Advanced Sustainable Renewable Energy With Analytical And Emerging Aspects

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***Abstract*—We use a lot of resources to meet our energy needs in our daily life. These sources include natural gas, Bio fuels, Nuclear power, fossil fuels, etc. Some of these sources are very expensive to produce energy and has big impact on our earth and environment. That's why we try to get most of energy from the renewable sources that include Geothermal, Wind energy, Solar power etc. These sources are very reliable and we can produce very inexpensive and most efficient energy. These sources are very friendly to our environment. The aim of sustainable development is for the improvement to be achieved whilst maintaining the ecological processes on which life depends. However, renewable energy supplies are much more compatible with sustainable development than are fossil and nuclear fuels, in regard to both resource limitations and environmental impacts. The demand for renewable energy sources is driven largely by government policies including those that stem from national obligations under international environmental agreements. Finally, renewable energy is directly linked with various social, economic and environmental areas both on national and international level and therefore, production of renewable energy provides work and income for the local population. With the development of these new energy sources, our world would become a cleaner place and the energy crisis would straighten itself out.**

Keywords—Sustainable renewable energy, Environmental impact, Energy security, Waste Management, Pollution.

1. Introduction

Renewable energy is a energy that comes from various resources which are continuously replenished such as sunlight, wind, rain, tides, waves and geothermal heat. Renewable energy includes solar, wind, advanced hydroelectric power, biomass and geothermal energy has the potential to replace conventional fossil fuels and nuclear power. However, non-hydro renewable sources presently provide just 2.3% of electricity in the U.S. This type of energy is technically and economically feasible for a diverse mix of existing renewable technologies to completely meet our energy needs. In fact, as much as 20% of U.S. electricity could immediately come from non-hydro renewable energy sources without any negative effects to the stability or reliability of the electrical grid. "The great advantage of renewable energy systems is that they are generally safe and stable economically, whereas the availability of finite fossil and nuclear fuels will diminish and their prices will escalate unpredictably" [1].

2. WHY RENEWABLE ENERGY?

Renewable Energy

_ Reliable

_ In expensive

_ Most efficient energy

_ Friendly to our environment

3. How much Renewable energy is there?

The combination of wind, solar, advanced hydroelectric power, and some biomass and geothermal energy could completely meet U.S. electricity needs. The potential of domestic renewable resources is more than 85 times current U.S. energy use in the longer term. In U.S 2011, about 82% of the nation’s energy comes from fossil fuels, 8% is derived from nuclear, and 9% comes from renewable sources [7] in figure as below. It can also play a significant role in alleviating other pressing problems such as energy security by providing a distributed, diversified energy infrastructure. In U.S, Wind is the fastest growing renewable source, but contributes only 1% of total energy used in the U.S.

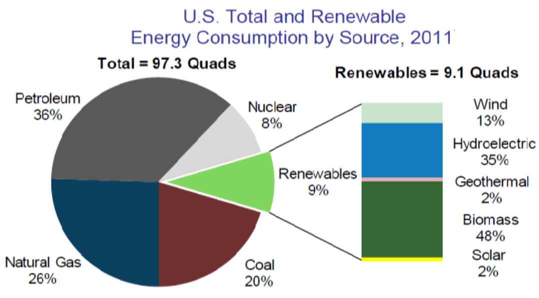

Figure 1: Renewable Sources [7]

4. Sustainable Development for Renewable Energy

"Sustainable development can be promoted by policies designed to encourage development, deployment, and, when appropriate, transfer of technologies which are intended to reduce to a justified minimum the use of energy. raw materials, creation of wastes, and release to environmental media of contaminants in order to produce the goods and services demanded by society" [2]. All national energy plans include four vital factors for improving or maintaining social benefit from energy [6] as (a) increased harnessing of renewable supplies (b) increased efficiency of supply and end-use (c) reduction in pollution (d) consideration of lifestyle.

