

International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES15

## **Review Article-Renewable Energies**

**Javid Mohtasham**

**Department of Chemistry, Istanbul Technical University**

**Maslak – Istanbul 34469 Turkey**

**Sustainability, Health & Safety Program, Mt. Hood Community College**

**Gresham, Oregon 97030 USA**

---

### **Abstract**

A majority of the communities around the world rely heavily on oil, natural gas and coal for their energy needs. These fuels draw on lots of resources that will eventually diminish, which in turn makes them too expensive or too environmentally damaging to recover. This review article discusses the advantages and disadvantages of renewable energies; therefore based on the benefits of these energy resources, the use of renewable energies, instead of, fossil fuels will be a good solution for the control of the environmental, social and economical problems of our communities.

© 2015 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the Euro-Mediterranean Institute for Sustainable Development (EUMISD)

*Keywords:* Renewable Energy, Environment, Sustainability, Green Energy

---

## **1. Background**

Based on statistical data from 2011 by the US Department of Energy Information, primary consumption of energy by source and sectors were [1]:

Table1. Energy sources for different sectors of the society in the US

Sources of Energy	% Use	Consumption by Sectors	%Use
Petroleum	36%	Commercial	40%
Natural Gas	26%	Transportation	28%
Coal	20%	Industrial	21%
Renewable Energy	9%	Residential	11%
Nuclear Electric Power	8%		

The above data shows almost 90% of sources of energy in the US were non-renewable; therefore it would be beneficial to employ renewable energy resources (wind, solar, geothermal, wave and biomass energy) because of their availability and cleanliness.

Renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, wind, rain, tides of ocean, biomass and geothermal resources from heat generated deep within the earth. In2008, about 19% of global final energy consumption came from renewable, with 13% coming from traditional biomass, and 3.2% from hydroelectricity. The share of renewable in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3% from new renewable. Renewable energy replaces conventional fuels in four distinct areas: power generation, hot water, transport fuels and rural (off-grid) energy services [2]

The selection of energy has global implications that affect greenhouse gas emissions, water resource distribution, mineral consumption, and equipment manufacturing and transportation. The school of thought is that renewable energy technologies are more sustainable than many current sources of energy. There is a need for verification of the sustainability of renewable energy, which can easily be done by resource-use optimization, techno-economic feasibility and cost analysis, life cycle assessment, environmental externalities analysis, cost benefits analysis, manufacturing cost analysis, research and development targets and barrier identification and water requirements and distribution analysis. [3]

In general renewable energies are not adaptable to every single community because of two main factors, the distribution of the natural resources that has dependency on the geographical locations and energy-use with its dependency on the culture of individual community. The other limitations are growth rate and infrastructure.

Application of any renewable energy requires a sustainability analysis, which has dependency on three main components: environmental effects, externalities costs, and economics and financing. Each one of these variables has a major impact on the application of renewable energies; therefore before committing communities to different sorts of renewable energies, a thorough research must be done in order to have an assurance that no social, environmental or economical problems arise or are compromised because of them. [3]

## 2. Renewable Energies

This paper reviews advantages and disadvantages of few common renewable energies: hydropower, solar power, wind power, geothermal power and biomass. Hopefully after studying this review article, the public has a better

understanding about renewable energies.

### *2.1. Hydropower*

Hydropower is a clean and renewable energy source. Considering the economic, technical and environmental benefits of hydropower, most countries give priority to its development. For example, China has the richest hydro resources on the planet with a total theoretical hydropower potential of 694GW. Developing hydropower is of great importance to alleviate the energy crisis and environmental pollution resulting from the rapid economic growth of China and other countries in the 21st century. [4]

Hydropower is generated using the mechanical energy of flowing water by forcing it through piping called a penstock, which then turns a generator in order to produce electricity. Water power also consists of wave and tidal energy, which are both in the infant stage of research, as scientists try to discover how to harness the energy produced from movement of the ocean. [5]

Hydropower has several advantages over most other sources generating electrical power. These include a high level of reliability, proven technology, high efficiency, very low operating and maintenance costs, and the ability to easily adjust to load changes. Generally many hydropower plants are located in conjunction with reservoirs, which provide water, flood control, and recreation benefits for the community. In addition, hydropower does not produce waste products that cause acid rain, and greenhouse gases.

