Role of Non-Conventional Energy Resources

V V Satya Sai Kiran Kusumanchi

Abstract— **The development of infrastructure is an important factor to sustain economic growth. The power sector is one of the most important constituents of infrastructure. The achievement of energy security necessitates diversification of our energy resources and the sources of their supply, as well as measures for conservation of energy. So far, we were dependent on conventional sources of energy like thermal, hydro (large hydro) and nuclear. Fortunately, India is blessed with the third largest coal supplies in the world, although not of the best quality but we cannot use them indefinitely. The increasing prices for petroleum products, projection that petroleum resources would be exhausted in a relatively short period of time and the use of fossil fuel resources for political purposes will adversely affecting worldwide economic and social development. The impact of the energy crisis is particularly felt in developing countries like India, where an ever-increasing percentage of national budgets earmarked for development must be diverted to the purchase of petroleum products. After independence large hydroelectric projects have been executed, some of them are still under construction and some have been planned for future. The inherent drawbacks associated with large hydro are; large gestation period, large area along with vegetation has to be submerged, shifting of people etc. from the sites. Political and environmental implications have made planners to think for some other alternative to the large hydro. For nuclear power plants also there is a problem of getting proper fuel, processing and safety from radiations. In addition, global warming caused largely by greenhouse gas emission from fossil fuel generating systems is also a major concern. To overcome the problems associated with conventional sources of energy, most countries including India have shifted their focus to develop non-conventional sources of energy. Among these resources are solar energy, wind, geo thermal energy, biomass and small hydropower. 263 districts in 16 states and one Union Territory have so far been covered under the Integrated Rural Energy Programme of government of India, which aims at providing a cost effective energy mix of non-conventional sources to meet the energy need of the rural areas. With the various initiatives taken by the government, a healthy power sector would emerge in the country which would pave the way for fast industrialisation, growth in agricultural production, rural development and a better quality of life through non-conventional energy sources.**

Index Terms—**Non conventional energy sources, global warming, rural energy, solar energy.**

I. INTRODUCTION

In India the potential of renewable energy source is about 81,200 MW out of which only 26,246.11 MW i.e. 32.32% has been harnessed so far. The potential and capacity harnessed so far is given in Table 1. India's need for power is growing at a prodigious rate, annual electricity generation and consumption in India have both nearly doubled since 1990, and it's projected 2.6% (low end) to 4.5 % (high end). Annual rate of increase for electricity consumption (through 2020) is the highest for any major country. India is currently the seventh greatest electricity consuming country (accounting for about 3.5% of the world total annual electricity consumption) but will soon overtake both Germany and Canada in that regard. India now faces an electricity shortages conservatively estimated at 11% and as high as 18% during peak demand periods.

Table 1: Potential and Installation of nonconventional Energy Systems

Sl. No.	Non conventional Energy Sources	Potential (MW)	Potential harnessed so far (MW)
1.	Wind	45,000	19,564
2.	Small Hydro Up to (25 MW)	15,000	3,496
3.	Biomass	3,500	1,248
4.	Gasifiers	16,000	155.59
5.	Urban & industrial Waste	1700	96.08
6.	Solar Photo Voltaic (S.P.V.)	20/SQ km	1,686.44
TOTAL		81,200	26,246.11

II. WHY HAVE NON CONVENTIONALS EMERGED SO STRONGLY

Apart from rapid technological improvement, the strength of non-conventional lies in the diversity and the richness of their technology options and applications, as well as their widespread availability. Every country in the world has at least one non-conventional energy source that is significant. Some have many. Non-conventional offer a large portfolio of different sources and technologies because this, as a first order of effect, increases energy security. As a matter of fact, it is clear from analysis that those countries that have deployed non-conventional so far were driven by climate-change mitigation, but also by energy diversification, and the reduction of fossil-fuel imports. Other drivers have been economic-growth aspects such as job creation and, last but not least, mitigation of other, local pollution

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III. ADVANTAGES OF NON-CONVENTIONAL ENERGY TECHNOLOGIES

To augment the energy needs non-conventional energy options may be used to supply all substantial amount of energy as they do have the following advantages.