5. Importance of Advance Sustainable Solid Waste Management

Developing advanced sustainable waste management processes are timely and essential for several reasons can be

(i) Economic Development: Sustainable waste management technologies have the potential to create new jobs, produce renewable energy, and promote economic growth.

(ii) Public Health: Improper waste management can lead to infectious diseases, underground water contamination, and toxic air emissions that are harmful to human health. (c) Environment: Waste disposal can have an enormous environmental. Landfills require large amounts of land and must continually expand to accommodate increasing amounts of waste, utilizing more land resources and leaving less room for the conservation of green spaces for humans and wildlife. (d) Policy: Current federal policies under consideration focus on pollution reduction strategies and renewable energy technologies.

6. Types of Renewable Energy

There are several types of renewable energy such as Geothermal, Wind, Solar, Hydroelectric Energy and Biomass, etc. In this project, I am using five of these.

a. Geothermal Energy

This type of energy is in rocks under the ground, radioactive decay of elements, such as uranium, releases heat energy that warm the rocks. In some areas, the steam and hot water which rises naturally to the surface can be used to generate electricity. The largest geothermal power plant is in California and has an output of 750 megawatts and 57 wells.

To understand the key ingredients of the geothermal energy system, the energy produced can be calculated from the single well using following equation as

$$\text{Energy} = (c_p * F * \Delta T * \eta) - P \quad (1)$$

c_p is the specific heat of the working fluid

F is the flow rate from

ΔT is the sensible heat that can be extracted from the fluid produced by the production hole

η is the efficiency with which the heat energy can be used.

P is the parasitic losses

There is a significant investment required to prove that a geothermal resource is viable. Unlike wind and solar resources where the energy available can be measured at low cost, geothermal resources require drilling that costs 10's of millions of dollars to confirm the resource's potential.

b. Wind Energy

This type of energy is the result of the sun heating the Earth and creating convection currents in the Earth's atmosphere. Wind as a source of energy is not a new idea. For example, sailing ships, powered by the wind, have been around for thousands of years. Wind turbines (or aero-generators) use large blades to capture the kinetic energy of the wind. This kinetic energy is used to directly turn a turbine and produce electricity. Wind turbines do not produce any polluting waste; however, one drawback is that some people consider them to be an noisy and an eyesore. if there is poorly location, killing migrating birds.

The power in the wind is proportional to

- the area of windmill being swept by the wind
- the cube of the wind speed
- the air density which varies with altitude

The formula used for calculating the power in the wind is as

$$P = 1/2 * (\delta * A * V^3) \quad (2)$$

Therefore, P is power in watts (W)

δ is the air density in kilograms per cubic meters (kg/m3)

A is the swept rotor area in square meters (m2)

V is the wind speed in meters per second (m/s)

Wind power is a clean renewable energy source. There are some environmental considerations when planning a wind power scheme. They are:

(i)Electromagnetic interference - some television frequency bands are susceptible to interference from wind generators.

(ii)Noise - wind rotors, gearboxes and generators create acoustic noise when functioning; this needs to be considered when siting a machine.

(iii)Visual impact - modern wind machines are large objects and have a significant visual impact on their surroundings.

c. Hydroelectric power

Hydroelectric power is also very reliable. Hydroelectric power stations are able to start up electricity production quickly and need to be situated in high mountainous areas such as North Wales or Scotland. Large scale hydroelectric schemes involve building a dam across the end of a river valley to create a reservoir which is done high up in a mountains area. Damming the river causes the river valley to flood which could mean that houses and villages are destroyed.

Hydroelectric power schemes also cost a lot of money and take a long time to build. However, they do last a long time and they are able to produce large amounts of electricity. Once they are built, hydroelectric schemes provide a cheap and reliable source of electricity.

The general formula for any hydro system's power output is as

$$P = \eta * \delta * g * Q * H \qquad (3)$$

Where P is the mechanical power produced at the turbine shaft (Watts),

η is the hydraulic efficiency of the turbine

δ is the density of water (1000 kg/m3),

g is the acceleration due to gravity (9.81 m/s2),

Q is the volume flow rate passing through the turbine (m3/s),

H is the effective pressure head of water across the turbine (m).

