Non Conventional Sources of Energy

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ABSTRACT
Renewable energy has had a steady growth in power systems worldwide. The high uncertainty about what type of renewable technology meets technical and economic variables of the energy markets and what could be the participation in the energy matrix are important long term energy planning challenges different scenarios of future development OF the technological contribution of renewables. The scenarios illustrate the need to strengthen the transmission system and the importance of improving and / or incorporating mechanisms to reduce dependence on fossil fuels and the maximization of renewable resources. Future work will establish the impact of intermittent renewable technologies on power system operation.

General terms - Energy.
Keywords - Solar energy, wind energy, tidal energy, bio mass fuel, renewable energy.

1. INTRODUCTION
The Industrial Revolution of the 19thcentury ushered in new technologies. The spurt in inventions in that century was unprecedented in many ways. Some of these inventions involved use of natural resources like coal and oil. The thought of exhaustible nature of these resources and the environmental damage from the use of these resources never occurred either to the inventors or the subsequent generations. In the quest to sustain galloping economic activity, the dependence on coal and oil has soared at a phenomenal rate over the years. The burnt fuels result in the release of carbon dioxide and other gases into the atmosphere causing environmental damage. It has become imperative to look at energy technology with a new perspective. There are abundant renewable sources of energy such as wind, sun, water, sea, biomass apart from even daily wastes. These sources are pollution free and hence clean energy apart from being unlimited/ inexhaustible. Power generation in India has grown in size to around 1 lakh MW and in Tamil Nadu it has increased to 7924 MW which is distributed through a vast

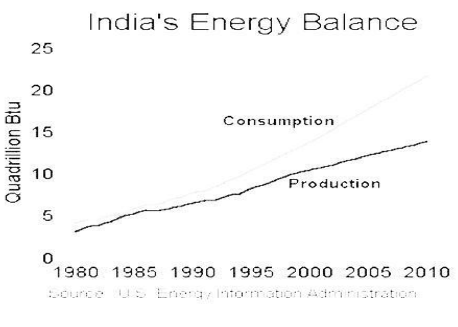

Figure 1 India's energy balance

network of transmission, sub transmission and distribution lines that reach all villages even in remote areas. The demand for power is growing rapidly. The problem will be compounded due to fast depletion of fossil fuel deposits,quality of fuels, heavy price to be paid for basic materials plus their transportation cost and above all the environmental degradation caused by the use of conventional energy sources. Under such conditions, environment-friendly and pollution-free, non-conventional and renewable energy sources known as 'clean and green energy' have emerged as an important alternatives to conventional energy sources. The renewable energy sources are clean and inexhaustible as they rely on sun, wind, biomass, etc., as primary sources of energy. It is estimated that, about 2000 MW can be generated from wind potential available in Tamil Nadu.As against this potential,19 MW of power in the State Sector mostly through demonstration wind farms and 838 MW in the private sector have been harnessed as on 31.3.02, Under Biomass, the estimated potential is about 500 MW and 154 MW capacity has been expected using biomass/bagasse. The country is endowed with large amount of sustainable resource base and non-conventional energy technologies which are well-suited for grid connected power generation, energy supplies in remote areas which are not/could not be connected to the grid and for captive consumption. Non-conventional energy sources like wind energy, solar energy through thermal as well as photovoltaic system, biomass and hybrid sources will help to a great extent in enhancing power generation capacity. Hence appropriate policies and programs that optimize the use of available energy resources with new technologies have to be propagated, promoted and adopted, if necessary, by budgetary support. India has done very well in promoting and harnessing renewable sources of energy particularly wind and bagasse based power generation. With a view to develop and propagate the non-conventional sources of energy.

2. WIND ENERGY
The evolution of windmills into wind turbines did not happen overnight and attempts to produce electricity with windmills date back to the beginning of the century. It was Denmark which erected the first batch of steel windmills specially built for generation of electricity. After World War II, the development of wind turbines was totally hampered due to the installation of massive conventional power stations using fossil fuels available at low cost. But the oil crisis of 1973 heralded a definite breakthrough in harnessing wind energy. Many European countries started pursuing the development of wind turbine technology seriously and their development efforts are continuing even today. The technology involves generation of

electricity using turbines, which converts mechanical energy created by the rotation of blades into electrical energy; sometimes the mechanical energy from the mills is directly used for pumping water from well also. The wind power programme in India was started during 1983-84 with the efforts of the Ministry of Non-Conventional Energy Sources. In India the total installed capacity from wind mills is 1612MW.The installation of 119 Wind electric generators for a total capacity of 19 MW as part of demonstration programmes has motivated and encouraged private sector to install 3003 Wind electric generators for a total capacity of 838 MW. The Wind Mills have a total capacity of 857 MW of which 181 MW capacity was added during the Ninth Plan and have generated and fed into the grid (6816.379 Mu.) Installation of windmill for water pumping was taken up by providing subsidy ranging from Rs.20, 000 to Rs.32, 000 from Government besides subsidy of Rs.30, 000 to Rs.45, 000 against the total cost of Rs.80, 000 for gear type and Rs.1, 45,000 for AV55 type Wind Mills. During Ninth plan period,18 gear type Wind Mills were installed from 1997 to 2000 and another 4 mills were also installed by the end of 2002.Wind monitoring stations were set up in 11 centers in Coimbatore, Erode, Kanyakumari and Tuticorin to conduct Wind Resource Assessment study which helps to identify potential locations for wind mills. [2]

Figure 2: A wind mill

2.1 Main parts

1. Anemometer: - Measures the wind speed and transmits wind speed data to the controller.

2. Blades: - Most turbines have either two or three blades.

3. Wind blowing over the blades causes the blades to "lift" and rotate.

4. Controller:- The controller starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 65 mph. Turbines cannot operate at wind speeds above about 65 mph because their generators could overheat.