Disadvantages of hydropower include high initial costs of facilities; dependence on precipitation (no control over amount of water available); changes in stream regimens (can affect fish, plants, and wildlife by changing stream levels, flow patterns, and temperature); inundation of land and wildlife habitat (creation of reservoir); and displacement of people living in the reservoir area. [6]

### *2.2. Solar Power*

Solar power is the most abundant renewable resource on our planet. In spite of this abundance, only 0.04% of the basic power used by humans comes directly from solar sources because using a photovoltaic (PV) panel costs more than burning fossil fuels. Organic materials have recently been intensively studied for PV applications, not because of harvesting the sun's power more efficiently, but because power generation from organic photovoltaic (OPV) materials will cost considerably less than other PV technologies. [7]

Concentrating solar power uses the heat from the sun to produce steam, which in turn powers a generator that creates electricity. This also has low operating costs and high efficiency, and can produce a reliable supply of energy by utilizing thermal storage. [8]

The cost of new photovoltaic power is dropping rapidly, and if the photovoltaic industry continues to grow and improve technologically, by 2020 the cost will be comparable to the cost of conventional power, as will the cost of solar thermal power. [9-10]

Solar energy is a true renewable resource. Most of planet earth has the ability to collect some amount of solar power. Solar energy is non-polluting, does not create greenhouse gases, such as oil based energy does, nor does it create waste that must be stored, such as nuclear energy. It is also far quieter to create and harness, drastically reducing the noise pollution required converting energy to a useful form. Residential size solar energy systems also have very little impact on the surrounding environment, in contrast with other renewable energy sources such as wind and hydro electric power. Solar panels have no moving parts and require very little maintenance beyond regular cleaning. Without moving parts to break and replace, after the initial costs of installing the panels, maintenance and repair costs are very reasonable. It should also be noted that photovoltaic solar panels are the only source considered with the potential to satisfy existing demand. [11-12]

The main problem of using solar energy is the cost involved. Despite advances in technology, solar panels remain almost prohibitively expensive. Even when the cost of the panels is ignored, the system required to store the energy for use can also be quite costly. Although some solar energy can be collected during even the cloudiest of days, efficient solar energy collection is dependent on sunshine. Even a few cloudy days can have a large effect on an energy system, particularly once the fact that solar energy cannot be collected at night is taken into account. [13]

### *2.3. Wind Power*

Wind power is a very simple process. A wind turbine converts the kinetic energy (motion) of wind into mechanical energy that is used to generate electricity. The energy is fed through a generator, converted a second time into electrical energy, and then fed into the grid to be transmitted to a power station.

Like other renewable energy sources, wind energy has many advantages. It reduces greenhouse gas emissions by using turbines, which produce energy and electricity when moved by the wind, and can reduce electricity costs. All the turbines need in order to function is wind, which is just air in natural motion, and air is everywhere. Wind signifies a free, abundant, and sustainable energy that will not depreciate if we take advantage of it. We are encouraged to maximize the benefits of this resource because it can only help make our world a better, cleaner place. It will also foster domestic growth for multiple reasons. First, the native materials used to construct the turbines promote the domestic economy. Second, the turbines are a profitable investment; growth and development in the technology predict a high potential return, and increases in investment augment the country's GDP. Lastly, wind energy opens new markets and new prospects. Right now, mechanics are working to increase capacity factors so that energy can be stored for times when there isn't much wind. This project can be seen as a new economic opportunity for the US, as production of a new energy efficient generation continues. Humans cannot master nature, or else society will stagnate. Wind power is an option that works in accord with nature to promote social progress by rejecting the gloomy forecast of a world that has exhausted oils and fuels. [8]

Wind power has been harnessed for thousands of years, but only in the last decade has it generated significant amounts of commercial energy. Many of the windiest areas around the world are located far from population centers- northern Canada and Russia- where transmission and maintenance cost would be very high. The intermittent and unpredictable nature of the wind power would limit its contribution to any region, unless large-scale energy storage or intercontinental transmission is available. Environmental constraints, such as the presence of forests and protected areas, further limit the location of the wind turbines, as would simple public acceptance. Wind farms are not necessarily attractive, and they have generated complaints about noise, interference with radio and TV signals, and the killing of, or interfering with, migratory birds. [14]