The best turbines can have hydraulic efficiencies in the range 80 to over 90%, although this will reduce with size. Micro-hydro systems (<100kW) tend to be 60 to 80% efficient It's capacitor factor is a ratio summarizing how hard a turbine is working. Therefore Capacity factor(CF) is calculated as:

$$CF(\%) = Energy/\{capacity * 8760hrs/year\} \qquad (4)$$

The annual energy output is then estimated using the Capacity Factor (CF) as

$$Energy(kWh/year) = P(kW)*CF*8760 \qquad (5)$$

Hydropower is currently the world's largest renewable source of electricity, accounting for 6% of worldwide energy supply or about 15% of the world's electricity. The electricity produced is proportional to the product of the head and the rate of flow. The following is an equation, which may be used to roughly determine the amount of electricity, which can be generated, by a potential hydroelectric power site as

$$POWER(kW) = 5:9 * FLOW * HEAD \qquad (6)$$

In this equation (6), FLOW is measured in cubic meters per second and HEAD is measured in meters.

Hydroelectric power has always been an important part of the world's electricity supply, providing reliable, cost effective electricity, and will continue to do so in the future. It environmental impacts are very different from those of fossil fuel power plants. The actual effects of dams and reservoirs on various ecosystems are only now becoming understood. The future of hydro-electric power will depend upon future demand for electricity, as well as how societies value the environmental impacts of hydro-electric power compared to the impacts of other sources of electricity.

d. Biomass

Biomass can come from waste or from purpose-grown energy crops and these crops can increase the emission of greenhouse gases such as nitrous oxide to the degree so some of these crops currently thought not to reduce global warming overall [1]. In fact, the simplest biomass energy sources are plants which can be burnt to produce steam to turn a turbine. Biomass fuels are renewable as more plants can be grown, producing more biomass.

In developing countries 40% of energy is derived from biomass, while in the USA it is 4%, in Sweden 14% and Austria 10% [9]. In biomass, a process called photosynthesis enables plants to capture sunlight and transform it into chemical energy, as shown in the following equation as

$$6CO_2+12H_2O+Light \rightarrow C_6H_{12}O_6+6O_2+6H_2O \qquad (7)$$

From this chemical equation, biomass energy can be obtained by reversing the photosynthesis process. The organic resources that are used to produce energy using these processes are collectively called Biomass. Biomass in general, among other renewable sources of energy, is the science and technology for a new type of energy may predict would be the challenge during the 21st Century.

There are two main available options for utilizing biomass.

(i) Construction stand-alone also known as Dedicated biomass are to be known in the Renewable Obligation as those which have been commissioned since 1st January, 1990 and are 'fuelled wholly by biomass in any month [10].

(ii) Co-firing of biomass with other fuels

The comparison table between renewable and Conventional Energy [6] as below:

