Scope of Polymer Electrolyte Membrane Fuel Cell for Enhanced Utilization of Renewable Energy Systems

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Abstract- *Renewable energy sources (RES) supply 14% of the total world energy demand. RES includes biomass, hydropower, geothermal, solar, wind and marine energies. The various renewable energy technologies ant its effectiveness are analyzed with its specific applications. In this paper, attempt has been made to find out the scope of renewable energy gadgets to meet out energy needs and mitigation potential of greenhouse gases mainly carbondioxide.*

I. INTRODUCTION

The renewable are the primary, domestic and clean or inexhaustible energy resources is dramatically increasing along with improvements in the quality of life, industrialization of developing nations, and increase of the world population[1] . It has long been recognized that this excessive fossil fuel consumption not only leads to an increase in the rate of diminishing fossil fuel reserves, but it also has a significant adverse impact on the environment, resulting in increased health risks and the threat of global climate change[2]-[5]. Changes towards environmental improvements are becoming more politically acceptable globally, especially in developed countries [6]. Society is slowly moving towards seeking more sustainable production methods, waste minimization, reduced air pollution from vehicles, distributed energy generation, conservation of native forests, and reduction of greenhouse gas emissions [7]. Increasing consumption of fossil fuel to meet out current energy demands alarm over the energy crisis has generated a resurgence of interest in promoting renewable alternatives to meet the developing world's growing energy needs. Excessive use of fossil fuels has caused global warming by carbon dioxide; therefore, renewable promotion of clean energy is eagerly required. To monitor emission of these greenhouse emissions an agreement was made with the overall pollution prevention targets, the objectives of the Kyoto Protocol agreement.

II. RENEWABLE ENERGY SOURCES

Renewable energy resources will play an important role in the world's future. The energy resources have been split into three categories: fossil fuels, renewable resources and nuclear resources Renewable energy sources are those resources which can be used to produce energy again and again, e.g. solar energy, wind energy, biomass energy, geothermal energy, etc. and are also often called alternative sources of energy[8]-[11]. Renewable energy sources that meet domestic energy requirements have the potential to provide energy services with zero or almost zero emissions of both air pollutants and greenhouse gases. Renewable energy system development will make it possible to resolve the presently most crucial tasks like improving energy supply reliability and organic fuel economy[12]; solving problems of local energy and water supply; increasing the standard of living and level of employment of the local population; ensuring sustainable development of the remote regions in the desert and mountain zones; implementation of the obligations of the countries with regard to fulfilling the international agreements relating to environmental protection Development and implementations of renewable energy project in rural areas can create job opportunities and thus minimizing migration towards urban areas. Harvesting the renewable energy in decentralized manner is one of the options to meet the rural and small scale energy needs in a reliable, affordable and environmentally sustainable way

III. CLIMATE CHANGE SCENARIO

Climate change is one of the primary concerns for humanity in the 21st century .It may affect health through a range of pathways, for example as a result of increased frequency and intensity of heat waves, reduction in cold related deaths, increased floods and droughts, changes in the distribution of vector-borne diseases and effects on the risk of disasters and malnutrition. The overall balance of effects on health is likely to be negative and population sin low income countries are likely to be particularly vulnerable to the adverse effects. The experience of the 2003 heat wave in Europe showed that high-income countries may also be adverselyaffected. The potentially most important environmental problem relating to energy is global climate change (global warming or the greenhouse effect). The increasing concentration of green house gases such as CO2, CH4, CFCs, halons, N2O, ozone, and peroxyacetylnitrate in the atmosphere is acting to trap heat radiated from Earth's surface and is raising the surface temperature of Earth .A schematic representation of this global climate change problem is illustrated in .reveals Humankind is contributing with a great manyeconomic activities to the increase atmospheric concentration of various greenhouse gases. Current situation and the role of various greenhouse gases are given in. Many scientific studies reveal that overall CO_2 levels have increased 31% in the past 200 years, 20 Gt of Carbon added to environment since 1800 only due to deforestation and the concentration of methane gas which is responsible for ozone layer depletion has more than doubled since then. The global mean surface temperature has increased by 0.4–0.8 ◦C in the last century above the baseline of 14 ◦C. Increasing global temperature ultimately increases global mean sea levels at an average annual rate of 1–2 mm over the last century. Arctic sea ice thinned by 40% and decreased in extent by 10–15% in summer since the 1950s .

