

A Brief Review on Recent Trends in Alternative Sources of Energy

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Abstract—Alternative energy is any energy source that is an alternative to fossil fuel. These alternatives are intended to address concerns about such fossil fuels. Today, because of the variety of energy choices and differing goals of their advocates, defining some energy types as "alternative" is highly controversial. Most of the recent and existing alternative sources of energy are discussed below.

Keywords—Athra Quinone Disulphonic Acid (AQDS), Renewable Methanol (RM), Solid Oxide Fuel Cell (SOFC), Maximum Power Point Tracking (MPPT).

I. INTRODUCTION

NON renewable sources of energy are the energy limited sources on Earth in quantity and; therefore, are exhaustible. The non-renewable energy sources include, non-exclusively: fossil source: petroleum, natural gas, coal original mineral/chemical: uranium, shale gas. Fossil fuels are non-renewable, un-sustainable resources, which will eventually decline in production [1] and become exhausted, with consequences to societies that remain dependent on them. Fossil fuels are actually slowly forming continuously, but are being consumed quicker than are formed [2]. Extracting fuels becomes increasingly extreme as society consumes the most accessible fuel deposits.

Extraction in fuel mines get intensive and oil rigs drill deeper. [3] Extraction of fossil fuels results in environmental degradation, such as the strip mining and mountaintop removal of coal. Combustion of fossil fuels leads to the release of pollution into the atmosphere. The commitments to mitigate climate change are driving efforts to develop sources of alternative and renewable energy. New energy industries include the renewable energy industry, comprising alternative and sustainable manufacture, distribution, and sale of alternative fuels. The renewable sources of energy are the energy source which is freely regenerated in a short period and has practically limitless reserves. Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves and geothermal heat.[4]

Alternative sources of energy replaces conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural energy services. In a general

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sense, alternative energy as it is currently conceived, is that which is produced or recovered without the undesirable consequences inherent in fossil fuel use, particularly high carbon dioxide emissions, an important factor in global warming.

II. WIND ENERGY SYSTEMS

Wind has been utilized as a source of power for thousands of years for such tasks as propelling sailing ships, grinding grain, pumping water, and powering factory machinery. The world's first wind turbine used to generate electricity was built by a Dane, Poul la Cour, in 1891. Wind energy has the biggest share in the renewable energy sector [1], [3]. The important features associated with a wind energy conversion system are: Available wind energy, Type of wind turbine employed, Type of electric generator and power electronic circuitry employed for interfacing with the grid. Wind energy – Wind speeds, air pressure, atmospheric temperature, earth surface temperature etc., are highly inter-linked parameters. The power that can be extracted from the wind is

$$P_w = \frac{1}{2} \pi R^2 \rho V^3 C_p(\lambda) \quad (1)$$

where R is the blade length, ρ is the density of air, V is the wind velocity, λ is called the tip speed ratio, C_p and is called the power coefficient. The tip speed ratio is defined as the ratio of the tip speed to wind speed. It is accepted that the maximum attainable efficiency for wind energy conversion is 0.59 [5]. The present day variable speed wind turbines follow the point to extract the maximum power. This is enabled by variable speed operation and the power electronic module interfacing the turbine and the grid.

One way to classify wind turbines is in terms of the axis around which the turbine blades rotate. Most are horizontal axis wind turbines (HAWT), but there are some with blades that spin around a vertical axis (VAWT). The only vertical axis machine that has had any commercial success is the Darrieus rotor, named after its inventor the French engineer G. M. Darrieus, who first developed the turbines in the 1920s [11]. The shape of the blades is that which would result from holding a rope at both ends and spinning it around a vertical axis. Based on the aerodynamic principle utilized, wind turbines are classified into drag based and lift based turbines.

The principal advantage of vertical axis machines, such as the Darrieus rotor, is that they don't need any kind of yaw control to keep them facing into the wind. [9] A second advantage is that the heavy machinery contained in the nacelle be located down on the ground, where it can be serviced

easily. Since the heavy equipment is not perched on top of a tower, the tower itself need not be structurally as strong as that for a HAWT.

