NON-CONVENTIONAL ENERGY RESOURCES

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ABSTRACT: Energy is the key input to drive and improve the life cycle. Primarily, it is the gift of the nature to the mankind in various forms. The consumption of the energy is directly proportional to the progress of the mankind. With ever growing population, improvement in the living standard of the humanity, industrialization of the developing countries, the global demand for energy is expected to increase rather significantly in the near future. The primary source of energy is fossil fuel, however the finiteness of fossil fuel reserves and large scale environmental degradation caused by their widespread use, particularly global warming, urban air pollution and acid rain, strongly suggests that harnessing of non-conventional, renewable and environment friendly energy resources is vital for steering the global energy supplies towards a sustainable path. This paper describes in brief the non-conventional energy sources and their usage in India with a case study of Punjab State.

1. INDIAN ENERGY SCENARIO

ndia ranks sixth in the world in total energy consumption, whereas more than 70% of its primary energy needs are Ibeing met through imports, mainly in the form of crude oil and natural gas. Coming to the power generation in the country, India has increased installed power capacity from 1362 MW to over 112,058 MW since independence and electrified more than 500,000 villages. This achievement is impressive but not sufficient. It is a matter of concern that 44% of house holds do not have access to the electricity (Census 2001) and as many as 80,000 villages are yet to be electrified. The electricity supply is not even sufficient for those who have been connected. The country still encounters peak and energy shortage of 7.7% and 12.3% respectively (Up to Aug '05). The annual per capita consumption of 580Kwh is amongst the lowest in the world. The Ministry of Power has now drawn a road map to ensure 'power on demand' by 2012. The anticipated demand as per 16th Electric Power Survey requires an addition of 1, 00,000 MW. In other words, the achievements of more than five decades need to be replicated in the next decade. This requires resources of Rs.8, 00,000 crores. The task is daunting but not unachievable. India has a vast hydro potential of 150,000 MW out of which only 17% has been tapped so far. Then there are coal reserves to last for more than 200 years along with other exploitable energy reserves such as oil and gas etc. Even the potential of renewables is 82,000 MW. It is significant that the ministry envisions adding 10,000MW up to 2012 through non-conventional energy sources alone. Till now, the total installed capacity based on these sources is only about 6422 MW consisting of 3595 MW wind, 1705 MW small hydro, 750 MW biomass, 264 KW solar, 66 MW gasifiers and 42 MW from urban/industrial waste energy. This constitutes only 7.8% of total installed capacity in the country. The MOP (Ministry of Power) has drafted New and Renewable Energy Policy Statement 2005 issuing guidelines to indigenously develop new and renewable energy technologies, products & services, at par with international standards, specifications, and performance parameters for deployment in a manner so as to arrive at an optimal fuel-mix that most effectively meets the overall concerns of the country. To ensure integrated development, a Coordination Committee for Power has been constituted for close coordination amongst the concerned Ministries to deliberate on issues pertaining to generation programmes, evacuation schemes, operational issues and grid related problems. India has pioneered in the world in many administrative actions of renewable energy promotion, such as;

- Electricity regulatory commission within liberalized market, 1991
- Mandatory environmental audits for power projects, 1992
- Energy conservation bill, 2000
- Renewable energy promotion bill, 2005.

Today, India is among the leaders in the world in utilization of several RE technologies.

2. PREDICTIONS REGARDING FOSSIL FUEL RESERVES

Fossil fuels supply most of the energy consumed today. They are relatively concentrated and pure energy sources and technically easy to exploit, and provide cheap energy. Presently Oil 40%, natural gas 22.5%, coal 23.3%, hydroelectric 7.0%, nuclear 6.5%, biomass and others 0.7% provide almost all of the world's energy requirements.

However the reserves of fossil fuels are limited as under:

- Conservative predictions are that conventional oil production will peak in 2007.
- The pessimists predict a peak for conventional gas production between 2010 and 2020.
- There are today 200 years of economically exploitable reserves of coal at the current rate of consumption.
- The raw material for nuclear power i.e. uranium reserves will last for 50 years at the present rate of use. (Though there are other alternatives raw materials such as thorium but this technology is yet to be developed.)