5. Gear box:- Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1200 to 1500 rpm, the rotational speed required by most generators to produce electricity. Tis a costly (and heavy) part of the wind turbine and engineers are exploring ‘direct-drive’ generators that operate at lower rotational speeds and don't need gear boxes.

6. Generator: - Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.

7. High-speed shaft: - Drives the generator. Low-speed shaft. The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

8. Nacelle: - The rotor attaches to the nacelle, which sits atop the tower and includes the gear box, low- and high-speed shafts, generator, controller, and brake. A cover protects the components inside the nacelle. Some nacelles are large enough for a technician to stand inside while working.

9. Pitch: - Blades are turned, or pitched, out of the wind to keep the rotor from turning in wind that are too high or too low to produce electricity.

10. Rotor: - The blades and the hub together are called the rotor.

11. Tower: - Towers are made from tubular steel (shown here) or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.

12. Wind direction: - This is an ‘upwind’ turbine, so-called because it operates facing into the wind. Other turbines are designed to run ‘downwind’, facing away from the wind.

13. Wind vane: - Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.

14. Yaw drive: - Upwind turbines face into the wind; the yaw drive is used to keep the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive, the wind blows the rotor downwind.

15. Yaw motor: - Powers the yaw drive [3]

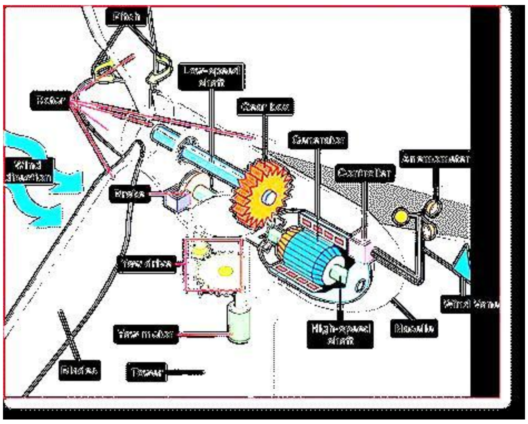

Figure 3: cross sectional structure

2.2 Wind Power

Wind possesses energy by virtue of its motion .Any device capable of slowing down the mass of moving air can extract part of the energy and convert into useful work. Following factors control the output of wind energy converter: -

* The wind speed
* Cross-section of the wind swept by rotor
* Conversion efficiently of rotor
* Generator
* Transmission system

Theoretically it is possible to get 100% efficiency by halting and preventing the passage of air through the rotor. However, a rotor is able to decelerate the air column only to one third of its free velocity.A 100% efficient wind generator is able to convert maximum up to 60% of the available energy in wind into mechanical energy. In addition to this, losses incurred in the generator or pump decrease the overall efficiency of power generation to 35%.

2.3 Principle of Energy Conversion

Wind mills or turbines works on the principle of converting kinetic energy of the wind into mechanical energy.

Power available from wind mill} = ½ □ A V^3

Where, □ – air density = 1.225 Kg. / m^3 at sea level. (Changes by 10-15% due to temperature and pressure variations)

A – Area swept by windmill rotor = □ D^2 sq.-m. (D – Diameter)

V – Wind speed m/sec.

Air density, which linearly affects the power output at a given speed, is a function of altitude, temperature and barometric pressure. Variation in temperature and pressure can affect air density up to 10 % in either direction. Warm climate reduces air density. This equation tells us that maximum power available depends on rotor diameter. Practically, wind turbines are able to convert only a fraction of available wind power into useful power

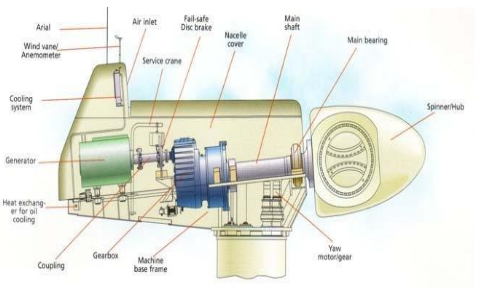

Figure 4 Cross sectional view

As the free wind stream passes through the rotor, it transfers some of its energy to the rotor and its speed decreases to a minimum in the rotor wake. After some distance from the rotor wind stream regains its speed from the surrounding air. We can Also observe drop in pressure as the wind stream passes through the rotor. Finally air speed and pressure increases to ambient atmospheric condition.

2.4 Site Selection

Following factors are to be considered for selection of good site for wind power generation:-

- High annual wind speed.
- No tall obstructions for a radius of 3 Km.
- Open plain or open shore
- Top of a smooth, well rounded hill with gentle slopes
- Mountain gap which produces wind funneling.
- High annual average wind speed.
- Availability of wind curve at the proposed site.
- Availability of anemometry data.
- Wind structure at the proposed site.
- Attitude of the proposed site.
- Terrain and it's aerodynamic
- Local ecology.
- Distance to roads and railways.
- Nature of ground.
- Nearness of site to local center\users.
- Favorable land cost.
- Wind Electric conversion System

2.5 Energy Storage

Wind power turbines have operational limitations over very high and very low speeds. When the power generated exceeds the demand, excess energy can be stored to be used at other times. Excess energy can be conveniently stored in storage batteries in the form of chemical energy. Excess energy can also be stored in water power storage in the form of mechanical energy. Wind power plant (WPP) along with Hydroelectric power plant (HPP), when generated power (Pg) exceeds the power demand (Pd), helps to partly divert hydro power plant output to Pumping motor (PM) to pump water from an auxiliary reservoir at the bottom of the dam to main reservoir.