There are several disadvantages of vertical axis turbines, the principal one being that the blades are relatively close to the ground where wind speeds are lower. The power in the wind increases as the cube of velocity so there is considerable incentive to get the blades up into the faster wind speeds that exist higher up. Another fundamental design decision for wind turbines relates to the number of rotating blades. Wind turbines with many blades operate with much lower rotational speed than those with fewer blades. With fewer blades, the turbine can spin faster before this interference becomes excessive. And a faster spinning shaft means that generators can be physically smaller in size. With respect to the rotation of the rotor, wind turbines are classified into fixed speed and variable speed turbines [5]. Power electronic circuits play a crucial enabling role in variable speed based wind energy conversion systems. Fixed speed wind turbines are simple to operate, reliable and robust. However the speed of the rotor is fixed by the grid frequency.

III. PV MODULES

The PV modules and the power electronics converters are the basic parts of a PV installation. The PV modules comprise several solar cells which convert the energy of the sunlight directly into electricity, and are connected in a proper way, to provide desired levels of DC current and voltage. They produce electricity due to a quantum mechanic process known as the "photovoltaic effect" [10]. The most commonly used semiconductor materials are monocrystalline Si cells, polycrystalline Si cells and amorphous Si cells, although several other thin film technologies exist in the market.

The efficiency of monocrystalline Si cells is almost 17%, for polycrystalline cells reaches almost 15%, while an efficiency of 10% is achieved in the case of amorphous Si PV cells [10]. In grid connected applications the energy is provided directly to the grid. The necessary parts are the PV modules and the inverters. This reduces the cost of the system and it also reduces the necessary maintenance, as the batteries are the most maintenance demanding components. The inverters for grid connected applications may have different topology and operation than offgrid ones. [7] They have to produce excellent quality sine wave output, follow the frequency and voltage of the grid and extract maximum power from the PV modules through the MPPT.

Off grid PV systems are used in cases, where the grid is not present and the use of batteries to store energy is required. Blocking diodes are used to prevent the batteries to discharge on the modules during the night, while they also protect the batteries from short circuit. If more than one string is used, they also provide over current protection of the strings in case of short circuits [12]. Charge regulators control the charging of the batteries. In off grid systems, there is the need to use dc voltage and current with stable characteristics, independent from irradiance fluctuations. In order to maximize the performance of the string, in most charge regulators a

maximum power point tracker (MPPT) controller is used. The MPPT applies heuristic algorithms to track the array voltage which results in maximum power, given a solar irradiance level. The efficiency of modern MPPTs is between 92% - 97%, getting a typical 20% - 45% power gain in winter and a 10% - 15% in summer [13]. Actual gain can vary widely depending on temperature, battery state of charge, and other factors.

IV. BLOOM ENERGY SERVER

The Bloom Energy Server is a solid oxide fuel cell (SOFC) made by Bloom Energy, of Sunnyvale, California, that can use a wide variety of inputs to generate electricity on the site where it will be used. It can withstand temperatures of up to 1,800 °F (980 °C) that would cause many other fuel cells to break down or require maintenance. [20]. A single cell generates 25 watts. Two hundred servers have been deployed in California for corporations including eBay, Google, and Wal-Mart. The Bloom Energy Server uses thin white ceramic plates that are made from "beach sand". Each plate is coated with a green nickel oxide-based ink on one side, forming the anode, and another black ink on the cathode side. Bloom's secret technology lies in the proprietary green ink that acts as the anode and the black ink that acts as the cathode but in fact these materials are widely known in the field of SOFCs. The electrolyte includes yttria stabilized zirconia and a scandia-stabilized zirconia, such as a scandia ceria stabilized zirconia. ScSZ has a higher conductivity than YSZ at lower temperatures, which provides greater efficiency and higher reliability when used as an electrolyte. Scandia is scandium oxide (Sc_2O_3) which is a transition metal oxide in 99.9% pure form. The Bloom Energy Server uses inexpensive metal alloy plates for electric conductance between the two ceramic fast ion conductor plates. In competing lower temperature fuel cells, platinum is required at the cathode. Bloom Energy is the company that develops, builds, and installs Bloom Energy Servers. [20] The Bloom Energy Server company, started in 2002 by CEO K.R. Sridhar is one of 26 named a 2010 Tech Pioneer by the World Economic Forum.