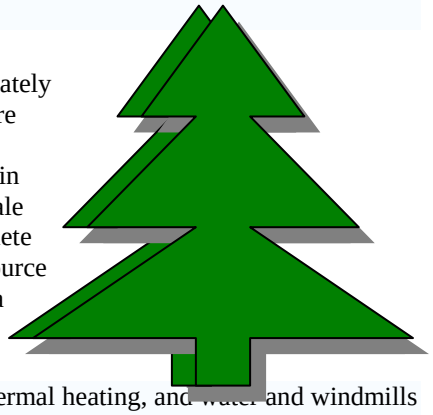
Hence the need was felt to explore and develop renewable energy sources to meet with ever growing demand of energy.

3. GENERATION OF ENERGY

All the energy we consume is generated by using the three fundamental interactions of nature: gravity, electromagnetism and the nuclear reaction to create force, fission and fusion. Most forms of terrestrial energy can be traced back to fusion reaction inside the sun. Geothermal energy is believed to be generated primarily by radioactive decay inside the Earth. Radioactive decay energy is generated by both the nuclear and electromagnetic force. Tidal energy comes from the gravity energy and kinetic energy of the Earth/Moon system.

4. NON-CONVENTIONAL AND RENEWABLE SOURCES OF ENERGY

To meet the future energy demands and to give quality and pollution free supply to the growing and today's environment conscious population, the present world attention is to go in for natural, clean and renewable energy sources. These energy sources capture their energy from on-going natural processes, such as geothermal heat flows, sunshine, wind, flowing water and biological processes.



Most renewable forms of energy, other than geothermal and tidal power ultimately come from the Sun. Some forms of energy, such as rainfall and wind power are considered short-term energy storage, whereas the energy in biomass is accumulated over a period of months, as in straw, and through many years as in wood. Fossil fuels too are theoretically renewable but on a very long time-scale and if continued to be exploited at present rates then these resources may deplete in the near future. Therefore, in reality, Renewable energy is energy from a source that is replaced rapidly by a natural process and is not subject to depletion in a human timescale.

Renewable energy resources may be used directly, such as solar ovens, geothermal heating, and water and windmills or indirectly by transforming to other more convenient forms of energy such as electricity generation through wind turbines or photovoltaic cells, or production of fuels (ethanol etc.) from biomass.