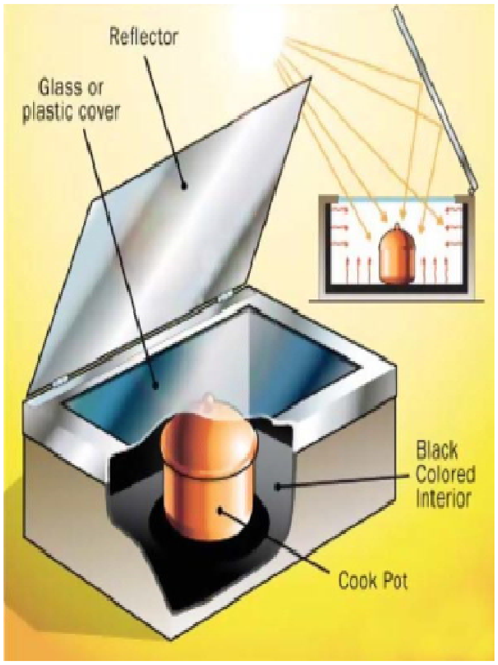


Fig 1. Solar powered heater

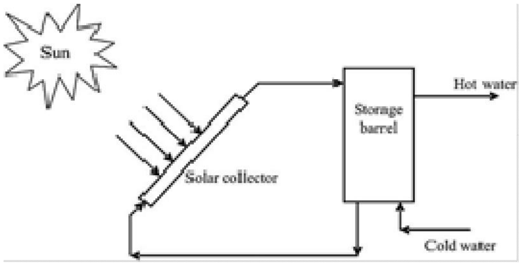


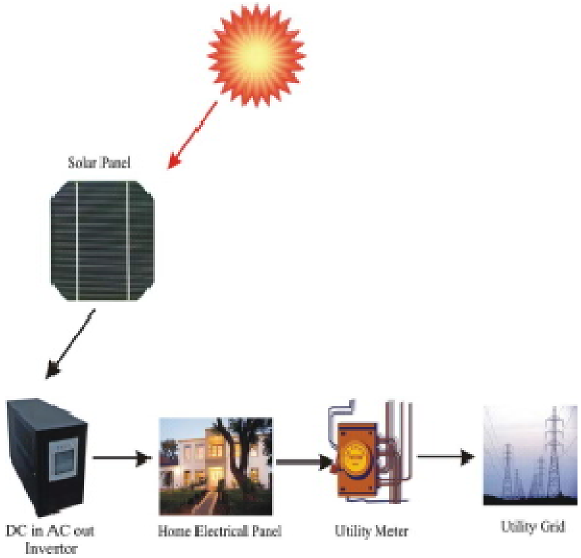
Fig.2 Block diagram of solar water heater

compared to the petrol substitution. This is primarily due to low efficiency of fuel utilization in the diesel engine pump.

IV. WIND ENERGY

The renewable energy technologies applied to electricity generation, wind energy ranks second only to hydroelectric in terms of installed capacity and is experiencing rapid growth. India is one of the most promising countries for wind power development in theworld .Expansion of wind energy installed capacity is poised to play a key role in climate change mitigation. However, wind energy is also susceptible to global climate change. Some changes associated with climate evolution will most likely benefit the wind energy industry while other changes may negatively impact wind energydevelopments, with such ‘gains and losses’ depending on the region under consideration .Wind power may prove practical for small power needs in isolated sites, but for maximum flexibility, it should be used in conjunction with other methods of power generation to ensure continuity.Wind energy potential studies show that the world-wide wind resources are abundant. The world-wide potential for wind energy is estimated to be 26,000 TWh/yr, while a capacity of 9000 TWh/yr may be utilized due to economical and other reasons.

Wind energy for electricity production today is a mature, competitive, and virtually pollution-free technology widely used inmany areas of the world .Wind technology converts the energy available in wind to electricity or mechanical power through theuse of wind turbines .The function of a wind turbine is to convertthe motion of the wind into rotational energy that can be used to drive a generator, as illustrated in. Wind turbines capture the power from the wind by means of aerodynamically designed blades and convert it into rotating mechanical power. Wind turbine blades use airfoils to develop mechanical power. In the power-starved developing countries, wind power is theviable source of electricity, which can be installed and transmitted very rapidly, even in remote, inaccessible and hilly areas. Electricity generation from wind never depletes and never increases in price. The electricity produced by these systems could save several billion barrels of oil and avoid many million tons of carbon and other emissions . At a mean wind speed of 4.5 m/s, the estimated value of net annual CO_2 emission mitigation potential is the lowest (2874 kg) for GM-II model and highest (7401 kg) for SICO model in the case of diesel substitution. Similarly, for the case of electricity substitution for the same wind speeds, it is estimated at 2194 kg and 5713 kg, respectively, for the above-mentioned two models.