(i) Non-conventional energy is an indigenous source available in considerable quantities to all developing nations and capable, in principle of having a significant local, regional or national economic impact.

(ii) Several non-conventional options are financially and economically competitive for certain applications, such as in remote locations, where the costs of transmitting electrical power or transporting conventional fuels are high.

(iii) Rapid scientific and technological advantages are expected to expand the economic range of non-conventional energy applications over the next 8-10 years making it imperative for international decision makers and planners to keep abreast of these developments.

(iv)Non-conventional are free for the taking. The power plants based on non-conventional do not have any fuel cost and hence negligible running cost.

(v) Non-conventional have low energy density and more or less there is no pollution or ecological balance problem.

(vi) The use of non-conventional energy could help to conserve foreign exchange and generate local employment if conservation technologies are designed, manufactured, assembled and installed locally.

(vii) Provide energy in environmentally benign manner.

(viii) Short gestation period and low investment.

(ix) With the help of State/ Union Govt. incentives, these schemes have become more attractive for private sector participation.

IV. MAIN NON-CONVENTIONAL ENERGY SOURCES

- Solar Energy
- Wind Energy
- Biomass and Biogas Energy
- Ocean Thermal Energy Conversion
- Tidal Energy
- Geo Thermal Energy
- Small Hydropower
- Hydrogen Energy and Fuel Cells
- Light tubes

A. Solar Energy

Solar energy has the greatest potential of all the sources of non-conventional energy and if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy specially when other sources in the country have depleted energy comes to the earth from the sun. This energy keeps the temperature of the earth above than in colder space, causes current in the atmosphere and in ocean, causes the water cycle and generate photosynthesis in plants. The solar power where sun hits atmosphere is 1017 Watts, whereas the solar power on earth's surface is 1016 Watts. The total worldwide power demand of all needs of civilization is 1013 Watts. Therefore the sun gives us 1000 times more power than we need. If we can use 5% of this energy, it will be 50 times what the world will require [3]. Electricity can be produced from the solar energy by photovoltaic solar cells, which convert the solar energy directly to electricity. The most significant applications of photovoltaic cell in India are the energisation of pump sets for irrigation, drinking water supply and rural electrification covering street lights, community TV sets, medical refrigerators and other small power loads

B. Wind Energy

Wind energy, which is an indirect source of solar energy conversion, can be utilized to run windmill, which in turn drives a generator to produce electricity. Wind can also be used to provide mechanical power such as for water pumping. In India generally wind speeds obtainable are in the lower ranges. Attempts are, therefore, on the development of low cost, low speed mills for irrigation of small and marginal farms for providing drinking water in rural area. The developments are being mainly concentrated on water pumping wind mill suitable for operation in a wind speed range of 8 to 36 km per hour. In India high wind speeds are obtainable in coastal areas of Saurashtra, western Rajasthan and some parts of central India [5]. Among the different non-conventional energy sources, wind energy is currently making a significant contribution to the installed capacity of power generation, and is emerging as a competitive option. India with an installed capacity of 19564MW ranks fifth in the world after Germany, USA, Spain and Denmark in wind power generation. Energy of wind can be economically used for the generation of electrical energy. Wind energy equipment are modular in nature and the investment requirement for these equipment as compared to conventional energy equipment is not large and the industry is able to attract private investment thereby reducing the burden on the encourages such investment.

C. Biomass and Biogas Energy

The potential for application of biomass, as an alternative source of energy in India is large. We have plenty of agricultural and forest resources for production of biomass. Biomass is produced in nature through photosynthesis achieved by solar energy conversion. As the word clearly signifies Biomass means organic matter. In simplest form, the process of photosynthesis is in the presence of solar radiation. Biomass energy co-generation programme is being implemented with the main objective of promoting technologies for optimum use of country's biomass resources and for exploitation of the biomass power generation potential, estimated at 19500 MW. The technologies being promoted include combustion, gasification and cogeneration, Either for power in captive or grid connected modes, or for heat applications.