Comparison of renewable and conventional energy systems

	Renewable energy supplies (green)	*Conventional energy supplies (brown)*
Examples	Wind, solar, biomass, tidal	Coal, oil, gas, radioactive ore
Source	Natural local environment	Concentrated stock
Normal state	A current or flow of energy. An income	Static store of energy. Capital
Initial average intensity	Low intensity, dispersed: $\le 300\,W\,m^{-2}$	Released at $\ge 100\,kW\,m^{-2}$
Lifetime of supply	Infinite	Finite
Cost at source	Free	Increasingly expensive.
Equipment capital cost per kW capacity	Expensive, commonly $\approx$US\$1000 kW^{-1}	Moderate, perhaps \$500 kW^{-1} without emissions control; yet expensive >US\$1000 kW^{-1} with emissions reduction
Variation and control	Fluctuating; best controlled by change of load using positive feedforward control	Steady, best controlled by adjusting source with negative feedback control
Location for use	Site- and society-specific	General and invariant use
Scale	Small and moderate scale often economic, large scale may present difficulties	Increased scale often improves supply costs, large scale frequently favoured
Skills	Interdisciplinary and varied. Wide range of skills. Importance of bioscience and agriculture	Strong links with electrical and mechanical engineering. Narrow range of personal skills
Context	Bias to rural, decentralised industry	Bias to urban, centralised industry
Dependence	Self-sufficient and 'islanded' systems supported	Systems dependent on outside inputs
Safety	Local hazards possible in operation: usually safe when out of action	May be shielded and enclosed to lessen great potential dangers; most dangerous when faulty
Pollution and environmental damage	Usually little environmental harm, especially at moderate scale	Environmental pollution intrinsic and common, especially of air and water
	Hazards from excess biomass burning Soil erosion from excessive biofuel use Large hydro reservoirs disruptive Compatible with natural ecology	Permanent damage common from mining and radioactive elements entering water table. Deforestation and ecological sterilisation from excessive air pollution Climate change emissions
Aesthetics, visual impact	Local perturbations may be unpopular, but usually acceptable if local need perceived	Usually utilitarian, with centralisation and economy of large scale

Figure 2: Renewable and Conventional Energy [6]

e. Solar Energy

Solar Panels turn light energy from the Sun directly into electricity. Therefore, manufacturing solar cells is very expensive and requires the use of highly toxic materials. However, once the solar cell is built it produces no pollution and requires little maintenance. One of the advantages of Solar cells are ideal for use in remote locations where maintenance is difficult and other sources of electricity would be expensive. One of the disadvantage is that solar cells suffer from a low efficiency because only light with enough energy causes an electron to be released which is only about 25% of all sunlight. The amount of electricity a solar panel can produce depends on two factors such as surface area and the light intensity.

Solar cells have shown to be ecological and could play a significant role for the sustainable energy generation of the future. A photovoltaic (PV) cell, also known as solar cell, is a semi-conductor device that generates electricity when exposed to light. Photovoltaic are likely to provide the nation with a significant portion of its future electrical energy [3]. However, it produces electricity when sunlight excites electrons in the cells. Test photovoltaic cells that consist of silicon solar cells are currently up to 21% efficient in converting sunlight into electricity [4]. The durability of photovoltaic cells, now approximately 20 years, needs to be lengthened and current production costs reduced about fivefold to make them economically feasible. Currently, production of electricity from photovoltaic cells costs approximately 30¢/kWh, but the price is projected to fall to approximately 10¢/kWh by the end of the decade and perhaps reach as low as 4¢ by the year 2030, provided the needed improvements are made. In order to make photovoltaic cells truly competitive, the target cost for modules would have to be approximately 8¢/ kWh [3]. For a solar cell that consists of only one semiconductor material, the maximum energy conversion efficiency is obtained for a band gap in the range between 1.4 and 1.6 eV [8]. The major environmental problem associated with photovoltaic (PV) systems is the use of toxic chemicals such as cadmium sulfide and gallium arsenide, in their manufacture [5].

The major types of materials for building PV cells include crystalline and thin films, which differ in terms of light absorption efficiency, energy conversion efficiency, manufacturing technology, and cost of production. Existing electronic models for solar cells characterize properties such as the open circuit voltage (V_{oc}), the maximum power voltage(V_{mp}), and the maximum power current (Imp) in terms of the short circuit current (I_{sc}), which is in turn modeled as a function of the beam and diffuse irradiance, air mass (AM_a), incident angle (AOI),and panel temperature (T_c). First, the short circuit current is

$$Is=I_{sc0}*f1(AM_a)((Eb*f_2(AOI)+f_d*E_{diff}/E_0)(1+I_{sc}:(T_c-T_0)) \quad (8)$$