V. ETHANOL FUEL

In 1917, Alexander Graham Bell advocated ethanol from corn, wheat and other foods as an alternative to coal and oil, stating that the world was in measurable distance of depleting these fuels. For Bell, the problem requiring an alternative was lack of renewability of orthodox energy sources.[18] Since the 1970s, Brazil has had an ethanol fuel program which has allowed the country to become the world's second largest producer of ethanol and the world's largest exporter. Brazil's ethanol fuel program uses modern equipment and cheap sugar cane as feedstock, and the residual cane-waste is used to process heat and power. There are no longer light vehicles in Brazil running on pure gasoline. By the end of 2008 there were 35,000 filling stations throughout Brazil with at least one ethanol pump.[19]

Cellulosic ethanol can be produced from a diverse array of

feedstocks, and involves the use of the whole crop. This new approach should increase yields and reduce the carbon footprint because the amount of energy-intensive fertilizers and fungicides will remain the same, for a higher output of usable material. [18], [19] As of 2008, there are nine commercial cellulosic ethanol plants which are either operating, or under construction, in the United States. Second-generation biofuels technologies are able to manufacture biofuels from inedible biomass and could hence prevent conversion of food into fuel."As of July 2010, there is one commercial second-generation (2G) ethanol plant Inbicon Biomass Refinery, which is operating in Denmark.

VI. CARBON-NEUTRAL AND NEGATIVE FUELS

Carbon-neutral fuels are synthetic fuels produced by hydrogenating waste carbon dioxide recycled from power plant flue-gas emissions, recovered from automotive exhaust gas, or derived from carbonic acid in seawater. Commercial fuel synthesis companies can produce synthetic fuels for less than petroleum fuels when oil costs more than \$55 per barrel. [21] Renewable methanol (RM) is a fuel produced from hydrogen and carbon dioxide by catalytic hydrogenation where the hydrogen has been obtained from water electrolysis. It can be blended into transportation fuel or processed as a chemical feedstock.

VII. FLOW BATTERY

Flow batteries are well suited to renewable energy because they can store many hours of energy and the storage capacity can be expanded independently from the power rating. As with all grid storage technologies other than pumped hydro and compressed air storage, the costs need to come down. Flow batteries use two big tanks of liquid electrolytes, which are circulated several times through a vessel where an electrochemical reaction takes place across a membrane. When connected to a load, a current is produced when electrons move from negative electrolyte to the positive. During recharge, a current is applied to reverse the reaction. Flow batteries are generally considered safe, an important issue for grid-scale batteries where thermal runaway of conventional batteries has caused fires at least two cases.

A flow battery is a type of rechargeable battery where recharge ability is provided by two chemical components dissolved in liquids contained within the system and separated by a membrane. Ion exchange occurs through the membrane while both liquids circulate in their own respective space. Cell voltage is chemically determined by the Nernst equation and ranges, in practical applications, from 1.0 to 2.2 Volts. A flow battery is technically akin both to a fuel cell and an electrochemical accumulator cell. In 2013 researchers announced the use of 9,10-anthraquinone-2,7-disulphonic acid as a charge carrier in metal-free flow batteries [8].

Each of the carbon-based molecules holds two units of electrical charge, compared with one unit in conventional batteries, implying that a battery could store twice as much as energy in a given volume. [22] AQDS undergoes rapid,

reversible two-electron/two-proton reduction on a glassy carbon electrode in sulphuric acid. The organic anthraquinone species can be synthesized from inexpensive commodity chemicals. This organic approach permits tuning of the reduction potential and solubility by adding functional groups. Adding two hydroxy groups to AQDS increases the open circuit potential of the cell by 11%. While it has technical advantages such as potentially separable liquid tanks and near unlimited longevity over most conventional rechargeable, current implementations are comparatively less powerful and require more sophisticated electronics.

VIII. FLOATING WIND FARMS

Floating wind farms are similar to a regular wind farm, but the difference is that they float in the middle of the ocean. Offshore wind farms can be placed in water up to 40 metres (130 ft) deep, whereas floating wind turbines can float in water up to 700 metres (2,300 ft) deep[14.] The advantage of having a floating wind farm is to be able to harness the winds from the open ocean. Without any obstructions such as hills, trees and buildings, winds from the open ocean can reach up to speeds twice as fast as coastal areas. [1], [3].

A prototype planned by Italian start-up TWIND has a pair of balloons at 2600 feet. The open sails move antagonistically so while one moves downwind the other moves upwind. This movement spins a turbine to generate power. The option of offshore flying wind turbines is also being explored to solve the airspace competition issue. At higher altitudes, wind has more power and velocity and is more consistently predictable. As power generated goes up because of higher wind resistance proportional to the cube of relative velocity, more power can be generated. That works out to be some 8-27 times the power produced at ground level. The tethers can haul in the kites/balloons housing the turbines during storms or for general maintenance work. Less pollution is an advantage, as well as the fact that it will not take up much precious ground space for installation. This plan certainly presents plenty of challenges for air traffic and other unmanned aircraft by its need of minimum 2 mile no fly zone. The offshore option also has extra effort of transporting the energy from sea to land based power plants. Since this plan of flying wind farms involve diverse major aspects like sharing airspace, geography, and technology.