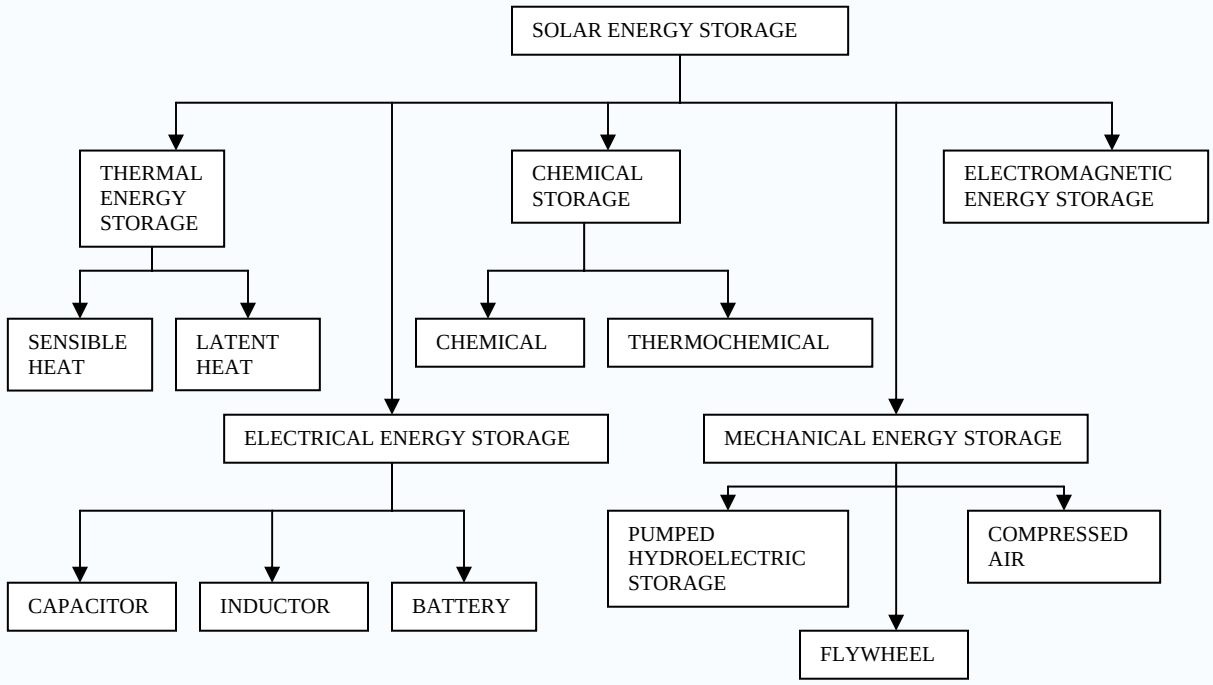
5. RENEWABLE ENERGY UTILIZATION STATUS IN THE WORLD

Hydro	Wind	Solar	Geothermal	World Status
Canada	Germany	Japan	US	1
US	US	Germany	Philippines	2
Brazil	Spain	Italy	US	3
China	Denmark	Mexico	India	4
Russia	India	Indonesia	Australia	5

6. BRIEF DESCRIPTION OF NON-CONVENTIONAL ENERGY RESOURCES

6.1 Solar Energy

Since most renewable energy is ultimately "solar energy" that is directly collected from sun light. Energy is released by the Sun as electromagnetic waves. This energy reaching the earth's atmosphere consists of about 8% UV radiation, 46% visible light and 46% infrared radiations. Solar energy storage is as per figure given below:



Solar energy can be used in two ways:

- Solar heating.
- Solar electricity.

Solar heating is to capture/concentrate sun's energy for heating buildings and for cooking/heating foodstuffs etc. Solar electricity is mainly produced by using photovoltaic solar cells which are made of semi-conducting materials that directly convert sunlight into electricity. Obviously the sun does not provide constant energy to any spot on the Earth, so its use is limited. Therefore, often Solar cells are used to charge batteries which are used either as secondary energy source or for other applications of intermittent use such as night lighting or water pumping etc. A solar power plant offers good option for electrification in areas of disadvantageous locations such as hilly regions,

forests, deserts, and islands where other resources are neither available nor exploitable in techno economically viable manner. MNES has identified 18, 000 such villages to be electrified through non-conventional sources.

India is a vast country with an area of over 3.2 million sq. km. Most parts of the country have about 250-300 sunny days. Thus there is tremendous solar potential.

- ❖ 140 MW solar thermal/naphtha hybrid power plant with 35 MW solar trough component will be constructed in Rajasthan raising India into the 2nd position in the world in utilization of solar thermal.
- o Grid interactive solar photovoltaic power projects aggregating to 2490 KW have so far been installed and other projects of 800 KW capacity are under installation.

6.2 Wind Energy

The origin for Wind energy is sun. When sun rays fall on the earth, its surface gets heated up and as a consequence unevenly winds are formed. Kinetic energy in the wind can be used to run wind turbines but the output power depends on the wind speed. Turbines generally require a wind in the range 5.5 m /s (20 km/h). In practice relatively few land areas have significant prevailing winds. Otherwise Wind power is one of the most cost competitive renewable today and this has been the most rapidly-growing means of electricity generation at the turn of the21st century and provides a complement to large-scale base-load power stations. Its long-term technical potential is believed 5 times current global energy consumption or 40 times current electricity demand.

- ➢ India now has the 5^{th} largest wind power installed capacity, of 3595 MW, in the world.
- ➢ The estimated gross Wind potentials in India is 45,000 MW.

6.3 Water Power

Energy in water can be harnessed and used, in the form of motive energy or temperature differences. Since water is about a thousand times heavier than air is, even a slow flowing stream of water can yield great amounts of energy.

There are many forms:

- Hydroelectric energy, a term usually reserved for hydroelectric dams.
- Tidal power, which captures energy from the tides in horizontal direction. Tides come in, raise water levels in a basin, and tides roll out. The water is made to pass through a turbine to get out of the basin. Power generation through this method has a varying degree of success.
- Wave power, which uses the energy in waves. The waves will usually make large pontoons go up and down in the water. The wave power is also hard to tap.