$f(AM_a)$ and f(AOI) are functions of air mass and incident angle, respectively, and are defined as

$$f(AM_a)=A_0+A_1*AM_a+A2*AM^2_a+A3*AM^3_a+A4*AM^4_a \quad (9)$$

$$f(AOI)=B_0+B_1*AOI+B_2*AOI_2+B_3*AOI_3+B_4*AOI_4 \quad (10)$$

E_e is defined as the ratio of the measured short-circuit

current to the short-circuit current at reference conditions

$$E_e=I_{sc}/I_{sco}*(1+\alpha I_{sc}*(T_c-T_0)) \quad (11)$$

The open-circuit voltage is

$$V_{oc}=V_{0c0}+N_s*\delta(T_c)*\ln(E_e)+\beta V_{oc}*(T_c-T_0) \quad (12)$$

The maximum power is defined as

$$P_{mp}=V_{mp}-I_{mp} \quad (13)$$

Where,

$$I_{mp}=I_{mp0}*(C_1*E_e+C_2*E^2_e)*(1+\alpha_{Imp}(T_c-T_0)) \quad (14)$$

$$V_{mp}=V_{mp0}+C_3N_s\delta(T_c)*\ln(E_e)+C_4N_s*((\delta(T_c)\ln(E_e))^2+\beta V_{mp}*(T_c-T_0) \quad (15)$$

Parameters appearing in Eqns. (8) – (15) are:

- $I_{sc0,}$ short circuit current at reference conditions.
- V_{0c0}, open circuit voltage at reference conditions.
- E_b, beam irradiance (W /m2).
- E_{diff} , diffuse irradiance (W /m2).
- $f_{d,}$ fraction of diffuse irradiance (1 for non-concentrating

modules)

- αI_{sc}, β_{voc}, α_{Imp}, β_{vmp}, temperature-related co-efficient.
- T_c, T_0: current temperature and reference temperature.
- δ is a function of temperature.
- N_s, number of solar cells.
- A_i, $B_{i;}$, C_i (i = 1, 2, 3, 4), empirical parameters.

As in Fig 3 below, these included: channel-above PV as Mode 1, channel-below PV as Mode 2, PV between single pass channels as Mode 3, and finally the double-pass design as Mode 4. The numerical analysis showed that while Mode 1 has the lowest performance, the other three have comparable energy yields. In addition, Mode 3 consumes the least fan power. Tripanagnostopoulos et al. conducted outdoors tests on PVT/a and PVT/w collectors of different design configurations for horizontal-mounted applications. They found that PVT/a collectors are around 5% higher in production costs than the PV modules. This would be around 8% for PVT/w collectors with pc-Si cells, and around 10% when the entire system costs were considered. It T.T. Chow / Applied Energy 87 (2010) [8] was suggested that when the collectors are placed in parallel rows and keeping a distance between rows to avoid shading, low-cost booster diffuse reflectors can be placed between the adjacent rows to increase the radiation received at collector surfaces. Their experimental tests gave a range of thermal efficiency from 38% to 75% for PVT/a collectors and 55% to 80% for PVT/w designs, based on the steady state noon-hour measurements in the University of Patra in Greece [8].

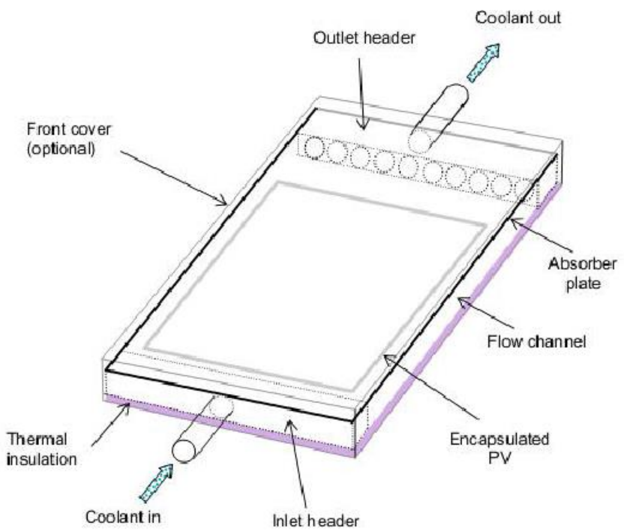

Figure 3: Main features of flat-plate PVT Collector [3][4][8]

