuels provided 2.7% of the world's fuels for road transport, a contribution largely made up of ethanol and biodiesel. Global ethanol fuel production reached 86 billion liters (23 billion gallons US) in 2010, with the United States and Brazil as the world's top producers, accounting together for 90% of global production. The world's largest biodiesel producer is the European Union, accounting for 53% of all biodiesel production in 2010.

Biomass is the only renewable energy source that requires careful management to avoid local depletion.

VPM's B N Bandodkar College of Science, Thane