IX. BIOMASS BRIQUETTES

Biomass briquettes are being developed in the developing world as an alternative to charcoal. The technique involves the conversion of almost any plant matter into compressed briquettes that typically have about 70% the calorific value of charcoal. There are relatively few examples of large scale briquette production. One exception is in North Kivu, in eastern Democratic Republic of Congo, where forest clearance for charcoal production is considered to be the biggest threat to Mountain Gorilla habitat. The staff of Virunga National Park have successfully trained and equipped over 3500 people to produce biomass briquettes, thereby replacing charcoal

produced illegally inside the national park, and creating significant employment for people living in extreme poverty in conflict affected areas.

X. BIODIESEL

Biodiesel is produced from oils or fats using transesterification and is a liquid similar in composition to fossil/mineral diesel. Chemically, it consists mostly of fatty acid methyl esters. Feedstocks for biodiesel include animal fats, vegetable oils, soy, rapeseed, jatropha, mahua, mustard, flax, sunflower, palm oil, hemp, field pennycress, *Pongamia pinnata* and algae. Pure biodiesel is the lowest-emission diesel fuel. Although liquefied petroleum gas and hydrogen have cleaner combustion, they are used to fuel much less efficient petrol engines and are not as widely available. Biodiesel can be used in any diesel engine when mixed with mineral diesel. Electronically controlled 'common rail' and 'unit injector' type systems from the late 1990s onwards may only use biodiesel blended with conventional diesel fuel. [19]. Since biodiesel is an effective solvent and cleans residues deposited by mineral diesel, engine filters may need to be replaced more often, as the biofuel dissolves old deposits in the fuel tank and pipes. It also effectively cleans the engine combustion chamber of carbon deposits, helping to maintain efficiency. Biodiesel is also an oxygenated fuel, meaning it contains a reduced amount of carbon and higher hydrogen and oxygen content than fossil diesel. This improves the combustion of biodiesel and reduces the particulate emissions from unburnt carbon. Biodiesel is also safe to handle and transport because it is as biodegradable as sugar, one-tenth as toxic as table salt, and has a high flash point of about 300°F (148°C) compared to petroleum diesel fuel, which has a flash point of 125°F (52°C). [7]

XI. GREEN DIESEL

Green diesel is produced through hydrocracking biological oil feedstocks, such as vegetable oils and animal fats. Hydrocracking is a refinery method that uses elevated temperatures and pressure in the presence of a catalyst to break down larger molecules, such as those found in vegetable oils, into shorter hydrocarbon chains used in diesel engines [13]. It may also be called renewable diesel, hydrotreated vegetable oil [15] or hydrogen-derived renewable diesel. Green diesel has the same chemical properties as petroleum-based diesel. It does not require new engines, pipelines or infrastructure to distribute and use, but has not been produced at a cost that is competitive with petroleum. Gasoline versions are also being developed.

XII. BIOGAS

Biogas is methane produced by the process of anaerobic digestion of organic material by anaerobes.[17] It can be produced either from biodegradable waste materials or by the use of energy crops fed into anaerobic digesters to supplement gas yields. The solid byproduct, digestate, can be used as a biofuel or a fertilizer. Biogas can be recovered from mechanical biological treatment waste processing systems.

Landfill gas, a less clean form of biogas, is produced in landfills through naturally occurring anaerobic digestion. If it escapes into the atmosphere, it is a potential greenhouse gas. Farmers can produce biogas from manure from their cattle by using anaerobic digesters.

XIII. GEOTHERMAL ENERGY

Geothermal energy is thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. The geothermal energy of the Earth's crust originates from the original formation of the planet (20%) and from radioactive decay of minerals (80%).[14] The geothermal gradient, which is the difference in temperature between the core of the planet and its surface, drives a continuous conduction of thermal energy in the form of heat from the core to the surface.