### *2.4. Geothermal Power*

The geothermal process involves trapping heat underground, then building energy that rises near the surface in the form of heat. When this heat naturally creates hot water or steam, it is harnessed and then used to turn a steam turbine to generate electricity. The Italians were the first to use geothermal energy for commercial purposes in the early 1900's. Geothermal energy is extremely kind to the environment. It offers a constant, efficient supply of clean energy with minimal impact on its surroundings. [15]

Geothermal energy, or energy derived from heat coming from the earth's interior, has many different uses. These uses can be grouped into three categories: for heating systems (and direct use), for generation of electricity, and for use in geothermal heat pumps. Besides these practical uses of geothermal energy, there are many other things that make geothermal energy a very valuable energy resource. Since the earth's core continuously produces heat with the

radioactive decay of elements such as potassium and uranium, geothermal energy turns out to be a renewable, abundant, and reliable energy source. A geothermal energy plant does not make use of fuel, thus, it is both sustainable and safe for the environment. Emissions of geothermal energy operations are low. These operations neither pollute the air nor contribute to global warming. [16]

Renewable energies also meet the growing energy needs and allow the technological developments without damaging the future of our planet, the atmosphere and the environment. Geothermal energy, which is one of these energies, has great importance for some part of world. For example, Turkey has very rich geothermal energy resources and it is ranked fifth in the world after China, Japan, USA and Iceland; and the Turkish government support and promotion of the renewable energies has also been a major boost in the geothermal power. [17]

The drawbacks of geothermal energy power plants are its location because finding suitable locations for these power plants is not an easy task. The number of locations that can accommodate geothermal power plants is very limited. The location must have hot rocks so they can easily be drilled. Besides the rarity of suitable geothermal power plant locations, there is also the issue of safety. The concentration of geothermal energy can usually be found along plate boundaries, where volcanoes are concentrated and earthquakes are most frequent. Once in a while, geothermal energy locations run out of steam for a couple of months, during which the power plant is unable to produce electricity. Geothermal energy provides relatively smaller amount of power compared to other energy sources. Power derived from geothermal energy is difficult to transport. Thus, geothermal power plants can only provide energy to the areas surrounding them. While the steam itself can be clean and safe, it can come out with hazardous materials from underground such as hydrogen sulfide, mercury, ammonia, and arsenic. Finally geothermal energy can also cause earthquakes. [15]

## 2.5. Biomass

People have used biomass energy, or bioenergy as long as one can imagine! Wood is still the largest biomass energy resource today, but other sources of biomass can also be used. These include food crops, grassy and woody plants, residues from agriculture or forestry, oil-rich algae, and the organic component of municipal and industrial wastes. Even the methane fume from landfills can be used as a biomass energy source.

The use of biomass energy has the potential to greatly reduce greenhouse gas emissions, dependence on foreign oil, landfills, and finally supports local agricultural and forest-product industries. The main biomass feed-stocks for power are paper mill residue, lumber mill scrap, and municipal waste. For biomass fuels, the most common feed-stocks used today are corn grain (for ethanol) and soybeans (for biodiesel). Long-term plans include growing and using dedicated energy crops, such as fast-growing trees and grasses, and algae. These feed-stocks can grow sustainably on land that will not support intensive food crops. Another benefit of biomass is its capability to convert into a range of valuable fuels, chemicals, materials, and products—much like crude oil: [18]

1. Biofuel – Converting biomass into liquid fuels for transportation
2. Biopower - Burning biomass directly, or converting it into gaseous or liquid fuels that burn more efficiently, to generate electricity
3. Bioproducts - Converting biomass into chemicals for making plastics and other products that typically are made from petroleum.