2.6 Safety Interlocks

1. Modern wind turbines are controlled by computers. If it shows any error in operational parameters, then wind turbine is stopped.

2. Emergency stop – During unfavorable conditions for wind turbines, it can be immediately stopped using emergency stop.

3. Wind velocity is measured and if gusts of wind are too strong or if the average speed is too high, wind turbine is stopped.

4. To prevent rotor from racing, two revolution counters are mounted on the shaft. If wind turbine speed exceeds 24 rpm, it activates the emergency stop system.

5. If the wind turbine speed exceeds 28 rpm, a parachute attached to the blade tip is pulled out and thereby speed of the wind turbine decreases.

6. The three blades and wind turbine cap are grounded through lightning rods to protect them from lightning.[4]

3. BIO ENERGY

Biomass is yet another important source of energy with potential to generate power to the extent of more than 50% of the country's requirements. India is predominantly an agricultural economy, with huge quantity of biomass available in the form of husk, straw, shells of coconuts wild bushes etc. With an estimated production of 350 million tons of agricultural waste every year, biomass is capable of supplementing coal to the tune of about 200 million tonnes producing 17,000 MW of power and resulting in a saving of about Rs.20, 000 crores every year. Biomass available in India comprises of rice husk, rice straw, bagasse, coconut shell, jute, cotton, husk etc. Biomass can be obtained by raising energy farms or may be obtained from organic waste. The biomass resources including large quantities of cattle dung can be used in bio-energy technologies viz., biogas, gasifier, biomass combustion, co-generation etc. to produce energy-thermal or electricity. Biomass can be used in three ways – one in the form of gas through gasifiers for thermal applications, second in the form of methane gas to run gas engines and produce power and the third through combustion to produce steam and thereby power. Wind results from air in motion due to pressure gradient that is caused by the solar energy irradiating the earth.[5]

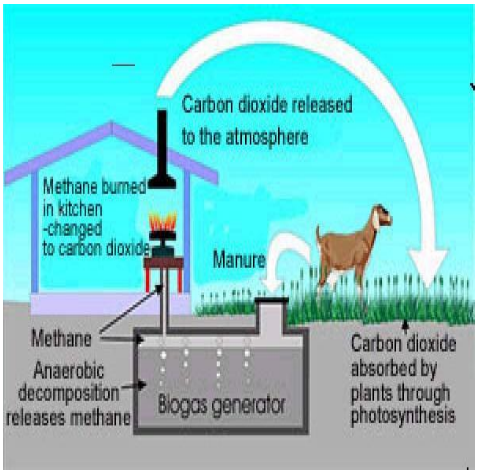

Figure 5 : Bio Fuel

4. SOLAR ENERGY

Solar Power was once considered, like nuclear power, 'too cheap to meter' but this proved illusory because of the high cost of photovoltaic cells and due to limited demand. Experts however believe that with mass production and improvement in technology, the unit price would drop and this would make it attractive for the consumers in relation to thermal or hydel power. The Solar Photo Voltaic (SPV) technology which enables the direct conversion of sun light into electricity can be used to run pumps, lights, refrigerators, TV sets, etc., and it has several distinct advantages, since it does not have moving parts, produces no noise or pollution, requires very little maintenance and can be installed anywhere. These advantages make them an ideal power source for use especially in remote and isolated areas which are not served by conventional electricity making use of ample sunshine available in India, for nearly 300 days in a year. A Solar Thermal Device, on the other hand capture and transfer the heat energy available in solar radiation. The energy generated can be used for thermal applications in different temperature ranges. The heat can be used directly or furtherconverted into mechanical or electrical energy. [7]

Figure 6 : Collector system

4.1 Electricity from Sunlight (Photovoltaic) and PV Terminology

Electricity can be produced from sunlight through direct heating of fluids to generate steam for large-scale centralized electrical generation (solar thermal electrical generation). Electricity can alternatively be produced from sunlight through a process called photovoltaic (PV)1, which can be applied, in either a centralized or decentralized fashion.

4.1.1 Solar Cell:

The PV cell is the component responsible for converting light to electricity. Some materials (e.g., silicon is the most common) produce a photovoltaic effect, where sunlight frees electrons striking the silicon material. The freed electrons cannot return to the positively charged sites ('holes') without flowing through an external circuit, thus generating current. Solar cells are designed to absorb as much light as possible and are interconnected in series and parallel electrical connections to produce desired voltages and currents.