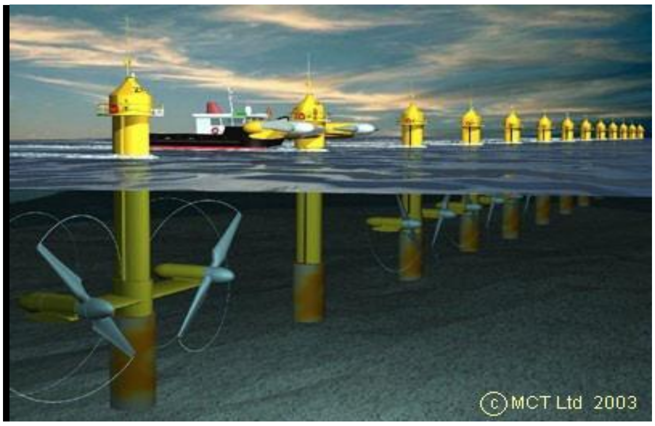
D. Ocean Thermal Energy Conversion

This is also an indirect method of utilizing solar energy. A large amount of solar energy is collected and stored in tropical oceans. The surface of the water acts as the collector for solar heat, while the upper layer of the sea constitutes infinite heat storage reservoir. Thus the heat contained in the oceans, could be converted into electricity by utilizing the fact that the temperature difference between the warm surface waters of the tropical oceans and the colder waters in the depth is about 20 – 250K. Utilization of this energy, with its associated temperature difference and its conversion into work, forms the basis of ocean thermal energy conversion (OTEC) systems. The surface water, which is at higher temperature, could be used to heat some low boiling organic fluid and the vapours of which would run a heat engine. The exit vapour would be conducted by pumping cold water from the deeper regions. The amount of energy available for ocean is replenished continuously. All the systems of OTEC method work on a closed routine cycle and use low boiling organic fluids like ammonia, Propane, R – 12, R – 22 etc.

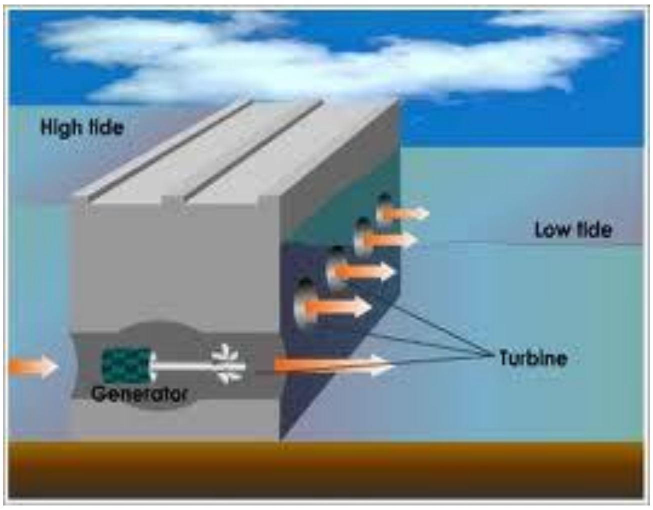
E. Tidal Energy

The tides in the sea are the result of the universal gravitational effect of heavenly bodies like sun and moon on the earth. Due to fluidity of water mass, the effect of this force becomes apparent in the motion of water, which shows a periodic rise and fall in levels which is in synthesis with the daily cycle of rising and setting of sun and moon. This periodic rise and fall of the water level of sea is called tide. These tides can be used to produce electrical power which is known as tidal power. When the water is above the mean sea level, it is called flood tide and when the level is below the mean sea level, it is called ebb tide. To harness the tides, a dam is to be built across the mouth of the bay. It will have large gates in it and also low head hydraulic reversible turbines are installed in it. A tidal basin is formed, which gets separated from the sea by dam. The difference in water level is obtained between the basin and sea. By using reversible water turbines, turbines can be run continuously, both during high tide and low tide. The turbine is coupled to generator, potential energy of the water stored in the basin as well as energy during high tides used to drive turbine, which is coupled to generator, generating electricity.

a) Tidal stream generator:



Tidal barrage:



F. Geo Thermal Energy

This is the energy, which lies embedded within the earth. According to various theories the earth has a molten core. The steam and the hot water come naturally to the surface of the earth in some locations of the earth. Two ways of electric power production from geothermal energy has been suggested. In one of these heat energy is transferred to a working fluid which operates the power cycle. This may be particularly useful at places of fresh volcanic activity, where the molten interior mass of earth vents to the surface through fissures and substantially high temperatures, such as between 450 to 5500C can be found. By embedding coil of pipes and sending water through them can be raised. In the other, the hot geothermal water and or steam is used to operate the turbines directly. At present only steam coming out of the ground is used to generate electricity, the hot water is discarded because it contains as much as 30% dissolved salts and minerals and these cause serious rust damage to the turbine.