V.INTRODUCTION OF PEM CELL

The polymer electrolyte membrane fuel cell (PEMFC), also known as proton exchange membrane fuel cell, takes its name from the type of electrolyte: a polymeric membrane with high proton conductivity when the membrane is conveniently

Basic PEM Fuel Cell Structure

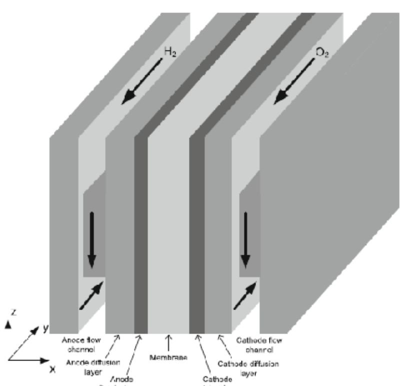


Fig 4. Structure of PEM Fuel cell

Basically, the physical structure of a PEMFC consists of seven components, according to feeding channels, diffusion layer, and catalytic layer in the anode; membrane; catalytic layer, diffusion layer, and feeding channels in the cathode. The PEMFC combines in a very compact unit the electrodes and the electrolyte. This structure, well known as membrane electrode assembly (MEA), is not thicker than a few hundred microns. It is the heart of the fuel cell and is fed with hydrogen and oxygen, generating electrical power with a power density of around the polymeric solid electrolyte forms a thin electronic insulator and a barrier for gases between both electrodes, allowing fast proton transport and high current. Usually, the fuel cell is fed with atmospheric air instead of pure oxygen. The oxygen mole fraction in atmospheric air is 0.21

Description of PEM Fuel Cells System 51 density. The solid electrolyte has the advantage, as opposed to those of liquid type, that allows the FC to operate in any spatial position. The electrodes consist of a catalytic layer of great superficial area on a substratum of coal, permeable to gases. Electro catalyst materials are necessary to obtain a good operation, increasing the speed of the chemical reaction. In this way, the gases can react with a lower energy of activation, allowing the reaction to take place at a lower temperature. The electro catalyst used in PEMFC is platinum, which is one of the major drawbacks of this technology because of its high cost.

However, there are research advances of high temperature PEM fuel cells (HT-PEMFCs) in several fields because there are several reasons for operating at temperatures above 100◦C. First, the electrochemical kinetics for the reactions incathode and anode are enhanced. Second, the water management issue can be simplified because there would be no liquid water. Third, the cooling system is simplified due to the increased temperature gradient between the fuel cell stack and the coolant. Fourth, the waste heat can be exploited using cogeneration. Fifth, the tolerance to CO is increased allowing the use of lower quality reformed hydrogen. Unfortunately, the area of HT-PEMFCs is incipient and still needs much research to be implemented in commercial applications.

Advantages and Disadvantages of PEM Fuel Cells

The main advantage of PEM fuel cells is their high efficiency compared with other energy conversion devices This allows the efficiency of a fuel cell vehicle using direct- 7. Hydrogen Fuel CellHydrogen FC to be twice that in a gasoline Moreover, unlike the internal combustion engines where the efficiency is maximum with the highest loads, the FC efficiency is also high with partial loads. This is advantageous because in typical driving conditions, like urban and suburban scenarios, most of the time the vehicle is demanding a small fraction of the nominal FC power Thus, an FC vehicle will be working mostly at high efficiencies. At the same time, using direct hydrogen FC, the local emissions problem in densely urban areas can be eliminated. Another important advantage of PEMFC, in contrast to other types of fuel cells, is the low operation temperature (below 80◦C) allowing to reach the operation point quickly.

Generic Structure of a Fuel Cell-Based Power Generation System

In order to be able to produce energy, it is necessary to integrate the fuel cell stack with other components to form a fuel cell-based power generation system. A generic scheme showing the interrelation between the main components of the power generation system is presented in. These components can be divided into thefollowing subsystems .

VI.. REACTANT FLOW SUBSYSTEM

The reactant flow subsystem consists of the hydrogen and air supply circuits. The objective is to supply the adequate reactant flow to ensure fast transient response and minimal auxiliary power consumption. The hydrogen supply circuit is generally composed of a pressurized tank with pure H2 connected to the anode through a pressure-reduction valve and a pressure-controlled valve, meanwhile, the air supply circuit is generally composed of an air compressor which feeds the cathode with pressurized air from the atmosphere. The anode output is generally operated in dead ended mode and a purge valve in the. In case the anode output is not closed its possible to re inject the out-flowing hydrogen into the anode input. On the other hand, the cathode output is normally open through a fixed restriction. The cathode air supply will be studied where we propose to close the cathode output with a controlled valve.