4.1.2 PV Module:

A PV module is composed of interconnected solar cells that are encapsulated between a glass cover and weatherproof backing. The modules are typically framed in aluminum frames suitable for mounting. PV modules are rated by their total power output, or peak Watts2. A thin silicon cell, four inches across, can produce more than one watt of direct current (DC) electrical power in full sun. Individual solar cells can be connected in series and parallel to obtain desired voltages and currents. These groups of cells are packaged into standard modules that protect the cells from the environment while providing useful voltages and currents. PV modules are extremely reliable since they are solid state and there are no moving parts. Silicon PV cells manufactured today can provide over thirty years of useful service life. A 50 Wp PV module in direct sunlight operating at 25°C will generate 50 Watts per hour (referred to as a Watt-hour-[WH]). This same module will produce less power at higher temperatures; at 55°C this same module can only produce about 42.5 W. Modules can be connected together in series and/or parallel in an array to provide required voltages and currents for a particular application. PV systems are made up of a variety of components, which aside from the modules, may include conductors, fuses, and disconnect controls, batteries, trackers, and inverters. Components will vary somewhat depending on the application. PV systems are modular by nature, thus systems can be readily expanded and components easily repaired or replaced if needed. PV systems are cost effective for many remote power applications, as well as for small stand-alone power applications in proximity to the existing electric grid. PV is a relatively new and unknown technology, which offers a new vision for consumers and business as to how power can be provided. PV technology is already proving to be a force for social change in rural areas in less developed countries. The unique aspect of PV is that it is a 'radical' or 'disruptive' type of technology as compared to conventional power generation technologies. PV is a technology that does not build from the old technology base, but rather replaces that base from the bottom up. PV allows people the opportunity to ignore traditional electrical power supply structures and meet their own power needs locally. In rural regions of the world today, where there are no power companies offering electricity, PV is often the technology of choice. The best performing renewable energy electrification systems are those that meet the expectations of the users. It is important to satisfy the basic needs of the user in order to ensure acceptance of renewable energy systems. Ownership and subsequent accountability is the key to system sustainability for PV. One 50 Wp PV module is enough to power four or five small fluorescent bulbs, a radio, and a 15-inch black-and-white television set for up to 5 hours a day. Obviously this is only a modest amount of energy, however, this represents an important Quality of life improvement for many rural people with

4.2 Global Photo Voltaic Markets

The fast growing world market for PV greatly reflects the growing rural electrification demand of less developed countries around the world. The global PV market has grown at an average rate of 16 percent per year over the decade with village power driving demand worldwide PV production in 1980 was only 6.5 megawatts (MW) and by 1997 this had increased to 126.7 MW There are over 500,000 homes using PV today in villages around the world for electricity. In Kenya**, more rural households receive electricity from PV than from the conventional power grid. The single largest market sector for PV is village power at about 45 percent of worldwide sales. This is mostly comprised of small home lighting systems and water pumping. Remote industrial applications such as communications are the second largest market segment.

4.3 Photovoltaic Cost

For many applications, especially remote site and small power applications, PV power is the most cost-effective option available, not to mention its environmental benefits. New PV modules generally retail for about Rs.225 per peak watt, depending on quantities purchased. Batteries, inverters, and other balance of system components can raise the overall price of a PV system to over Rs.450_Rs.675 per installed Watt. Manufacturers from 10 to 20 years today guarantee PV modules in the market, while many of these should provide over 30 years of useful life. It is important when designing PV systems to be realistic and flexible, and not to over design the system or overestimate energy requirements (e.g., overestimating water-pumping requirements) so as not to have to spend more money than needed. PV conversion efficiencies and manufacturing processes will continue to improve, causing prices to gradually decrease.PV conversion efficiencies have increased with commercially available modules that are from 12 to 17 percent efficient, and research laboratory cells demonstrate efficiencies above 34percent. A well-designed PV system will operate unattended and requires minimum periodic maintenance, which can result in significant labour savings guaranteed by the manufacturer from 10 to 25 years and should last well over 30 years. PV conversion efficiencies and manufacturing processes will continue to improve, causing prices to gradually decrease, however no dramatic overnight price breakthroughs are expected.

4.4 Common Photovoltaic Applications

PV is best suited for remote site applications that have small to moderate power requirements, or small power consuming applications even where the grid is in existence. A few power companies are also promoting limited grid-connected PV systems, but the large market for this technology is for stand-alone (off grid) applications. Some common PV applications are as follows:

4.4.1 Water Pumping

Pumping water is one of the most competitive arenas for PV power since it is simple, reliable, and requires almost no maintenance. Agricultural watering needs are usually greatest During sunnier periods when more water can be pumped with a solar system. PV powered pumping systems are excellent for small to medium scale pumping needs (e.g., livestock tanks) and rarely exceed applications requiring more than a 2 hp motor. PV pumping systems main advantages are that no fuel is required and little maintenance is needed. PV powered water pumping system is similar to any other pumping system, only the power source is solar energy; PV pumping systems have, as a minimum, a PV array, a motor, and a pump.PV water pumping arrays are fixed mounted or sometimes placed on passive trackers (which use no motors) to increase pumping time and volume. AC and DC motors with centrifugal or displacement pumps are used with PV pumping systems.

4.4.2 Gate Openers

Commercially available PV powered electric gate openers use wireless remote controls that start a motorized actuator that releases a gate latch, opens the gate, and closes the gate behind the vehicle. Gates are designed to stop if resistance is met as a safety mechanism. Units are available that can be used on gates up to 16 feet wide and weighing up to 250 pounds. Small PV modules of only a few watts charge batteries. Digital keypads are available to allow access with an entry code for persons without a transmitter. Solar powered gate-opening assemblies with a PV module and transmitter sell for about RS.31500.

4.4.3 Electric Fences

PV power can be used to electrify fences for livestock and animals. Commercially available packaged units have maintenance free 6 or 12 volt sealed gel cell batteries (never need to add water) for day and night operation. These units deliver safe (non-burning) power spikes (shocks) typically in the 8,000 to 12,000 volt range. Commercial units are UL rated and can effectively electrify about 25 to 30 miles of fencing.