Earth's internal heat is thermal energy generated from radioactive decay and continual heat loss from Earth's formation. Temperatures at the core-mantle boundary may reach over 4000 °C (7,200 °F).[13] The high temperature and pressure in Earth's interior cause some rock to melt and solid mantle to behave plastically, resulting in portions of mantle convecting upward since it is lighter than the surrounding rock. Rock and water is heated in the crust, sometimes up to 370°C (700°F). Worldwide, 11,400 megawatts (MW) of geothermal power is online in 24 countries in 2012.[13] An additional 28 gigawatts of direct geothermal heating capacity is installed for district heating, space heating, spas, industrial processes, desalination and agricultural applications [6].

Geothermal power is cost effective, reliable, sustainable, and environmentally friendly, [2] but has historically been limited to areas near tectonic plate boundaries. Recent technological advances have dramatically expanded the range and size of viable resources, especially for applications such as home heating, opening a potential for widespread exploitation. Geothermal wells release greenhouse gases trapped deep within the earth, but these emissions are much lower per energy unit than those of fossil fuels. As a result, geothermal power has the potential to help mitigate global warming if widely deployed in place of fossil fuels. The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs, but only a very small fraction may be profitably exploited. Drilling and exploration for deep resources is very expensive.

XIV. HYDROELECTRICITY

Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy, accounting for 16 percent of global electricity generation. The cost of hydroelectricity is relatively low, making it a competitive source of renewable electricity. Hydro is also a flexible source of electricity since plants can be ramped up and down very quickly to adapt to changing energy demands. However, damming interrupts the flow of rivers and can harm

local ecosystems, and building large dams and reservoirs often involves displacing people and wildlife.[1]

Once a hydroelectric complex is constructed, the project produces no direct waste, and has a considerably lower output level of the greenhouse gas carbon dioxide (CO₂) than fossil fuel powered energy plants. Most hydroelectric power comes from the potential energy of dammed water driving a water turbine and generator. The power extracted from the water depends on the volume and on the difference in height between the source and the water's outflow. This height difference is called the head. The amount of potential energy in water is proportional to the head. A large pipe (the "penstock") delivers water to the turbine.[11]

A simple formula for approximating electric power production at a hydroelectric plant is: $P = \rho * h * r * g * k$, where: P is Power in watts, ρ is the density of water (~1000 kg/m³), h is height in meters, r is flow rate in cubic meters per second, g is acceleration due to gravity of 9.8 m/s², k is a coefficient of efficiency ranging from 0 to 1. Efficiency is often higher (that is, closer to 1) with larger and more modern turbines.

Pumped storage method produces electricity to supply high peak demands by moving water between reservoirs at different elevations. At times of low electrical demand, excess generation capacity is used to pump water into the higher reservoir. When there is higher demand, water is released back into the lower reservoir through a turbine. Pumped-storage schemes currently provide the most commercially important means of large-scale grid energy storage and improve the daily capacity factor of the generation system. Pumped storage is not an energy source, and appears as a negative number in listings. [16]

Run-of-the-river hydroelectric stations are those with small or no reservoir capacity, so that the water coming from upstream must be used for generation at that moment, or must be allowed to bypass the dam. A tidal power plant makes use of the daily rise and fall of ocean water due to tides; such sources are highly predictable, and if conditions permit construction of reservoirs, can also be dispatchable to generate power during high demand periods. Tidal power is viable in a relatively small number of locations around the world. An underground power station makes use of a large natural height difference between two waterways, such as a waterfall or mountain lake. An underground tunnel is constructed to take water from the high reservoir to the generating hall built in an underground cavern near the lowest point of the water tunnel and a horizontal tailrace taking water away to the lower outlet waterway. Hydroelectricity eliminates the flue gas emissions from fossil fuel combustion, including pollutants such as sulfur dioxide, nitric oxide, carbon monoxide, dust, and mercury in the coal.

Hydroelectricity also avoids the hazards of coal mining and the indirect health effects of coal emissions. Compared to nuclear power, hydroelectricity generates no nuclear waste, has none of the dangers associated with uranium mining, nor nuclear leaks. Compared to wind farms, hydroelectricity power plants have a more predictable load factor. If the project has a storage reservoir, it can generate power when needed.

Hydroelectric plants can be easily regulated to follow variations in power demand.