Biomass with all of its benefits may cause harm for the environment, if one does not choose its crop for the production of biomass energy from the following list:

1. Energy crops that do not compete with food crops for land
2. Portions of crop residues such as wheat straw or corn stover
3. Sustainably-harvested wood and forest residues

#### 4. Clean municipal and industrial wastes

Beneficial biomass use can also be considered part of the terrestrial carbon cycle—the balanced cycling of carbon from the atmosphere into plants and then into soils and the atmosphere during plant decay. [19]

Besides all of biomass energy advantages, there are also some downsides to it. For example biomass energy is insufficient source of energy compare to fossil fuels (ethanol vs gasoline). It could also be a great possibility for the global warming emissions associated with growing and harvesting biomass feedstock, transporting feedstock to the power plant, and burning or gasifying the feedstock. Transportation and combustion emissions are roughly equivalent for all types of biomass. Thus, it is important to distinguish between biomass resources that are beneficial in reducing net carbon emissions, those that have an ambiguous impact, and those that increase net emissions. [20] Another environmental impact of biomass energy is associated with land erosion because of the removal of the green vegetation. [21] And finally land-use for the growth of the materials that are considered as biomass energy generators!

Finally on the basis of the science, it is wrong to support the use of all biomass resources, with any conversion technology and for any application. It would also be unreasonable to oppose all biomass on the basis that some of the biomass resources, conversion or applications are not sustainable or beneficial! Therefore the best solution is to educate our communities to choose the best resources for generation of biomass energy!

### 3. Results

It is very clear scientists are faced with a very hard job to convince public to divert their attentions toward renewable energies and forget about the convenience of working and dealing with fossil fuels on a daily basis! Having said that I know for fact all it takes to make public aware of the problems associated with fossil fuels is to present them with some statistical data about health issues as well as environmental catastrophe from some of the major big cities around the world! We should also create an environment in which usage of renewable energies becomes rewarding (i.e., tax incentive) in order to encourage people to use them.

One of the best communities within the U.S. that promotes renewable energies as well as sustainable living is the City of Portland in Oregon! Portland could and should be used as a role model within the field of sustainability everywhere; because of its promotion of renewable energies for the new and existing communities, public transportation, and the famous three Rs (Recycle, Reuse and Reduce)!

Luckily based on the performance of the available renewable energy sources and findings of the U.S. Energy Information Administration (Fig. 1-3), public has realized the health impacts of fossil fuels as well as its impact on the environment; therefore they have slowly turned toward renewable energies [22]. Hopefully within the next decade, the jump in the consumption of the renewable energies will be far greater than few percent!

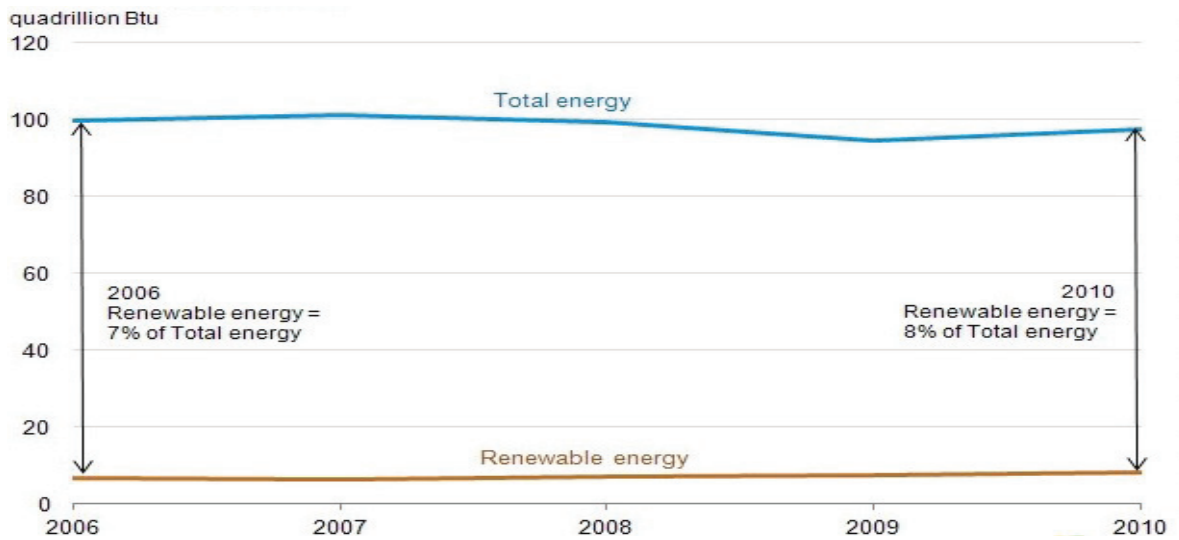


Fig. 1. U.S. Energy consumption and Renewable Energy consumption 2006-2010 [22].