7. Cost

The renewable energy sector is demonstrating its capacity to deliver cost reductions, provided that appropriate policy frameworks are in place and enacted. Costs have been decreasing and a portfolio of renewable energy technologies is becoming cost-competitive in an increasingly broad range of circumstances because they are far cheaper for society. However, the established technologies such as hydro and geothermal are often fully competitive. Where resources are favorable, technologies such as onshore wind are almost competitive. Consequently, Wind power is competitive with nuclear power and fossil fuels at around $0.05-0.06 per kWh and the price of solar PV has fallen to roughly $0.25-0.30 per kWh. In general, costs need to be reduced further. Moreover, fossil fuel subsidies and the lack of a global price on carbon are significant barriers to the competitiveness of renewable energy sources.

8. VARIABILITY AND INTERMITTENCY OF RENEWABLE ENERGY

Regardless, the abilities of renewable technologies and the vastness of the resource, renewable energy is still often depicted as far too. It is possible to harness these sources of energy in a way that substantially reduces the problems of intermittency and variability.

9. POTENTIAL FOR EFFICIENCY

Using renewable energy more efficiently plays an important part of moving to a clean energy future. It is a cheapest and easiest way to reduce electricity use and facilitate the transition to renewable technologies.

10. Impact of advance sustainable renewable energy on energy security

Energy security and diversification of the energy mix is a major policy driver for advance sustainable renewable source of energy. However, the growth of renewable energy generally contributes to energy diversification, in terms of the technology portfolio and also in terms of geographical sources. In fact, it can also reduce fuel imports and insulate the economy to some extent from fossil fuel price rises and swings which increases energy security. Hence, concentrated growth of variable renewable energy can make it harder to balance power systems that should be duly addressed.

11. Pollution and environmental impact

The environmental impact of renewable energy depends on the particular technology and circumstances Harmful emissions can be classified as chemical (as from fossil fuel and nuclear power plant), physical (including acoustic noise and radioactivity) and biological (including pathogens); such pollution from energy generation is overwhelmingly a result of using ‘brown’ fuels, fossil and nuclear. In contrast, renewable energy is always extracted from flows of energy already compatible with the environment. The energy is then returned to the environment, so no thermal pollution can occur on anything but a small scale. Likewise material and chemical pollution in air, water and refuse tend to be minimal. Environmental pollution does occur if non-renewable energy is used for the materials and manufacture of renewable energy devices, but this is small over the lifetime of the equipment.

12. Conclusion

There are many artificial regulatory barriers limiting the immediate growth of renewable energy technologies. Renewable energy markets are growing rapidly principally in response to global concerns regarding electricity security and environmental quality. Cost has been the major obstacle to past renewable energy growth. The cost of generating electricity from renewable sources, excepting biomass, is higher than that for most fossil fuels. Government policies have played a prominent role in the development of certain renewable energy sectors. An environmentally sound and techno-economically viable methodology to treat wastes is highly crucial for the sustainability of modern societies. The implementation of advanced waste conversion technologies as a method for safe disposal of solid and liquid biomass wastes, and as an attractive option to generate heat, power and fuels, can greatly reduce environmental impacts of a wide array of wastes. To conclude:(a) Renewable energy resources are very reliable (b) Renewable energy is very efficient energy to produce. (c) Renewable energy is very cheap to produce as compare to some other non-renewable resources. (d) Renewable Energy has very less impact on our environment.

13. The future

The influence of modern science and technology indicates that are considerable improvements to older technologies, and subsequently standards of living can be expected to rise, especially in rural and previously less developed sectors. That's the reason, it is impossible to predict exactly the long-term effect of such changes in energy supply, but the advance sustainable nature of renewable energy should produce greater socio-economic stability than has been the case with fossil fuels and nuclear power. Hence, we can expect the great diversity of renewable energy supplies to be associated with a similar diversity in local economic and social characteristics.

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