Geo Thermal Energy station:

G. Small Hydropower

Energy from small hydro is probably the oldest and yet, the most reliable of all non-conventional energy sources. The term 'small hydro' has a wide range in usage, covering schemes having installed capacities from a few kW to 25 MW. In India small hydro schemes are further classified as micro hydro up to 100 kW plant capacity, mini hydro from 101 kW to 2000 kW and small hydro up to 25000 kW plant capacity. The advantage of this resource is that it can be harnessed almost everywhere in India from any nearby stream or canal – in the most environmentally benign manner, and without encountering any submergence, deforestation or resettlement problems which are generally encountered in the development of large hydro power development. Small hydropower development can reduce the load on conventional sources of energy. Small hydro technology is mature and proven. Civil works and installation of equipment involve simple processes, which offer ample employment opportunities to local people and use locally available material. Gestation period is also short. Simple and proven design concepts suit local conditions. The development of small-scale hydropower in India started almost in the pace with the world's first hydroelectric installation in 1882 at Appleton USA. The 130 KW installations in Sidrapong (Darjeeling) in the year 1897 was the first installation in India. The other installations were Shivasamundram at Mysore (2000 kW), and Bhoorisingh in Chamba (40 kW) in 1902, Galogi at Mussoorie (3000 kW) in 1907, Jubbal (50 kW) in 1911 and Chhaba (1750 kW) at Shimla in 1913. These plants were used primarily for lighting in important towns and are still working. The country has an estimated SHP potential of about 15000 MW. So far 514 SHP projects with an aggregated installed capacity of 1693 MW have been installed.

H. Hydrogen Energy and Fuel Cells

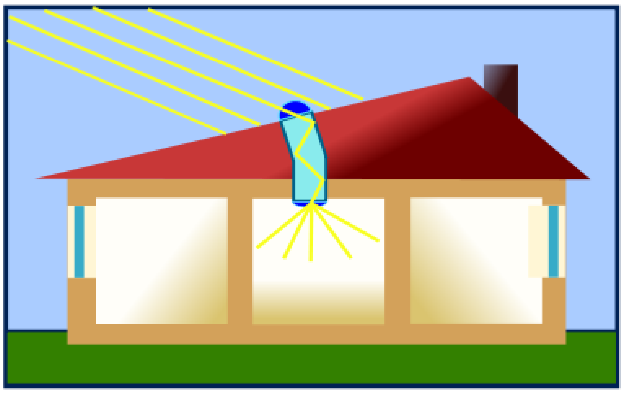
In recent years hydrogen has been receiving worldwide attention as a clean and efficient energy carrier with a potential to replace liquid fossil fuels. Significant progress has been reported by several countries including India in the development of hydrogen energy as an energy carrier and an alternative to fossil fuels. Serious concerns relating to energy security. Depleting fossil fuel reserves, greenhouse gas emissions and air quality are driving this global transformation effort towards a hydrogen-based economy. Hydrogen has high-energy content, when burnt, it produces only water as a by-product and is, therefore, environmentally benign. At present hydrogen is available as a by-product from several chemical processes, plants or industries.

I. Light tubes

Light tubes or **light pipes** are used for transporting or distributing natural or artificial light. In their application to day lighting, they are also often called **sun pipes**, **sun scopes**, **solar light pipes**, **sky lights** or **daylight pipes**.