XV. HYDROGEN ECONOMY

The hydrogen economy is a proposed system of delivering energy using hydrogen. [17] The concept was proposed earlier by geneticist J.B.S. Haldane. Proponents of a hydrogen economy advocate hydrogen as a potential fuel for motive power and on-board auxiliary power, stationary power generation, and as an energy storage medium. Molecular hydrogen of the sort that can be used as a fuel does not occur naturally in convenient reservoirs; nonetheless it can be generated by steam reformation of hydrocarbons, water electrolysis or by other methods. Hydrogen has a high energy density by weight but has a low energy density by volume when not highly compressed or liquefied.

Hydrogen is industrially produced from steam reforming, which uses fossil fuels such as natural gas, oil, or coal.[1] The energy content of the produced hydrogen is less than the energy content of the original fuel, some of it being lost as excessive heat during production. Steam reforming leads to carbon dioxide emissions, in the same way as a car engine would do. A small quantity of H₂ is produced by electrolysis using electricity and water. The Kvaerner-process or Kvaerner carbon black & hydrogen process (CB&H) is a method, developed in the 1980s by a Norwegian company of the same name, for the production of hydrogen from hydrocarbons (C_nH_m), such as methane, natural gas and biogas. Of the available energy of the feed, approximately 48% is contained in the hydrogen, 40% is contained in activated carbon and 10% in superheated steam. The storage methods of hydrogen are pipeline storage, Cryogenic storage, Underground hydrogen storage, etc. Power to gas is a technology which converts electrical power to a gas fuel.

Hydrogen has one of the widest explosive/ignition mix range with air of all the gases with few exceptions such as acetylene, silane, and ethylene oxide. That means that whatever the mix proportion between air and hydrogen, a hydrogen leak will most likely lead to an explosion, not a mere flame, when a flame or spark ignites the mixture. This makes the use of hydrogen particularly dangerous in enclosed areas such as tunnels or underground parking.[17] Pure hydrogen-oxygen flames burn in the ultraviolet color range and are nearly invisible to the naked eye, so a flame detector is needed to detect if a hydrogen leak is burning. Hydrogen is odorless.

XVI. NUCLEAR POWER

Nuclear power, or nuclear energy, is the use of exothermic nuclear processes, [23] to generate useful heat and electricity. The term includes nuclear fission, nuclear decay and nuclear fusion. Presently the nuclear fission of elements in the actinide series of the periodic table produce the vast majority of nuclear energy in the direct service of humankind, with nuclear decay processes, primarily in the form of geothermal energy, and radioisotope thermoelectric generators, in niche

uses making up the rest. Unlike fossil fuel power plants, the only substance leaving the cooling towers of nuclear power plants is water vapour and thus does not pollute the air or cause global warming. Nuclear power plants convert the energy released from the nucleus of an atom via nuclear fission that takes place in a nuclear reactor. The heat is removed from the reactor core by a cooling system that uses the heat to generate steam, which drives a steam turbine connected to a generator producing electricity. The nuclear fuel cycle begins when uranium is mined, enriched, and manufactured into nuclear fuel, which is delivered to a nuclear power plant. After usage in the power plant, the spent fuel is delivered to a reprocessing plant or to a final repository for geological disposition.

In reprocessing 95% of spent fuel can potentially be recycled to be returned to usage in a power plant. In a nuclear-fueled power plant much like a fossil fueled power plant water is turned into steam, which in turn drives turbine generators to produce electricity. The difference is the source of heat. At nuclear power plants, the heat to make the steam is created when uranium atoms split called fission. There is no combustion in a nuclear reactor. Pressurized Water Reactors keep water under pressure so that it heats, but does not boil. This heated water is circulated through tubes in steam generators, allowing the water in the steam generators to turn to steam, which then turns the turbine generator. Water from the reactor and the water that is turned into steam are in separate systems and do not mix. In Boiling Water Reactors, the water heated by fission actually boils and turns into steam to turn the turbine generator.

In fusion reactions, two light atomic nuclei fuse to form a heavier nucleus. Large-scale reactors using neutronic fuels and thermal power production (turbine based) are most comparable to fission power from an engineering and economics viewpoint. Both fission and fusion power plants involve a relatively compact heat source powering a conventional steam turbine-based power plant, while producing enough neutron radiation to make activation of the plant materials problematic. There are some power plant ideas which may significantly lower the cost or size of such plants; however, research in these areas is nowhere near as advanced as in tokamaks. Fusion power commonly proposes the use of deuterium, an isotope of hydrogen, as fuel and in many current designs also use lithium. The nuclear reactor is the heart of the plant. In its central part, the reactor core's heat is generated by controlled nuclear fission. With this heat, a coolant is heated as it is pumped through the reactor and thereby removes the energy from the reactor.