Heat and Temperature Subsystem

The heat and temperature subsystem includes the fuel cell stack cooling system and the reactant heating system. The thermal management of the fuel cell is critical since the performance depends strongly on the temperature. The stack temperature control can be done using a fan or a water refrigeration subsystem. Description of PEM Fuel Cells System .

Water Management Subsystem

The objective of the water management subsystem is to maintain an effective hydration of the polymer membrane and an adequate water balance, because the fuel cell performance is also strongly dependent on membrane hydration. Both the air and the hydrogen, are usually humidified before entering the fuel cell with humidifiers in both circuits. The water that leaves the cathode can be recovered in a water separator and reinjected in the humidifiers through a pump.

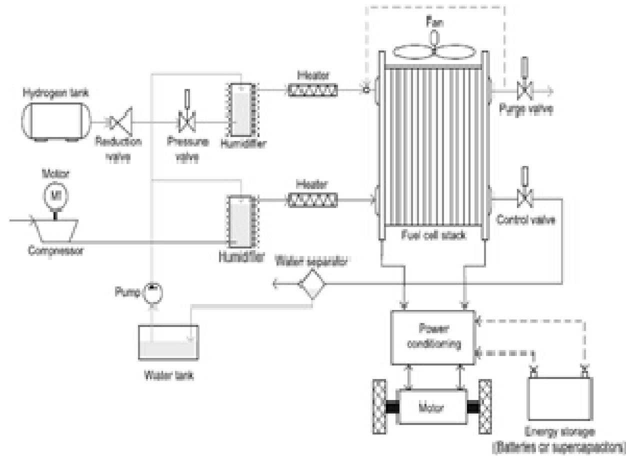


Fig 5. Block diagram of water management system

VII. THE “GAS BATTERY”

Sir William Grove (1811-96), a British lawyer and amateur scientist developed the first fuel cell in 1839. The principle was discovered by accident during an electrolysis experiment. When Sir William disconnected the battery from the electrolyzer and connected the two electrodes together, he observed a current flowing in the opposite direction, consuming the gases of hydrogen and oxygen (Fig. 2). He called this device a ‘gas battery’. His gas battery consisted of platinum electrodes placed in test tubes of hydrogen and oxygen, immersed in a bath of dilute sulphuric acid.

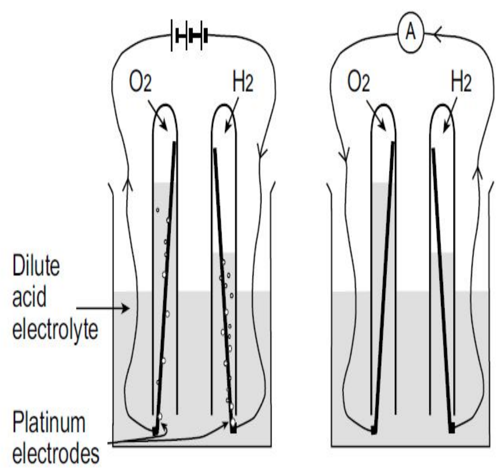


Fig 6. Structure of groves gas battery

It generated voltages of about one volt. In 1842 Grove connected a number of gas batteries together in series to form a 'gas chain'. He used the electricity produced from the gas chain to power an electrolyzer, splitting water into hydrogen and oxygen However, due to problems of corrosion of the electrodes and instability of the materials, Grove's fuel cell was not practical. As a result, there was little research and further development of fuel cells for many years to follow.

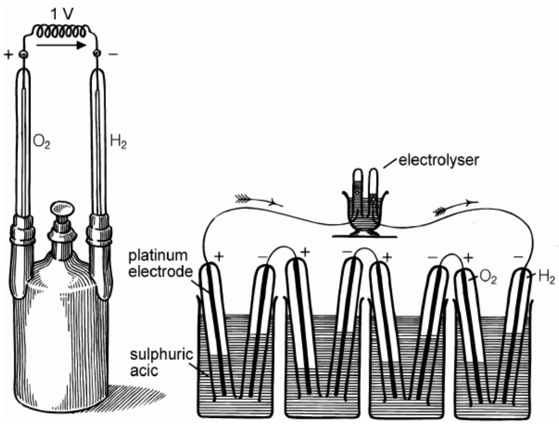


Fig.7 structure of gas battery

VIII. CONCLUSION

The California Low Emission Vehicle Program, administered by the California Air Resources Board (CARB), has been a large incentive for automobile manufacturers to actively pursue fuel cell development. This program requires that beginning in 2003, ten percent of passenger cars delivered for sale in California from medium or large sized manufacturers must be Zero Emission Vehicles, called ZEVs. Automobiles powered by fuel cells meet these requirements, as the only output of a hydrogen fuel cell is pure water.

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