Hydroelectric energy is therefore the only viable option. However, even probably this option is also not there with the developed nations for future energy production, because most major sites within these nations with the potential for harnessing gravity in this way are either already being exploited or are unavailable for other reasons such as environmental considerations. On the other side, large hydro potential of millions of megawatts is available with the developing countries of the world but major bottleneck in the way of development of these large Hydro projects is that each site calls for huge investment.

6.31 Micro/Small Hydro Power

This is non-conventional and renewable source and is easy to tap. Quantitatively small volumes of water, with large falls (in hills) and quantitatively not too large volumes of water, with small falls (such that of canals), can be tapped. The force of the flowing and falling water is used to run water turbines to generate energy.

- The estimated potential of Small Hydro Power in India is about 15,000 MW.

- In the country, Micro hydro projects up to 3 MW of total capacity of 240MW and 420 small hydropower projects up to 25 MW station capacity with an aggregate capacity of over 1423 MW have been set up and over 187 projects in this range with aggregate capacity of 521 MW are under construction.

6.4 Geothermal Energy

Geothermal energy is a very clean source of power. It comes from radioactive decay in the core of the Earth, which heats the Earth from the inside out and thus energy/power can be extracted owing to the temperature difference between hot rock deep in the earth and relatively cool surface air and water. This requires that the hot rock be relatively shallow, so it is site - specific and can only be applied in geologically active areas.

It can be used in two ways:

- Geothermal heating
- Geothermal electricity

As stated above, the geothermal energy from the core of the Earth is closer to the surface in some areas than in others. Where hot underground steam or water can be tapped and brought to the surface it may be used directly to heat and cool buildings or indirectly it can be used to generate electricity by running the steam/gas turbines. Even otherwise, on most of the globe, the temperature of the crust a few feet below the surface is buffered to a constant 7-14 degree Celsius, so a liquid can be pre-heated or pre-cooled in underground pipelines, providing free cooling in the summer and heating in the winter by using a heat pump.

6.5 BIOMASS

6.51 Solid Biomass

Plants use photosynthesis to store solar energy in the form of chemical energy. The easiest way to release this energy is by burning the dried up plants. Solid biomass such as firewood or combustible field crops including dried manure is actually burnt to heat water and to drive turbines. Field crops may be grown specifically for combustion or may be used for other purposes and the processed plant waste then used for combustion. Most sorts of biomass, including Sugarcane residue, wheat chaff, corn cobs and other plant matter can be, and is, burnt quite successfully. Currently, biomass contributes 15% of the total energy supply world wide.

A drawback is that all biomass needs to go through some of these steps: it needs to be grown, collected, dried, fermented and burned. All of these steps require resources and an infrastructure.

- In the area of small scale biomass gasification, significant technology development work has made India a world leader.
- A total capacity of 55.105 MW has so far been installed, mainly for stand-alone applications.
- A 5 x 100 KW biomass gasifier installation on Gosaba Island in Sunderbans area of West Bengal is being successfully run on a commercial basis to provide electricity to the inhabitants of the Island through a local grid.
- A 4X250 kW (1.00 MW) Biomass Gasifier based project has recently been commissioned at Khtrichera, Tripura for village electrification.

- A 500 KW grid interactive biomass gasifier, linked to an energy plantation, has been commissioned under a demonstration project.

6.52 Biofuel

Biofuel is any fuel that derives from biomass - recently living organisms or their metabolic byproducts, such as manure from cows. Typically biofuel is burned to release its stored chemical energy. Biomass, can be used directly as fuel or to produce liquid biofuel. Agriculturally produced biomass fuels, such as biodiesel, ethanol, and bagasse (often a by-product of sugarcane cultivation) can be burned in internal combustion engines or boilers.

India is the largest producer of cane sugar and the Ministry is implementing the world's largest co-generation programme in the sugar mills.

- India has so far commissioned a capacity of 537 MW through bagasse based co-generation in sugar mills and 536 MW is under installation.
- It has an established potential of 3,500 MW of power generation.