Generally speaking, a **light pipe** or **light tube** may refer to:

- a tube or pipe for *transport* of light to another location, minimizing the loss of light;
- a transparent tube or pipe for *distribution* of light over its length, either for equidistribution along the entire length or for controlled light leakage



The case study of light pipes in comparison with roof lights

CASE STUDY LIGHT PIPES Vs ROOF LIGHTS:

FLOOR AREA	80,700sq-ft
NO.OF. LIGHT PIPES	100 nos of 750 mm dia
COST OF IMPLEMENTATION OF LIGHT PIPES	Rs.25 lakhs
ROOF LIGHT AREA	1050 sq-ms
COST OF IMPLEMENTATION OF ROOF LIGHT	Rs.26,25,000.00(@Rs.2500/-per sq-m)
AVERAGE LIGHTING AVAILABLE WITH LIGHT PIPES	300 lux

The capital and generation cost of RET systems is given in Table 3 below

Capital and Generation Cost of RET Systems.

S. No.	Sources	Capital Cost (Rs. Crores/MW)	Cost of Generation (Rs/kWh)
1.	SHP	3.00 to 6.00	1.00 to 2.50
2.	Wind	4 to 4.50	2.25 to 2.75
3.	Bio mass/ Cogeneration	2.50	1.75 to 2.00
4.	Biomass/ Gasification	2.50 to 3.00	1.75 to 2.00
5.	S.P.V.	20.00 to 25.00	9.00 to 12.00

V. TRENDS IN NON-CONVENTIONAL ENERGY RESOURCES

By 2010, the total cumulative Non-conventional energy capacity installed (excluding large Hydro power) across the globe was 305 GW (Source - REN21 Renewables Global Status Report 2010). Of this, the contribution of wind energy was about 159 GW, followed by 60 GW from small hydro and 54 GW from bio-mass based power generation. China leads the table with an installed capacity of 62 GW followed by USA, Germany, Spain, India and Japan. By 2030, the RE sector globally is expected to grow four - fold to reach a capacity of 1120 GW. The biomass sector which is manpower intensive is expected to grow faster and would be the major contributor of the total power generation (about 59 %) followed by Solar PV (31 %) and Wind (10 %) by 2030 (Source - REN21 Renewables Global Status report 2008 & 2009 update). India has an installed capacity of 17,174 MW (excluding large hydro) as on 30th June 2010, which is about 10.4 % of the total power generation capacity (Source: http://www.powermin.nic.in/ indian_electricity_scenario/introduction.htm) . Currently the Wind sector contributes a major portion of this capacity (12,010 MW) followed by the Small Hydro (2,767 MW). MNRE has ambitious plans for growth in all the RE sectors, some of which are highlighted below – Generate 20,000 MW from on-grid solar power by 2022 under the Jawaharlal Nehru National Solar Mission, Increase small hydro power addition from the present level of 300 MW / year to 500 MW / year in the next 3 years (Source - http://mnre.gov.in/speeches/clean-energy-speech-23062010. pdf), Generation based incentive to increase wind energy by another 4000 MW in the years 2010 – 12 (end of 11th plan)

VI. CASE STUDIES REGARDING THE NON-CONVENTIONAL ENERGY RESOURCES

How soon before solar energy affects the lives of most humans, on- and off-grid?

For off-grid systems, in many cases, solar is the most competitive solution today. But there are barriers to exploiting that potential more broadly. One,of them is the lack of information and awareness. Second, the absence of business and financial models, because people lack the money to buy a PV [photovoltaic] system. What you need is a kind of business model, e.g. soft loans or small tariffs over time that people can repay in order to install a PV system. Third, some kind of policy failure. The fact that currently there are very attractive incentives for on-grid PV in many countries has a simple consequence: most PV systems are installed there [in those countries], and the industry tends to forget markets where PVs are already competitive. Of course, this will change over time – it is just a transitional problem. In on-grid situations, I want to stress that the cost of solar is going down very fast, in particular for PV. The competitiveness of solar systems will depend very much on what they are competing with. If solar is applied in the right places – in sunny places – it can supply energy when there is the maximum of peak demand, i.e. when electricity is sold at the highest price. In some countries, notably Italy, PV systems are very close to the retail electricity price. This still implies a hidden incentive, because someone else pays the retail electricity distribution costs. But when hundreds of thousands, even millions, of people realise that if they buy a PV system they will pay less than their electricity bill, this is an enormous trigger for investment. In the next five to ten years in many countries, we will probably see an avalanche effect as solar gains adherents.