Heat from nuclear fission is used to raise steam, which runs through turbines, which in turn powers either ship's propellers or electrical generators. Since nuclear fission creates radioactivity, the reactor core is surrounded by a protective shield. This containment absorbs radiation and prevents radioactive material from being released into the environment [24]. In nuclear power plants, different types of reactors, nuclear fuels, and cooling circuits and moderators are used.

XVII. CONCLUSION

Electricity is one of the key resources of the 21st century. Almost nothing can be manufactured and no comforts of the modern world can be enjoyed without electricity. The current generation is highly dependent on the non renewable sources of energy which are fast exhausting and polluting. Thus the need of reduction of the dependence on non renewable sources of energy arises. The alternative sources of energy like solar, wind, geothermal, hydrogen, biofuels are an excellent replacement to the conventional sources. The use of alternative sources of energy reduces the pollution and the environmental hazards as well as strengthens the power system.

REFERENCES

- [1] Renewable Energy Sources and Climate Change Mitigation: Summary for Policymakers and Technical Summary: Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, 2011
- [2] India's Energy Security. Edited by Ligia Noronha, Anant Sudarshan.
- [3] "Big Rig Building Boom". Rigzone.com. 2006-04-13. Archived from the original on 2007-10-21. Retrieved 2008-01-18.
- [4] "The myth of renewable energy Bulletin of the Atomic Scientists". Thebulletin.org. 2011-11-22. Retrieved 2013-10-03.
- [5] http://en.wikipedia.org/wiki/Renewable_energy.
- [6] S. C. Singhal, "Advances in solid oxide fuel cell technology," Elsevier Solid State Ionics, 2000, pp.305-313.
- [7] Muhammad H. Rashid, "Power Electronics Handbook," Ph.D., Fellow IEE, Fellow IEEE, Academic press, Copyright 2001.
- [8] www.eia.doe.gov/oiaff/ieo/highlights.html
- [9] Frede Blaabjerg, Zhe Chen, and Soren Baekhoej Kjaer, "Power Electronics as Efficient Interface in Dispersed Power Generation Systems," IEEE Trans. Power Electron., vol. 19, no. 5, pp. 1184-1194, Sep. 2004.
- [10] Fragkiadakis I., "Photovoltaic systems", Professor of T.E.I. of Crete, Zito press, Copyright 2004.
- [11] Steve Leone (25 August 2011). "U.N. Secretary-General: Renewables Can End Energy Poverty". Renewable Energy World.
- [12] "Solar Energy Perspectives: Executive Summary" (PDF). International Energy Agency. 2011. Archived from the original on 2011-12-03.
- [13] Glassley, William E. (2010). Geothermal Energy: Renewable Energy and the Environment, CRC Press, ISBN 9781420075700.
- [14] Fridleifsson, Ingvar. "ScienceDirect Renewable and Sustainable Energy Reviews : Geothermal energy for the benefit of the people". Retrieved 14 November 2011.
- [15] "Hydroelectric power - energy from falling water". Clara.net.
- [16] Atkins, William (2003). "Hydroelectric Power". *Water: Science and Issues* 2: 187-191.
- [17] Werner Zittel; Reinhold Wurster (1996-07-08). "Chapter 3: Production of Hydrogen. Part 4: Production from electricity by means of electrolysis". HyWeb: Knowledge - Hydrogen in the Energy Sector. Ludwig-Bölkow-Systemtechnik GmbH.
- [18] Evans, Jon (14 January 2008). "Biofuels aim higher". Biofuels, Bioproducts and Biorefining (BioFPR). Retrieved 2008-12-03.
- [19] National Renewable Energy Laboratory (2007-03-02). "Research Advantages: Cellulosic Ethanol". National Renewable Energy Laboratory. Retrieved 2012-04-02.
- [20] Bloom Energy Server unveiled, Bloom Box not for the home just yet by Mobile News Desk
- [21] Carbon neutral fuels Wikipedia
- [22] Flow battery From Wikipedia
- [23] "World Nuclear Power Reactors 2007-08 and Uranium Requirements". World Nuclear Association. 2008-06-09. Archived from the original on March 3, 2008. Retrieved 2008-06-21.
- [24] "How nuclear power works". *HowStuffWorks.com*. Retrieved September 25, 2008.

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