6.53 Biogas

Biogas can easily be produced from current waste streams, such as: paper production, sugar production, sewage, animal waste and so forth. These various waste streams have to be slurried together and allowed to naturally ferment, producing 55% to 70% inflammable methane gas. India has world's largest cattle population – 400 million thus offering tremendous potential for biogas plants. Biogas production has the capacity to provide us with about half of our energy needs, either burned for electrical productions or piped into current gas lines for use. It just has to be done and made a priority. Though about 3.71 millions biogas plants in India up to March, 2003 are successfully in operation but still it is utilizing only 31% of the total estimated potential of 12 million plants. The pay back period of the biogas plants is only 2/3 years, rather in the case of Community and Institutional Biogas Plants is even less. Therefore biogas electrification at community/Panchayat level is required to be implemented.

7. CUMULATIVE ACHIEVEMENTS OF RENEWABLE ENERGY IN INDIA

	Source/Technologies	Units	Cumulative Physical Achievements up to 31/3/05	India's Position in the World
	Power Generation			
1	Wind Power	MW	3,595	Fifth
2	Small Hydro Power (up to 25 MW)	MW	1,705	Tenth
3	Biomass based Power	MW	749.53	Fourth
4	Biomass Gasifiers	MW	66.23	First
5	Solar Photovoltaics Power	MW	264	Fifth
6	Energy Recovery from Urban & Industrial Wastes	MW	41.98	
	Thermal Applications			
1	Biogas Plants	Number in Million	3.71	Second
2	Improved Biomass Chulha (Cookstoves) (31-3-03)	Number in Million	35.2	Second

Water Pumping				
1	Wind Pumps	Number	1,015	
2	Solar PV Pumps	Number	6,818	
Solar Lighting Systems				
1	Solar Street Lighting Lamps	Number	54,795	
2	Home Lighting Systems	Number in Million	0.342	
3	Solar Lanterns	Number in Million	0.56	

8. PUNJAB STATE ELECTRICITY BOARD – CASE STUDY

8.1 Power Generation in Punjab

Thermal and hydel are only two conventional sources of power generation in Punjab. The installed capacity of its own thermal and hydro units (excluding share from central sector) is 2130 MW and 999 MW respectively. As at present, the state does not have any major hydro potential and so far thermal generation is concerned, Punjab is geographically located far away from the coal mines. While exploring other sources of energy, it was noticed that some falls were available on canals in Punjab, where micro/mini hydro plants can be constructed. Further, the State has 4.2 million hectares of well-irrigated and fertile land which produces more than 15 millions tons of wheat and 10 million tons of rice. So it was felt that crop residue (biomass) based power also provides specific advantages to Punjab. Thus it was the beginning of an era for setting up non-conventional power generation units in Punjab.

8.2 Non-Conventional Energy Projects Commissioned &Under Execution in Punjab

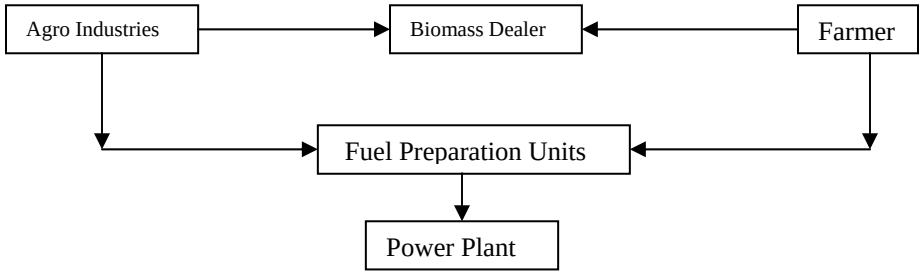
S. No.	Type	Capacity In Use		Capacity Under Execution	
		Total Units	Capacity (MW)	Total Units	Capacity (MW)
1	Micro/Mini Hydel	16	19.2	41	36
2	Biomass	2	16	1	6
3	Solar plants	1	0.2	3	0.125
4	Co-generation	2	12.3	3	23
5	Waste to Energy	1	1	1	6
6	Solar PV pumps	1700	-	700	-
7	Solar street lights	2666	-	-	-
8	Home lights	3570	-	-	-
9	Solar lanterns	14995	-	-	-