4.4.4 Water Tank De-Ices

For the north plains of Texas in the winter, PV power can be used to melt ice for livestock tanks, which frees a rancher from going out to the tank with an axe to break the surface ice so that the cows can drink the water. The PV module provides power to a small compressor on the tank bottom that generates air bubbles underwater, which rise to the surface of the tank. This movement of the water with the air bubbles melts the tank's surface ice. Commercially available units are recommended for tanks 10 feet in diameter or greater, and can also be used with ponds. Performance is the best for tanks that are sheltered and insulated. Installation is not recommended for small, unsheltered tanks in extremely cold and windy sites. An approximate cost for a complete owner- installed system, including a PV module, compressor, and mounting pole is about Rs.20250.

4.4.5 Commercial Lighting

PV powered lighting systems are reliable and a low cost alternative widely used. Security, billboard sign, area, and outdoor lighting are all viable applications for PV. It's often cheaper to putting a PV lighting system as opposed to installing a grid lighting system that requires a new transformer, trenching across parking lots, etc. Most stand-alone PV lighting systems operate at 12 or 24 volts DC. Efficient fluorescent or sodium lamps are recommended for their high efficiency of lumens per watt. Batteries are required for PV lighting systems. Deep cycle batteries specifically designed for PV applications should be used for energy storage for lighting systems. Batteries should relocate in protective enclosures, and manufacturer's installation and maintenance instructions should be followed. Batteries should be regulated with a quality charge controller. Lighting systems prices vary depending on the size. Residential power Over 500,000 homes worldwide use PV power as their only source of electricity. In Texas, a residence located more than a mile from the electric grid can install a PV system more inexpensively than extending the electric grid. A Texas residence opting to go solar requires about a 2 kW PV array to meet its energy needs, at a cost of about Rs. 675,000. The first rule with PV is always energy efficiency. A PV system can provide enough power for an energy efficient refrigerator, lights, television, stereo, and other common household appliances.

4.4.6 Evaporative Cooling

PV powered packaged evaporative cooling units are commercially available and take advantage of the natural relation that when maximum cooling is required is when maximum solar energy is available. These units are most appropriate for comfort cooling in the dry climate of West Texas where performance is best. Direct evaporative coolers save 70% of the energy over refrigerated units. Battery storage is obviously required if cooler operation is desired at night. Array size would vary with the power requirements of the cooler motor. A linear current booster (LCB) is useful between the PV modules and the cooler's DC motor if the cooler is coupled directly to the PV array. Packaged PV evaporative cooling systems for residences generally run from Rs. 22500 to Rs.67500, depending on size.

4.4.7 Telecommunications

This was one of the early important markets for PV technologies, and continues to be an important market. Isolated mountaintops and other rural areas are ideal for stand-alone PV systems where maintenance and power accessibility makes PV the ideal technology. These are often large systems, sometimes placed in hybrid applications with propane or other type of generators.

4.4.8 Consumer Electronics

Consumer electronics that have low power requirements are one of the most common uses for PV technologies today. Solar powered watches, calculators, and cameras are all everyday applications for PV technologies. Typically, these applications use amorphous PV technologies that work well even in artificial light environments such as offices and classrooms.[9]

4.5 Current Research in Solar Energy

Today, solar energy research has a similar pattern to nuclear energy. The emphasis is on an arrow technical options and test facilities. An example is a power tower§, which is a system for collection solar energy from a large field of mirrors and converting it to heat at high temperature for efficient generation of electricity. All the mirrors track the sun and the heat is focused on a single broiler thermal system. The purpose is to only cover the midday load as experienced by utilities. To counter the effect of passing cloud, there is a thermal storage capability filled with oil. This area concentrates more on materials research, which primarily deals with what materials will efficiently absorb solar energy. The idea is to have solar collectors for heating pool, interior of house during winter or for providing hot water. Other thermal applications include intermediate applications. Solar energy can be used to produce steam for industrial processes. The iron industries for example, consume 23% of energy. Imagine the billions of rupees that can be saved by reducing their reliance on the congenital form of power. The other application is the use of water pumps for irrigation.

4.6 Solar power for agriculture

Solar cells are also being used in developing countries. Solar panels can power a 17" b/w TV, a radio or a fan. Some electric lighting systems provide sufficient current for up to 10 hours of lightning each evening. Locally produced car batteries can provide up to 5 nights of energy for an8-watt DC fluorescent light. The new Mazda 929, uses solar cells to activate a fan to ventilate the car when the car is idle and parked during a sunny hot day.

Figure 7: First church with solar system

Figure 8: Use of solar plant in agriculture

4.7 Future of Solar Energy

The success of solar power will depend on the answer to the following question: 'What do you do when the sun goes down?' The simple answer is to build an auxiliary system that will store energy when the sun is out. However, the problem is that such storage systems are unavailable today. Simple systems, like water pipes surrounded by vacuum, do exist. It is based on the concept that provided the pipes are insulated, the water will store thermal energy. The ocean is a natural reservoir of solar power and could be used as a source for thermal energy. If we can draw warm water from the surface and cold water from the depths, an ocean thermal plant could operate 24 hours a day. Cold water from the pipe and warm water from the surface were pumped into a plant on shore. It produced 22KW when the water temperatures were optimum and 12KW when seasonal current fluctuation reduced the efficiency. There are also the hybrid systems. Wyoming has a system that holds backwater on a neighboring hydroelectric plant when the wind is blowing, which for the time being, runs the turbines. As discussed earlier, wind is an indirect form of solar energy. Thus the hybrid system is used in the fuel saver mode. Research on photovoltaic cells will continue. Compared to the other options, majority of the resources will probably flow into research for developing better and more efficient solar cells. Parallel to that, more research will be undertaken to develop rechargeable batteries that will last longer hours.

