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Exploring Renewable Energy Sources: Need of the hour

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ABSTRACT

Tremendous demand for energy has been upraised by growing population worldwide, leading to resilient emphasis on discussion and attention about the renewable energy sources. All energy-rich fuels, adequate for the human kind for a very long duration, with a capacity of replenishing over and over again, are known as renewable energy sources [RES's]. Our society aims at developing such appliance and practices, through which we can solely rely upon these RES's for achieving most of our demands. Most remarkable RES is Sun, which is a center of the supreme amount of energy. Others include wind energy, bioenergy, hydro-power, and geothermal energy etc. The principal utilization of energy is done for electricity generation, heating and transportation etc.

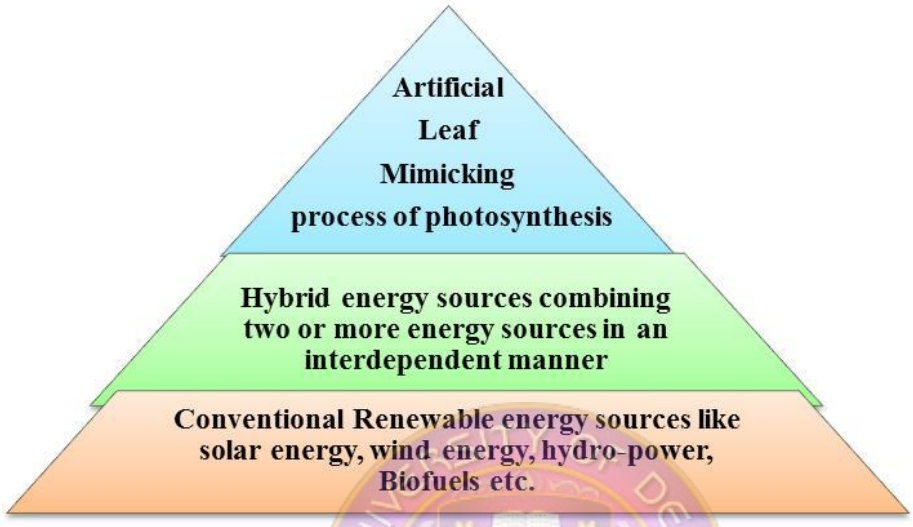
For identifying the theoretical, technical and economic potential of the renewable energy sources, our society had been trying to follow the top-down approach. Recently, a large number of methods have been optimized and accessed for the control, conversion and final usage of these energy sources. This article aims to review benefits and limitations of some of the RES's and the latest advancements in this field for resolving the grave environmental issues like sustainable development, greenhouse effect and global warming etc.

Keywords: Artificial leaf, Biofuels, Hybrid energy sources, Hydrogen fuel, Renewable energy sources, Solar energy, Wing energy, etc.

INTRODUCTION

With an increasing discussion on renewable energy, the efficiency of these resources and their popularity is also rising and hence following the principle of demand and supply, the cost of these renewable energy sources is decreasing. Over all, the constructed buildings like houses and shops exhaust almost half of the total annual energy consumed across the globe (1). Most of the energy is used for heating/ cooling of residential and commercial places, along with lighting and air conditioning etc. CO_2, NO_x and Chloro-Fluoro carbons (CFCs) etc. are the most widely emitted gases which are responsible for the most important concerns of mankind like greenhouse effect and global warming etc. The major challenge

in this field is to make these resources completely environment friendly so that the severe problem of pollution can be tackled. Quite recently, Ellabban et. al., 2014 have reviewed the current and the future status of the usage of renewable energy sources, where they have not only mentioned about the latest developments in the field but also the future prospects of the utilization of RES's (2). Sustainable development of an economy through utilization of renewable energy sources had always been a major concern for the scientific community and hence has attracted the attention of a large number of reviews (3-6). Evolution of these renewable energy sources through time has been pictorially represented in this review.



[Figure 1.] Some of such conventional, non-conventional/ alternative, artificial and hybrid renewable energy resources along with their advantages and disadvantages, **[Table I]** have been discussed in the following section.