8.2 Jalkheri Power Plant:

Punjab State Electricity Board (PSEB) took the first step to exploit the non-conventional energy sources, when a 10 MW plant was set up in village Jalkheri (Distt. Patiala) in 1991. This was a demonstration unit wholly designed and manufactured by the BHEL, India. This is basically a mini thermal plant which uses biomass as fuel instead of coal for releasing heat energy. The heat so liberated goes into water which is converted into superheated steam. The steam is then used to rotate the steam turbine. Thus heat energy is converted into the kinetic energy of rotation. The

turbine is on the same shaft as the generator, therefore this kinetic energy is converted into electrical energy and the latter runs the turbine to generate power. The generation voltage of power is 11KV which is stepped up to 66KV for linking it to PSEB transmission network.

In order to ensure adequate raw-material for the plant a consortium of following type has been formed:



The requirement of water for the plant is met from nearby canal.

Though, there was no dearth of the crop residue as fuel but initial difficulties in arranging biomass at site and some drawbacks in the plant forced its shut down. There after, modifications/improvements were carried out in the plant. Two major modifications carried out were:

i) The conveyor system for feeding fuel to the furnace was entirely changed so that any type of biomass may be used as fuel in the plant. Accordingly, rice/wheat straw, mustard straw, rice husk, saw dust, cotton waste, bagasse and tree chips i.e., any conceivable biomass, can be used as fuel.

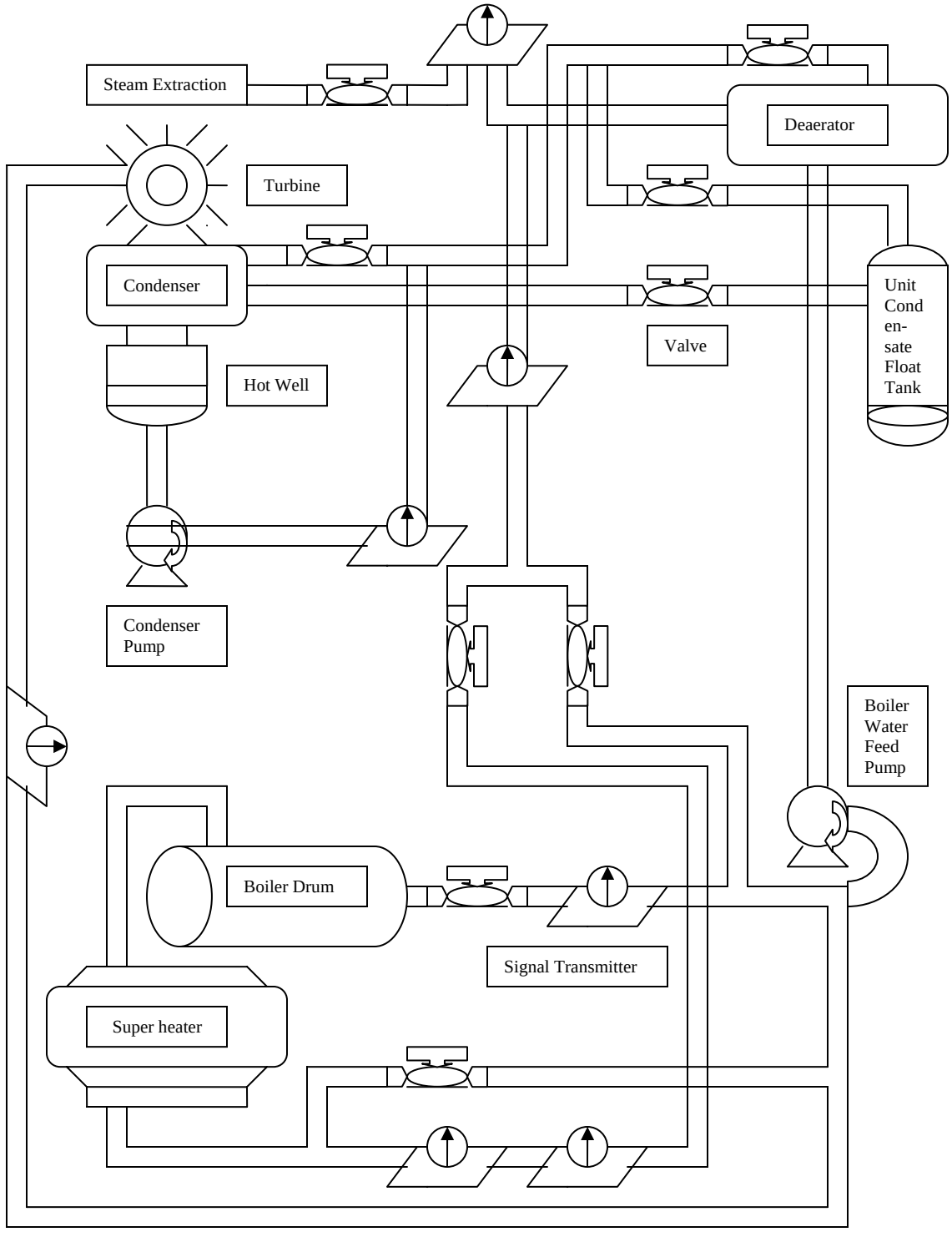
ii) Automation of the plant was carried out which enables the handling of all main controls and monitoring all the performance parameters from a single computer so as to obtain optimum generation.