Why is solar energy being used by indigenous cultures?

One could be that we are in trouble of running out of fossil fuel and environmentalists will eventually have their way with dams. Another could be that there is a market in solar energy. Governments are beginning to get involved and policies in these countries are shaping that encourage use of solar energy. Indigenous cultures are usually off of the grid, meaning they have no access to electricity. For fuel, many of these cultures use firewood or kerosene. Investors of traditional energy sources aren't typically interested in these rural communities because of economic inopportunity. Providing traditional sources of electricity for these traditional communities is terribly expensive and environmentally harmful. Although these areas are being electrified decades after many places in the world, this form of electricity is wise because it is beginning from a source of renewable energy-the sun. The use of solar as a form of energy embellishes the sustainable form of life these people have been leading while also advancing them in technology toward an increased standard in living. However, one must remember that in this day and age, no new development program comes without incentive, usually a marketable one. Solar implementation in developing nations is marketable because it allows these poor places to enter into the global market. But before we get too critical about globalization, the benefit of this type of development is that is environmentally sound and involves the people that live in these areas. [11]

Where are solar energy projects being implemented the most?

The answer is-in developing nations. More specifically we find them in Asia, Africa, the Caribbean and Latin America. One example of the application of solar energy is in this village in Ghana, Africa. For just under $200,000, this community of 300,000 people will be using solar energy. Not only will they be solar electrified, but also a solar learning center will be built teaching classes about such things as solar cooking. The World Bank has a programme to install home lighting system in 200,000 homes to Indonesia. SELF (Solar Electric Light Fund, Inc.) operates a rural solar enterprise in Karnataka, which provides solar services to rural households, and arrange financing and leasing of solar electric system. The largest percentage of solar energy in the world is being utilized by developing nations [12]

4.8 Applications:

1. Home lighting systems
2. Street and garden lighting system
3. Traffic control system
4. Railway signaling equipment
5. Battery charging e.g. Mobile, telephones.

Figure 9: VSAT Equipment's powered by Solar

5. OTHER SOURCES

The other sources of renewable energy are geothermal, ocean, hydrogen and fuel cells. These have immense energy potential, though tapping this potential for power generation and other applications calls for development of suitable technologies.

5.1 Geothermal Energy

Geo-Thermal energy is renewable heat energy from underneath the earth. Heat is brought to near surface by thermal conduction and by intrusion into the earth's crust. It can be utilized for power generation and direct heat applications. Potential sites for geo-thermal power generation have been identified mainly in central and northern regions of the country. Suitable technologies are under development to make its exploitation viable.[13]

5.1.1 Advantages of Geothermal Energy

Geothermal energy can be used instead of fossil fuels to produce electricity. Replacing fossil fuels will reduce the amount of air pollutants which can cause acid rain and contribute to global warming. Reducing the amount of oil shipped to the Big Island (officially called the Island of Hawaii) for electrical generation lessens the possibility of oil spills.

5.1.2 Electrical power generation.

A 30-megawatt geothermal power plant on the Big Island displaces the need to burn about 500,000 barrels of fuel oil every year. It eliminates the need to ship that amount of fuel oil from the refineries on the Island of Oahu to the Big Island, thus significantly reducing the risk of oil spills HDR electric plant could continuously generate power 24 hours a day and supply additional peak load power for a few hours each day. It is a reliable energy and stable with time since it does not depend on atmospheric or climatic conditions. It respects the environment, and has little or no effect on it. It generates almost no polluting substances, very little carbon dioxide and only a small quantity of hydrogen sulfide (HS). Most of these products are reinjected into the groundwater and not into the environment. Geothermal wells have a very limited visual impact. Once a well has been drilled it is completely invisible, since the wellhead is buried. One of the main advantages of HDR geothermal energy is the low environmental impact. As the energy is derived from converting heat extracted from hot rocks there are no gas emissions. Unlike burning fossil fuels, no CO2 is released into the atmosphere. The process does not produce any waste dumps and has a low noise impact. The construction of a HDR geothermal power plant leaves only a small environmental footprint. Site disturbance is limited to drill holes and pipelines, and a building to house the power plant.

5.2 Ocean *thermal and Tidal energy*

The vast potential of energy of the seas and oceans which cover about three fourth of our planet, can make a significant contribution to meet the energy needs. Ocean contains energy in the form of temperature gradients, waves and tides and ocean current, which can be used to generate electricity in an environment-friendly manner. Technologies to harness tidal power, wave power and ocean thermal energy are being developed, to make it commercially viable. [15]