What is an example of such change?

[Under] the 450 Scenario of the WEO 2011, in the electricity sector, non-conventional will almost have 50% of the mix by 2035, which is a huge amount. If you see it in absolute terms and not just in share, the increase is even clearer. Today, non-conventional, including hydro, produce roughly 3 700 terawatt hours (TWh) in the world; by 2035 in the 450 Scenario its 15 000 [TWh]. In the scenario biofuels reach 27% of total transport energy demand [by 2035]. The 450 Scenario is a very non-conventional-friendly scenario. **I**f one asks, what is the share of non-conventional energy in total of global energy consumption, most people will answer 2%, 3%, maybe 5%. Wrong! It is two or three times that, *around* 13% because biofuels (mainly wood, charcoal and agro-residues) alone *should* account for more than 10%. When talking about non-conventional energy, one should be careful with the figures because of the extreme difficulty in getting the right numbers; it is important to add caution words such as “around” or “should” when trying to quantify production and consumption of non-conventional. The non-marketed nature of most non-conventional explains in part the poor quality of the data. But the limited knowledge about non-conventional, especially biomass, in some countries could lead to dramatic consequences such as acceleration of desertification.

Cost-competitive wind power

Wind is competitive due to its strength both on economic terms, when examining the cost of generating energy, and its many environmental and social benefits. The average cost of energy for wind has been continually decreasing and will fall further – this is not the case for many conventional energy sources. Bloomberg New Energy Finance has calculated a 14% decrease in cost of energy for every doubling of cumulative onshore capacity installed since the 1980s. This is due to improvements across the board, including declining turbine and balance-of-plant prices, lower operation and maintenance costs, increasing capacity factors (mainly due to more efficient designs, with longer, more aerodynamic blades relative to the same generator output), higher hub heights, economies of scale and better quality and efficiency of manufacturing.

In the table cited below indicates the shares of the different non-conventional energy resources in that the following indications mean:

MWe = Megawatt equivalent; MW = Megawatt; kW = kilowatt; kWp = kilowatt peak; sq. m. = square meter

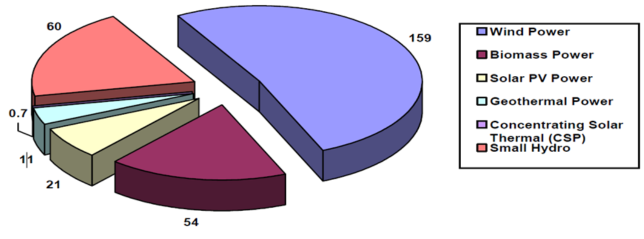
Sl.no.	Sources / Systems	Estimated Potential	Cumulative Achievements
I. Power From Non-conventional			
A. Grid-interactive non-conventional power			
1.	Bio Power (Agro residues)	16,8811 MWe	510.00 MW
2.	Wind Power	45,1952 MWe	6315.00 MW
3.	Small Hydro Power (up to 25 MW)	15,0003 MWe	1905.00 MW
4.	Cogeneration-bagasse	5,0004 MWe	602.00 MW
5.	Waste to Energy	2,7005 MWe	40.95 MW
	Sub Total (in MW) (A)	**84,7766 MWe**	**9372.95 MW**
B. Distributed non-conventional power			
6.	Solar Power	-	2.92 MW
7	Biomass Power / Cogen.(non-bagasse)	-	34.30 MW