Figure-I Evolution of Renewable Energy sources with time

1. CONVENTIONAL RENEWABLE ENERGY SOURCES

Solar Energy:

Solar power being the biggest source of energy has an advantage of working through low cost solar panels which can easily be installed, used and has a long life span. Many research groups are already working on increasing the efficiency of these solar panels. Solar energy has its potential application everywhere, starting from residential, commercial, and industrial to remote applications. Predominantly, the prospective of solar energy was being exploited for providing electricity to the remote areas, where people in general do not have access to any of the energy sources and hence are bound to remain in dark. Many remote villages have already been provided light by using solar energy around the world. Many appliances like solar cooker, water heater, oven, battery chargers for laptops/ mobiles etc. have already been available to the end-users. Interestingly, solar pool/ pond, fountains are also available in market for saving energy. Solar signs have replaced normal traffic light signals in many cities around the world. Various skylights and tubular day lighting devices are also accessible which absorb solar energy during daytime and can be very competently used during night. The production cost of creating solar energy is decreasing day by day, due to the large funding support from government as well as private sector. In spite of all the help, solar energy has a long way to go, because it still has to

cross institutional, regulatory, financial and economic barriers (7). Many policy documents in support of solar energy have to be made soon so that this enormous amount of energy from Sun can be used at a very cheaper cost by our society.

Wind Energy:

Another important RES is wind energy which is also a very clean and environment friendly energy fuel, but this also has certain limitations. Wind energy, if harnessed efficiently can produce enormous amount of energy. However, the level of noise produced by wind turbines is a major concern. The offshore wind farm noise might ultimately harm the marine organisms by interfering in their life processes like migration, hunting of food, communication and fertilization etc. If this noise level can at least be decreased a little, using some technology, the wind energy can then be used as a very good alternative source of renewable energy. Wind energy has been considered a good renewable energy source, as it does not cause any carbon emissions and hence comparatively providing a cleaner source of energy. New technologies have been developed which are used for installing very high capacity turbines in deep water, but still there are lot of unknown and less understood factors related to the effect of wind turbines on marine organism's health. Studies collecting data and further providing key lessons for the understanding of the impact of wind turbines on aquatic life have quite recently been reviewed (8). Following these key lessons might further help in developing an understanding related to solving the major concerns of researchers related to harnessing wind energy and its probable effect on environment. Wind energy is used in numerous vehicles, cargo ships, water pumps etc. along with its extensive use in innumerable recreational activities like kite flying, para-gliding, wind skiing etc.

Hydrogen fuel:

Hydrogen fuel has also been of immense interest in the field of RES's, as it not only produces huge amount of energy but also is almost completely environment friendly. Water vapors are the only byproduct which is generated during the consumption of hydrogen fuel, hence it has a potential of eliminating the greenhouse gases also. Hydrogen fuel is actually an enormously proficient fuel, as it can even be used as rocket fuels, for powering space shuttles and various vehicles for transportation. Like electricity, hydrogen is also an energy carrier which means it can carry energy from the source to the end-user in its deliverable form. Hydrogen is a zero-emission fuel and is also being used in fuel cells which are supposed to generate electricity, water and heat, by a combination of hydrogen and oxygen. The disadvantage of hydrogen fuels is that it is still very costly and hence cannot be used in bulk scale. There is an urgent need for new research which might give some suggestive measures for making hydrogen fuels cheaper in cost (9).

Table I. Comparative summary of the related points on Renewable Energy Sources (10-12)

BENEFITS	HARMS
SOLAR ENERGY	
• Infinite energy source. • Solar energy is free.	• It can only be harnessed during daytime. • Solar collectors, panels and cells