Figure 10 : An ocean energy plant layout

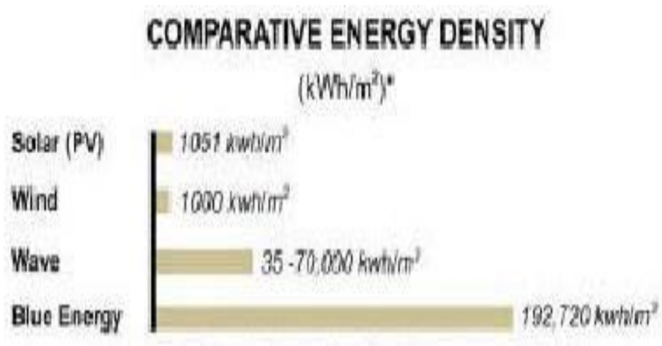

Figure 11: Energy Densities of different energies

5.3 *Hydrogen and Fuel Cells*

In both Hydrogen and Fuel Cells electricity is produced through an electro-chemical reaction between hydrogen and oxygen gases. The fuel cells are efficient, compact and reliable for automotive applications. Hydrogen gas is the primary fuel for fuel cells also. Hydrogen can be produced from the electrolysis of water using solar energy. It can also be extracted from sewage gas, natural gas, naptha or biogas. Fuel cells can be very widely used once they become commercially viable.

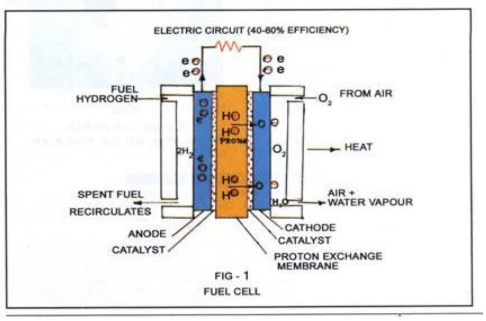

Figure 12: Fuel cell

5.3.1 Benefits of fuel cells

- Fuel cell power plants produce dramatically fewer emissions, and their byproducts are primarily water and carbon dioxide.
- Fuel cell power plants are nearly twice as efficient as conventional power plants.
- Small-scale fuel cell plants are just as efficient as large ones, and operation at partial load is as efficient as at full load.
- High-grade waste heat from fuel cell systems is perfect for use in cogeneration, heating, and air-conditioning.
- The fuel cell stack is the basic component of a fuel cell power plant. Stacks are combined into modules, and the number of modules determines plant capacity. The individual modules
- can go from ideal to full load in minutes.
- Fuel cells are one of the most reliable power generation technologies.
- Fuel cell power plants are reliable and safe, and can be sited in environmentally sensitive areas.
- Fuel cell needs hydrogen, which can be generated internally from natural gas, coal, methanol, landfill gas or other fuels containing hydrocarbons.
- Fuel cell technology meets public demand for clean, quite and efficient power.

Why Hydrogen?

Hydrogen is the perfect fuel because:

- It can be produced from variety of energy sources.
- It satisfies all energy needs from transportation to electric power generation
- It is the least polluting since its use produces water.
- It is the perfect carrier for solar energy in that it affords solar a storage media. [20]

5.4 *Bio fuels*

In view of worldwide demand for energy and concern for environmental safety there is needed to search for alternatives to petrol and diesel for use in automobiles. The Government of India has now permitted the use of 5% ethanol blended petrol.Tamilnadu is one of the nine States in the country where this programme will commence from January 2003. Ethanol produced from molasses/ cane juice, when used as fuel will reduce the dependence on crude oil and help contain pollution. Further, technology is also being developed to convert different vegetable oils especially non-edible oils as bio-diesel for use in the transport sector. They are however, in R & D stage only.

Figure 13 Bio fuel plant

Why Biofuels?

- Pollution threat
- Reduction of green house gas emission
- Regional development
- Social structure & Agriculture
- Security of supply.

Importance of Biodiesel

- Environment friendly
- Clean burning
- Renewable fuel
- No engine modification
- Increase in Engine life
- Biodegradable & non toxic
- Easy to handle and store.[21]

6. POTENTIAL AND EXPLOITATION OF RENEWABLE ENERGY SOURCES

India ranks fifth in the world in Wind power with installed capacity of 1612 MW out of an estimated potential of 45,000 MW.In biomass power the country has an installed capacity of 381 MW out of total potential of 19500 MW. In the potential available under solar photovoltaic energy is 20 MW per Sq.Km.But in view of high cost and heavy investment involved the progress is rather slow. In Solar thermal energy (Solar

Water Heater system) 15 lakh M2 collector area has been installed in the country against a potential of 1400 lakh M2.There is considerable scope for expanding this activity with suitable incentives. The major component of this has come from Wind Energy (858 MW) followed by co-generation in sugar industries (142 MW).Further, this has largely come about through private investment due to attractive policy initiatives of the State and Central Governments. It may be worthwhile to offer various incentives to enhance its share further in view of the vast potential available.

7. INTEGRATED RURAL ENERGY PLANNING (IREP)

The Objectives of the IREP Programme are:

(i) To provide for minimum domestic energy needs for cooking, heating and lighting purposes to rural people

(ii) To provide the most cost effective mix of various energy sources and options for meeting the requirements of sustainable agriculture and rural development with due environmental considerations.

(iii) To ensure people's participation in planning and implementation.

(iv) To develop and strengthen mechanisms and co-ordination arrangements for linking micro level planning for rural energy with national and State level planning and programmes. The programme is funded by Government of India which meets the staff cost and the State Government bears the scheme cost. The programmes implemented in the Ninth Plan period with subsidies ranging from 25% to 100% are:

1) Improved Chula (100% subsidy)

2) Frictionless foot valves (75% subsidy)

3) Solar Cookers (25%) subsidy.