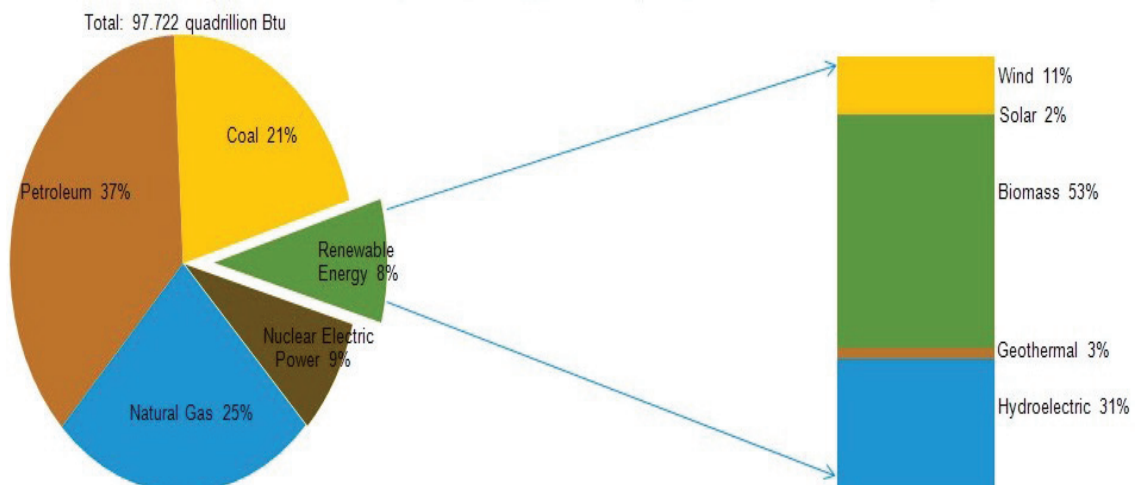


Fig. 2. Renewable Energy as share of total primary consumption in 2010 [22].