The plant was recommisioned in 9/2001 and is now being run by a private entrepreneur on lease hold basis and the plant is now running quite satisfactorily. The following table of fuel consumption and generation in the current financial year gives an idea of plant's present performance:

Month	Fuel Consumption in M.T.	Generation in MWh
April, 2005	7768.367	4960.8
May, 2005	7353.827	5201.0
June, 2005	7872.87	5519.8
July, 2005	9203.87	6132.8
August,2005	8131.215	5716.8
September,2005	4909.445	2985.2 (Under repair)
Total	45239.594	30516.4

PSEB is currently purchasing power @ Rs. 3.66 per unit from the supplier under an agreement. No doubt renewable supplies generally have higher costs than fossil fuels if the externalized costs of pollution are ignored, as is common. But with further R&D, the generation cost is bound to come down.

The automation of the plant has facilitated the monitoring and control of the plant from remote location. The logic control shown below has all the necessary commands. One can control the governor to regulate the steam in the turbine, the air supply and furnace draught can be changed and in case of fault in any equipment such as pumps etc., the stand by can also be selected while sitting before the computer screen.



ALARM | TURBINE | AIR & FLUE GAS | TOTALIZER | TRENDS

Logic Control of Biomass based Power Plant JALKHERI

9. ISSUES

9.1 Habitat Hazards

Some renewable energy systems entail unique environmental problems. For instance, wind turbines can be hazardous to flying birds, while hydroelectric dams can create barriers for migrating fish. Burning biomass and biofuels causes air pollution similar to that of burning fossil fuels, although it causes a lower greenhouse effect since the carbon placed in the atmosphere was already there before the plants were grown.

.9.2 Proximity to Demand

Significant resources are often located at distance from the major population centers where electricity demand exists. Exploiting such resources on a large scale is likely to require considerable investment in transmission and distribution networks as well as in the technology itself.

9.3 Availability

One recurring criticism of renewable sources is their intermittent nature. Solar energy, for example can only be expected to be available during the day (50% of the time). Wind energy intensity varies from place to place and somewhat on season to season. Constant stream of water is often not available throughout the year for generating optimum Hydro power.

10. 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 around the globe will rise by 1.4 to 5.8 degrees Celsius, which will cause a upsurge in the sea water levels drowning all lands at low elevation along the coastal lines. So the world has already made a beginning to bring about the infrastructural changes in the energy sector so as to be able to choose the renewable energy development trajectory. In developing countries, where a lot of new energy production capacity is to be added, the rapid increase of renewables is, in principle, easier than in the industrial countries where existing capacity would need to be converted if a rapid change were to take place. 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 developed countries first. Nevertheless, India must give more thrust to the research and development in the field of non-conventional energy sources not only to mitigate greenhouse effect but also to lessen dependence on 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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