• Solar energy does not cause pollution.	are relatively expensive. • Used to charge heavy batteries which are difficult to transport. • Requirement of large land area to capture the solar energy.
WIND ENERGY	
• The wind is free and can be captured efficiently. • Pollution free. • Land below wind turbine can be used for other purposes.	• The strength of the wind is not constant. • Wind turbines are noisy. • Wind turbines manufacture causes some pollution. • For generating enough electricity, big wind farms are required.
HYDRO-POWER	
• After initial construction of dam, power can continuously be generated. • Electricity can be switched on and off as per the requirement. • Dams are designed to last many decades to produce electricity for many generations. • It does not produce greenhouse gases.	• Dams are extremely expensive to build. • Natural environment is generally disturbed after flooding. • People in adjacent areas have to be moved due to the risk of flood, hence they lose their livelihood. • The building of large dams can cause serious geological damage and can also alter the natural water level.
GEO-THERMAL ENERGY	
• Independent of the weather conditions. • Intermediate or by-products are not produced. • Maintenance cost of geothermal power plants is very small and they don't occupy much space.	• Lesser available Geothermal Energy sites in the vicinity of cities. • Installation cost is very high and the total energy generation potential is too small. • It always has a danger of eruption of volcano.
BIOFUEL	
• Cleaner and pollution free. • A wide variety of sources and crops are needed for Biofuel production. • Biofuels reduce greenhouse gases. • Dependency on biofuels can provide economic securities to countries.	• Expensive to produce. • Biofuels are produced from crops needing fertilizers which may harm environment and cause water pollution. • Biofuels are obtained from crops which will take up agricultural space of other crops. • Requisite of bulk water amount for irrigating the biofuel crops.

HYDROGEN FUEL	
• It is very easily available and non-toxic. • Burning of hydrogen fuel does not produce very harmful byproducts. • It is very powerful and efficient. It can even be used to propel spaceship.	• Expensive and time-consuming to produce. • Hydrogen is also difficult to transport. • It's highly inflammable and has potential risks associated with it. • For separating hydrogen from oxygen, it is still dependent on fossil fuels.

2. BIOFUELS

Likewise, plant based biofuels has been explored quite extensively for meeting the increasing energy demands, but the problem associated with them is that the quantity required for biofuels for the energy production is much higher for the same energy production with fossil fuels. An extensive land area should then be used by them which might affect the crop production. To avoid these issues, alternative sources which might give biofuels without even using lands should then be discovered. Quite recently, microalgae have been used for the biodiesel production and new cultivation systems like open ponds and photo-bioreactors have been developed for the same (13). For efficient conversion of biomass into useful biofuels, various cost effective processes and technologies have already been discussed at length in a recent review (14). Various types of feed stocks have been used for the production of required chemicals using bio refinery concepts. The production of biofuels had already been categorized in three different generations, in which the first generation biofuels were centered on terrestrial crops like sugar cane, sugar beet, maize and rapeseed etc. The second generation biofuels were developed using lignocellulosic agriculture, forest residues and non-food crops. For bio-ethanol productions, agro-residues (cellulosic material) were used quite frequently. Bio-ethanol processing technology from cellulosic material to bio-ethanol required four processes of pre-treatment, enzymatic hydrolysis, fermentation and distillation (15). Third and the most viable generation of biofuels are solely dependent on micro-algae. The first and second generation of biofuels was found to be of lesser use, as they laid down heavy pressure on the usage of land, which was otherwise being used for growing other basic crops, required for mankind. The growing conditions for microalgae requires very basic things like light, sugar, carbon di-oxide, N, P and K etc., and they can produce very large amounts of proteins, lipids and carbohydrates, hence micro-algae is really becoming a biofuel of great interest which has an immense potential of substituting a major proportion of fossil fuels (16).

Biofuels especially dried dung, charcoal and wood are the biggest exploited sources, utilized for meeting the energy demands required during cooking and heating at residential places. Also, the biogas which is produced from biofuels has been used in gas engines for generating electricity. Biofuels in the form of biodiesel and bioethanol have also been used as a nice alternative fuel for transportation vehicles and even as jet fuel. In some countries, especially the developed ones, food waste and garbage have become really a troublesome issue. To cope up with this issue, scientists have developed a way of anaerobically digesting this food waste which in turn produces the energy. This energy from food waste has to pass through some specific processing parameters involving pre-treatment and co-

digestion. Zhang, et., al., 2014 have recently carried out an extensive survey of all these physiological, thermo-chemical and biological way of converting food waste into renewable energy through anaerobic digestion (17). This review had suggested that the digestion of food waste with some other substrates might improve the performance of this processing technology.