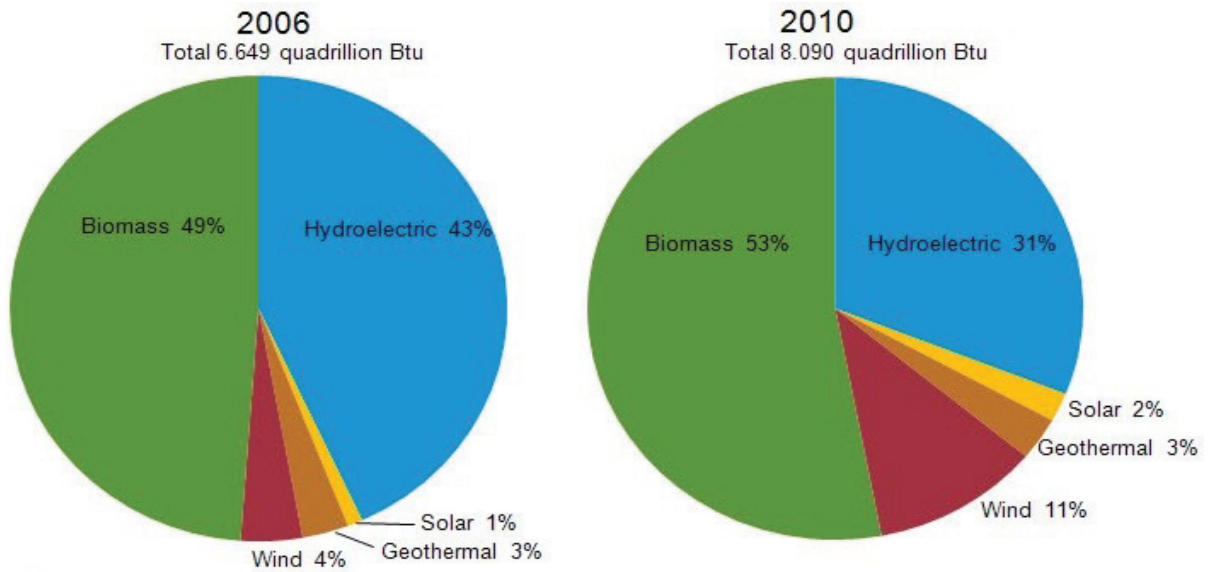


Fig. 3. Renewable Energy consumption by energy source [22].

## 4. Conclusion

It is necessary that we take precautions when distributing and consuming the earth's resources. The current use of natural gas and fossil fuels combined with increasing global population has caused the earth's resources to be abused and depleted. The effects on the environment are exhausting and threatening to the sustainability of the earth. The way we have been consuming fossil fuels is very scary; and the scarier point is the fact that during last couple of decades the consumption of fossil fuels has gone up. The oil reserves across the world are diminishing, and energy production currently depends too highly on oil and fuels, which contribute to the emission of greenhouse gases. Release of pollutants into the atmosphere has dire consequences, including global warming; therefore it is necessary to protect planet earth by incorporating renewable, eco-friendly energy sources in our daily lives!

## References

- [1] U.S. Energy Information Administration, 2011. Annual Energy Review, 343-348.
- [2] Khalil, E., 2012. ASHRAE Transactions. 118 (1): 64-72.
- [3] Mann, M., 2011. National Renewable Energy Laboratory, US Department of Energy  
[http://www.nrel.gov/analysis/sustainability\\_analysis.html](http://www.nrel.gov/analysis/sustainability_analysis.html)
- [4] Huang, Hailun, Yan, Zheng, 2009. Renewable & Sustainable Energy Reviews, 13 (6/7):1652-1656.
- [5] US Energy Information Administration, <http://www.eia.gov/>
- [6] Liu, J., Zuo, J., Zillante, G. and Chen, X., 2013. Renewable & Sustainable Energy Reviews, 9: 230-237.
- [7] Moule, A., 2010. Current Opinion in Solid State & Materials Science, 14 (6):123-130.
- [8] Bull, SR., 2001. Renewable energy today and tomorrow. Environmental Sciences and Pollution Management: Proceedings of the IEEE, 89(8): 1216-1226.
- [9] Delucchi, M. and Jacobson, M., 2013. Bulletin of the Atomic Scientists, 69(4):30-40.



- [10] Delucchi, M., and Jacobson, M. 2013. Providing all global energy with wind, water, and solar power. *Energy Policy*, 39(3): 1170-1190.
  - [11] Pogson, M., Hastings, and A., Smith, P., 2013. *GCB Bioenergy*, 5 (5): 513-524.
  - [12] Renewable-Energy-Sources: <http://www.renewable-energy-sources.com/>
  - [13] University of Minnesota: <http://www.tc.umn.edu/>
  - [14] Fetter, S., 2000. *Energy 2050*. *Bulletin of the Atomic Scientists*, 56 (4): 28-39.
  - [15] Geothermal Engineering Limited: <http://www.geothermalengineering.co.uk/>
  - [16] Alberta Geothermal: <http://www.albertageothermal.ca/>
  - [17] E Kılıc, F., and Kılıc, M., 2013. *Engineer & the Machinery Magazine*, 639:45-56.
  - [18] [http://www.nrel.gov/learning/re\\_biomass.html](http://www.nrel.gov/learning/re_biomass.html)
  - [19] Tilman, David, 2009. Beneficial Biofuels—the Food, Energy and Environment Trilemma. *Science*, July 17: 270-271.
  - [20] Spath, Pamela; Mann, Margaret, 2004. U.S. National Renewable Energy Laboratory
  - [21] David Pimentel, C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Crist, L. Shpritz, L. Fitton, R. Saffouri, R. Blair, 1995. *Science*, 267 (5201) 1117-1123.
  - [22] U.S. Energy Information Administration, 2012. *Trends in Renewable Energy Consumptions and Electricity*.
- /