8.	Biomass Gasifier	-	75.85 MW
Sl.no.	**Sources / Systems**	**Estimated Potential**	**Cumulative Achievements**
	Sub Total (B)	**-**	**124.10 MW**
	Total (A + B)	**-**	**9497.05 MW**
II.	**Remote Village Electrification**	-	2501 villages + 830 hamlets
III. Decentralized Energy Systems			
10.	Family Type Biogas Plants	120 lakh	38.90 lakh
11.	Solar Photovoltaic Programme	20 MW/sq.km.	
	i. Solar Street Lighting System	-	54659 nos.
	ii. Home Lighting System	-	301603 nos.
	iii. Solar Lantern	-	463058 nos.
	iv. Solar Power Plants	-	1859.80 kWp
12.	Solar Thermal Program	-	
	i. Solar Water Heating Systems	-	1.66million sq.m. collector area
13.	Wind Pumps	-	1141 nos.
14.	Aero-generator /Hybrid Systems	-	572 kW
15.	Solar Photovoltaic Pumps	-	7068 nos.
IV. Other Programmes			
16.	Energy Parks	-	493 nos.
17.	Akshay Urja Shops	-	104 nos.
18.	Battery Operated Vehicle	-	255 nos.

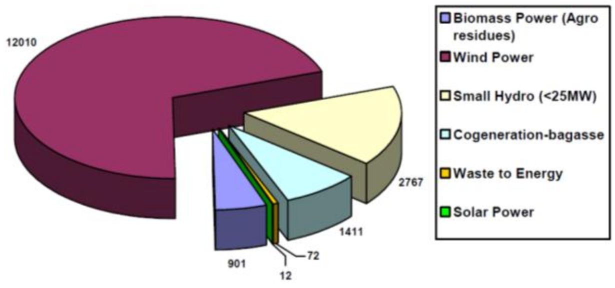
State- Wise & Year- Wise Wind Power Installed Capacity (as on January 01, 2007)

State	**Cumulative Installed Capacity (MW)**
Andhra Pradesh	121.60
Gujarat	401.40
Karnataka	745.60
Kerala	2.00
Madhya Pradesh	54.90
Maharashtra	1283.70
Rajasthan	440.80
Tamil Nadu	3216.10
West Bengal	1.10
Others	3.20
Total	**6270.40**

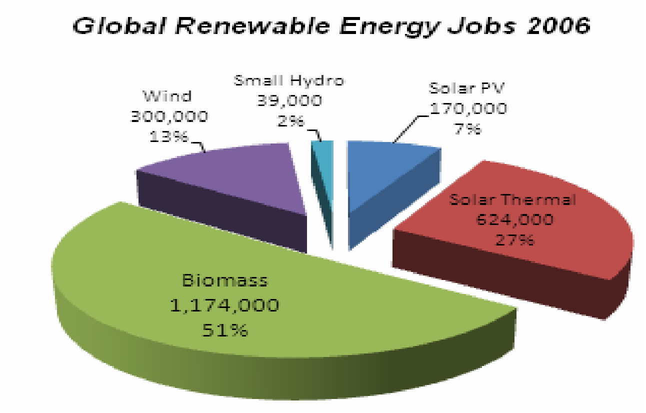
The pie diagrams representing the share of different non conventional energy resources by 2010



Cumulative capacities of non conventional energy resouces in india



The employment sector benefited by the non-conventional energy resources by 2006:



The employment sector benefited by the non-conventional energy resources by 2030:

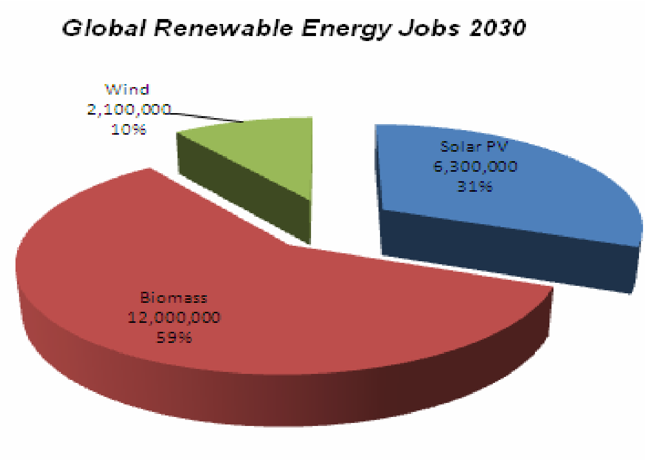
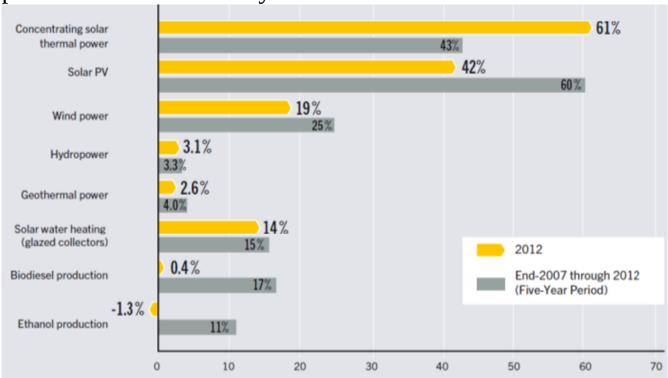