3. HYBRID RENEWABLE ENERGY SYSTEMS (HRES'S)

There are many research groups which are now exploring the possibility of "Hybrid energy resources" in which two or more forms of renewable energy sources like heat, light, wind, water, photovoltaic and biodiesel etc. are being combined for developing new source of energy. Mostly these hybrid systems like "photovoltaic and diesel hybrid system" have been quite successfully being used in rural areas in many countries to get an easy, environment friendly and cost effective solution for their energy needs. The storage devices of such hybrid sources have also been improved for increasing their efficiency. The physical modeling, methodologies and criteria of optimization of most of these hybrid sources has quite recently been reviewed for both small and large-scale energy productions (18). These HRES's are attaining admiration, as they can be used as stand-alone energy sources for both distant as well as outdoor applications. HRES's have shown their prospective in producing electricity which can further be used to power lots of house appliances like TV, refrigerator, motor pump, washing machines etc. Likewise, Hybrid cars have already been invented and exploited in market for various purposes, especially in sports, which utilizes a combination of different types of fuels like ethanol and petrol. These HRES's might be able to meet every type of demand of energy but it also has some limitations. Some of the disadvantages include the dependency of energy production through HRES's on natural cycles which have weather fluctuations, more costly initial set-ups, requirement of more efficient storage devices etc. (18).

4. ARTIFICIAL ENERGY SOURCES

In a quite recent and promising study, an "artificial leaf" had been designed which can split water into its components i.e. hydrogen and oxygen utilizing solar energy from sun light and mimicking the process of plant photosynthesis (19). This artificial leaf is fabricated by layering different inorganic substances on one another. It consumes solar power for splitting the chemical bonds between hydrogen and oxygen atoms. The central part of this "artificial leaf model" is termed as photovoltaic wafer, which transforms sunlight into wireless electricity. This electricity then crosses the barrier and hits the outer layer of the "leaf," which has a coating of special type of chemical catalysts on both the side. One type of catalysis initiates the process of hydrogen formation, while other catalyzes oxygen production. Hydrogen thus developed can be stored in the storage devices for its use during night, while the oxygen can be used to provide electricity during daytime by utilizing photovoltaic cells. This artificial leaf is claimed to be made up of relatively cheaper materials so that it can be utilized for developing comparatively cheaper, cleaner and sustainable energy for the benefit of the common people especially in the rural populations. To avoid the concerns like greenhouse effect and global warming, development of some alternatives to fossil fuels is extremely important. As during the process of photosynthesis, most of the fossil fuels are developed, hence some artificial process of replicating photosynthesis should be worked out so that some pollution free and cleaner alternative

energy sources like hydrogen can then be produced (20). Using enzymes like hydrogenases in various processes have already been analyzed in which the photocatalytic production of hydrogen is possible which will later have an aim of converting itself into a more easily storable form (20). Artificial methods of replicating photosynthesis have certain benefits over photovoltaic cells, as the former converts and stores solar energy directly, while the later converts it in two phases; from solar energy to electricity and then to chemical energy for storage. The limitations of this approach include the costly initial set ups along with the problem of corrosion of materials, which are used for fabrication of artificial leaf.

OUTLOOK AND FUTURE DIRECTIONS

Thousands of research laboratories and companies all across the world are working towards finding out more greener, sustainable and alternative forms of renewable energy sources. Lots of new devices and appliances are being developed across the globe for giving us more efficient, cost efficient and environment friendly alternative of energy sources, for meeting the increasing demands of our growing population. Other than managing production and consumption of these renewable energy sources, their storage is one of the biggest challenges for the scientists, as their storage is extremely difficult. As per the demands of the end user, these alternative energy sources have to be customized so that it can fulfill the demands of everybody (21).

To solve this issues related to alternative energy sources, various initiatives are required both at a small and large scale which should not only take in to account, the development of new alternative sources but also, certain modification in the conventional energy resources should be worked out.

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