4) Windmills for pumping water for community use (100% subsidy)

5) Other energy saving devices (25% subsidy)

8. ENERGY CONSERVATION & AUDIT

Energy Audit is a systematic approach for effecting energy conservation in an industry. Energy audit helps in identifying and assessing potential areas where energy could be conserved. The Government has made Energy Audit mandatory for the industrial sector and commercial sector with high tension power consumption with maximum demand exceeding 200 kVA under Phase I and between 1000 kVA to 2000 kVA under Phase II. (The new HT services covered under mandatory Energy Audit programmes are exempted from conducting energy audit for a period of 3 years from the date of service connection).

9. BOTTLENECKS & CONSTRAINTS

While the performance under the renewable energy sources programmes upto Eighth Five Year Plan was relatively good, the pace of implementation suffered during the Ninth Plan period due to various constraints, some of which are as follows:

(i) Renewable Energy Technologies are capital intensive and require high initial investment which investors could not mobilize in the absence of financial support including capital subsidy from the Central Government/ State Government.

(ii) The power purchase policy has not been encouraging for private entrepreneurs and suitable policy initiatives in the form of wheeling, and banking facilities, evacuation, arrangements, land allotment etc., need to be considered to boost investment.

(iii) Technologies for several renewable energy sources have not fully stabilized which has hampered the development and hence more intensive R&D efforts are called for with special focus on partnership with industry.

(iv) Since the cost of renewable energy gadgets/ devices such as solar cooker, biogas, solar geysers, solar lanterns etc., is high, it is not possible to generate sufficient demand for these items though the people are aware of the advantages. Hence, the cost needs to be reduced through suitable support to manufacturers.

(v) Fiscal incentives namely 100% depreciation attracted several private investors.

(vi) Adequate number of professionally skilled manpower has not been developed in the renewable energy sector and hence training programmes may be organized to develop required manpower.

9.1 Vision

- Provide and promote "clean and green energy" on much wider scale covering villages and towns to meet the decentralized energy requirements in agriculture, small scale industries, commercial establishments and households with priority for remote habitations which do not enjoy grid power.
- Enhance the generation of grid quality power through private investment for harnessing various renewable energy sources

10. GOAL AND OBJECTIVES

The national goal of meeting 10% of grid capacity from renewable sources by 2010.Under the Tenth Plan, the goal is to consolidate and stabilize the share of grid connected power with addition of 550 MW and also achieve decentralized power generation to meet the local energy needs in agriculture, agro-processing, households etc., especially in remote areas and expand the use of renewable energy sources and promote energy efficiency and thereby energy saving.

10.1 Strategies

i. Encourage and promote private investments in renewable energy through suitable policy initiatives at State level.

ii. Involve local bodies in developing decentralized power and its use in agriculture, household sectors etc.

iii. Establish field units to promote renewable energy at local levels by integrating existing programme staff.

iv. Enable suitable revision of power purchase rate for grid connected power to make it attractive for the investors.

v. Encourage research and development to improve efficiency of the devices and bring down the cost.

vi. Undertake awareness campaigns in Districts through seminars, exhibition, etc.[22]

11. NEW INITIATIVES

The following new initiatives are proposed:

i. Undertake further studies for micrositing for setting up of Wind Mills by identifying proper and suitable locations

ii. Undertake Biomass potential assessment studies at Taluk level and make data on Biomass potential available for prospective investors

iii. Merge the staff under Centrally sponsored schemes like IREP and National Biogas Development programme and create field outfits to provide guidance and support to local bodies in tapping renewable energy.

iv. Popularize and propagate renewable energy use among industries and households in rural and urban areas & secure

v. Arrange for suitable adjustments in wheeling and banking facilities, and third party sale to attract further investment in renewable energy sector and designate TEDA as single window agency to facilitate smooth clearance for projects upto certain capacity say 25MW [25]

12. CONCLUSIONS

The new mantra of the 21st century is sustainable development the future is bright for continued PV technology dissemination around the world. Technology fills a significant need in supplying electricity, creating local jobs and promoting economic development in rural areas, while also having the positive benefits of avoiding the external environmental costs associated with traditional electrical generation technologies. People, who choose to pursue a renewable and sustainable energy future now, are the ones showing the way for the future. Solar energy is presently being used on a smaller scale in furnaces for homes and to heat up swimming pools. On a larger scale, solar energy could be used to run cars, power plants, and space ships. This means that the local population should be able to absorb the development of a country or region. The people should be financially, mentally and physically able to support the improvement in the quality of their lives. We want the entire population to have access to uninterrupted supply of electricity. This puts a huge burden on the limited fossil fuel resources. The benefits of using wind power over other resources lies in its minimum operational cost. Depending on field of applications, various schemes can be adopted to get optimum output. [24] Various option of storage facility makes it versatile source of energy. Modern turbines are totally controlled by computers that are totally safe. Since wind is clean source of energy, the power conversion does not pose any environmental hazard. Wave energy is promising holds huge potential to reduce reliance on fossil fuels. Carefully choosing sites that can withstand the alterations to the environment caused by power plants will be crucial to effectively develop these technologies without harming the ocean. The expectations on fuel cell technology are very big .If you can manufacture PEM with long enough life spans, it will change the vehicle market completely. For small scale electric distribution there is a potential market provided that an acceptable fuel is nearby. For relatively small scale electric and heat production MCFC & SCFC have the potential of high efficiency. For larger scale power plants the image is not clear ,but one can reach a high efficiency.[25]

13. ACKNOWLEDGMENT

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