Table VI

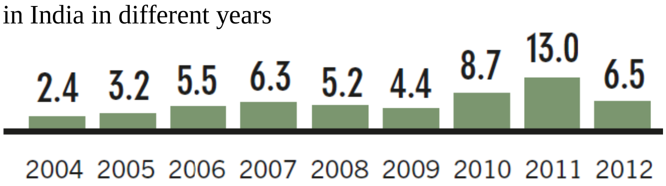
Comparision of contribution from different non convrntional energy resources in the diffrerent years

		2010	2011	2012
Investment in renewwable capacity(annual)	Billion USD	227	279	244
Renewable power capacity(excluding hydro)	GW	315	395	480
Renewable power capacity(including hydro)	GW	1250	1355	1470
Hydro power capacity(total)	GW	935	960	990
Bio-power generation	GWh	313	335	350
Solar PV capacity(total)	GW	40	71	100
Concentratin solar thermal plant(total)	GW	1.1	1.6	2.5
Wind power capacity(total)	GW	198	238	283
Solar hot water capacity(total)	GWth	195	223	255
2010		2011		2012
Ethanol production(annual)	Billion litres	85.0	84.2	83.1
Biodiesel production(annual)	Billion liters	18.5	22.4	22.5

GraphV: showing the comparison of the production of the renewable energy resources share in the energy sector by the period 2007-2012 and by the end of 2012



Graph VI: showing the Investment in renewable energy sector in India in different years



VII. CONCLUSION

Keeping in view the reserves of the fossil fuels and the economy concerns, these fuels are likely to dominate the world primary energy supply for another decade but environmental scientists have warned that if the present trend is not checked then by 2100,the average temperature of around the globe will rise by 1.4 To 5.8 degrees Celsius, which cause an upsurge in the sea water levels drowning all lands at low elevation along the coast lines.so the world has already made the begging to bring about the infrastructural changes in the energy sector so as be able to choose the renewable energy development trajectory. In developing countries, where a lot of energy production capacity would need to be converted if a rapid change were to take place take. That is developing countries could have the competitive advantage for driving the world market. However, strong participation of developed countries is needed since majority of energy technologies in use in developing countries have been developed and commercialized in in developed countries first .nevertheless , India must give more thrust to the research and development in the field of the non – conventional energy sources not only to mitigate greenhouse effect but also to lessen the dependence of oil/gas import ,which consumes major chunk of foreign exchange reserve.it is also clear that an integrated energy system consisting two or more renewable energy sources has the advantage of stability, reliability and are economically viable. Last but not the least, it is for the citizens also to believe in power of renewable energy sources, and understand its necessity and importance

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[12] http://mnre.gov.in/press-releases/press-release-17122009.pdf).
[13] The Journal of the International Energy Agency
[14] http://www.indiacore.com References regarding the table VI
[15] Investment data are from Bloomberg New Energy Finance and include all biomass, geothermal, and wind generation projects of more than 1 MW; all hydro projects of between 1 and 50 MW; all solar power projects; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more.
[16] Solar hot water capacity data include glazed water collectors only.
[17] Biofuel policies include policies listed both under the biofuels obligation
[18] Reference Table R15 (National and State/Provincial Biofuel Blend Mandates).
[19] Note: Numbers are rounded. Renewable power capacity (including and not including hydropower) and hydropower capacity data are rounded to nearest 5 GW; other statistics are rounded to nearest whole number except for very small numbers and biofuels, which are rounded to one decimal point.
[20] REN21 GLOBAL STATUS REPORT 2013.